SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

HITACHI DATA SYSTEMS CORPORATION
HITACHI UNIFIED STORAGE 150 *(WITH SSDS)*

SPC-1 V1.13

Submitted for Review: March 26, 2013
Submission Identifier: A00129
Revised: March 20, 2014

First Edition – March 2013

Trademarks

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AUDIT CERTIFICATION

Mel Boksenbaum
Hitachi Data Systems Corporation
750 Central Expressway M/S U9922
Santa Clara, CA 95050

December 4, 2013

The SPC Benchmark 1™ Reported Data listed below for the Hitachi Unified Storage 150*(with SSDs)*was produced in compliance with the SPC Benchmark 1™ v1.13 Onsite Audit requirements.

SPC Benchmark 1™ v1.13 Reported Data	
Tested Storage Product (TSP) Name: Hitachi Unified Storage 150 *(with SSDs)*	
Metric	**Reported Result**
SPC-1 IOPS™	125,018.87
SPC-1 Price-Performance	$1.63/SPC-1 IOPS™
Total ASU Capacity	1,717.987 GB
Data Protection Level	Protected 2 *(Mirroring)*
Total Price (including three-year maintenance)	$203,301.34
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

The following SPC Benchmark 1™ Onsite Audit requirements were reviewed and found compliant with 1.13 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by physical inspection and information supplied by Hitachi Data Systems 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.
- The total Application Storage Unit (ASU) Capacity was filled with random data, using an auditor approved tool, prior to execution of the SPC-1 Tests.

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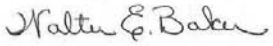
AUDIT CERTIFICATION *(CONT.)*

- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Physical verification of the components to match the above diagram.
- 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 Hitachi Data Systems 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.
  - ✓ 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 Hitachi Data Systems Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- The Priced Storage Configuration included a second 24-port FC switch as a spare to fulfill one of the requirements for a data protection level of **Protected 2**. If that second switch was added to the Tested Storage, there would be no impact on the measured SPC-1 performance.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

HITACHI
Inspire the Next

Date: December 5, 2012

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

Subject: SPC-1 Letter of Good Faith for the Hitachi Unified Storage 150

Hitachi Data Systems is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with Version 2.3.0 of the SPC-1 benchmark specification.

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

Regards,

Alan Cade
Vice President
Technical Operations

Hitachi Data Systems 2845 Lafayette Street · Santa Clara, CA 95050 408-970-7113

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Hitachi Data Systems Corporation –http://www.hds.com David Cordero – david.cordero@hds.com 750 Central Expressway M/S U9922 Santa Clara, CA 95050 Phone: (617) 838-4040 FAX: (617) 838-4040
Test Sponsor Alternate Contact	Hitachi Data Systems Corporation –http://www.hds.com Mel Boksenbaum – mel.boksenbaum@hds.com 750 Central Expressway M/S U9922 Santa Clara, CA 95050 Phone: (408) 970-7922 FAX: (408) 327-3066
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	V1.13
SPC-1 Workload Generator revision number	V2.3.0
Date Results were first used publicly	March 26, 2013
Date the FDR was submitted to the SPC	March 26, 2013
Date revised FDR was submitted to the SPC Revised pricing *(page 14)* Revised price-related SPC-1 Reported Data *(page 11)* New third-party quote *(page 79)*	March 20, 2014
Date the Priced Storage Configuration is available for shipment to customers	April 24, 2012
Date the TSC completed audit certification	March 19, 2013

Tested Storage Product (TSP) Description

Hitachi redefines unified storage with Hitachi Unified Storage. With trusted Hitachi reliability, it helps you meet application availability requirements and application latency requirements with lower investment. You will be able to deploy storage for all data types and easily grow to meet expanding requirements with software features like HDT and meet service level objectives for critical business applications. It simplifies operations with easy to use management and is part of a robust portfolio of storage solutions that can be managed from a single interface for optimal management efficiency. Combine all of this with the solution portfolio for the HUS portfolio and customers will find that the HUS platform will address all of their data center needs.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: Hitachi Unified Storage 150 *(with SSDs)*	
Metric	**Reported Result**
SPC-1 IOPS™	125,018.87
SPC-1 Price-Performance™	$1.63/SPC-1 IOPS™
Total ASU Capacity	1,717.987 GB
Data Protection Level	Protected 2 *(Mirroring)*
Total Price	$203,301.34
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

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

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

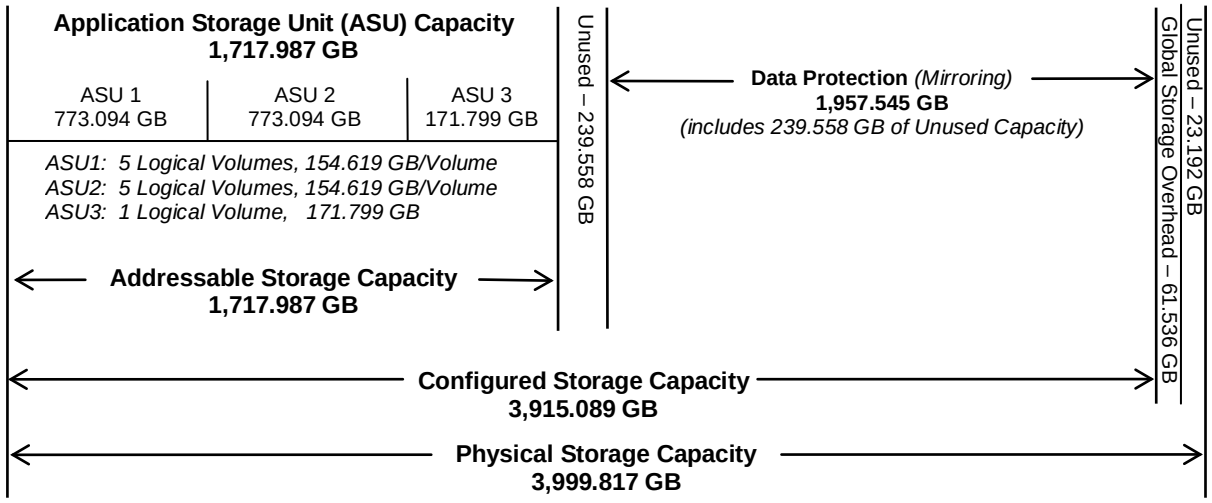
Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 14.

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

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

Storage Capacities, Relationships, and Utilization

The following diagram *(not to scale)* 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	42.95%
Protected Application Utilization	85.90%
Unused Storage Ratio	12.56%

Application Utilization: Total ASU Capacity *(1,717.987 GB)* divided by Physical Storage Capacity *(3,999.817 GB)*.

Protected Application Utilization: Total ASU Capacity *(1,717.987 GB)* plus total Data Protection Capacity *(1,957.545 GB)* minus unused Data Protection Capacity *(239.558 GB)* divided by Physical Storage Capacity *(3,999.817 GB)*.

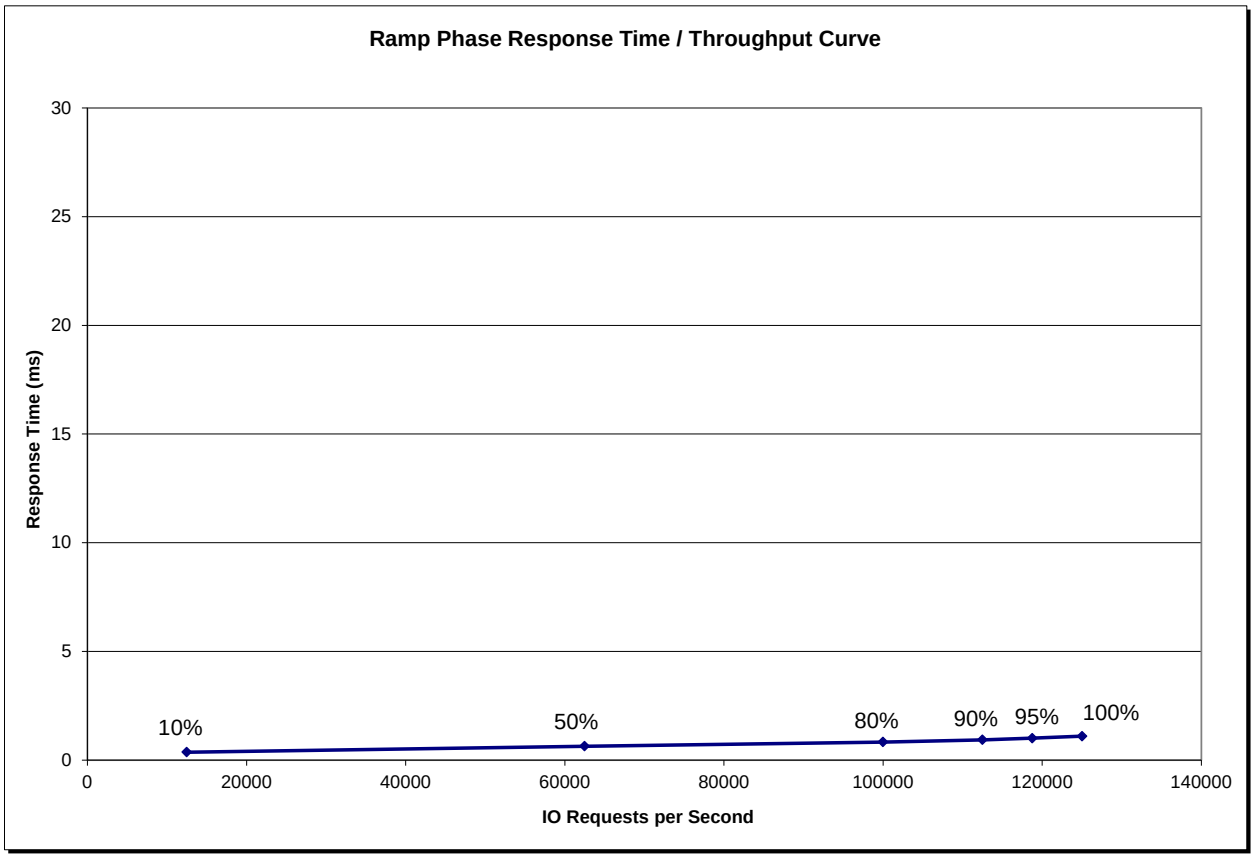
Unused Storage Ratio: Total Unused Capacity *(502.307 GB)* divided by Physical Storage Capacity *(3,999.817 GB)* and may not exceed 45%.

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

Response Time – Throughput Curve

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

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



Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	12,499.48	62,490.02	100,000.28	112,493.93	118,750.40	125,018.87
Average Response Time (ms):						
All ASUs	0.36	0.63	0.83	0.93	1.00	1.09
ASU-1	0.40	0.65	0.85	0.95	1.02	1.12
ASU-2	0.39	0.62	0.78	0.87	0.93	1.01
ASU-3	0.28	0.60	0.80	0.91	0.99	1.09
Reads	0.49	0.72	0.92	1.02	1.08	1.17
Writes	0.28	0.58	0.77	0.87	0.95	1.05

Priced Storage Configuration Pricing

Product Description	Qty	Unit List Price	Product List Price
AMS 19 in rack Americas MIN	1	$5,427.00	$5,427.00
HUS 200GB SSDs for CBSS/DBS-Base	20	$6,340.00	$126,800.00
HUS 150 8GB Cache Module	4	$1,930.00	$7,720.00
HUS 150 Controller, including (2) SAS IOC processors	2	$15,200.00	$30,400.00
HUS Drive Box - SFF 2U x 24	4	$5,890.00	$23,560.00
HUS 150 4x8Gbps FC Interface Adapter	4	$2,850.00	$11,400.00
Hitachi Unified Storage SAS Cable 5m	8	$760.00	$6,080.00
HUS 150 Base Controller Box	1	$7,600.00	$7,600.00
50/125 LC/LC PLN 5M 2f round SB 10gig OM3	16	$81.00	$1,296.00
12 outlet, single phase 208V/30AMP, NEMA, 10 ft cord	4	$735.00	$2,940.00
Hardware Components:		---	**$223,223.00**
HUS 150 Base Operating System Security Extension License	1	$400.00	$400.00
HUS 150 Base Operating System E Lic	1	$9,600.00	$9,600.00
Software Components:		---	**$10,000.00**
HUS 150 Installation Support	**1**	$2,750.00	$2,750.00
HUS 150 Hardware Maintenance Support - Includes 3 years of Standard Support (24 x 7 x 4 hour response)	**1**	$75,425.76	$75,425.76
HUS 150 Storage Software Support - Includes 3 years of Standard Support	**1**	$2,745.00	$2,745.00
Installation and Support:		---	**$80,920.76**
Brocade 360 switch w/ 24 active ports,Full Fabric,24 SWL 8Gb BR SFPs, Fixed Rack Mount	2	$4,827.00	$9,654.00
3 Year Support	1	$320.00	$320.00
13 mos support	1	$107.00	$107.00
Fibre Channel Cables	4	$21.25	$85.00
EMC LightPulse Dual Port Fibre Channel Host Bus Adapter LPE12002-E	2	$1,295.00	$2,590.00
Symantec VRTS STORAGE FOUNDATION 6.0 WIN FOR OS TIER STANDARD EDITION PER SERVER STD LIC EXPRESS BAND S	1	$440.00	$440.00
VRTS STORAGE FOUNDATION 6.0 WIN FOR OS TIER STANDARD EDITION PER SERVER INITIAL ESSENTIAL 3 YEARS EXPRESS BAND S	1	$402.00	$402.00
Third Party Components:		---	**$13,598.00**

	List Price	Std Discount	Std Buy Price
Hardware Components	**$223,223.00**	**54%**	**$102,682.58**
Software Components	**$10,000.00**	**39%**	**$6,100.00**
Installation & Support	**$80,920.76**	**0%**	**$80,920.76**
Third Party Components	**$13,598.00**	**0%**	**$13,598.00**
Total:			**$203,301.34**

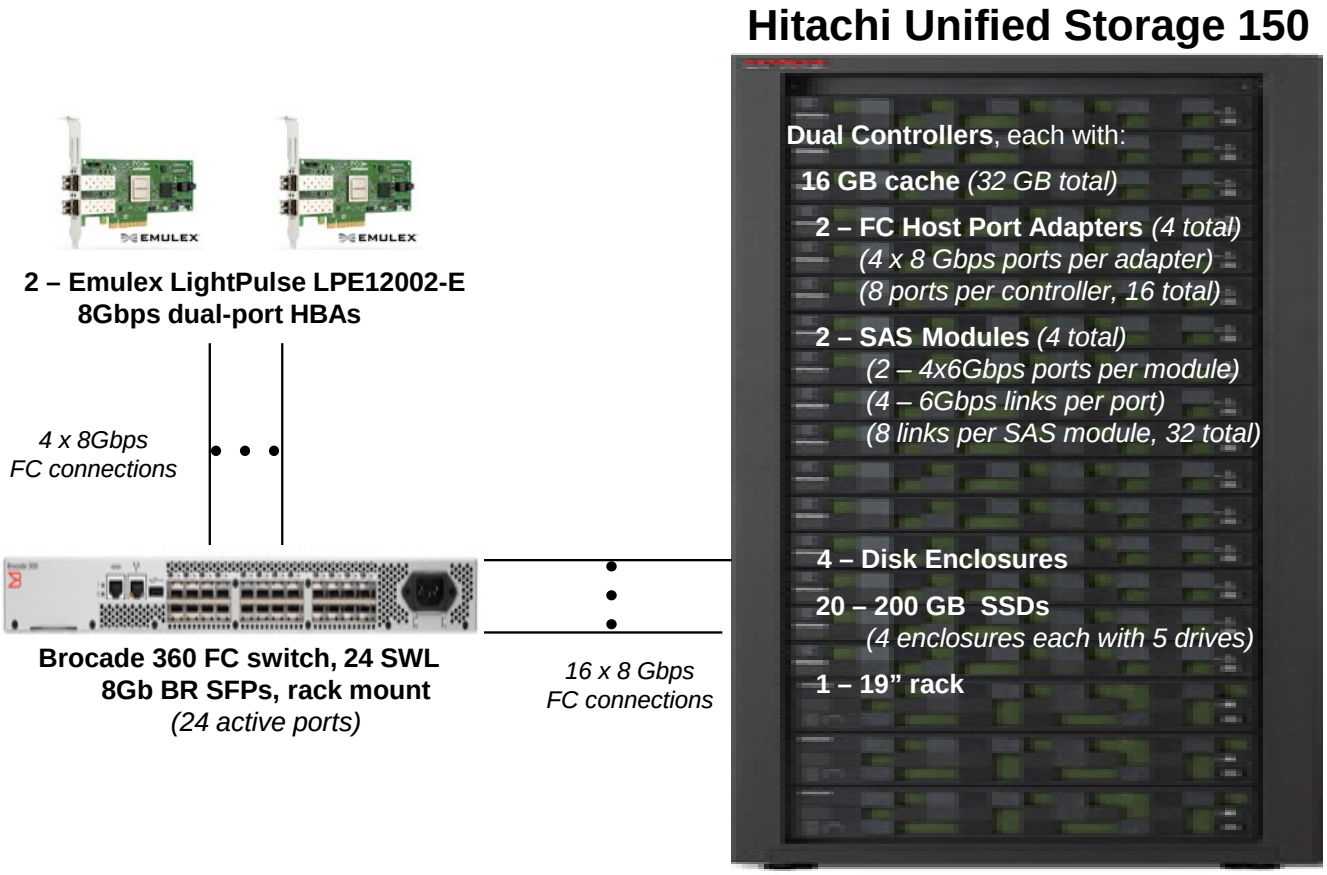
The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

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

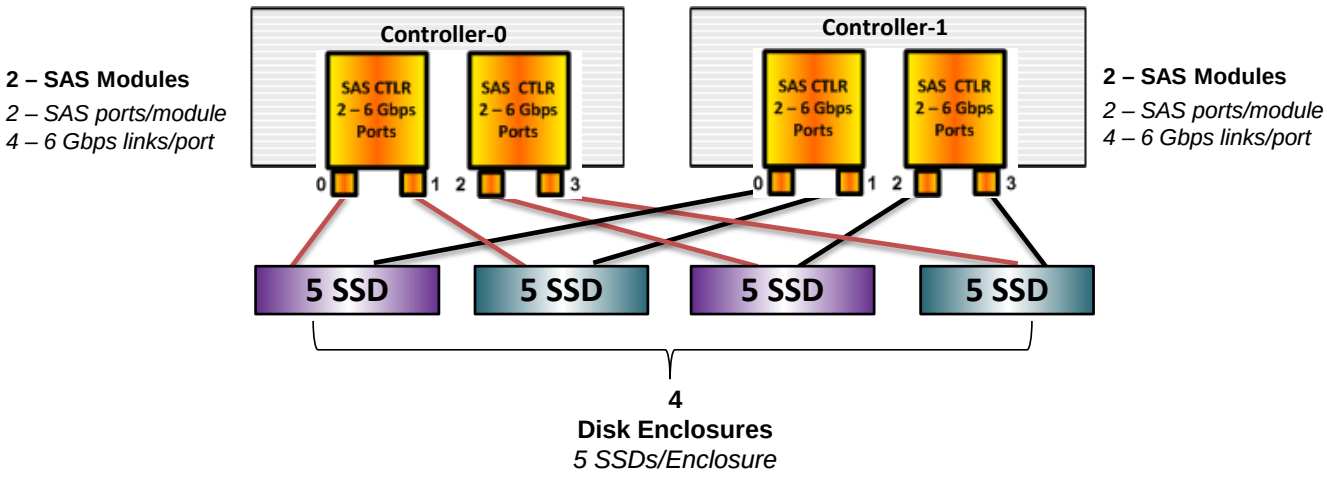
Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration

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

Priced Storage Configuration Diagram



Controllers, SAS Modules, Disk Enclosure and Disk Drive Details



Priced Storage Configuration Components

Priced Storage Configuration:
VERITAS Storage Foundation for Windows Standard Edition v6.0
2 – Emulex LightPulse LPe12002-E 8Gbps dual port FC HBAs
2 – Brocade 360 FC switch, 24 active ports, 24 8Gb SFPs *(second switch included as a spare)*
Hitachi Unified Storage 150 Dual Active-Active Controllers, each with 16 GB cache *(32 GB total)* 2 – FC Host Port Adapters *(4 total)* *(4 – 8 Gbps ports adapter)* *(8 ports per controller, 16 total, 16 used)* 2 – SAS Modules *(4 total)* *(2 – 8x6Gbps ports per module)* *(4 ports per module, 8 total, 8 used)* *(4 – 8x6Gbps links per port)* *(8 links per module, 32 total, 32 used)*
4 – Disk Enclosures
20 – 200 GB Solid State Drives (SSDs) *5 SSDs per Disk Enclosure*
1 – 19” rack with 4 PDUs

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

CONFIGURATION INFORMATION

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

Clause 9.4.3.4.1

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

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page 19*(Benchmark Configuration/Tested Storage Configuration Diagram).*

Storage Network Configuration

Clause 9.4.3.4.1

…

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

Clause 9.4.3.4.2

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

The storage network portion of Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page 19 *(Benchmark Configuration/Tested Storage Configuration Diagram).*

