



**SPC BENCHMARK 1™
FULL DISCLOSURE REPORT**

**NETAPP, INC.
NETAPP FAS3170**

SPC-1 V1.10.1

**Submitted for Review: June 10, 2008
Submission Identifier: A00066**

First Edition – June 2008

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AUDIT CERTIFICATION



Steve Daniel
NetApp, Inc.
7301 Kit Creek Road, Building 1
Research Triangle Park, NC 27709

June 7, 2008

The SPC Benchmark 1™ results listed below for the NetApp FAS3170 were produced in compliance with the SPC Benchmark 1™ V1.10.1 Remote Audit requirements.

SPC Benchmark 1™ V1.10.1 Results	
Tested Storage Configuration (TSC) Name: NetApp FAS3170	
Metric	Reported Result
SPC-1 IOPS™	60,515.34
SPC-1 Price-Performance	\$10.01/SPC-1 IOPS™
Total ASU Capacity	19,628,500 GB
Data Protection Level	Other Data Protection (NetApp RAID-DP™)
Total TSC Price (including three-year maintenance)	\$605,492

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with V1.10.1 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items, based on information supplied by NetApp, Inc.:
 - ✓ Physical Storage Capacity and requirements.
 - ✓ Configured Storage Capacity and requirements.
 - ✓ Addressable Storage Capacity and requirements.
 - ✓ Capacity of each Logical Volume and requirements.
 - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.

Storage Performance Council
643 Bair Island Road, Suite 103
Redwood City, CA 94062
AuditService@storageperformance.org
650.556.9384

AUDIT CERTIFICATION (CONT.)

NetApp FAS3170
SPC-1 Audit Certification

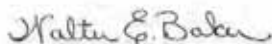
Page 2

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

Audit Notes:

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

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NetApp
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Sunnyvale, CA 94089

15 May, 2008

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

To: Walter Baker
Subject: SPC-1 Letter of Good Faith for the NetApp FAS3170

NetApp, Inc is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V1.10.1 of the SPC-1 benchmark specification.

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

Sincerely,

A handwritten signature in cursive script that reads 'Phil Brotherton'.

Phil Brotherton
Vice President
Enterprise Applications Business Unit

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	NetApp, Inc. – http://www.netapp.com/ Steve Daniel – daniel@netapp.com 7301 Kit Creek Road Building 1 Research Triangle Park, NC 27709 Phone (919) 476-5726 FAX: (919) 476-4272
Test Sponsor Alternate Contact	NetApp, Inc. – http://www.netapp.com/ Saad Jafri – saad@netapp.com 7301 Kit Creek Road Building 1 Research Triangle Park, NC 27709 Phone (919) 476-5541 FAX: (919) 476-4272-
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	V1.10.1
SPC-1 Workload Generator revision number	V2.00.04a
Date Results were first used publicly	June 10, 2008
Date the FDR was submitted to the SPC	June 10, 2008
Date the TSC is available for shipment to customers	June 10, 2008
Date the TSC completed audit certification	June 7, 2008

Tested Storage Product (TSP) Description

The FAS3100 Series Storage Systems are the newest members of the NetApp FAS family of storage systems which deliver outstanding price-performance and unsurpassed flexibility.

The FAS3170 performance is driven by a 64-bit architecture that uses high throughput, low latency links and PCI Express for all internal and external data transfers. Integrated 4 Gb/sec Fibre Channel ports and optional 10 Gb/sec Ethernet maximize the speed and throughput of connections to hosts and storage. The FAS3170 scales to a maximum of 840 disk drives and 840TB of capacity. NetApp FAS systems can be upgraded for performance or storage capacity by changing storage controllers with no need for painful data migration. Existing storage can be left in place, protecting the storage investment and minimizing disruption to operations.