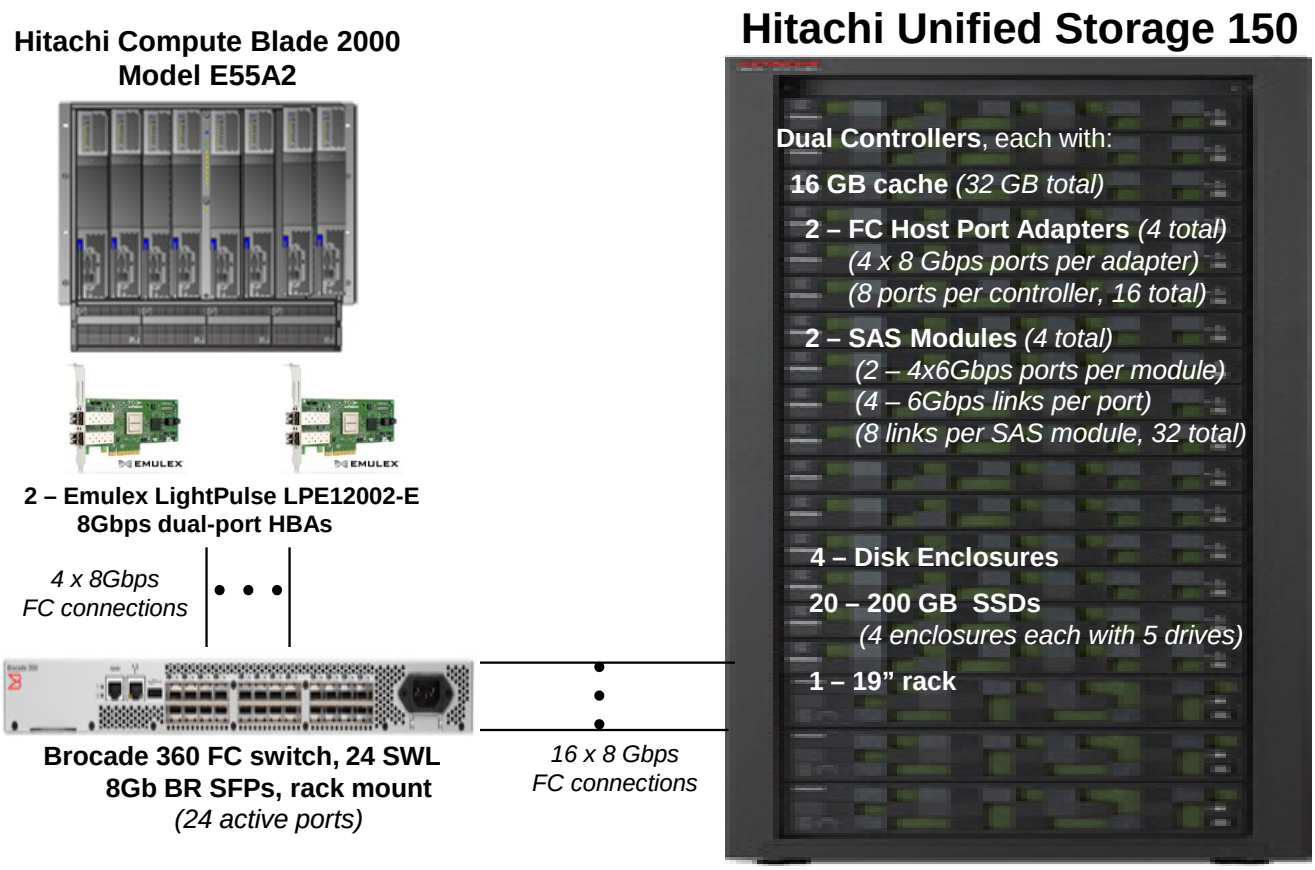
Host System(s) and Tested Storage Configuration (TSC) Table of Components

Clause 9.4.3.4.3

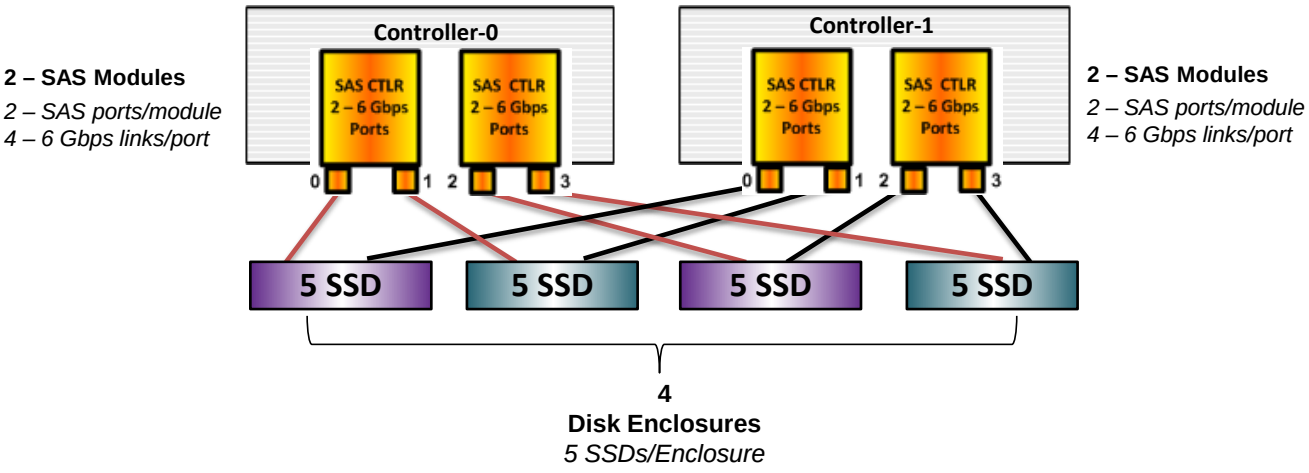
The FDR will contain a table that lists the major components of each Host System and the Tested Storage Configuration (TSC). Table 9-10 specifies the content, format, and appearance of the table.

The Host System(s) and TSC table of components may be found on page20*(Host System and Tested Storage Configuration Components).*

Benchmark Configuration/Tested Storage Configuration Diagram



Controllers, SAS Modules, Disk Enclosure and Disk Drive Details



Host System and Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):
Hitachi Compute Blade 2000 **Model E55A2** 2 – Intel® Xeon® 5690 six core 3.46 GHz processors,12 MB Intel® SmartCache per processor 64 GB main memory Microsoft Windows Server 2008 R2 Enterprise 6.7601, Service Pack 1 Build 7601	VERITAS Storage Foundation for Windows Standard Edition v6.0
	2 – Emulex LightPulse LPe12002-E 8Gbps dual port FC HBAs
	1 – Brocade 360 FC switch, 24 active ports, 24 8Gb SFPs
	Hitachi Unified Storage 150 Dual Active-Active Controllers, each with 16 GB cache *(32 GB total)* 2 – FC Host Port Adapters *(4 total)* *(4 – 8 Gbps ports adapter)* *(8 ports per controller, 16 total, 16 used)* 2 – SAS Modules *(4 total)* *(2 – 8x6Gbps ports per module)* *(4 ports per module, 8 total, 8 used)* *(4 – 8x6Gbps links per port)* *(8 links per module, 32 total, 32 used)*
	4 – Disk Enclosures
	20 – 200 GB Solid State Drives (SSDs) *5 SSDs per Drive Enclosure*
	1 – 19” rack with 4 PDUs

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 62 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 page63contains the detailed information that describes how to create and configure the logical TSC.

SPC-1 Workload Generator Storage Configuration

Clause 9.4.3.5.3

The FDR must include all SPC-1 Workload Generator storage configuration commands and parameters.

The SPC-1 Workload Generator storage configuration commands and parameters for this measurement appear in "Appendix D: SPC-1 Workload Generator Storage Commands and Parameters" on page 75.

ASU Pre-Fill

Clause 5.3.3

Each of the three SPC-1 ASUs (ASU-1, ASU-2 and ASU-3) is required to be completely filled with specified content prior to the execution of audited SPC-1 Tests. The content is required to consist of random data pattern such as that produced by an SPC recommended tool.

The configuration file used to complete the required ASU pre-fill appears in *"Appendix D: SPC-1 Workload Generator Storage Commands and Parameters"* on page 75.

SPC-1 DATA REPOSITORY

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-1 storage capacities and mappings used in the Tested Storage Configuration. "SPC-1 Data Repository Definitions" on page 58 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

The Physical Storage Capacity consisted of 3,999.817 GB distributed over 20 solid state drives (SSDs), each with a formatted capacity of 199.991 GB. There was 23.192 GB (0.58%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 61.536 GB (1.54%) of the Physical Storage Capacity. There was 479.115 GB (12.24%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.00 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(Mirroring)* capacity was 1,957.545 GB of which 1,717.987 GB was utilized. The total Unused Storage capacity was 502.307 GB.

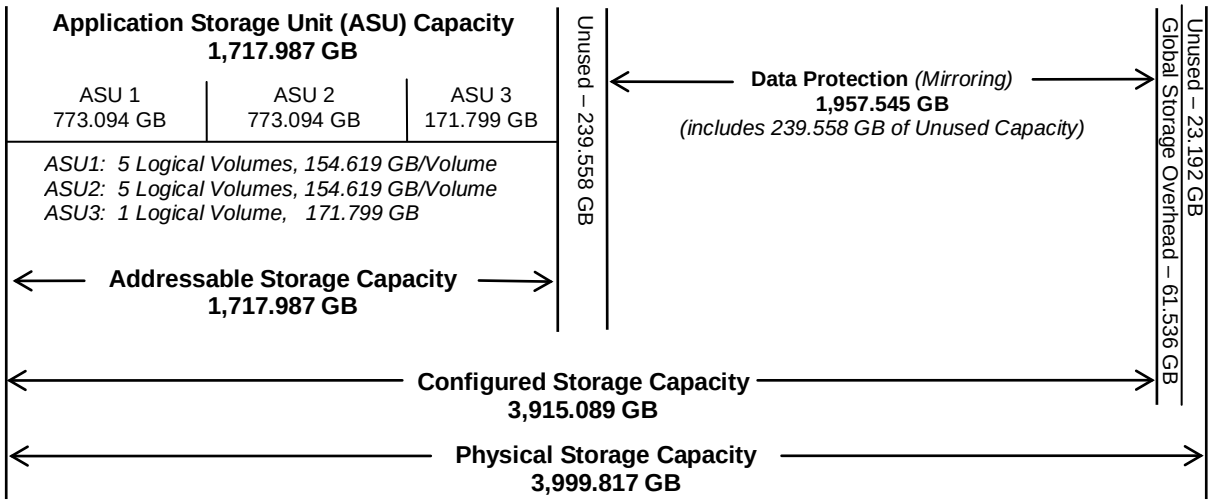
Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.

SPC-1 Storage Capacities

Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	1,171.987
Addressable Storage Capacity	Gigabytes (GB)	1,717.987
Configured Storage Capacity	Gigabytes (GB)	3,915.089
Physical Storage Capacity	Gigabytes (GB)	3,999.817
Data Protection *(Mirroring)*	Gigabytes (GB)	1,957.545
Required Storage	Gigabytes (GB)	0.000
Global Storage Overhead	Gigabytes (GB)	61.536
Total Unused Storage	Gigabytes (GB)	502.307

SPC-1 Storage Capacities and Relationships Illustration

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



SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	43.88%	42.95%
Required for Data Protection *(Mirroring)*		50.00%	48.94%
Addressable Storage Capacity		43.88%	42.95%
Required Storage		0.00%	0.00%
Configured Storage Capacity			97.88%
Global Storage Overhead			1.54%
Unused Storage:			
Addressable	0.00%		
Configured		12.24%	
Physical			0.58%

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	42.95%
Protected Application Utilization	85.90%
Unused Storage Ratio	12.56%

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 (773.094 GB)	**ASU-2 (773.094 GB)**	**ASU-3 (171.799 GB)**
5 Logical Volumes 154.619 GB per Logical Volume (154.619 GB used per Logical Volume)	5 Logical Volumes 154.619 GB per Logical Volume (154.619 GB used per Logical Volume)	1 Logical Volume 171.799 GB per Logical Volume (171.799 GB used per Logical Volume)

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

SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. An SPC-1 glossary on page 58 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 eight (8) hour Measurement Interval. This Test Phase also serves to insure that the TSC has reached Steady State prior to reporting the final maximum I/O Request Throughput result (SPC-1 IOPS™).

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.4.3.7.1

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 77.

Sustainability Test Results File

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

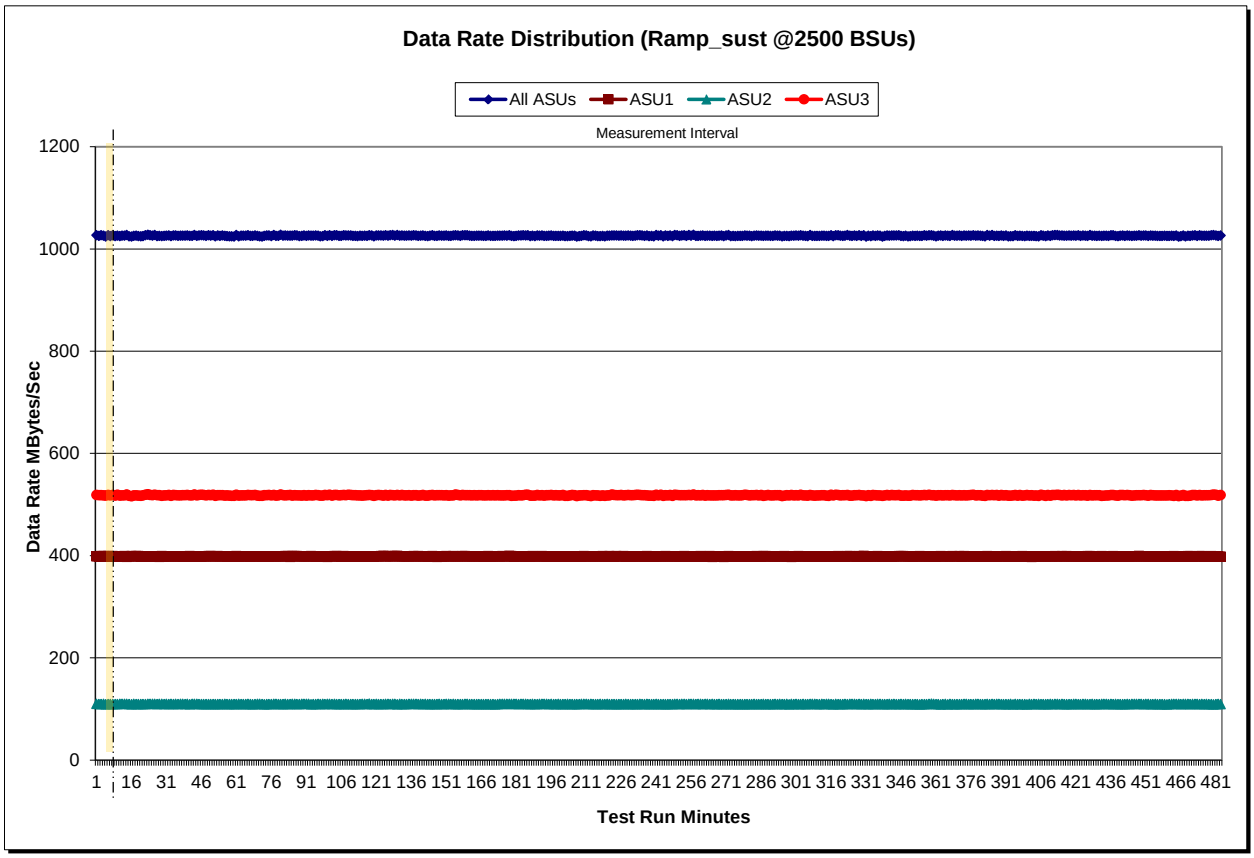
Sustainability Test Results File

Sustainability – Data Rate Distribution Data (MB/second)

The Sustainability Data Rate table of data is not embedded in this document due to its size. The table is available via the following URL:

Sustainability Data Rate Table

Sustainability – Data Rate Distribution Graph

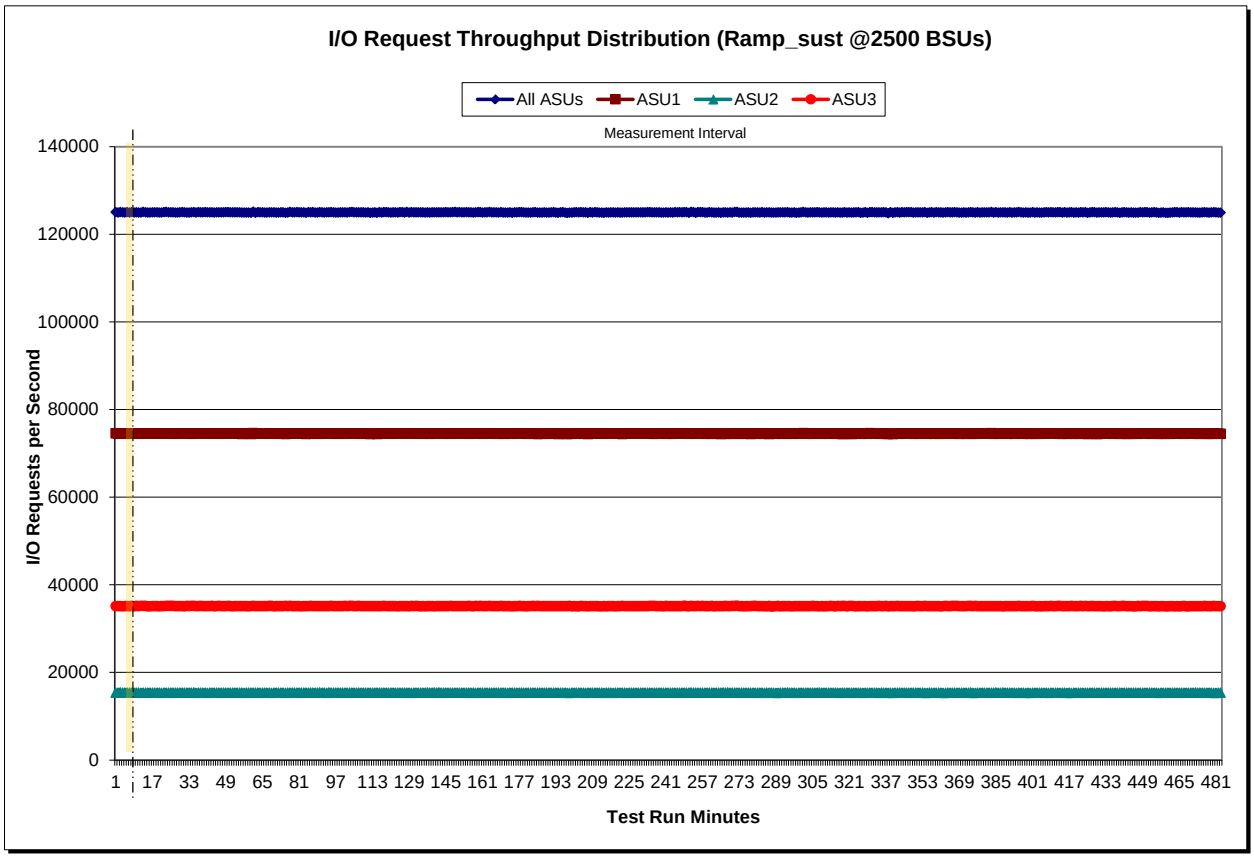


Sustainability – I/O Request Throughput Distribution Data

The Sustainability I/O Request Throughput table of data is not embedded in this document due to its size. The table is available via the following URL:

Sustainability I/O Request Throughput Table

Sustainability – I/O Request Throughput Distribution Graph

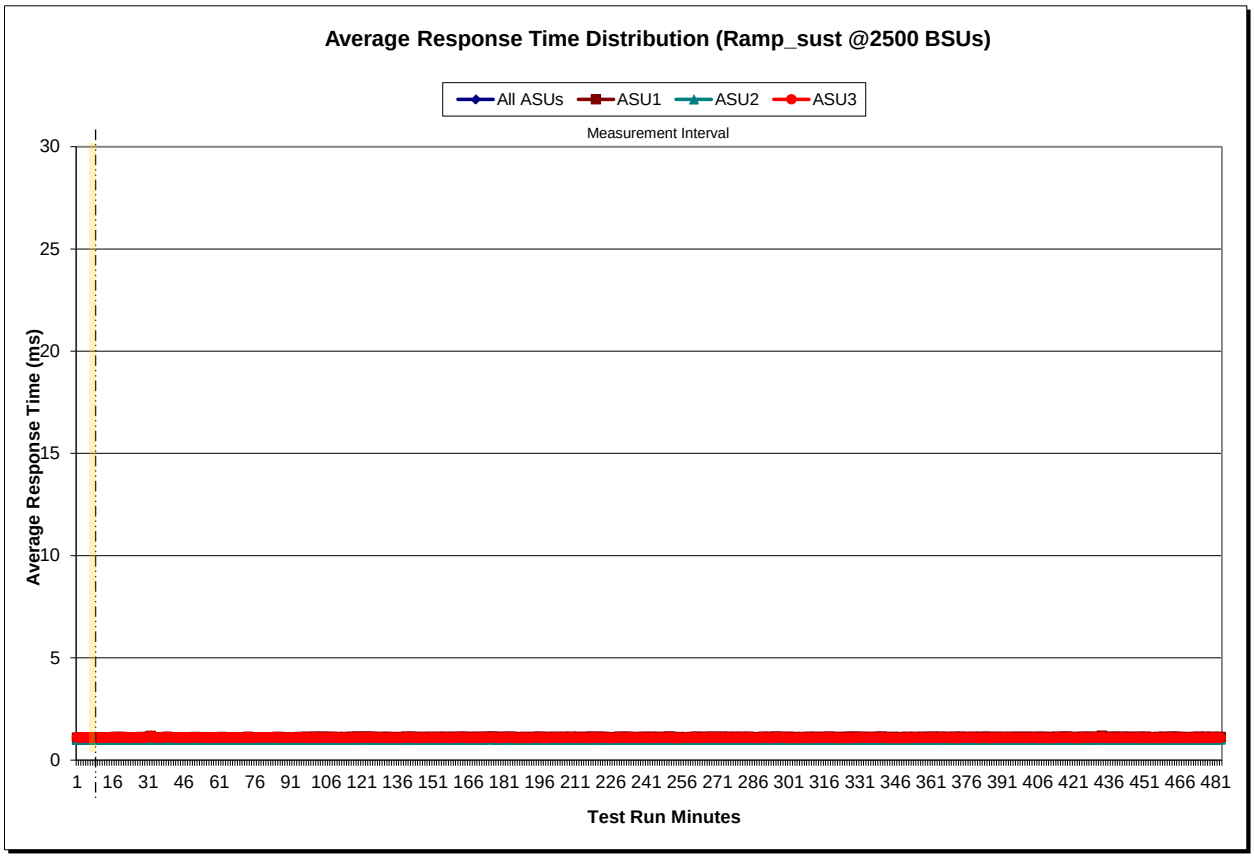


Sustainability – Average Response Time (ms) Distribution Data

The Sustainability Average Response Time table of data is not embedded in this document due to its size. The table is available via the following URL:

Sustainability Average Response Time Table

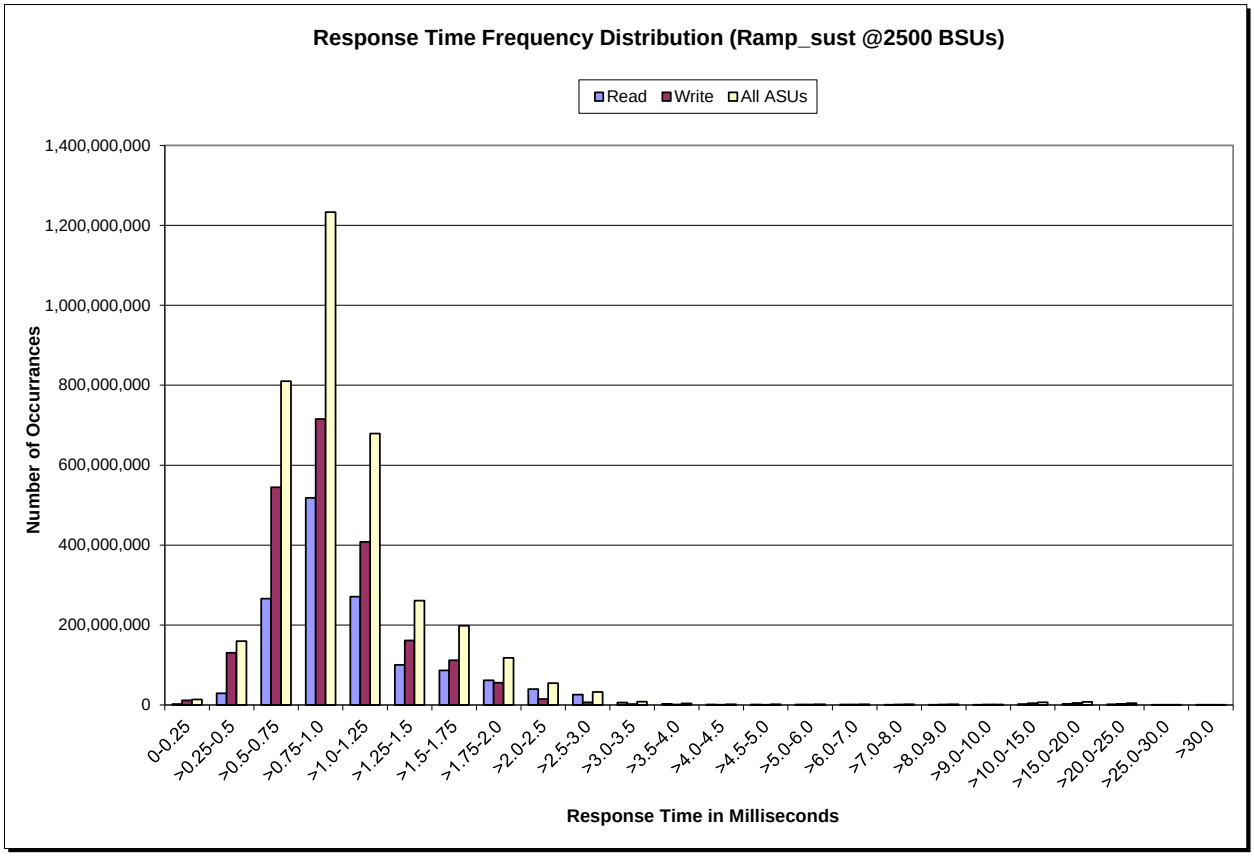
Sustainability – Average Response Time (ms) Distribution Graph



Sustainability – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	1,968,034	29,172,396	265,717,451	517,978,704	270,939,377	100,013,316	86,619,420	61,798,431
Write	11,490,349	130,570,382	544,644,086	715,134,784	408,181,728	161,069,316	111,592,479	55,727,379
All ASUs	13,458,383	159,742,778	810,361,537	1,233,113,488	679,121,105	261,082,632	198,211,899	117,525,810
ASU1	6,763,276	82,730,671	469,343,898	748,575,735	403,667,137	151,560,670	117,322,868	74,325,195
ASU2	3,033,689	29,960,493	119,186,544	146,750,936	68,992,912	25,460,035	20,706,106	13,502,132
ASU3	3,661,418	47,051,614	221,831,095	337,786,817	206,461,056	84,061,927	60,182,925	29,698,483
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	39,625,089	25,622,606	5,874,655	2,526,262	1,005,807	822,354	956,823	726,138
Write	15,000,979	6,493,093	2,074,387	1,175,949	565,510	475,626	801,220	770,861
All ASUs	54,626,068	32,115,699	7,949,042	3,702,211	1,571,317	1,297,980	1,758,043	1,496,999
ASU1	40,280,915	24,560,104	5,890,805	2,603,096	1,073,265	890,527	1,151,114	944,248
ASU2	6,555,300	4,354,178	1,160,854	596,528	244,417	189,787	217,667	161,790
ASU3	7,789,853	3,201,417	897,383	502,587	253,635	217,666	389,262	390,961
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	638,416	536,633	471,348	2,262,356	2,821,179	1,640,321	61,873	81,395
Write	781,495	780,481	779,908	4,097,413	4,896,725	2,843,653	82,961	124,829
All ASUs	1,419,911	1,317,114	1,251,256	6,359,769	7,717,904	4,483,974	144,834	206,224
ASU1	874,865	787,841	733,743	3,726,908	4,792,366	2,828,357	95,721	134,293
ASU2	141,988	122,195	110,535	517,051	514,932	267,356	9,359	11,545
ASU3	403,058	407,078	406,978	2,115,810	2,410,606	1,388,261	39,754	60,386

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.001	0.001	0.003	0.001	0.002	0.001

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

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

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

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

Clause 9.4.3.7.2

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 77.

IOPS Test Results File

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

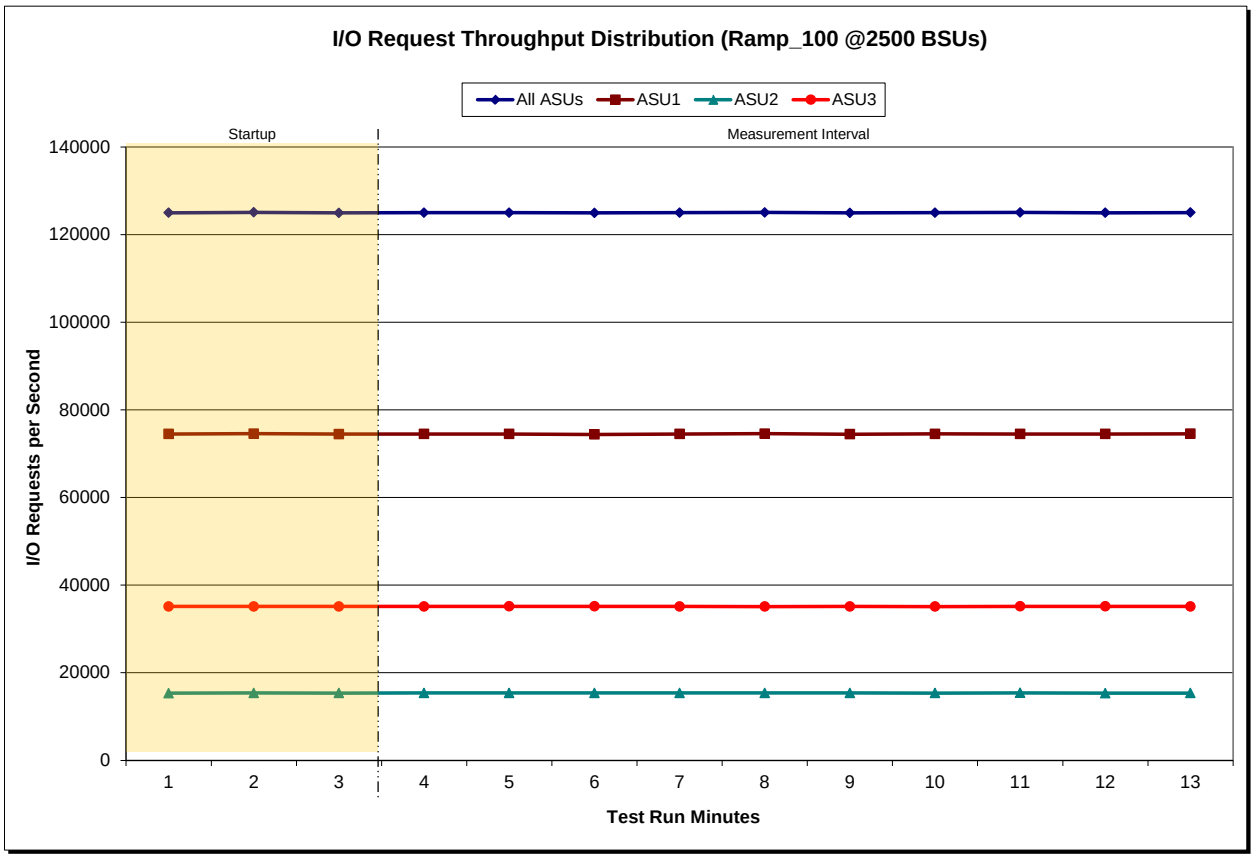
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

2,500 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:02:07	4:05:08	0-2	0:03:01
Measurement Interval	4:05:08	4:15:08	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	124,995.77	74,512.62	15,349.55	35,133.60
1	125,100.42	74,583.37	15,392.77	35,124.28
2	124,973.12	74,471.85	15,375.25	35,126.02
3	125,016.58	74,496.73	15,377.67	35,142.18
4	125,032.20	74,492.03	15,392.30	35,147.87
5	124,959.25	74,412.55	15,395.87	35,150.83
6	125,013.97	74,495.23	15,387.57	35,131.17
7	125,063.80	74,564.93	15,390.93	35,107.93
8	124,974.68	74,445.75	15,382.63	35,146.30
9	125,009.50	74,523.65	15,373.27	35,112.58
10	125,065.00	74,493.53	15,405.58	35,165.88
11	125,005.85	74,500.05	15,348.63	35,157.17
12	125,047.90	74,542.05	15,363.62	35,142.23
Average	***125,018.87***	***74,496.65***	***15,381.81***	***35,140.42***

IOPS Test Run – I/O Request Throughput Distribution Graph

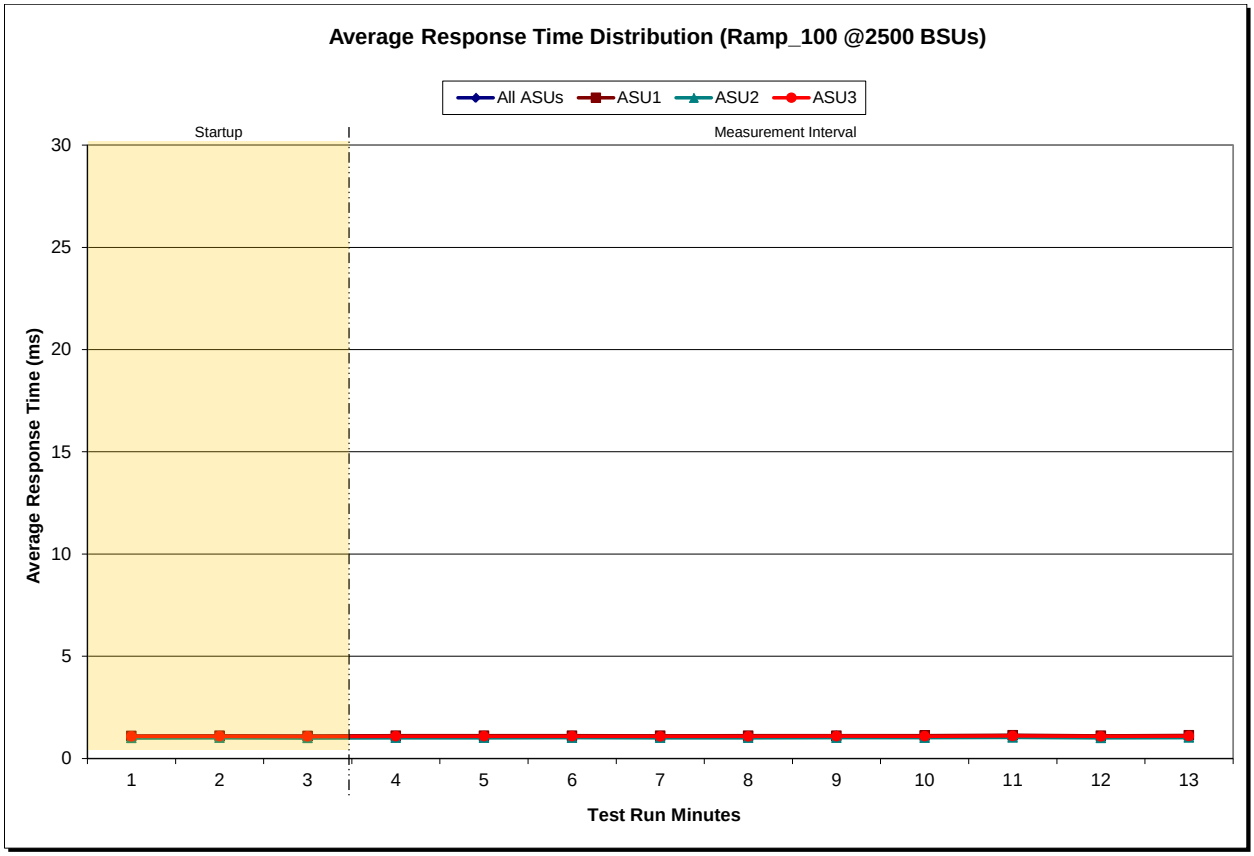


IOPS Test Run – Average Response Time (ms) Distribution Data

2,500 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:02:07	4:05:08	0-2	0:03:01
Measurement Interval	4:05:08	4:15:08	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.08	1.09	1.00	1.08
1	1.09	1.11	1.01	1.08
2	1.08	1.10	1.00	1.07
3	1.09	1.11	1.01	1.08
4	1.09	1.11	1.01	1.08
5	1.09	1.11	1.01	1.09
6	1.09	1.11	1.01	1.08
7	1.09	1.11	1.01	1.08
8	1.09	1.11	1.01	1.09
9	1.10	1.12	1.02	1.09
10	1.11	1.13	1.02	1.10
11	1.09	1.11	1.00	1.08
12	1.11	1.13	1.02	1.10
Average	***1.09***	***1.12***	***1.01***	***1.09***

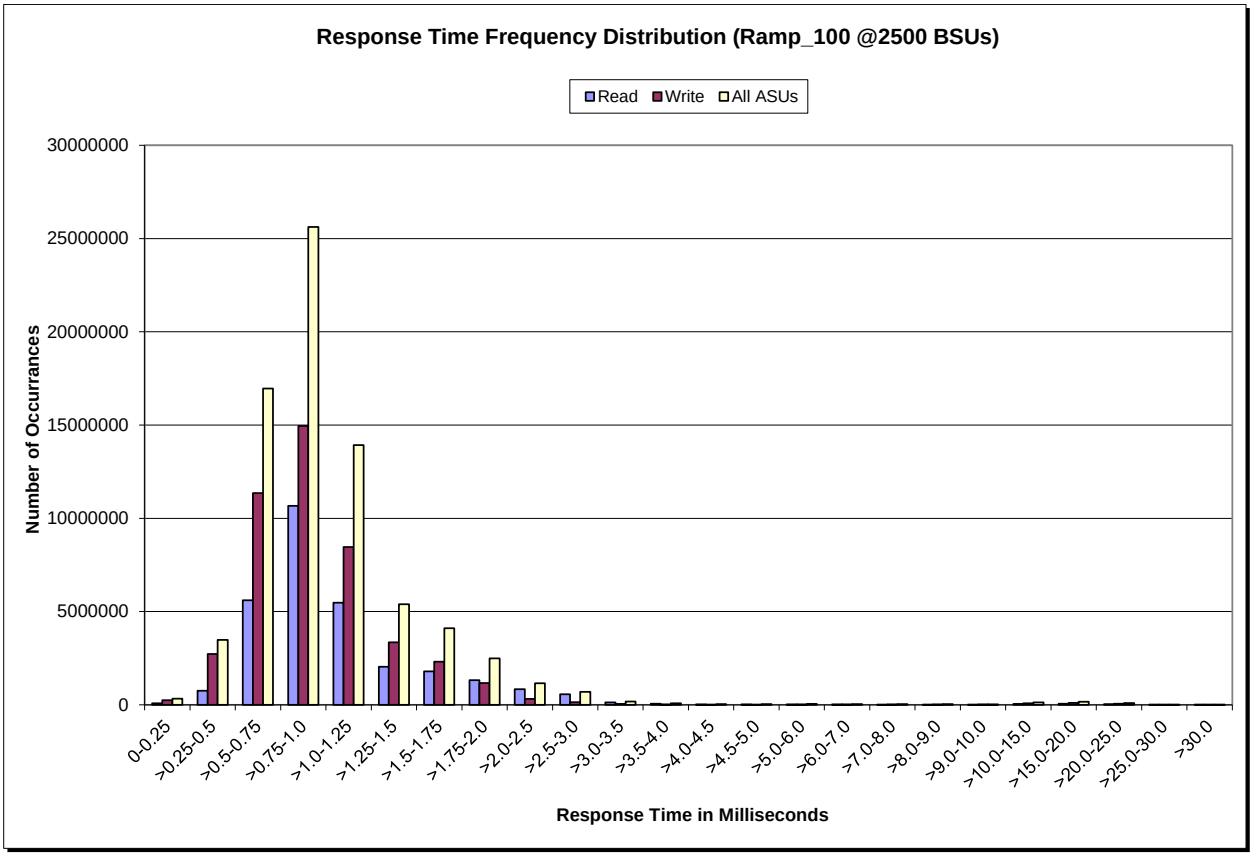
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	82,725	755,661	5,606,576	10,664,815	5,475,682	2,037,098	1,794,296	1,317,224
Write	244,827	2,729,570	11,357,135	14,952,019	8,454,885	3,348,588	2,305,108	1,167,547
All ASUs	327,552	3,485,231	16,963,711	25,616,834	13,930,567	5,385,686	4,099,404	2,484,771
ASU1	179,683	1,843,824	9,822,491	15,567,152	8,208,750	3,094,695	2,439,291	1,590,833
ASU2	69,695	636,328	2,473,078	3,037,783	1,428,762	532,805	432,751	287,256
ASU3	78,174	1,005,079	4,668,142	7,011,899	4,293,055	1,758,186	1,227,362	606,682
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	834,111	559,854	131,288	60,717	23,720	19,463	21,804	16,158
Write	316,948	133,592	43,359	24,325	11,838	9,874	17,201	15,960
All ASUs	1,151,059	693,446	174,647	85,042	35,558	29,337	39,005	32,118
ASU1	844,406	532,533	129,927	61,376	24,839	20,573	25,603	20,444
ASU2	141,972	95,433	25,676	13,489	5,439	4,233	4,896	3,620
ASU3	164,681	65,480	19,044	10,177	5,280	4,531	8,506	8,054
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	14,159	11,328	10,163	47,314	58,152	35,150	1,130	1,317
Write	15,985	16,132	16,115	84,749	100,787	61,690	1,210	1,875
All ASUs	30,144	27,460	26,278	132,063	158,939	96,840	2,340	3,192
ASU1	18,791	16,564	15,458	77,575	98,502	60,870	1,701	2,055
ASU2	3,193	2,529	2,289	10,924	10,791	5,764	142	221
ASU3	8,160	8,367	8,531	43,564	49,646	30,206	497	916

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
75,011,224	3,192	75,008,032

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2809	0.0700	0.2099	0.0180	0.0700	0.0350	0.2811
COV	0.001	0.000	0.001	0.001	0.002	0.001	0.002	0.001

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.4.3

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

The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 13.

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

Clause 9.4.3.7.3

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

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

SPC-1 Workload Generator Input Parameters

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

Response Time Ramp Test Results File

A link to each test result file generated from each Response Time Ramp Test Run list listed below.