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: NetApp FAS3170	
Metric	Reported Result
SPC-1 IOPS™	60,515.34
SPC-1 Price-Performance	\$10.01/SPC-1 IOPS™
Total ASU Capacity	19,628.500 GB
Data Protection Level	Other Data Protection (<i>NetApp RAID-DP™</i>)
Total TSC Price (including three-year maintenance)	\$605,492

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

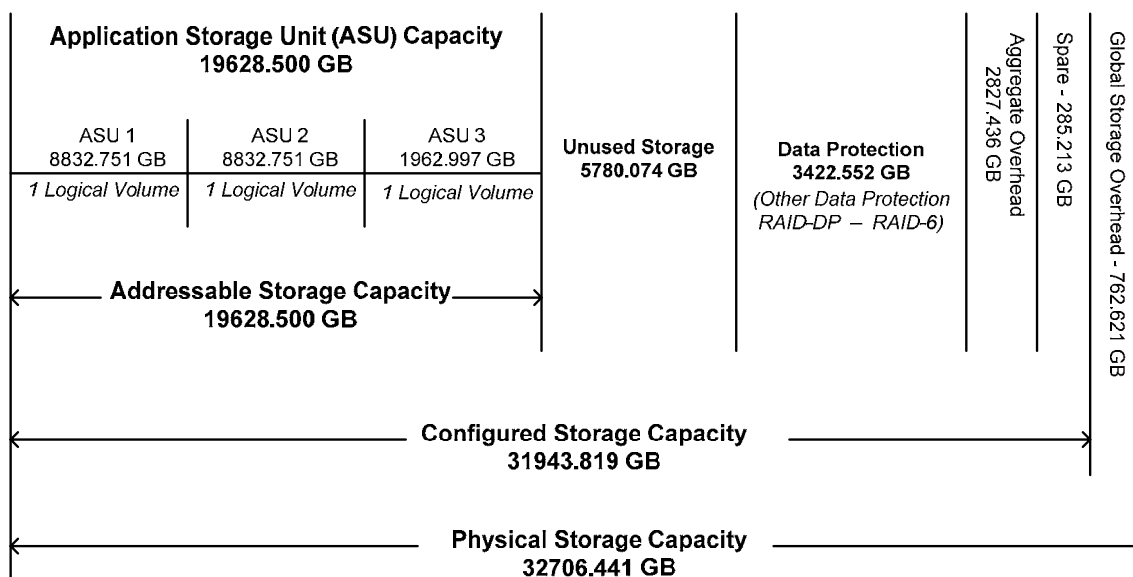
Total ASU (Application Storage Unit) Capacity represents the total storage capacity read and written in the course of executing the SPC-1 benchmark.

A **Data Protection Level** of “Other Protection Level” utilized NetApp’s RAID-DP™, a RAID 6 implementation, which provides double-parity RAID protection against data loss with negligible performance overhead and no cost penalty compared to single-parity RAID. Additional information is available at the following location:

<http://www.netapp.com/products/software/raid-dp.html>

Storage Capacities and Relationships

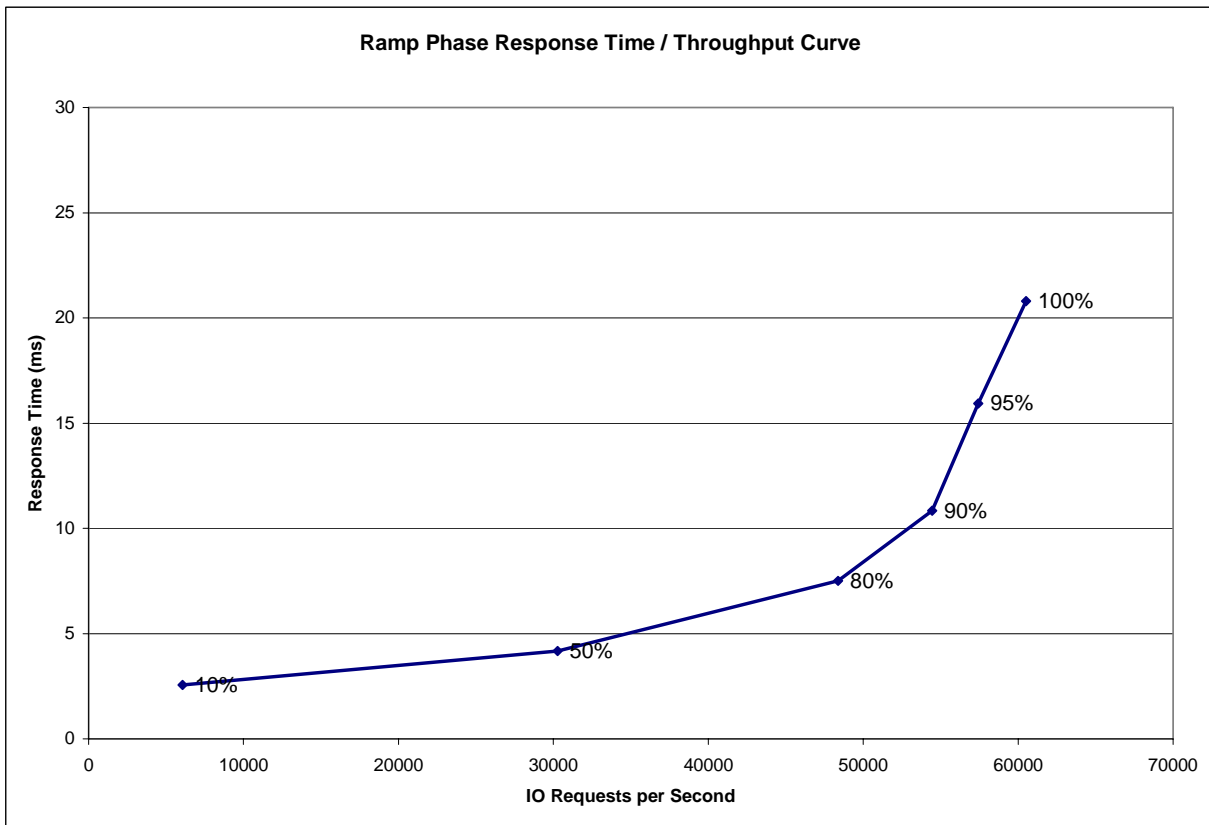
The following diagram documents the various storage capacities, used in this benchmark, and their relationships.



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	6,051.65	30,259.87	48,382.46	54,437.98	57,435.07	60,515.34
Average Response Time (ms):						
All ASUs	2.56	4.16	7.51	10.83	15.93	20.80
ASU-1	3.47	5.40	9.38	13.04	19.99	25.90
ASU-2	2.79	4.87	8.41	12.15	14.90	18.77
ASU-3	0.52	1.23	3.14	5.56	7.77	10.86
Reads	5.73	8.78	14.31	19.09	26.25	32.70
Writes	0.49	1.16	3.07	5.45	9.21	13.04