95% Load Level

90% Load Level

80% Load Level

50% Load Level

10% Load Level

Response Time Ramp Distribution (IOPS) Data

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

100% Load Level - 2500 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:02:07	4:05:08	0-2	0:03:01
Measurement Interval	4:05:08	4:15:08	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	124,995.77	74,512.62	15,349.55	35,133.60
1	125,100.42	74,583.37	15,392.77	35,124.28
2	124,973.12	74,471.85	15,375.25	35,126.02
3	125,016.58	74,496.73	15,377.67	35,142.18
4	125,032.20	74,492.03	15,392.30	35,147.87
5	124,959.25	74,412.55	15,395.87	35,150.83
6	125,013.97	74,495.23	15,387.57	35,131.17
7	125,063.80	74,564.93	15,390.93	35,107.93
8	124,974.68	74,445.75	15,382.63	35,146.30
9	125,009.50	74,523.65	15,373.27	35,112.58
10	125,065.00	74,493.53	15,405.58	35,165.88
11	125,005.85	74,500.05	15,348.63	35,157.17
12	125,047.90	74,542.05	15,363.62	35,142.23
Average	***125,018.87***	***74,496.65***	***15,381.81***	***35,140.42***

95% Load Level - 2375 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:15:26	4:18:27	0-2	0:03:01
Measurement Interval	4:18:27	4:28:27	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	118,772.92	70,806.70	14,608.32	33,357.90
1	118,704.67	70,748.55	14,614.92	33,341.20
2	118,767.00	70,810.83	14,599.83	33,356.33
3	118,740.73	70,803.42	14,590.48	33,346.83
4	118,764.72	70,780.15	14,618.88	33,365.68
5	118,727.35	70,780.20	14,589.78	33,357.37
6	118,722.97	70,768.13	14,598.13	33,356.70
7	118,730.20	70,791.47	14,613.80	33,324.93
8	118,803.60	70,755.75	14,642.65	33,405.20
9	118,814.12	70,802.45	14,619.53	33,392.13
10	118,734.43	70,761.87	14,590.48	33,382.08
11	118,727.33	70,747.57	14,603.52	33,376.25
12	118,738.53	70,749.85	14,606.83	33,381.85
Average	***118,750.40***	***70,774.09***	***14,607.41***	***33,368.90***

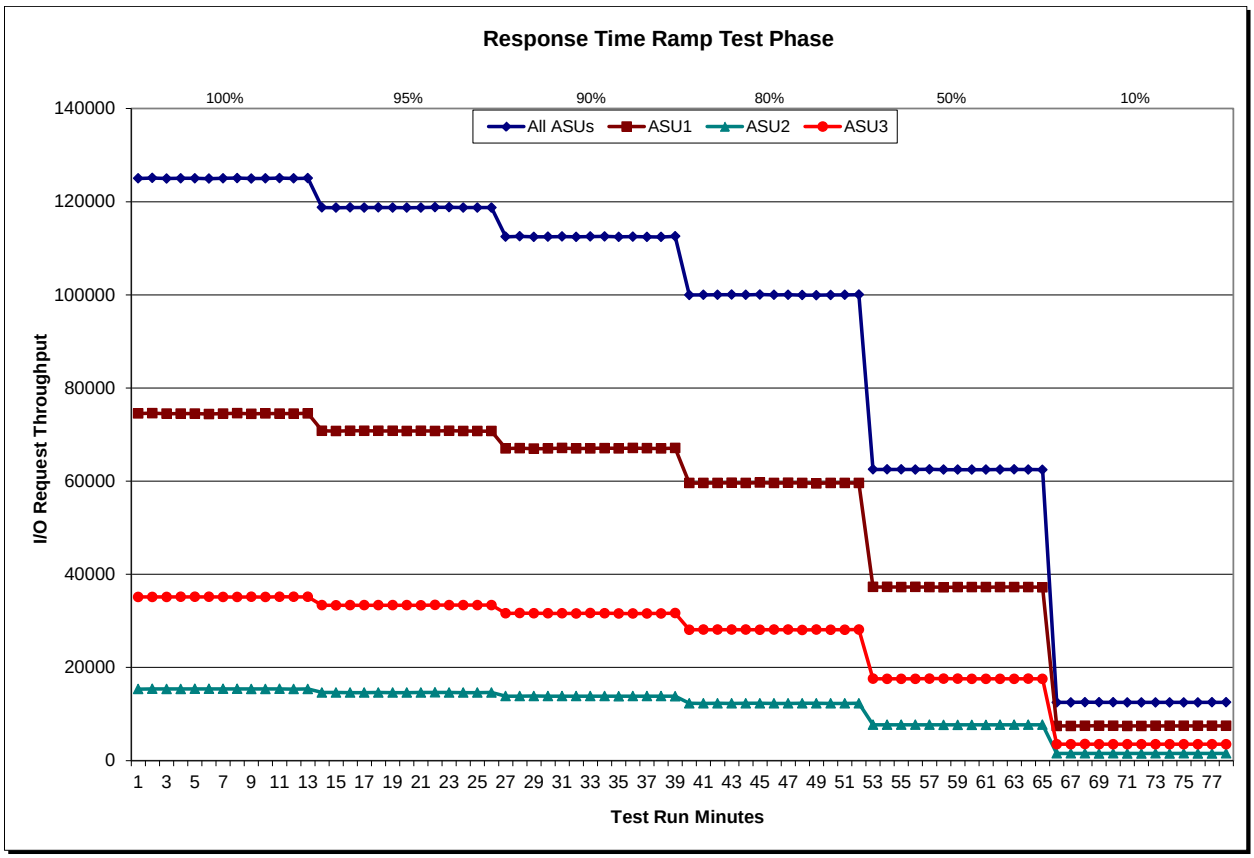
90% Load Level - 2250 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:28:44	4:31:45	0-2	0:03:01
Measurement Interval	4:31:45	4:41:45	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	112,472.03	67,020.70	13,831.60	31,619.73
1	112,570.02	67,078.53	13,845.95	31,645.53
2	112,443.07	66,955.32	13,860.57	31,627.18
3	112,470.98	67,016.70	13,846.10	31,608.18
4	112,530.42	67,096.02	13,834.30	31,600.10
5	112,445.48	67,019.43	13,844.97	31,581.08
6	112,529.92	67,021.73	13,847.95	31,660.23
7	112,554.87	67,081.37	13,838.10	31,635.40
8	112,443.00	67,027.52	13,822.87	31,592.62
9	112,506.87	67,110.05	13,840.65	31,556.17
10	112,457.48	67,052.47	13,826.73	31,578.28
11	112,439.63	67,012.23	13,835.30	31,592.10
12	112,560.68	67,092.88	13,821.67	31,646.13
Average	***112,493.93***	***67,053.04***	***13,835.86***	***31,605.03***

80% Load Level - 2000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:42:01	4:45:02	0-2	0:03:01
Measurement Interval	4:45:02	4:55:02	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	99,985.63	59,585.83	12,306.40	28,093.40
1	99,987.28	59,578.77	12,287.37	28,121.15
2	100,028.78	59,616.60	12,297.97	28,114.22
3	100,041.78	59,645.45	12,280.48	28,115.85
4	99,989.67	59,585.75	12,301.18	28,102.73
5	100,076.62	59,690.98	12,297.77	28,087.87
6	99,987.37	59,597.72	12,286.30	28,103.35
7	100,025.82	59,633.95	12,285.58	28,106.28
8	99,950.48	59,615.50	12,294.82	28,040.17
9	99,919.92	59,519.58	12,291.55	28,108.78
10	99,976.82	59,609.67	12,276.58	28,090.57
11	99,997.90	59,620.47	12,285.58	28,091.85
12	100,036.47	59,591.50	12,313.87	28,131.10
Average	***100,000.28***	***59,611.06***	***12,291.37***	***28,097.86***

50% Load Level - 1250 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:55:14	4:58:15	0-2	0:03:01
Measurement Interval	4:58:15	5:08:15	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	62,529.87	37,271.83	7,687.78	17,570.25
1	62,511.18	37,277.08	7,684.30	17,549.80
2	62,515.50	37,263.92	7,701.03	17,550.55
3	62,498.97	37,275.12	7,682.50	17,541.35
4	62,531.33	37,252.20	7,691.00	17,588.13
5	62,475.08	37,217.87	7,666.37	17,590.85
6	62,481.92	37,239.62	7,675.33	17,566.97
7	62,463.08	37,257.75	7,667.73	17,537.60
8	62,472.65	37,239.23	7,674.22	17,559.20
9	62,503.33	37,265.20	7,700.08	17,538.05
10	62,514.52	37,268.38	7,688.67	17,557.47
11	62,504.20	37,248.07	7,682.53	17,573.60
12	62,455.12	37,207.67	7,689.28	17,558.17
Average	***62,490.02***	***37,247.11***	***7,681.77***	***17,561.14***

10% Load Level - 250 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:08:22	5:11:23	0-2	0:03:01
Measurement Interval	5:11:23	5:21:23	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	12,491.42	7,435.90	1,540.55	3,514.97
1	12,485.65	7,433.08	1,542.43	3,510.13
2	12,527.37	7,460.02	1,544.13	3,523.22
3	12,509.55	7,471.78	1,536.68	3,501.08
4	12,503.68	7,458.87	1,538.38	3,506.43
5	12,480.35	7,443.45	1,535.22	3,501.68
6	12,486.03	7,445.42	1,535.10	3,505.52
7	12,497.25	7,454.42	1,541.32	3,501.52
8	12,501.40	7,453.67	1,533.82	3,513.92
9	12,500.00	7,451.87	1,540.58	3,507.55
10	12,500.67	7,459.33	1,537.20	3,504.13
11	12,511.07	7,460.37	1,530.92	3,519.78
12	12,504.82	7,450.68	1,538.57	3,515.57
Average	***12,499.48***	***7,454.99***	***1,536.78***	***3,507.72***

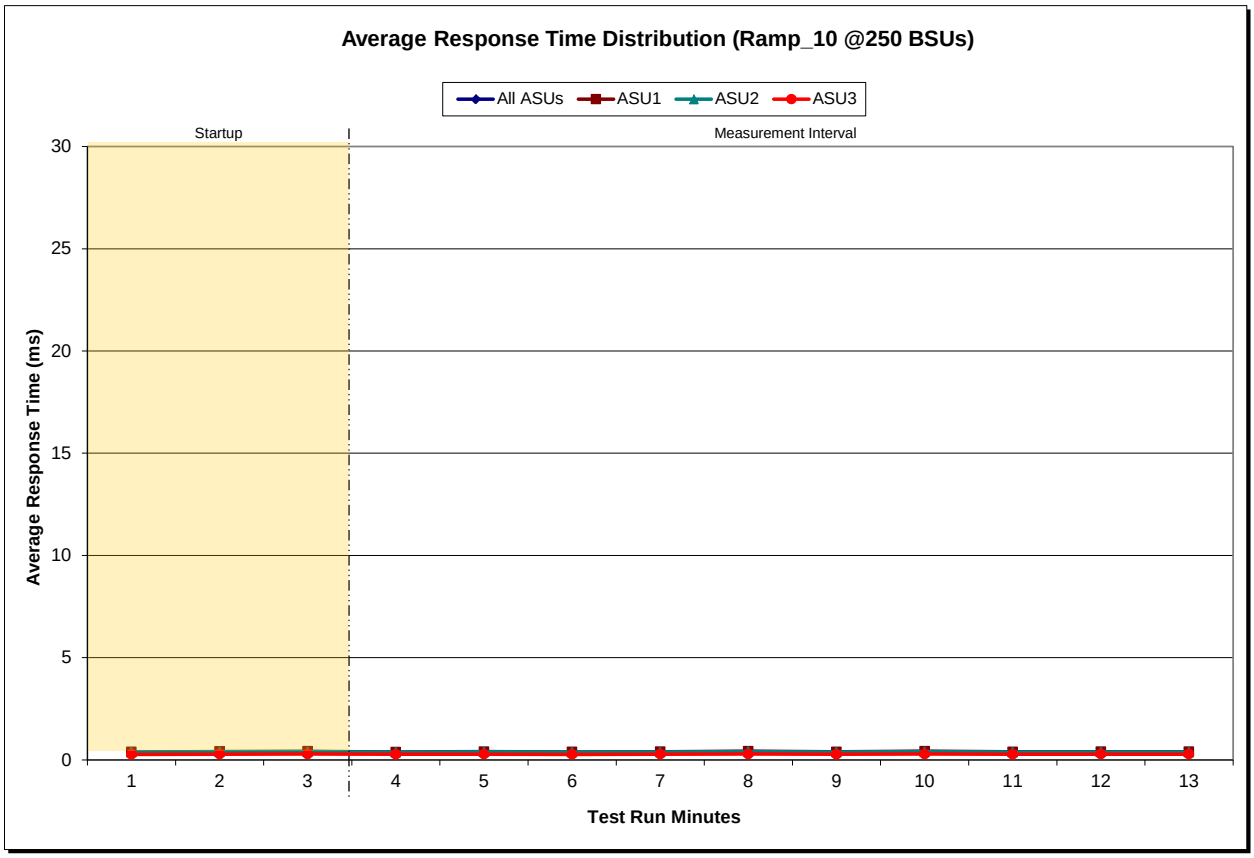
Response Time Ramp Distribution (IOPS) Graph



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

250 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:08:22	5:11:23	0-2	0:03:01
Measurement Interval	5:11:23	5:21:23	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.35	0.39	0.37	0.27
1	0.37	0.41	0.39	0.28
2	0.38	0.42	0.40	0.28
3	0.35	0.38	0.38	0.27
4	0.36	0.40	0.39	0.28
5	0.35	0.39	0.38	0.27
6	0.36	0.40	0.38	0.28
7	0.38	0.43	0.41	0.28
8	0.36	0.39	0.38	0.27
9	0.38	0.43	0.40	0.29
10	0.36	0.39	0.38	0.27
11	0.36	0.39	0.39	0.28
12	0.36	0.39	0.38	0.28
Average	***0.36***	***0.40***	***0.39***	***0.28***

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



SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0351	0.2812	0.0700	0.2102	0.0180	0.0700	0.0349	0.2806
COV	0.005	0.001	0.004	0.002	0.009	0.002	0.006	0.002

Repeatability Test

Clause 5.4.5

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

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

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

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

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

Clause 9.4.3.7.4

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 77.

Repeatability Test Results File

The values for the SPC-1 IOPS™, SPC-1 LRT™, and the Repeatability Test measurements are listed in the tables below.

	SPC-1 IOPS™
Primary Metrics	***125,018.87***
Repeatability Test Phase 1	125,011.23
Repeatability Test Phase 2	125,001.06

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 greater than 95% of the reported SPC-1 IOPS™ Primary Metric.

	SPC-1 LRT™
Primary Metrics	***0.36 ms***
Repeatability Test Phase 1	0.36 ms
Repeatability Test Phase 2	0.36 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).

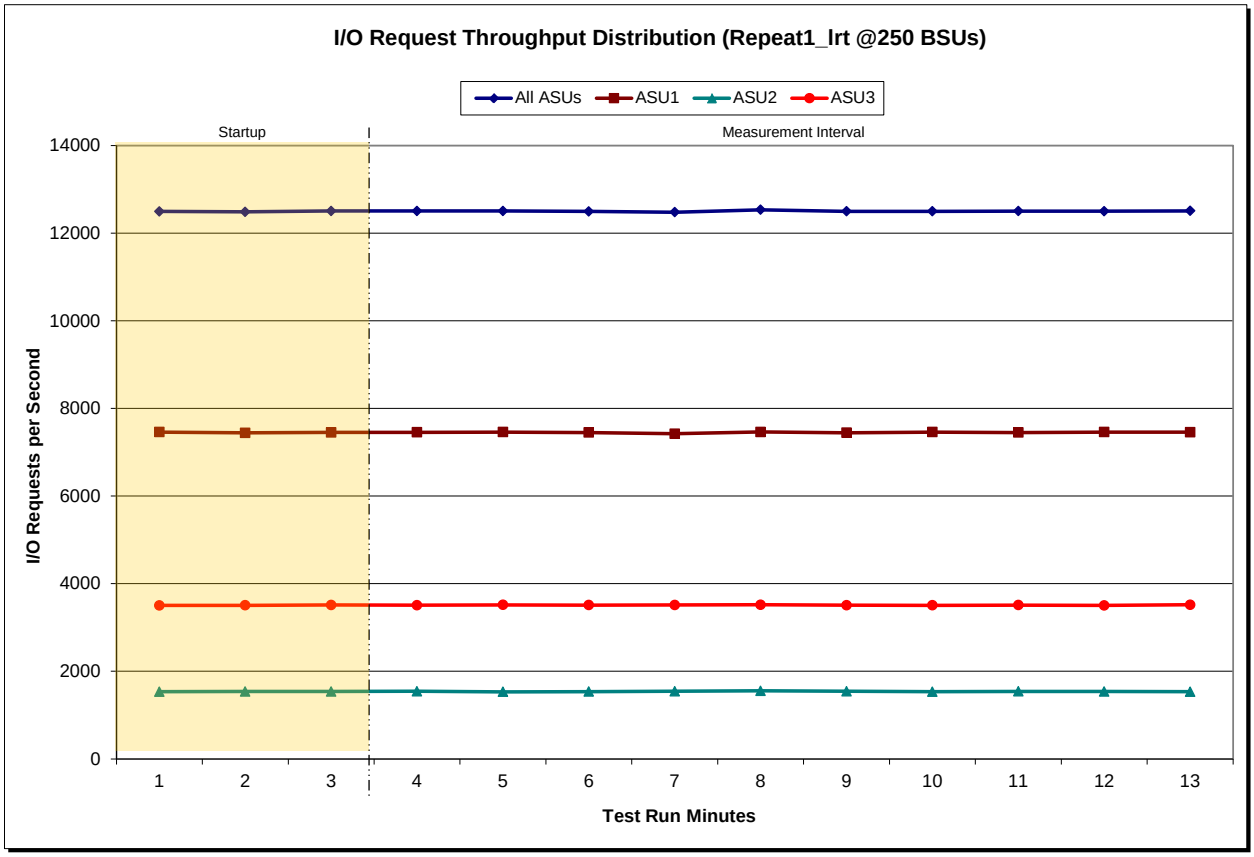
A link to the test result file generated from each Repeatability Test Run is listed below.

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

250 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:21:34	5:24:34	0-2	0:03:00
Measurement Interval	5:24:34	5:34:34	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	12,497.87	7,460.52	1,533.47	3,503.88
1	12,486.95	7,443.22	1,538.38	3,505.35
2	12,506.70	7,453.50	1,540.08	3,513.12
3	12,508.12	7,454.47	1,544.57	3,509.08
4	12,508.25	7,460.52	1,531.50	3,516.23
5	12,497.72	7,451.12	1,535.23	3,511.37
6	12,478.33	7,422.00	1,543.48	3,512.85
7	12,534.22	7,461.92	1,552.90	3,519.40
8	12,500.22	7,446.10	1,544.43	3,509.68
9	12,499.40	7,460.28	1,534.07	3,505.05
10	12,504.68	7,451.10	1,542.55	3,511.03
11	12,502.62	7,459.85	1,538.35	3,504.42
12	12,509.25	7,457.95	1,533.17	3,518.13
Average	***12,504.28***	***7,452.53***	***1,540.03***	***3,511.73***

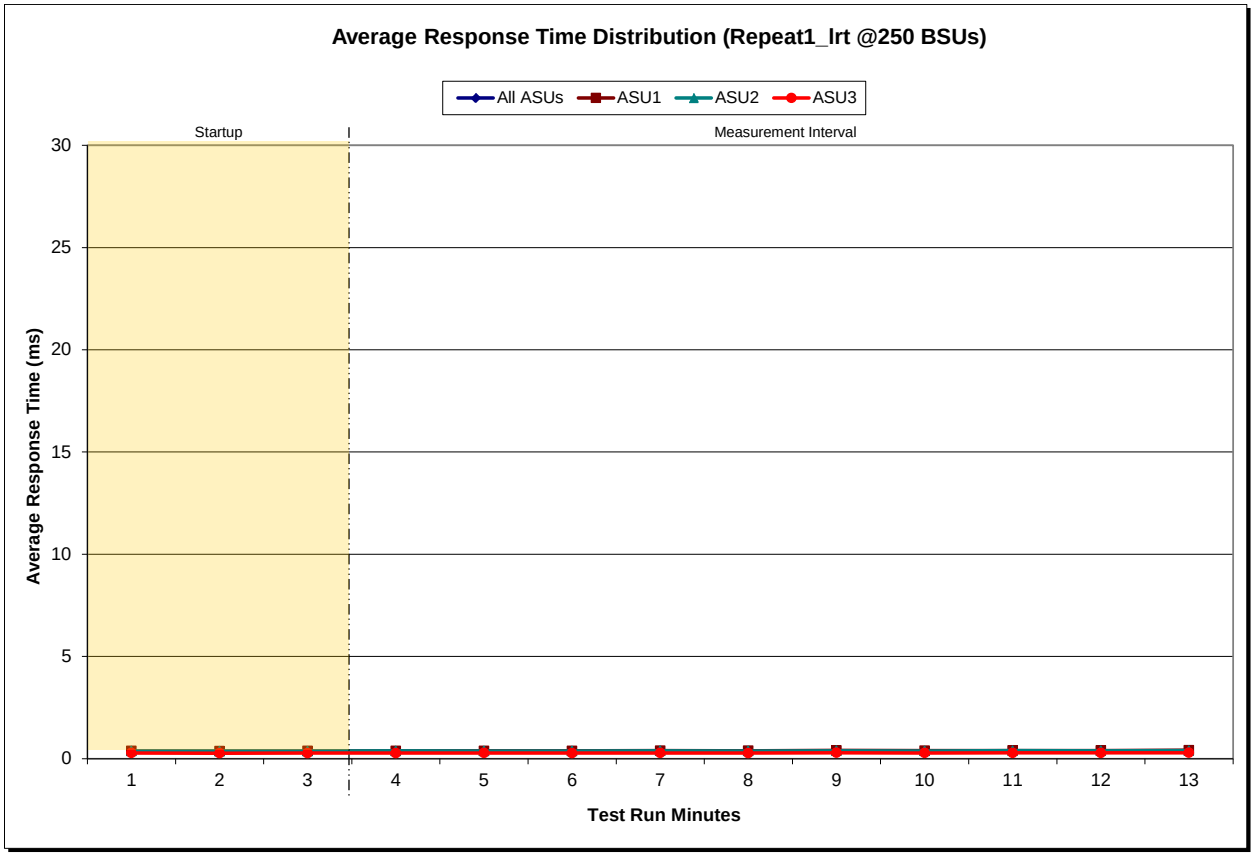
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

250 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:21:34	5:24:34	0-2	0:03:00
Measurement Interval	5:24:34	5:34:34	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.35	0.37	0.37	0.28
1	0.34	0.37	0.37	0.27
2	0.35	0.37	0.37	0.27
3	0.35	0.38	0.38	0.27
4	0.35	0.38	0.37	0.28
5	0.35	0.38	0.37	0.27
6	0.36	0.39	0.38	0.28
7	0.35	0.38	0.37	0.27
8	0.37	0.40	0.39	0.29
9	0.36	0.39	0.38	0.28
10	0.36	0.39	0.39	0.28
11	0.36	0.40	0.39	0.28
12	0.37	0.41	0.39	0.29
Average	***0.36***	***0.39***	***0.38***	***0.28***

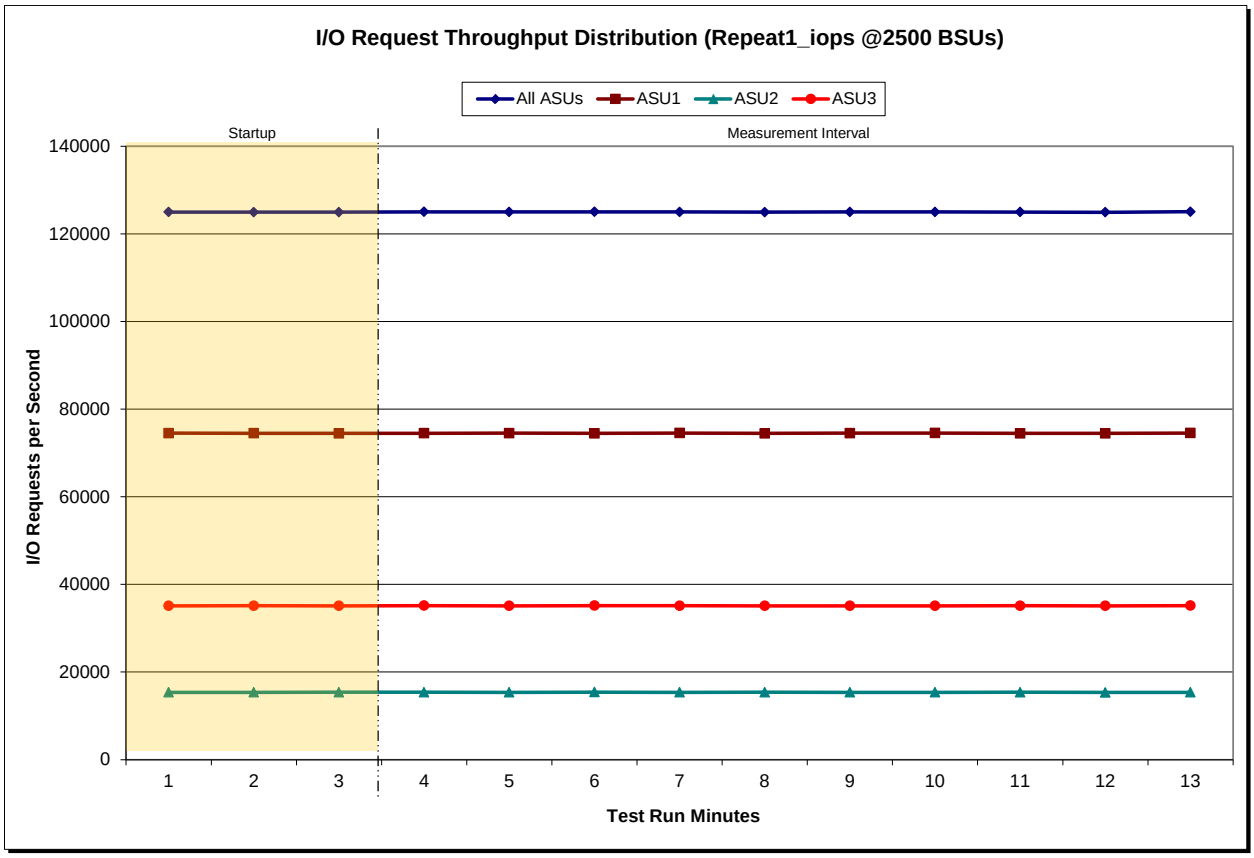
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

2,500 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:34:53	5:37:54	0-2	0:03:01
Measurement Interval	5:37:54	5:47:54	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	125,000.78	74,535.13	15,354.03	35,111.62
1	124,982.27	74,488.97	15,357.17	35,136.13
2	124,968.47	74,466.28	15,388.25	35,113.93
3	125,054.10	74,509.93	15,381.77	35,162.40
4	125,012.37	74,533.32	15,366.85	35,112.20
5	125,034.20	74,472.70	15,411.18	35,150.32
6	125,031.67	74,545.40	15,359.33	35,126.93
7	124,970.25	74,471.17	15,384.87	35,114.22
8	125,012.55	74,522.20	15,373.08	35,117.27
9	125,009.43	74,546.03	15,362.70	35,100.70
10	124,992.25	74,463.35	15,382.53	35,146.37
11	124,933.97	74,483.97	15,340.55	35,109.45
12	125,061.55	74,545.48	15,364.97	35,151.10
Average	***125,011.23***	***74,509.36***	***15,372.78***	***35,129.10***

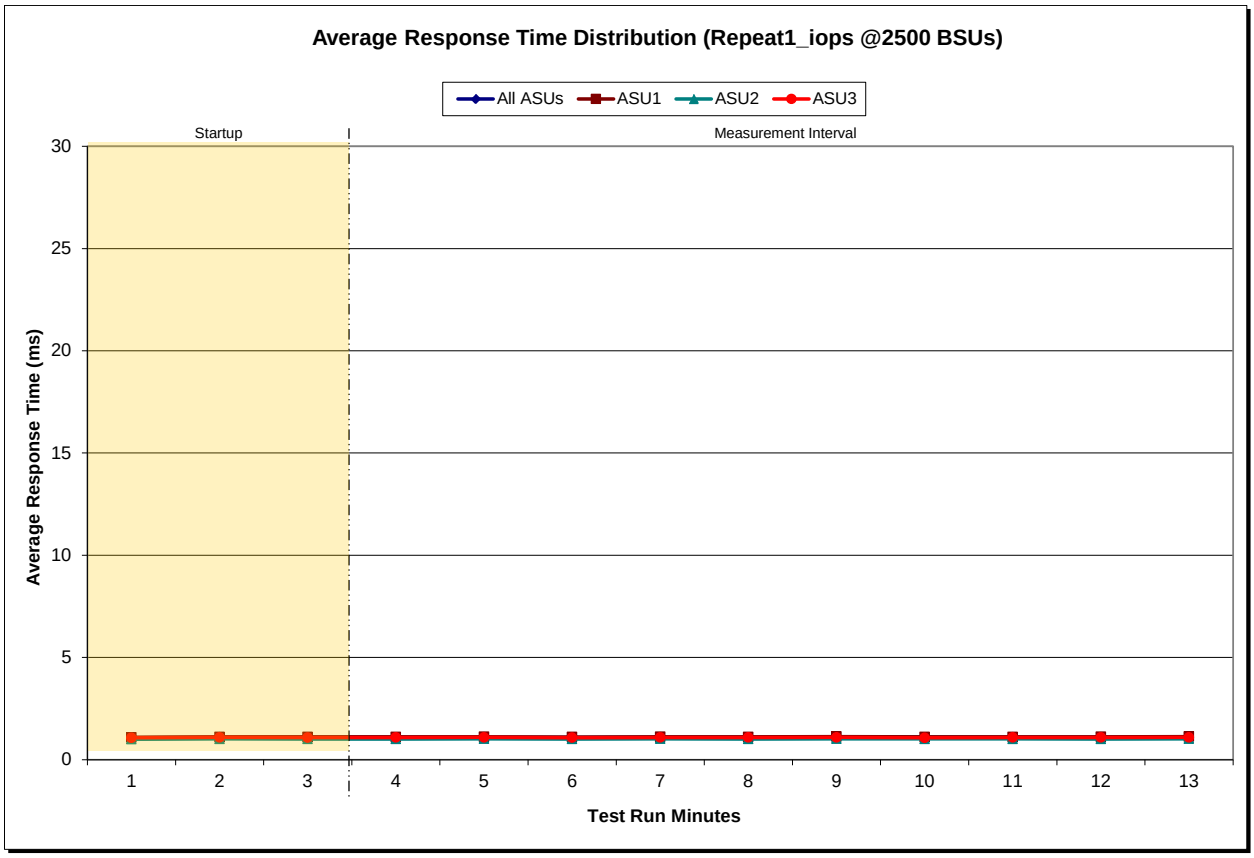
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

2,500 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:34:53	5:37:54	0-2	0:03:01
Measurement Interval	5:37:54	5:47:54	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.08	1.09	1.00	1.07
1	1.09	1.11	1.02	1.09
2	1.09	1.11	1.01	1.08
3	1.09	1.11	1.01	1.08
4	1.10	1.12	1.02	1.09
5	1.09	1.11	1.01	1.08
6	1.10	1.12	1.02	1.08
7	1.09	1.11	1.01	1.08
8	1.10	1.13	1.02	1.09
9	1.09	1.11	1.01	1.07
10	1.09	1.11	1.01	1.09
11	1.09	1.12	1.01	1.08
12	1.10	1.13	1.02	1.09
Average	***1.09***	***1.12***	***1.01***	***1.08***

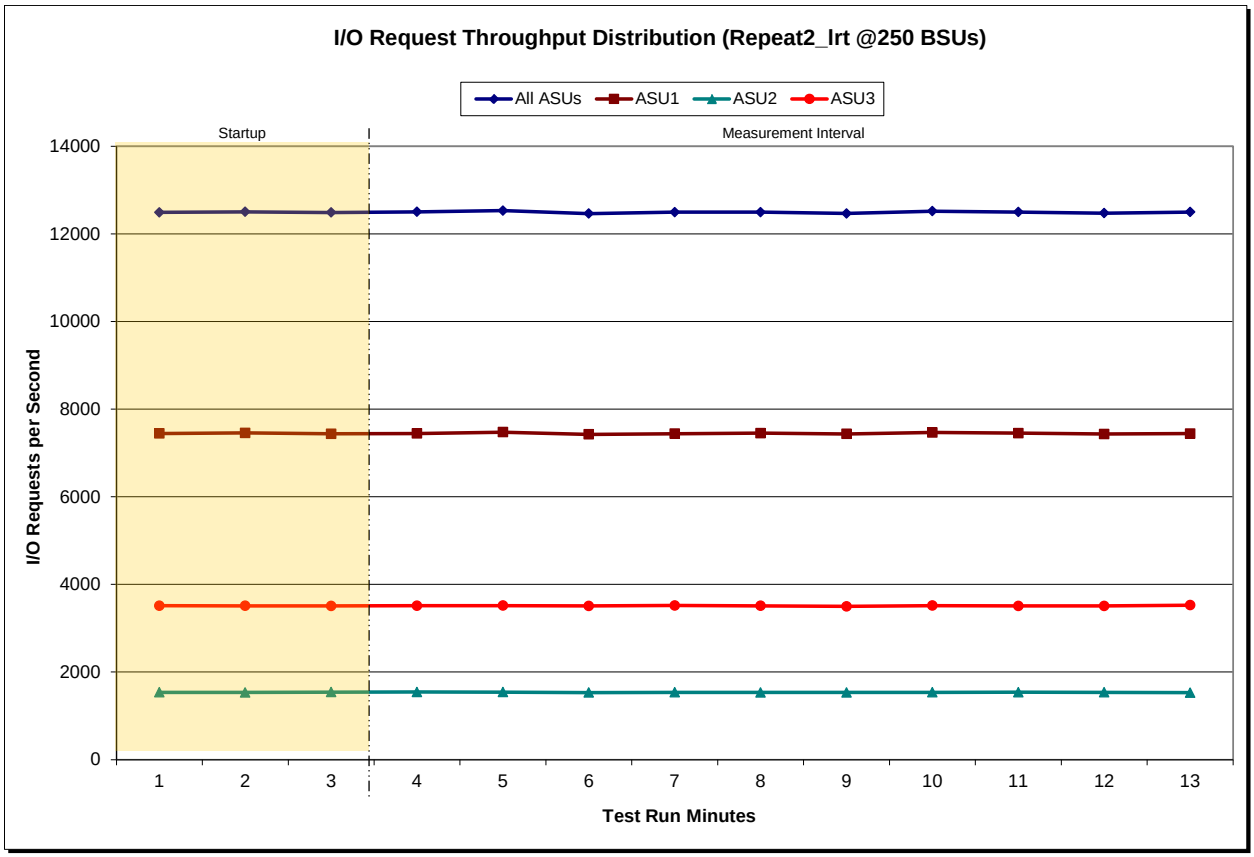
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

250 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:48:06	5:51:06	0-2	0:03:00
Measurement Interval	5:51:06	6:01:06	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	12,492.78	7,444.02	1,536.23	3,512.53
1	12,505.48	7,458.75	1,534.55	3,512.18
2	12,488.70	7,437.15	1,542.13	3,509.42
3	12,503.38	7,444.48	1,545.13	3,513.77
4	12,531.30	7,474.80	1,540.47	3,516.03
5	12,464.35	7,425.12	1,531.53	3,507.70
6	12,496.08	7,440.05	1,537.65	3,518.38
7	12,497.47	7,451.75	1,533.73	3,511.98
8	12,466.88	7,435.25	1,534.42	3,497.22
9	12,519.53	7,466.72	1,536.02	3,516.80
10	12,500.47	7,453.80	1,537.95	3,508.72
11	12,475.30	7,431.73	1,535.92	3,507.65
12	12,498.73	7,442.73	1,529.82	3,526.18
Average	***12,495.35***	***7,446.64***	***1,536.26***	***3,512.44***

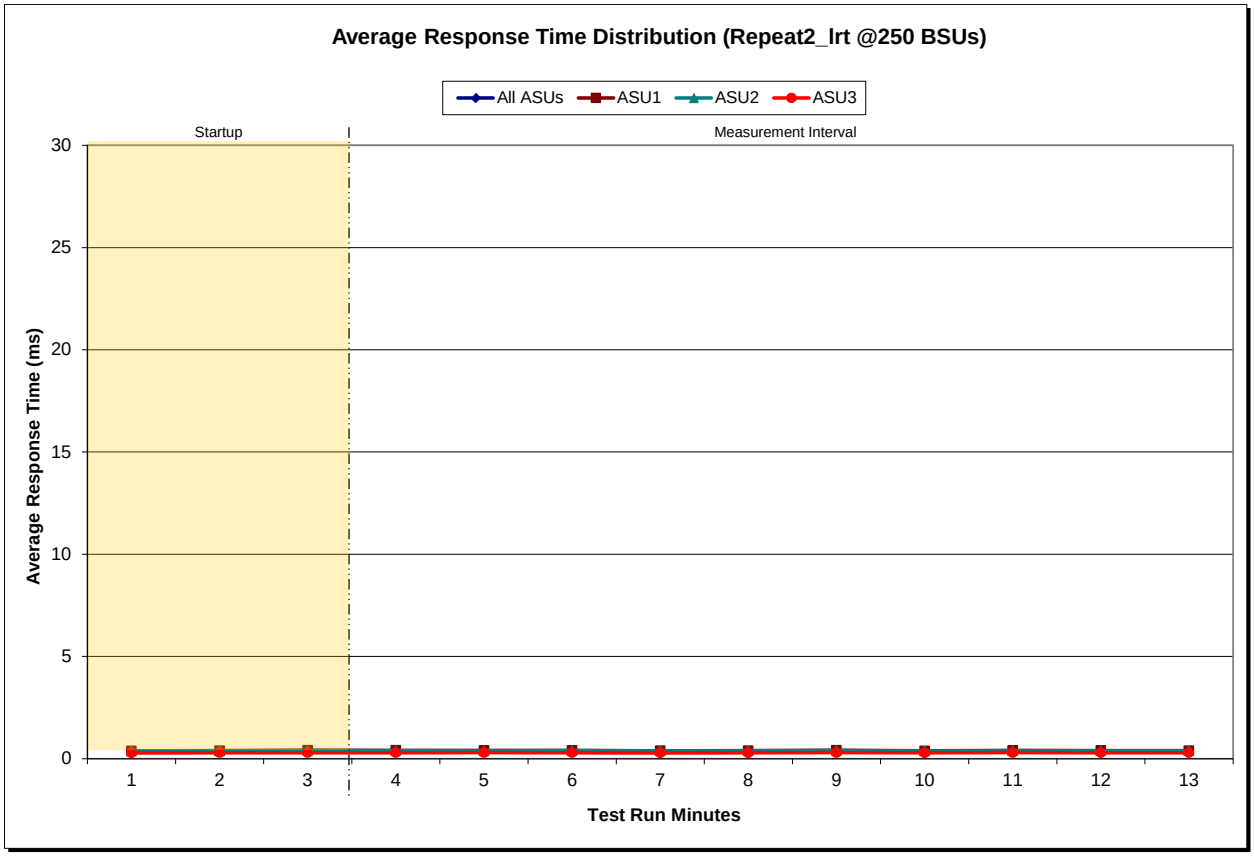
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

250 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:48:06	5:51:06	0-2	0:03:00
Measurement Interval	5:51:06	6:01:06	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.35	0.38	0.37	0.28
1	0.36	0.39	0.38	0.29
2	0.38	0.41	0.39	0.29
3	0.37	0.41	0.39	0.29
4	0.37	0.40	0.38	0.29
5	0.37	0.40	0.39	0.29
6	0.36	0.39	0.38	0.28
7	0.36	0.39	0.39	0.28
8	0.38	0.41	0.40	0.30
9	0.35	0.38	0.37	0.28
10	0.37	0.40	0.38	0.29
11	0.36	0.40	0.39	0.29
12	0.36	0.39	0.39	0.29
Average	***0.36***	***0.40***	***0.39***	***0.29***

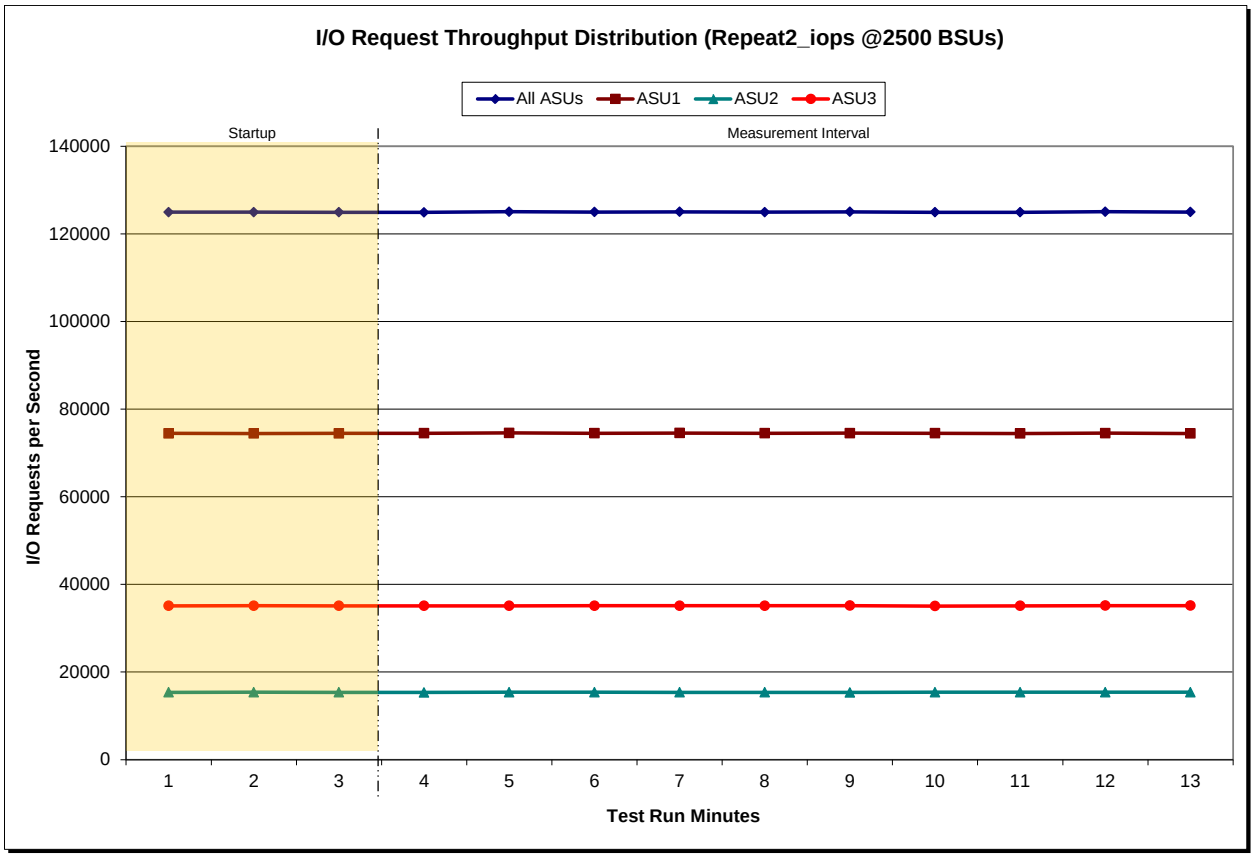
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

2,500 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	6:01:25	6:04:26	0-2	0:03:01
Measurement Interval	6:04:26	6:14:26	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	124,971.37	74,481.50	15,375.98	35,113.88
1	124,960.35	74,448.17	15,381.87	35,130.32
2	124,940.85	74,471.15	15,367.98	35,101.72
3	124,932.63	74,495.50	15,331.58	35,105.55
4	125,072.35	74,578.07	15,384.75	35,109.53
5	125,000.45	74,492.53	15,384.67	35,123.25
6	125,043.63	74,558.67	15,357.82	35,127.15
7	124,974.02	74,497.15	15,353.52	35,123.35
8	125,045.18	74,537.12	15,349.63	35,158.43
9	124,935.22	74,496.33	15,380.33	35,058.55
10	124,953.57	74,452.50	15,382.60	35,118.47
11	125,060.43	74,516.42	15,379.92	35,164.10
12	124,993.08	74,462.47	15,376.83	35,153.78
Average	***125,001.06***	***74,508.68***	***15,368.17***	***35,124.22***