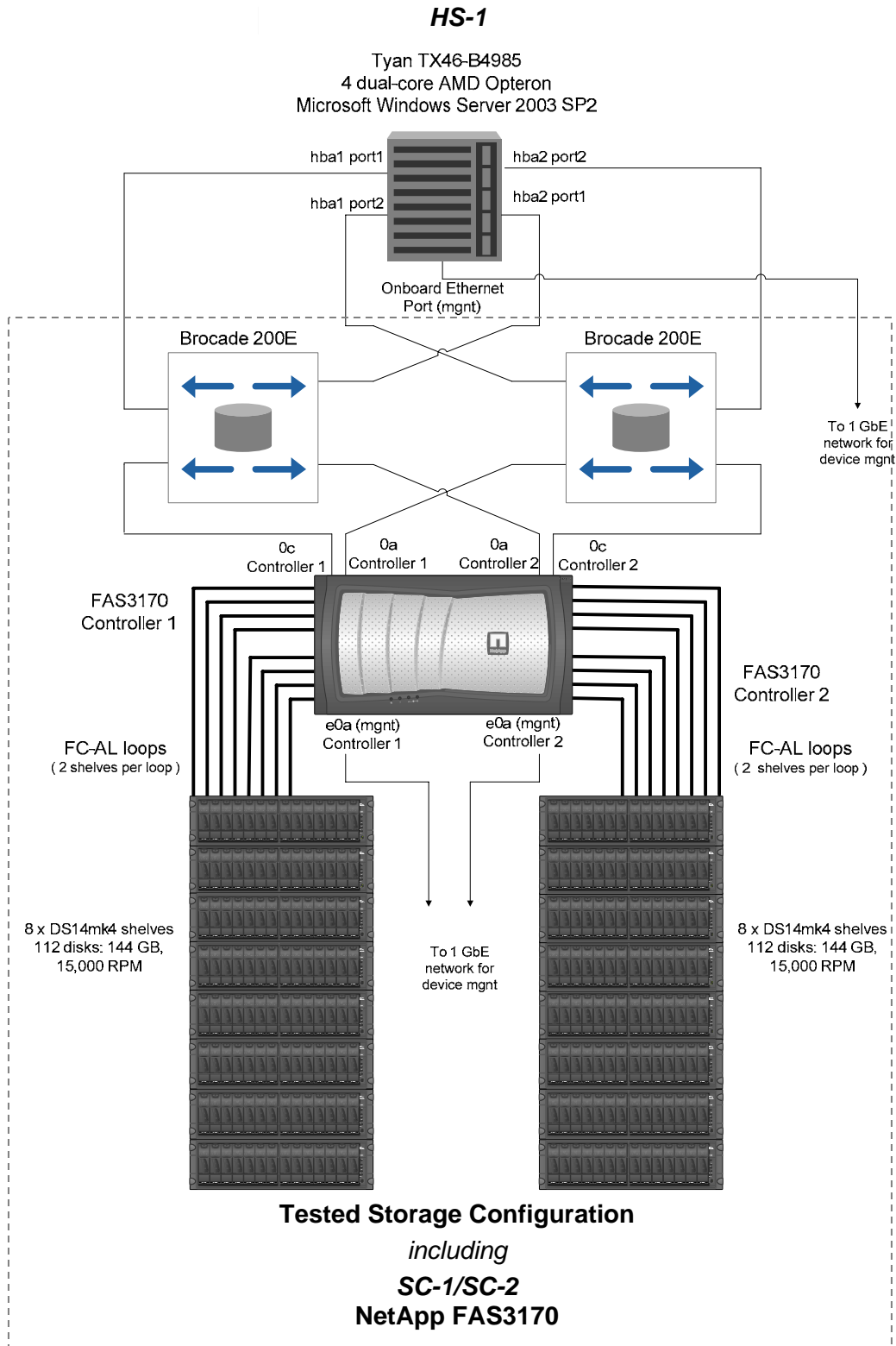
Tested Storage Configuration Pricing (Priced Storage Configuration)