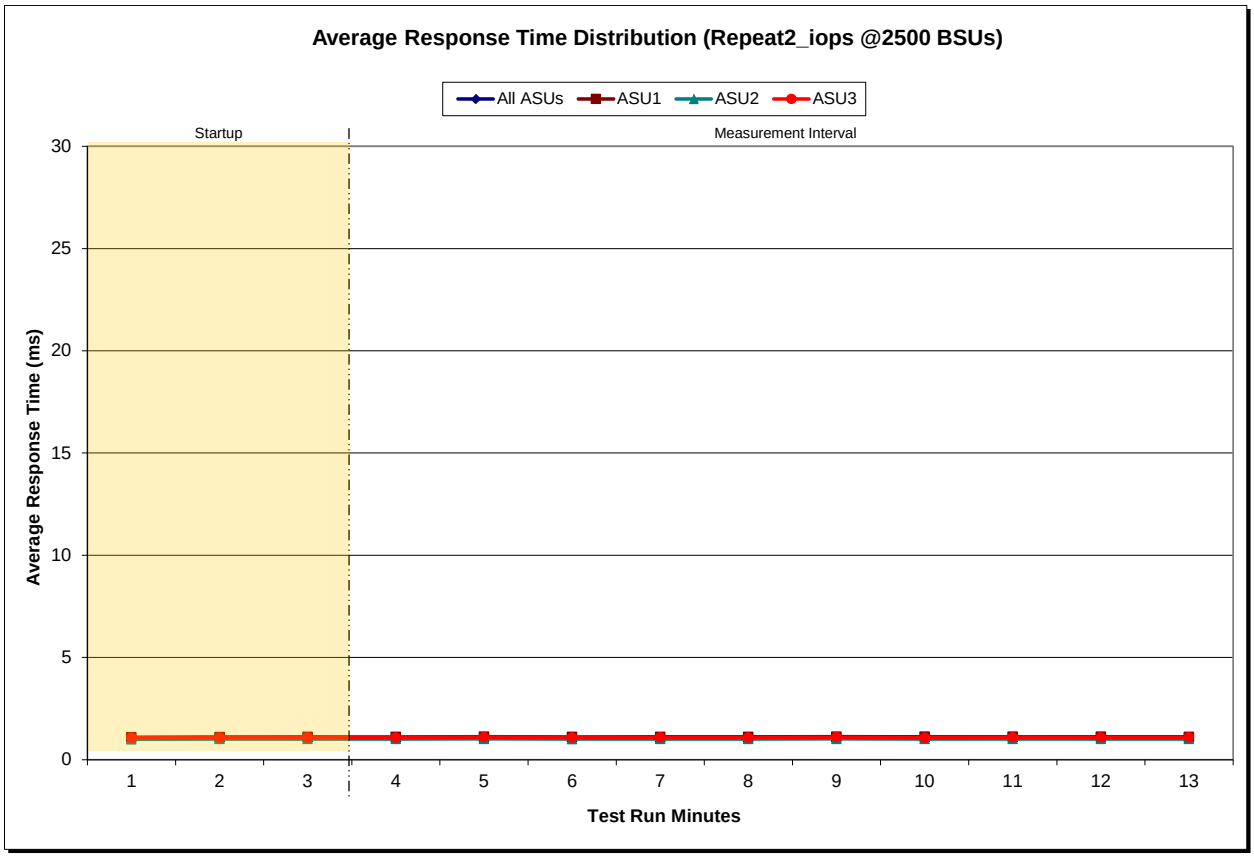
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

2,500 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	6:01:25	6:04:26	0-2	0:03:01
Measurement Interval	6:04:26	6:14:26	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.07	1.09	0.99	1.07
1	1.09	1.10	1.01	1.08
2	1.09	1.11	1.01	1.08
3	1.09	1.11	1.01	1.08
4	1.10	1.12	1.02	1.10
5	1.09	1.11	1.01	1.08
6	1.09	1.11	1.01	1.09
7	1.09	1.11	1.01	1.08
8	1.10	1.12	1.02	1.10
9	1.09	1.12	1.01	1.07
10	1.10	1.12	1.01	1.09
11	1.09	1.12	1.01	1.08
12	1.09	1.11	1.01	1.09
Average	***1.09***	***1.12***	***1.01***	***1.09***

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.*

Clauses5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2809	0.0699	0.2102	0.0179	0.0701	0.0351	0.2808
COV	0.006	0.003	0.005	0.002	0.011	0.006	0.007	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.001	0.001	0.003	0.002	0.002	0.000

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.2099	0.0180	0.0699	0.0350	0.2811
COV	0.006	0.002	0.005	0.002	0.008	0.005	0.005	0.002

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
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2809	0.0700	0.2101	0.0180	0.0700	0.0250	0.2810
COV	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.001

Data Persistence Test

Clause 6

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

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

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

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

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

Clause 9.4.3.8

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

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

SPC-1 Workload Generator Input Parameters

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

Data Persistence Test Results File

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

Persistence 1 Test Results File

Persistence 2 Test Results File

Data Persistence Test Results

Data Persistence Test Results	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	613,305
Total Number of Logical Blocks Verified	510,276
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	5 minutes
Size in bytes of each Logical Block	1,024
Number of Failed I/O Requests in the process of the Test	0

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

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

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

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 9.4.3.9

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

The Hitachi Unified Storage 150as documented in this Full Disclosure Report became available on April 24, 2012 for customer purchase and shipment.

PRICING INFORMATION

Clause 9.4.3.3.6

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

Pricing information may be found in the Priced Storage Configuration Pricing section on page 14.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.8

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

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration may be found in the Executive Summary portion of this document on page 14.

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Onsite Audit of the Hitachi Unified Storage 150.

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 gigibyte (GiB) is equal to 1,073,741,824 (2^{30}) bytes.

A tebibyte (TiB) is equal to 1,099,511,627,776 (2^{40}) bytes.

A pebibyte (PiB) is equal to 1,125,899,906,842,624 (2^{50}) bytes.

An exbibyte (EiB) is equal to 1,152,921,504,606,846,967 (2^{60}) bytes.

SPC-1 Data Repository Definitions

Total ASU Capacity: The total storage capacity read and written in the course of executing the SPC-1 benchmark.

Application Storage Unit (ASU): The logical interface between the storage and SPC-1 Workload Generator. The three ASUs (Data, User, and Log) are typically implemented on one or more Logical Volume.

Logical Volume: The division of Addressable Storage Capacity into individually addressable logical units of storage used in the SPC-1 benchmark. Each Logical Volume is implemented as a single, contiguous address space.

Addressable Storage Capacity: The total storage (sum of Logical Volumes) that can be read and written by application programs such as the SPC-1 Workload Generator.

Configured Storage Capacity: This capacity includes the Addressable Storage Capacity and any other storage (parity disks, hot spares, etc.) necessary to implement the Addressable Storage Capacity.

Physical Storage Capacity: The formatted capacity of all storage devices physically present in the Tested Storage Configuration (TSC).

Data Protection Overhead: The storage capacity required to implement the selected level of data protection.

Required Storage: The amount of Configured Storage Capacity required to implement the Addressable Storage Configuration, excluding the storage required for the three ASUs.

Global Storage Overhead: The amount of Physical Storage Capacity that is required for storage subsystem use and unavailable for use by application programs.

Total Unused Storage: The amount of storage capacity available for use by application programs but not included in the Total ASU Capacity.

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

Average Response Time: The sum of the Response Times for all Measured I/O Requests divided by the total number of Measured I/O Requests.

Completed I/O Request: An I/O Request with a Start Time and a Completion Time (see "I/O Completion Types" below).

Completion Time: The time recorded by the Workload Generator when an I/O Request is satisfied by the TSC as signaled by System Software.

Data Rate: The data transferred in all Measured I/O Requests in an SPC-1 Test Run divided by the length of the Test Run in seconds.

Expected I/O Count: For any given I/O Stream and Test Phase, the product of 50 times the BSU level, the duration of the Test Phase in seconds, and the Intensity Multiplier for that I/O Stream.

Failed I/O Request: Any I/O Request issued by the Workload Generator that could not be completed or was signaled as failed by System Software. A Failed I/O Request has no Completion Time (see "I/O Completion Types" below).

I/O Request Throughput: The total number of Measured I/O requests in an SPC-1 Test Run divided by the duration of the Measurement Interval in seconds.

In-Flight I/O Request: An I/O Request issued by the I/O Command Generator to the TSC that has a recorded Start Time, but does not complete within the Measurement Interval (see "I/O Completion Types" below).

Measured I/O Request: A Completed I/O Request with a Completion Time occurring within the Measurement Interval (see "I/O Completion Types" below).

Measured Intensity Multiplier: The percentage of all Measured I/O Requests that were issued by a given I/O Stream.

Measurement Interval: The finite and contiguous time period, after the TSC has reached Steady State, when data is collected by a Test Sponsor to generate an SPC-1 test result or support an SPC-1 test result.

Ramp-Up: The time required for the Benchmark Configuration (BC) to produce Steady State throughput after the Workload Generator begins submitting I/O Requests to the TSC for execution.

Ramp-Down: The time required for the BC to complete all I/O Requests issued by the Workload Generator. The Ramp-Down period begins when the Workload Generator ceases to issue new I/O Requests to the TSC.

Response Time: The Response Time of a Measured I/O Request is its Completion Time minus its Start Time.

Start Time: The time recorded by the Workload Generator when an I/O Request is submitted, by the Workload Generator, to the System Software for execution on the Tested Storage Configuration (TSC).

Start-Up: The period that begins after the Workload Generator starts to submit I/O requests to the TSC and ends at the beginning of the Measurement Interval.

Shut-Down: The period between the end of the Measurement Interval and the time when all I/O Requests issued by the Workload Generator have completed or failed.

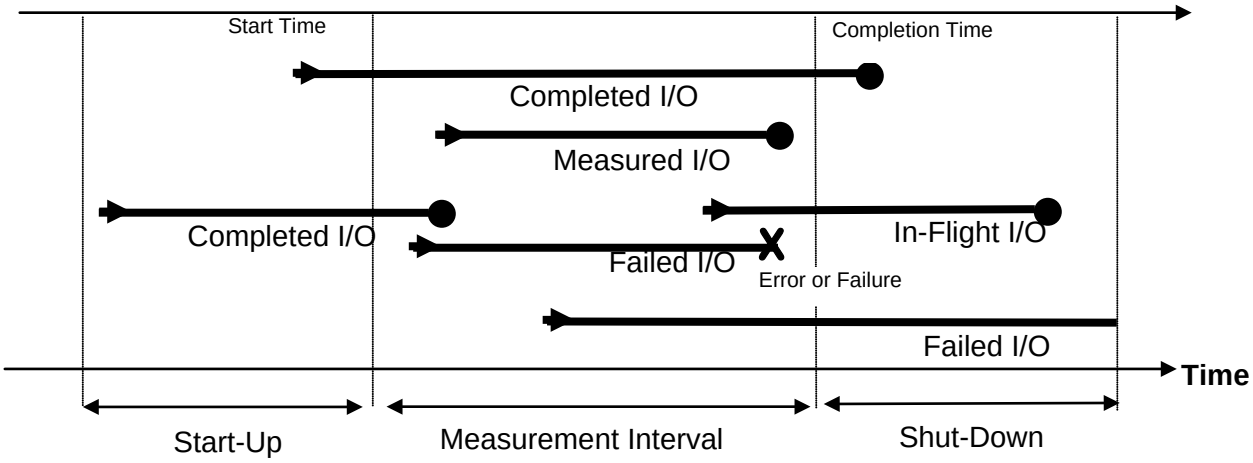
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

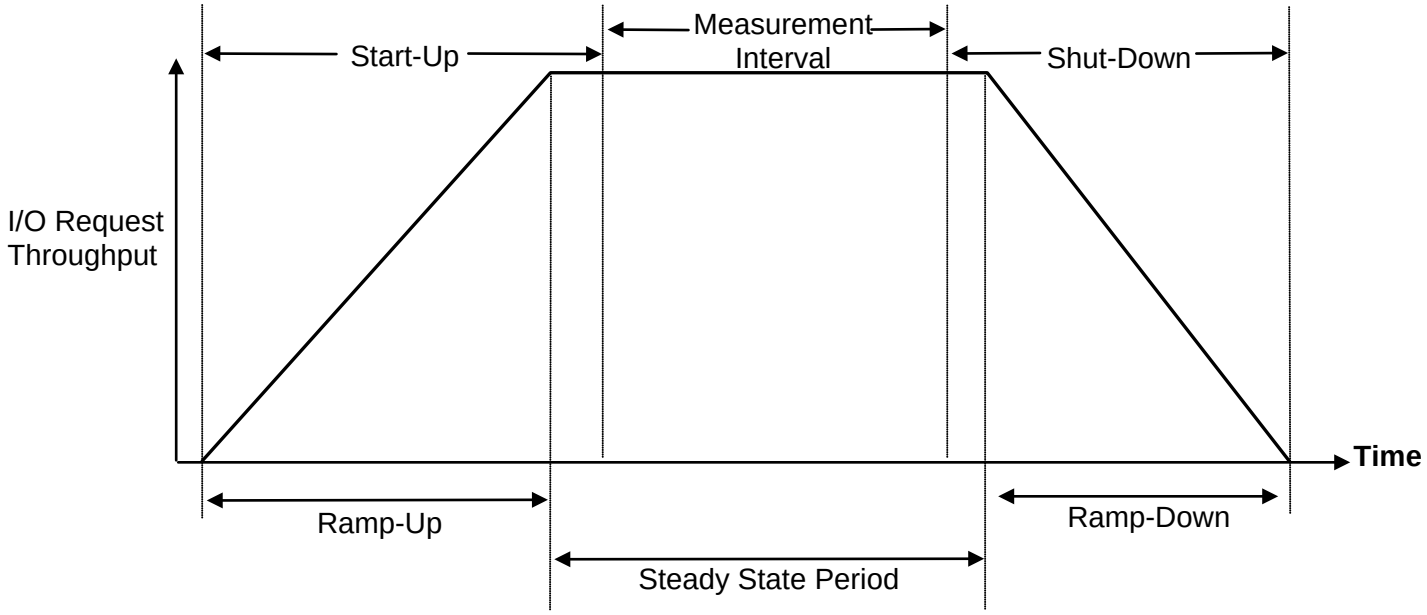
Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have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

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

I/O Completion Types



SPC-1 Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

The following customer tunable parameters and options were changed from their default values for this benchmark. The **Set Parameter and Options** section of *"Appendix C: Tested Storage Configuration (TSC) Creation"* documents how those parameters and options were changed.

Parameter/Option (*SPC-1_set_monitoring.bat*)	**Default Value**	**New Value**
Disable performance monitor collection for the (8) performance measurement items listed in script.	***enable***	***disable***
verify *(Online Verify)* *This feature checks the medium in the drive. When it detects an error, the data on the error medium is verified from other drives.*	***enable***	***disable***
detailedtrace *(Detailed Trace Mode)* *This feature enhances logging by providing more detailed information if unusual hardware or software issues occur.*	***on***	***off***

Parameter/Option (*SPC-1_set_sysparms.bat*)	**Default Value**	**New Value**
readwrite: *This option setting allows multiple sequential streams to a given LUN trigger sequential reads and writes.*	***disable***	***-readwrite enable*** *(set for ASU-3 only)*
seqcount *(Count of Judgment Sequential)* *This parameter determines how many previous I/Os of any stream must be in cache, including the I/O being executed, before triggering pre-fetch. A value of 1 will trigger pre-fetch for every I/O*	***3***	***0*** *(ASU-1 and ASU-2)* ***1*** *(ASU-3)*
dtystart *(Dirty Data Opportunity)* *This defines the amount of Write Pending data allowed in cache before triggering a "Full Power" destage instead of it being a background task.*	***5***	***20***
dtystop *(Dirty Data Stop Opportunity)* *This defines the point at which "Full Power" destage ends.*	***5***	***10***
loadbalancing *This is a feature that enables balancing of controller CPU loads.*	***enable***	***disable***

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The Storage Navigator Modular2 (SNM2) commands and scripts and Veritas Volume Manager scripts, which appear at the end of this section, were executed to create and configure the Tested Storage Configuration (TSC). Each SNM2 command and script was executed from a command window on the Host System where SNM2 was installed and configured for use. The **STONAVM_HOME** environment variable was set to point to the home directory of the SNM2 installation so that the bin directory and command files could be found.

The SNM2 scripts were used to configure cache partitions, create RAID Groups and Logical Units, map LUNs to the storage front-end ports, and set the parameters documented in Appendix B. Once these SNM2 scripts were successfully executed, the host system was rebooted. This enabled discovery of the storage LUNs on the host, which were then displayed as Windows disks in the VERITAS Disk Management console. After confirming the presence of 44 Windows disks, the VERITAS command-line utility was used to prepare and configure the Windows disks into the striped logical volumes (LVs) that were used for the three ASUs. After the LVs were created, the TSC creation was complete.

1. Registration of the Unit

The Hitachi Unified Storage 150 (HUS 150) was registered by executing the following commands in a command window on the Host System where SNM2 is installed:

```
set UNAME=(Your Unit Name)
auunitadd  -unit %UNAME%  -LAN -ctl0  (IP address of controller0) –ctl1 (IP address
of controller1)
Unit (Unit Name) has been registered.
```

2. Cache Partition Configuration

By default, the cache memory of the HUS 150 has two cache partitions (CPs), CP0 and CP1. For this testing, the cache was divided into four CPs. First, the size of CP0 and CP1 (used for ASU-1 and ASU-2) was reduced. Then CP2 and CP3 were newly created (and used for ASU-3). These four actions were executed using the following four commands in a command window on the host system where SNM2 was installed. The required user responses to the command prompts are shown below.

First, the following two commands were executed to reduce the size of CP0 and CP1:

```
set UNAME=(Your Unit Name)
aucachept  -unit %UNAME%  -chg –pt 0 –ptsize 308
aucachept  -unit %UNAME%  -chg –pt 1 –ptsize 308
```

Following each of these ***aucachept*** commands was a series of prompts, listed below with their required responses:

```
The size of cache partition 0 (1) is changed into 3080MB.
Do you want to continue processing?  (y/n [n]):  y
The pair cache partition may be changed into "Auto".  Please confirm pair cache
partition after reboot.
Do you want to continue processing?  (y/n [n]):  y
In order to complete the changing, it is necessary to reboot the subsystem.
When not restarting, the changing will be registered, but it will not become
effective on the subsystem.
Please execute this command again without restarting, if you want to continue
setting of the cache partition.
Do you restart the subsystem?  (y/n [n]): n
Are you sure you want to change the cache partition? (y/n [n]):  y
The cache partition has been changed successfully.
Please restart the subsystem to enable the settings.
```

Then the two commands below were executed to create CP2 and CP3. The command prompts and user responses are listed below.

```
aucachept –unit %UNAME% –add –ptsize 250 –segsize 16 –ctl0


The reserved cache partition 2 in size 2500MB is set up to CTL0.

Do you want to continue processing?  (y/n [n]):  y

In order to complete the setting, it is necessary to reboot the subsystem.

When not restarting, the setting will be registered, but it will not become
effective on the subsystem.

Please execute this command again without restarting, if you want to continue
setting of the cache partition.

Do you restart the subsystem?  (y/n [n]):  n

Are you sure you want to set the cache partition?  (y/n [n]):  y

The cache partition has been set successfully.

Please restart the subsystem to enable the settings.


aucachept –unit %UNAME% –add –ptsize 250 –segsize 16 –ctl1

The reserved cache partition 3 in size 2500MB is set up to CTL1.

Do you want to continue processing?  (y/n [n]):  y

In order to complete the setting, it is necessary to reboot the subsystem.

When not restarting, the setting will be registered, but it will not become
effective on the subsystem.

Please execute this command again without restarting, if you want to continue
setting of the cache partition.

Do you restart the subsystem?  (y/n [n]):  y

Host will be unable to access the subsystem while restarting……(long)

Do you agree with restarting?  (y/n [n]):  y

Are you sure you want to execute?  (y/n [n]):  y

Now restarting the subsystem.  Start Time nn:nn:nn  Time Required  7 – 25min.
```

3. RAID Group (RG) Creation

After the subsystem was restarted, there were 4 RAID Groups, RGs #0-3 *(2D+2D, RAID1+0)* created for ASU-1 and ASU-2 and 2 RAID Groups, RGs #4-5 *(1D+1D, RAID1)* created for ASU-3. These RAID Groups were created using the **SPC-1_RG-Create.bat** script.

4. Logical Unit (LU) Creation

In RGs #0-3, there were 10 logical units (LUs) created per RG for a total of 40 LUs. Of these, 20 LUs were used for ASU-1 and the remaining 20 LUs were used for ASU-2.

In RGs #4-5, there were two LUs created per RG for a total of 4 LUs, which were used for ASU-3.

All LUs were created and their controller core ownerships assigned using the **SPC-1_LU-Create.bat** script.

5. Map LUs to Front-End Ports

44 LUs were assigned across 16 front-end ports as follows:

HUS150 LUN mapping															
0X				0Y				1X				1Y			
0A	0B	0C	0D	0E	0F	0G	0H	1A	1B	1C	1D	1E	1F	1G	1H
0	6	1	7	10	16	11	17	20	26	21	27	30	36	31	37
2	8	3	9	12	18	13	19	22	28	23	29	32	38	33	39
4	100	5		14	102	15		24	101	25		34	103	35	

The 44 mapped LUs were distributed as follows: 20 LUs for ASU-1, 20 LUs for ASU-2 and 4 LUs for ASU-3. The mapping of LUs to ASU is illustrated below.

LU#				ASU #
0	10	20	30	*ASU_1-1*
1	11	21	31	*ASU_1-2*
2	12	22	32	*ASU_1-3*
3	13	23	33	*ASU_1-4*
4	14	24	34	*ASU_1-5*
5	15	25	35	*ASU_2-1*
6	16	26	36	*ASU_2-2*
7	17	27	37	*ASU_2-3*
8	18	28	38	*ASU_2-4*
9	19	29	39	*ASU_2-5*
100	102	101	103	*ASU_3*

The **SPC-1_LU-Map.bat** script was executed to map the LUs to the front-end ports.

6. Set Parameters and Options

Each customer tunable and option that was changed from its default value for the benchmark execution is described in *Appendix B: Customer Tunable Parameters and Options*.

The **SPC-1_set_monitoring.bat** script disables performance monitor collection, trace and verification setting on the HUS 150.

The **SPC-1_set_sysparms.bat** script sets performance tuning on the HUS 150.

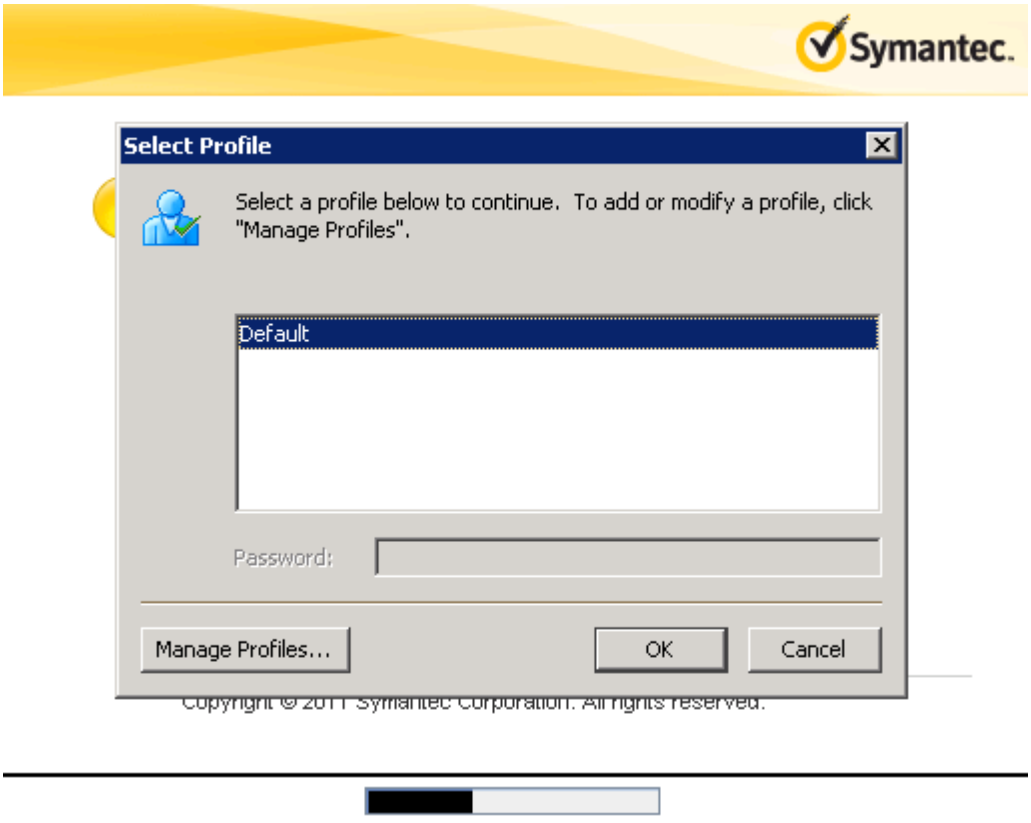
7. Reboot the Host System

A reboot of the host system was then done to enable discovery of the LUNs on the host. After reboot, the LUNs appeared as Windows disks in the VERITAS Volume Management console.

8. Prepare SAN Disks for Logical Volume Creation

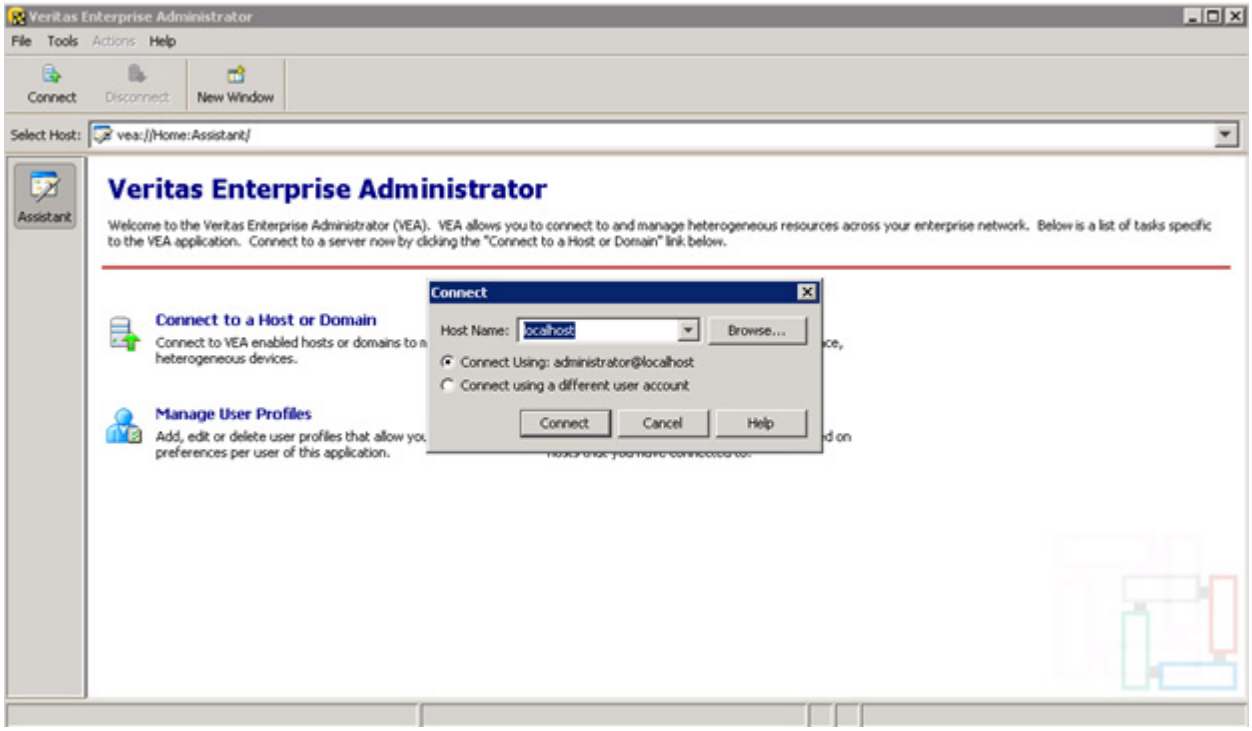
The Veritas Enterprise Administrator GUI Console was used to detect all the 44 SAN disks and bring the disks online, as described below.

- Start the Veritas Enterprise Administrator GUI Console by clicking ***Start*** / ***All Programs*** / ***Veritas Storage Foundation*** / ***Veritas Enterprise Administrator***.

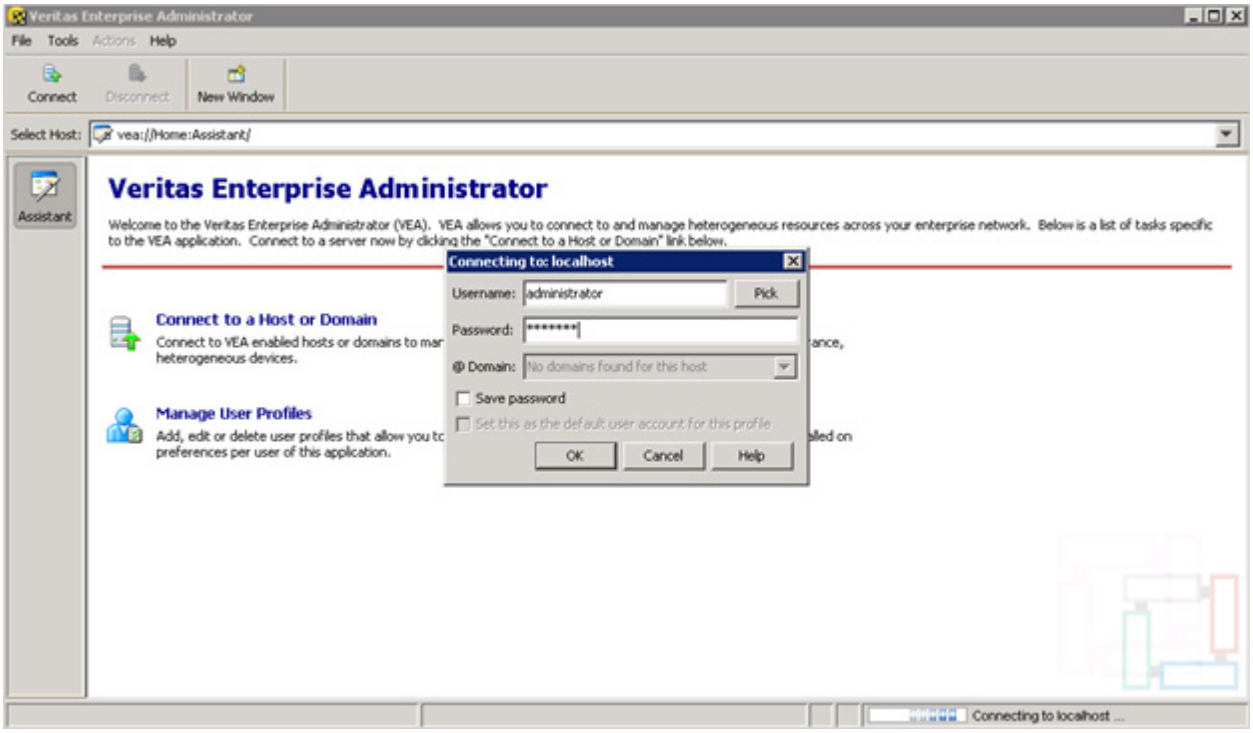


- Click ***OK*** and the following screen is displayed.

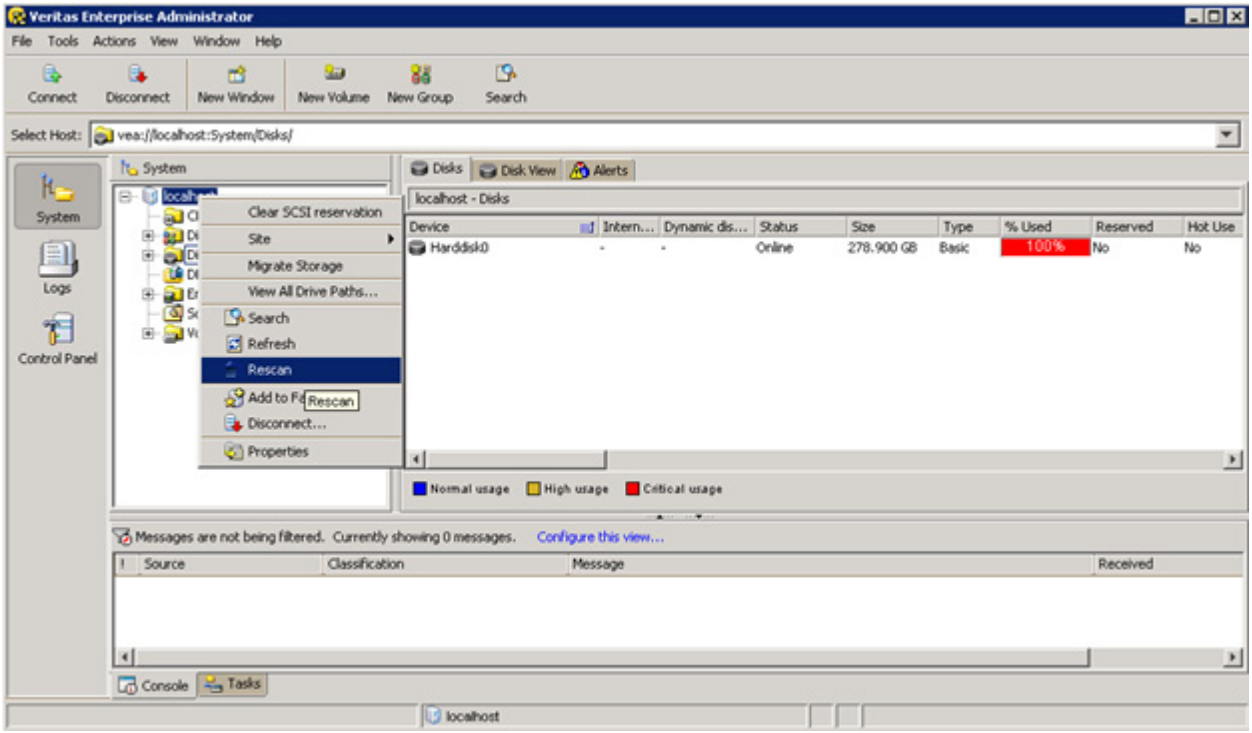
- Click on ***Connect to a Host or Domain***, select **localhost** in the drop down window and click on ***Connect***.



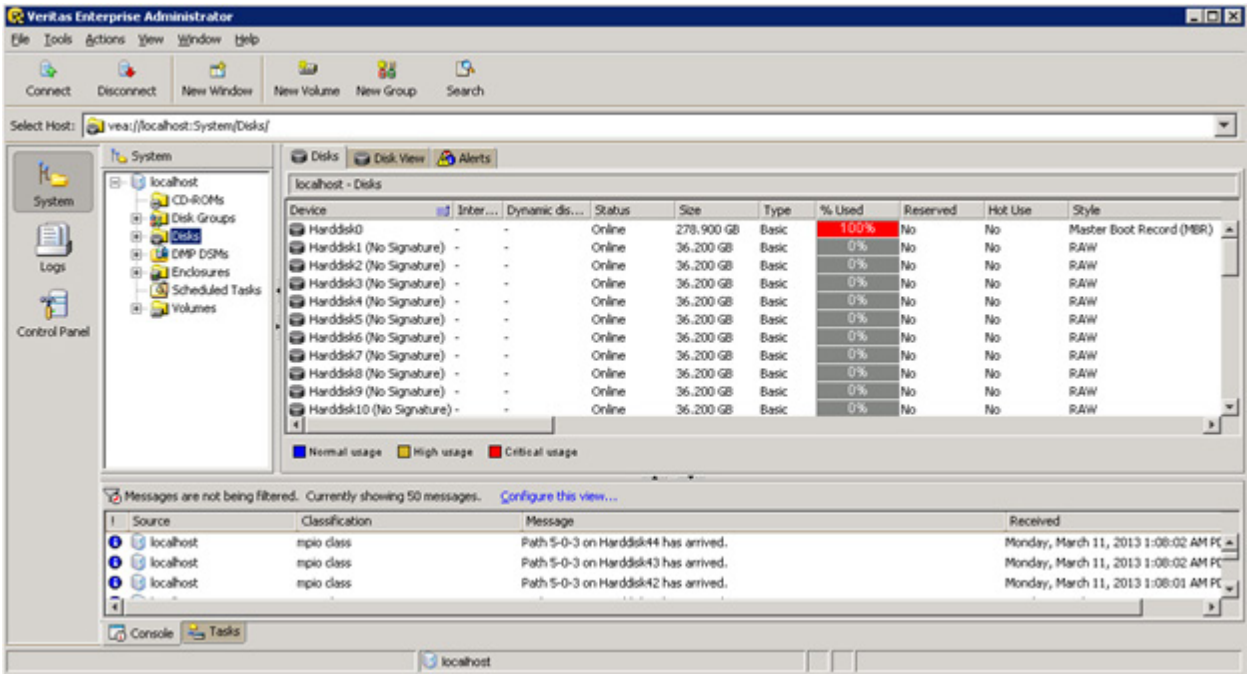
- Login using the system login and password.



- Right click on ***localhost***, and then click on ***Rescan***.



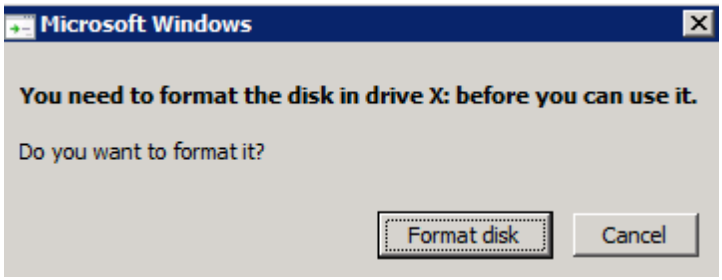
- The 44 SAN disks are displayed and are online.



Then the Veritas command line utility was used create a SPC-1 disk group (DG) and all the 44 disks were imported to the DG by using the **SPC-1_DG_Creat.bat** script. This script also writes the signature on each disk, assigns MBR format and converts the disks from basic to dynamic.

9. Create Striped Logical Volumes

Finally, the logical volumes used for ASU-1, ASU-2, and ASU-3 were created by executing the **SPC-1_VolCreate.bat** script. This script creates a 32MB partition on each of the 44 disks followed by 11 striped logical volumes (with drive letters G through Q) from the 44 Windows disks. For ASU-1 and ASU-2, there were five LVs each, where each LV was striped across 4 disks. For ASU-3, there was one LV, striped across four disks. As the LVs are created, there's a Windows dialog box that prompts for formatting:



The "Cancel" button was clicked.

Upon completion of this script, the Windows logical volumes were ready for use, striped across storage LUNs according to the following table:

Windows Drive Letter	Storage LUN Numbers	SPC-1 ASU Detail
G:\	0, 10, 20, 30	ASU 1-1
H:\	1, 11, 21, 31	ASU 1-2
I:\	2, 12, 22, 32	ASU 1-3
J:\	3, 13, 23, 33	ASU 1-4
K:\	4, 14, 24, 34	ASU 1-5
L:\	5, 15, 25, 35	ASU 2-1
M:\	6, 16, 26, 36	ASU 2-2
N:\	7, 17, 27, 37	ASU 2-3
O:\	8, 18, 28, 38	ASU 2-4
P:\	9, 19, 29, 39	ASU 2-5
Q:\	100, 102, 101, 103	ASU 3

TSC Creation/Configuration Scripts

SPC-1_RG-Create.bat

```
aurgadd -unit %UNAME% -rg 0 -RAID10 -drive 0.0-0.1 2.0-2.1 -pnum 1
aurgadd -unit %UNAME% -rg 1 -RAID10 -drive 1.0-1.1 3.0-3.1 -pnum 1
aurgadd -unit %UNAME% -rg 2 -RAID10 -drive 0.2-0.3 2.2-2.3 -pnum 1
aurgadd -unit %UNAME% -rg 3 -RAID10 -drive 1.2-1.3 3.2-3.3 -pnum 1
aurgadd -unit %UNAME% -rg 10 -RAID1 -drive 0.4 2.4 -pnum 1
aurgadd -unit %UNAME% -rg 11 -RAID1 -drive 1.4 3.4 -pnum 1
```

SPC-1_LU-Create.bat

```
  for /L %%n in (0,1,9) DO auluadd -unit %UNAME% -rg 0 -lu %%n -size 76000000 -
cachept 0 -noluformat
  for /L %%n in (10,1,19) DO auluadd -unit %UNAME% -rg 1 -lu %%n -size 76000000 -
cachept 0 -noluformat
  for /L %%n in (20,1,29) DO auluadd -unit %UNAME% -rg 2 -lu %%n -size 76000000 -
cachept 1 -noluformat
  for /L %%n in (30,1,39) DO auluadd -unit %UNAME% -rg 3 -lu %%n -size 76000000 -
cachept 1 -noluformat
for /L %%n in (100,1,101) DO auluadd -unit %UNAME% -rg 10 -lu %%n -size 91000000 -
noluformat
for /L %%n in (102,1,103) DO auluadd -unit %UNAME% -rg 11 -lu %%n -size 91000000 -
noluformat
 aulucachept -unit %UNAME% -set -lu 100 -pt 2
 aulucachept -unit %UNAME% -set -lu 101 -pt 3
 aulucachept -unit %UNAME% -set -lu 102 -pt 2
 aulucachept -unit %UNAME% -set -lu 103 -pt 3

 for /L %%n in (0,1,9) DO autuningluown -unit %UNAME% -set -lu %%n -ctl0 -coreX

 for /L %%n in (10,1,19) DO autuningluown -unit %UNAME% -set -lu %%n -ctl0 -coreY
 for /L %%n in (20,1,29) DO autuningluown -unit %UNAME% -set -lu %%n -ctl1 -coreX
 for /L %%n in (30,1,39) DO autuningluown -unit %UNAME% -set -lu %%n -ctl1 -coreY

 autuningluown -unit %UNAME% -set -lu 100 -ctl0 -coreX
 autuningluown -unit %UNAME% -set -lu 101 -ctl1 -coreX
 autuningluown -unit %UNAME% -set -lu 102 -ctl0 -coreY
 autuningluown -unit %UNAME% -set -lu 103 -ctl1 -coreY

for /L %%n in (0,1,9) DO auformat -unit %UNAME% -lu %%n
for /L %%n in (10,1,19) DO auformat -unit %UNAME% -lu %%n
for /L %%n in (20,1,29) DO auformat -unit %UNAME% -lu %%n
for /L %%n in (30,1,39) DO auformat -unit %UNAME% -lu %%n
for /L %%n in (100,1,101) DO auformat -unit %UNAME% -lu %%n

for /L %%n in (102,1,103) DO auformat -unit %UNAME% -lu %%n
```

SPC-1_LU-Map.bat

```
auhgmap -unit %UNAME% -MappingMode off
auhgmap -unit %UNAME% -MappingMode on

auhgmap -unit %UNAME% -add 0 A 0 0 0
auhgmap -unit %UNAME% -add 0 A 0 1 2
auhgmap -unit %UNAME% -add 0 A 0 2 4

auhgmap -unit %UNAME% -add 0 B 0 0 6
auhgmap -unit %UNAME% -add 0 B 0 1 8
```

```
auhgmap -unit %UNAME% -add 0 C 0 0 1
auhgmap -unit %UNAME% -add 0 C 0 1 3
auhgmap -unit %UNAME% -add 0 C 0 2 5

auhgmap -unit %UNAME% -add 0 D 0 0 7
auhgmap -unit %UNAME% -add 0 D 0 1 9

auhgmap -unit %UNAME% -add 0 E 0 0 10
auhgmap -unit %UNAME% -add 0 E 0 1 12
auhgmap -unit %UNAME% -add 0 E 0 2 14

auhgmap -unit %UNAME% -add 0 F 0 0 16
auhgmap -unit %UNAME% -add 0 F 0 1 18

auhgmap -unit %UNAME% -add 0 G 0 0 11
auhgmap -unit %UNAME% -add 0 G 0 1 13
auhgmap -unit %UNAME% -add 0 G 0 2 15

auhgmap -unit %UNAME% -add 0 H 0 0 17
auhgmap -unit %UNAME% -add 0 H 0 1 19

auhgmap -unit %UNAME% -add 1 A 0 0 20
auhgmap -unit %UNAME% -add 1 A 0 1 22
auhgmap -unit %UNAME% -add 1 A 0 2 24

auhgmap -unit %UNAME% -add 1 B 0 0 26
auhgmap -unit %UNAME% -add 1 B 0 1 28

auhgmap -unit %UNAME% -add 1 C 0 0 21
auhgmap -unit %UNAME% -add 1 C 0 1 23
auhgmap -unit %UNAME% -add 1 C 0 2 25

auhgmap -unit %UNAME% -add 1 D 0 0 27
auhgmap -unit %UNAME% -add 1 D 0 1 29

auhgmap -unit %UNAME% -add 1 E 0 0 30
auhgmap -unit %UNAME% -add 1 E 0 1 32
auhgmap -unit %UNAME% -add 1 E 0 2 34

auhgmap -unit %UNAME% -add 1 F 0 0 36
auhgmap -unit %UNAME% -add 1 F 0 1 38

auhgmap -unit %UNAME% -add 1 G 0 0 31
auhgmap -unit %UNAME% -add 1 G 0 1 33
auhgmap -unit %UNAME% -add 1 G 0 2 35

auhgmap -unit %UNAME% -add 1 H 0 0 37
auhgmap -unit %UNAME% -add 1 H 0 1 39

auhgmap -unit %UNAME% -add 0 B 0 2 100
auhgmap -unit %UNAME% -add 0 F 0 2 102
auhgmap -unit %UNAME% -add 1 B 0 2 101
auhgmap -unit %UNAME% -add 1 F 0 2 103
```

SPC-1_set_monitoring.bat

```
aupfmstatiscfg -unit %UNAME% -set -port stop -rglu stop -cache stop -processor stop
-drive stop -driveopr stop -backend stop –managementarea stop
auonlineverify -unit %UNAME% -set -verify disable
ausystuning -unit %UNAME% -set -detailedtrace off
```

SPC-1_set_sysparms.bat

```
ausystuning -unit %UNAME% -set -dtystart 20 -dtystop 10
ausystuning -unit %UNAME% -set -loadbalancing disable


autuningmultistream -unit %UNAME% -default
autuningmultistream -unit %UNAME% -set -scope lu -lu 0-39 -seqcount 0
autuningmultistream -unit %UNAME% -set -scope lu -lu 100-103 -readwrite enable -
seqcount 1 -criteria base
```

SPC-1_DG_Create.bat

```
cd c:\Program Files\Veritas\Veritas Volume Manager

vxdisk sig P4C0T0L0 diskstyle=MBR
vxdisk sig P4C0T0L1 diskstyle=MBR
vxdisk sig P4C0T0L2 diskstyle=MBR
vxdisk sig P4C0T1L0 diskstyle=MBR
vxdisk sig P4C0T1L1 diskstyle=MBR
vxdisk sig P4C0T1L2 diskstyle=MBR
vxdisk sig P4C0T2L0 diskstyle=MBR
vxdisk sig P4C0T2L1 diskstyle=MBR
vxdisk sig P4C0T2L2 diskstyle=MBR
vxdisk sig P4C0T3L0 diskstyle=MBR
vxdisk sig P4C0T3L1 diskstyle=MBR
vxdisk sig P4C0T3L2 diskstyle=MBR
vxdisk sig P5C0T0L0 diskstyle=MBR
vxdisk sig P5C0T0L1 diskstyle=MBR
vxdisk sig P5C0T0L2 diskstyle=MBR
vxdisk sig P5C0T1L0 diskstyle=MBR
vxdisk sig P5C0T1L1 diskstyle=MBR
vxdisk sig P5C0T1L2 diskstyle=MBR
vxdisk sig P5C0T2L0 diskstyle=MBR
vxdisk sig P5C0T2L1 diskstyle=MBR
vxdisk sig P5C0T2L2 diskstyle=MBR
vxdisk sig P5C0T3L0 diskstyle=MBR
vxdisk sig P5C0T3L1 diskstyle=MBR
vxdisk sig P5C0T3L2 diskstyle=MBR
vxdisk sig P6C0T0L0 diskstyle=MBR
vxdisk sig P6C0T0L1 diskstyle=MBR
vxdisk sig P6C0T0L2 diskstyle=MBR
vxdisk sig P6C0T1L0 diskstyle=MBR
vxdisk sig P6C0T1L1 diskstyle=MBR
vxdisk sig P6C0T1L2 diskstyle=MBR
vxdisk sig P6C0T2L0 diskstyle=MBR
vxdisk sig P6C0T2L1 diskstyle=MBR
vxdisk sig P6C0T2L2 diskstyle=MBR
vxdisk sig P6C0T3L0 diskstyle=MBR
vxdisk sig P6C0T3L1 diskstyle=MBR
vxdisk sig P6C0T3L2 diskstyle=MBR
vxdisk sig P7C0T0L0 diskstyle=MBR
vxdisk sig P7C0T0L1 diskstyle=MBR
vxdisk sig P7C0T1L0 diskstyle=MBR
vxdisk sig P7C0T1L1 diskstyle=MBR
vxdisk sig P7C0T2L0 diskstyle=MBR
vxdisk sig P7C0T2L1 diskstyle=MBR
vxdisk sig P7C0T3L0 diskstyle=MBR
vxdisk sig P7C0T3L1 diskstyle=MBR
```

```
vxdg init -gSPC-1 P4C0T0L0 P4C0T0L1 P4C0T0L2 P4C0T1L0 P4C0T1L1 P4C0T1L2 P4C0T2L0
P4C0T2L1 P4C0T2L2 P4C0T3L0 P4C0T3L1 P4C0T3L2 P5C0T0L0 P5C0T0L1 P5C0T0L2 P5C0T1L0
P5C0T1L1 P5C0T1L2 P5C0T2L0 P5C0T2L1 P5C0T2L2 P5C0T3L0 P5C0T3L1 P5C0T3L2 P6C0T0L0
P6C0T0L1 P6C0T0L2 P6C0T1L0 P6C0T1L1 P6C0T1L2 P6C0T2L0 P6C0T2L1 P6C0T2L2 P6C0T3L0
P6C0T3L1 P6C0T3L2 P7C0T0L0 P7C0T0L1 P7C0T1L0 P7C0T1L1 P7C0T2L0 P7C0T2L1 P7C0T3L0
P7C0T3L1
```

SPC-1_VolCreate.bat

```
cd c:\Program Files\Veritas\Veritas Volume Manager

vxassist -gSPC-1 make dmy_001 65473S P4C0T0L0
vxassist -gSPC-1 make dmy_002 65473S P4C0T0L1
vxassist -gSPC-1 make dmy_003 65473S P4C0T0L2
vxassist -gSPC-1 make dmy_004 65473S P4C0T1L0
vxassist -gSPC-1 make dmy_005 65473S P4C0T1L1
vxassist -gSPC-1 make dmy_006 65473S P4C0T1L2
vxassist -gSPC-1 make dmy_007 65473S P4C0T2L0
vxassist -gSPC-1 make dmy_008 65473S P4C0T2L1
vxassist -gSPC-1 make dmy_009 65473S P4C0T2L2
vxassist -gSPC-1 make dmy_010 65473S P4C0T3L0
vxassist -gSPC-1 make dmy_011 65473S P4C0T3L1
vxassist -gSPC-1 make dmy_012 65473S P4C0T3L2
vxassist -gSPC-1 make dmy_013 65473S P5C0T0L0
vxassist -gSPC-1 make dmy_014 65473S P5C0T0L1
vxassist -gSPC-1 make dmy_015 65473S P5C0T0L2
vxassist -gSPC-1 make dmy_016 65473S P5C0T1L0
vxassist -gSPC-1 make dmy_017 65473S P5C0T1L1
vxassist -gSPC-1 make dmy_018 65473S P5C0T1L2
vxassist -gSPC-1 make dmy_019 65473S P5C0T2L0
vxassist -gSPC-1 make dmy_020 65473S P5C0T2L1
vxassist -gSPC-1 make dmy_021 65473S P5C0T2L2
vxassist -gSPC-1 make dmy_022 65473S P5C0T3L0
vxassist -gSPC-1 make dmy_023 65473S P5C0T3L1
vxassist -gSPC-1 make dmy_024 65473S P5C0T3L2
vxassist -gSPC-1 make dmy_025 65473S P6C0T0L0
vxassist -gSPC-1 make dmy_026 65473S P6C0T0L1
vxassist -gSPC-1 make dmy_027 65473S P6C0T0L2
vxassist -gSPC-1 make dmy_028 65473S P6C0T1L0
vxassist -gSPC-1 make dmy_029 65473S P6C0T1L1
vxassist -gSPC-1 make dmy_030 65473S P6C0T1L2
vxassist -gSPC-1 make dmy_031 65473S P6C0T2L0
vxassist -gSPC-1 make dmy_032 65473S P6C0T2L1
vxassist -gSPC-1 make dmy_033 65473S P6C0T2L2
vxassist -gSPC-1 make dmy_034 65473S P6C0T3L0
vxassist -gSPC-1 make dmy_035 65473S P6C0T3L1
vxassist -gSPC-1 make dmy_036 65473S P6C0T3L2
vxassist -gSPC-1 make dmy_037 65473S P7C0T0L0
vxassist -gSPC-1 make dmy_038 65473S P7C0T0L1
vxassist -gSPC-1 make dmy_039 65473S P7C0T1L0
vxassist -gSPC-1 make dmy_040 65473S P7C0T1L1
vxassist -gSPC-1 make dmy_041 65473S P7C0T2L0
vxassist -gSPC-1 make dmy_042 65473S P7C0T2L1
vxassist -gSPC-1 make dmy_043 65473S P7C0T3L0
vxassist -gSPC-1 make dmy_044 65473S P7C0T3L1

 vxassist -gSPC-1 make ASU1_1 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=G p4c0t0l0 p4c0t1l0 p4c0t2l0 p4c0t3l0
 vxassist -gSPC-1 make ASU1_2 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=H p6c0t0l0 p6c0t1l0 p6c0t2l0 p6c0t3l0
```

```
 vxassist -gSPC-1 make ASU1_3 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=I p4c0t0l1 p4c0t1l1 p4c0t2l1 p4c0t3l1
 vxassist -gSPC-1 make ASU1_4 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=J p6c0t0l1 p6c0t1l1 p6c0t2l1 p6c0t3l1
 vxassist -gSPC-1 make ASU1_5 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=K p4c0t0l2 p4c0t1l2 p4c0t2l2 p4c0t3l2
 vxassist -gSPC-1 make ASU2_1 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=L p6c0t0l2 p6c0t1l2 p6c0t2l2 p6c0t3l2
 vxassist -gSPC-1 make ASU2_2 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=M p5c0t0l0 p5c0t1l0 p5c0t2l0 p5c0t3l0
 vxassist -gSPC-1 make ASU2_3 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=N p7c0t0l0 p7c0t1l0 p7c0t2l0 p7c0t3l0
 vxassist -gSPC-1 make ASU2_4 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=O p5c0t0l1 p5c0t1l1 p5c0t2l1 p5c0t3l1
 vxassist -gSPC-1 make ASU2_5 144G Type=stripe Column=4 StripeUnit=4096
DriveLetter=P p7c0t0l1 p7c0t1l1 p7c0t2l1 p7c0t3l1
 vxassist -gSPC-1 make ASU3_1 160G Type=stripe Column=4 StripeUnit=4096
DriveLetter=Q p5c0t0l2 p5c0t1l2 p5c0t2l2 p5c0t3l2
```

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

ASU Pre-Fill

The content of command and parameter file, used in this benchmark to execute the required ASU pre-fill, is listed below.

```
compratio=1

sd=sd1,lun=\\.\G:,threads=8
sd=sd2,lun=\\.\H:,threads=8
sd=sd3,lun=\\.\I:,threads=8
sd=sd4,lun=\\.\J:,threads=8
sd=sd5,lun=\\.\K:,threads=8
sd=sd6,lun=\\.\L:,threads=8
sd=sd7,lun=\\.\M:,threads=8
sd=sd8,lun=\\.\N:,threads=8
sd=sd9,lun=\\.\O:,threads=8
sd=sd10,lun=\\.\P:,threads=8
sd=sd11,lun=\\.\Q:,threads=8


wd=wd1,sd=sd1,rdpct=0,seek=-1,xfersize=1m
wd=wd2,sd=sd2,rdpct=0,seek=-1,xfersize=1m
wd=wd3,sd=sd3,rdpct=0,seek=-1,xfersize=1m
wd=wd4,sd=sd4,rdpct=0,seek=-1,xfersize=1m
wd=wd5,sd=sd5,rdpct=0,seek=-1,xfersize=1m
wd=wd6,sd=sd6,rdpct=0,seek=-1,xfersize=1m
wd=wd7,sd=sd7,rdpct=0,seek=-1,xfersize=1m
wd=wd8,sd=sd8,rdpct=0,seek=-1,xfersize=1m
wd=wd9,sd=sd9,rdpct=0,seek=-1,xfersize=1m
wd=wd10,sd=sd10,rdpct=0,seek=-1,xfersize=1m
wd=wd11,sd=sd11,rdpct=0,seek=-1,xfersize=1m


rd=asu_prefill,wd=wd*,iorate=max,elapsed=100h,interval=10
```

Primary Metrics and Repeatability Tests

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

```
javaparms="-Xmx1500m -Xms1200m -Xss256k"

sd=asu1_1,lun=\\.\G:,size=154618822656
sd=asu1_2,lun=\\.\H:,size=154618822656
sd=asu1_3,lun=\\.\I:,size=154618822656
sd=asu1_4,lun=\\.\J:,size=154618822656
sd=asu1_5,lun=\\.\K:,size=154618822656
sd=asu2_1,lun=\\.\L:,size=154618822656
sd=asu2_2,lun=\\.\M:,size=154618822656
sd=asu2_3,lun=\\.\N:,size=154618822656
sd=asu2_4,lun=\\.\O:,size=154618822656
sd=asu2_5,lun=\\.\P:,size=154618822656
sd=asu3_1,lun=\\.\Q:,size=171798691840
```

SPC-2 Persistence Test

The content of SPC-2 Workload Generator command and parameter files, used in this benchmark to execute the SPC-2 Persistence Test, are listed below.

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

```
host=localhost,jvms=1,maxstreams=200

sd=sd1,lun=\\.\G:,size=154618822656
sd=sd2,lun=\\.\H:,size=154618822656
sd=sd3,lun=\\.\I:,size=154618822656
sd=sd4,lun=\\.\J:,size=154618822656
sd=sd5,lun=\\.\K:,size=154618822656
sd=sd6,lun=\\.\L:,size=154618822656
sd=sd7,lun=\\.\M:,size=154618822656
sd=sd8,lun=\\.\N:,size=154618822656
sd=sd9,lun=\\.\O:,size=154618822656
sd=sd10,lun=\\.\P:,size=154618822656
sd=sd11,lun=\\.\Q:,size=171798691840

maxlatestart=1
reportinginterval=5
segmentlength=512m

rd=default,rampup=180,periods=90,measurement=300,runout=0,rampdown=0,buffers=1
rd=default,rdpct=0,xfersize=1024k
rd=TR1-200s_SPC-2-persist-w,streams=200
```

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

```
host=localhost,jvms=1,maxstreams=200

sd=sd1,lun=\\.\G:,size=154618822656
sd=sd2,lun=\\.\H:,size=154618822656
sd=sd3,lun=\\.\I:,size=154618822656
sd=sd4,lun=\\.\J:,size=154618822656
sd=sd5,lun=\\.\K:,size=154618822656
sd=sd6,lun=\\.\L:,size=154618822656
sd=sd7,lun=\\.\M:,size=154618822656
sd=sd8,lun=\\.\N:,size=154618822656
sd=sd9,lun=\\.\O:,size=154618822656
sd=sd10,lun=\\.\P:,size=154618822656
sd=sd11,lun=\\.\Q:,size=171798691840

maxlatestart=1
reportinginterval=5
segmentlength=512m
maxpersistenceerrors=10

rd=default,buffers=1,rdpct=100,xfersize=1024k
rd=TR1-200s_SPC-2-persist-r
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

ASU Pre-Fill, Primary Metrics Test, Repeatability Test and Persistence Test Run 1

The following script was used to execute the required ASU pre-fill (**ASU-PreFill.bat**), 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)*, SPC-1 Persistence Test Run 1 and SPC-2 Persistence Test Run 1 (**spc2.bat**) in an uninterrupted sequence.

```
cd c:\vdbench503rc11
call ASU-PreFill.bat
cd c:\spc\spc1
call audit_step1.bat
```

ASU-PreFill.bat

```
cd c:\vdbench503rc11
vdbench -f ASUs_prefill.parm -o ASUs_prefill_Output
```

audit_step1.bat

```
set CLASSPATH=C:\spc\spc1
set BSU=2500
set XMS=1200m
set XMX=1500m
set XSS=256k
set java=C:\java32\jre7\bin\java.exe

cd C:\spc\spc1

%java% -Xms%XMS% -Xmx%XMX% -Xss%XSS% metrics -b %BSU% -t 28800
%java% -Xms%XMS% -Xmx%XMX% -Xss%XSS% repeat1 -b %BSU%
%java% -Xms%XMS% -Xmx%XMX% -Xss%XSS% repeat2 -b %BSU%

java -Xms%XMS% -Xmx%XMX% -Xss%XSS% persist1 -b 625

cd C:\spc\spc2

call spc2.bat -f persist1.cfg -o init -init
call spc2.bat -f persist1.cfg -o persist1
```

spc2.bat

```
@echo off


rem Windows: start Vdbench

rem Directory where this is executed from:
set dir=%~dp0

rem set current class path
set cp=%~dp0

set java=java

%java% -Xmx1500m -Xms1200m -Xss256k -cp %cp% vdbench %*
```

Persistence Test Run 2

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

```
cd c:\spc\spc1

call audit_step2.bat
```

step2.bat

```
set LIBPATH=C:\spc\spc1;C:\spc\spc2
set CLASSPATH=C:\spc\spc1;C:\spc\spc2
set XMS=1200m
set XMX=1500m
set XSS=256k

@rem cd C:\spc\spc1

@rem java -Xms%XMS% -Xmx%XMX% -Xss%XSS% persist2

cd C:\spc\spc2

call spc2.bat -f persist2.cfg -o persist2
```

APPENDIX F: THIRD-PARTY QUOTATIONS

Brocade 360 FC Switch

09/13/13

BROCADE

TO: Kien Tran

RE: HDS QUOTE

POs should be e-mailed to: HDS-OMDistribution@brocade.com

Product	Description	QTY	HDS PRICE	Total
HD-360-0008	Brocade 360 switch w/ 24 active ports,Full Fabric,24 SWL 8Gb BR SFPs, Fixed Rack Mount	1	$ 4,827.00	$ 4,827.00
(-M)	13 mos maintenance	1	$ 107.00	$ 107.00
HD-360-0008	Brocade 360 switch w/ 24 active ports,Full Fabric,24 SWL 8Gb BR SFPs, Fixed Rack Mount	1	$ 4,827.00	$ 4,827.00
(-M)	3 year support	1	$ 320.00	$ 320.00
				$ -
Total				$ 10,081.00

Yadira Aparicio
Account Manager
Brocade Communications

Emulex LPE12002-E LightPulse Dual Port FC HBAs and FC Cables

Celebrating 22 Years!

DeltaWare®
INCORPORATED

Quotation

Quote #	Date
60207	02/18/2013

Sales Rep
Paul Albright
210-691-1715

For	Customer #HS1167	Phones
Kien Tran HITACHI Data Systems 2845 Lafayette Street Accounts Payable Santa Clara CA 95050-2627		Wk 408-327- Cel 561-889-6000 mwk 408-327-4282

PO #	Terms	Ship Date	Ship Via
	NET 30		

	Part	Description	Qty	Price	Extended
1)	*LPE12002-E*	EMC LightPluse Dual Port Fibre Channel Host Bus Adapter 8GB 2PORT FC PCI EXPRESS 2 x LC - PCI Express 2.0 - 8Gbps	2	1,295.00	2,590.00
2)	*2-LCLC-Z50RT-010F*	2-LCLC-Z50RT-010F - 10FR LC - LC MM - 50 Standard	4	21.25	85.00

Thank you,
Paul Albright

Quotes are valid for 30 days.
4730 Shavano Oak Suite 215
San Antonio, Texas 78249

Subtotal	2,675.00
TOTAL	**$2,675.00**

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VERITAS Storage Foundation for Windows Standard Edition

COMPUGEN

ESSG Enterprise Server and Storage Solutions Group

Compugen Enterprise Server and Storage Solutions Group

Prepared for:	Prepared by:
	Damian Wan Storage Inside Sales Compugen Inc. T: 604-801-7465 F: 604-801-5551
VERITAS Storage Foundation for Windows Standard Edition	E: dwan@compugen.com

Description[1]	Manufacturer Code	Unit Price[2]	Qty.	Extended Price[2]	ETA
VERITAS Storage Foundation for Windows Standard Edition - (v. 6.0) - license - 1 server - Symantec Buying Programs : Express - level S (1+) - Win	QDTVWZF5-ZZZES	$ 440.00	1	$ 440.00	TBD
VERITAS Storage Foundation for Windows Standard Edition - (v. 6.0) - Essential Support (1 year) - 1 server - Symantec Buying Programs : Express - level S (1+) - Win	QDTVWZZ5-EI1ES	$ 134.00	3	$ 402.00	TBD
Totals[3]				**$ 842.00**	

[1] All purchases are subject to Compugen's return policy. Further details can be obtained from your Inside Sales Representative.
[2] Prices quoted are valid for 1 week and thereafter subject to change without notice.
[3] Prices do not include applicable taxes.
[4] Shipping, Software Load & Hardware Configuration not Included. Depends Upon Specification

Quote name: DW(021913-VERITAS Storage Foundation for Windows Standard Edition) Quote Data Entry
Date: 2/19/2013

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