Storage System		Ext Qty	List Price	Disc %	Net Price	Ext Net Price	
SES-SYSTEM	Support Edge Services Attach PN	1	\$0.00	0	\$0.00	\$0.00	
X1558A-R6-C	Cabinet Component Power Cable,48-IN,-C,R6	34	\$0.00	0	\$0.00	\$0.00	
X1941A-R6-C	Cable,Cluster 4X,Copper,5M,-C,R6	2	\$97.00	0	\$97.00	\$194.00	
X2055A-R6-C	HBA,FC,2-Port,4Gb,Disk,Optical,PCle,-C,R6	6	\$2,300.00	0	\$2,300.00	\$13,800.00	
X6530-R6-C	Cable,Patch,FC SFP to SFP,0.5M,-C,R6	20	\$0.00	0	\$0.00	\$0.00	
X6536-R6-C	Cable,Optical,LC/LC,5M,X,-C,R6	16	\$150.00	0	\$150.00	\$2,400.00	
X6539-R6-C	SFP,Optical,4.25Gb,-C,R6	12	\$120.00	0	\$120.00	\$1,440.00	
X8781-R6-C	Hardware Kit,Add-On Peripheral,Cabinet,-C,R6	17	\$0.00	0	\$0.00	\$0.00	
DOC-3XXX-C	Documents,3XXX,-C	1	\$0.00	0	\$0.00	\$0.00	
FAS3170A-CHASSIS-R5-C	FAS3170,ACT-ACT,Chassis,AC PS,-C,R5	1	\$10,000.00	0	\$10,000.00	\$10,000.00	
FAS3170AS-IB-SYS-R5	FAS3170A,IB,ACT-ACT,SAN,OS,R5	2					
FAS3170AS-BASE-R5-C	FAS3170A,IB,ACT-ACT,SAN,OS,-C,R5	2	\$54,300.00	0	\$54,300.00	\$108,600.00	
X74015B-ESH4-R5-C	DS14MK4 SHLF,AC,14x144GB,15K,B,ESH4,-C,R5	16	\$22,700.00	0	\$22,700.00	\$363,200.00	
SW-T5C-CLUSTERSAN-C	CFO Software,SAN Bundle,T5C,-C	2	\$7,700.00	0	\$7,700.00	\$15,400.00	
SW-T5C-FCPSAN-C	FCP Software,SAN Bundle,T5C,-C	2	\$0.00	0	\$0.00	\$0.00	
SW-T5C-ISCSISAN-C	iSCSI Software,SAN Bundle,T5C,-C	2	\$0.00	0	\$0.00	\$0.00	
SW-ONTAP4-3XXX	SW_DataONTAP4,3XXX	2	\$0.00	0	\$0.00	\$0.00	
SVC-A-4R-Z	HW Support,Standard Replace,4hr,z FAS3170-R5	Mths: 36	1	\$65,043.00	0	\$65,043.00	\$65,043.00
SW-SSP-A-4R-Z	SW Subs,Standard Replace,4hr,z FAS3170-R5	Mths: 36	1	\$5,544.00	0	\$5,544.00	\$5,544.00
Storage Subtotal						\$585,621.00	
Host Attach Hardware and Software							
X1558A-R6-C	Cabinet Component Power Cable,48-IN,-C,R6	2	\$0.00	0	\$0.00	\$0.00	
X5515A-R6	Rackmount Kit,4N2,DS14-Middle,R6	2	\$100.00	0	\$100.00	\$200.00	
X1610-R5-C	Brocade 8-Port 200e FC Switch,-C,R5	2	\$4,450.00	0	\$4,450.00	\$8,900.00	
SW-BSW2E-FF-C	Brocade 200E/300 Full Fabric,-C	2	\$1,200.00	0	\$1,200.00	\$2,400.00	
SVC-A-4R-Y	HW Support,Standard Replace,4hr,y BSWITCH-8PORT-R5	Mths: 36	2	\$600.75	0	\$600.75	\$1,201.50
SW-SSP-A-4R-Y	SW Subs,Standard Replace,4hr,y BSWITCH-8PORT-R5	Mths: 36	2	\$432.00	0	\$432.00	\$864.00
SW-SSP-COTERM	SSP,co-termed with existing agmnt BSWITCH-8PORT-R5	Mths: 36	2	\$0.00	0	\$0.00	\$0.00
X1089A-R6	HBA,QLogic QLE2462,2-Port,4Gb,PCle,R6	2	\$2,615.00	0	\$2,615.00	\$5,230.00	
SW-DSM-MPIO-WIN	Software,Data ONTAP DSM for Windows MPIO	1	\$1,000.00	0	\$1,000.00	\$1,000.00	
SW-FAK-WIN	FCP Windows Host Utilities	1	\$75.00	0	\$75.00	\$75.00	
Host Subtotal						\$19,870.50	
Total						\$605,491.50	

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

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

Benchmark Configuration/Tested Storage Configuration Diagram



Benchmark Configuration/Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):
HS-1: Tyan TX46-B4985	2 – Qlogic QLE2462, 2-Port 4Gb PCIe, R6 HBAs <i>(Host System)</i>
4 – dual-core AMD Opteron 8220 processors	6 – FC, 2-Port, PCIe, 4Gb, -C, R6 HBAs <i>(3 per FAS3170 controller)</i>
2.8 GHz cores, 2 MB L2 cache per CPU	
64 GB main memory	2 – Brocade 8-Port 200e FC switches
Windows Server 2003 Enterprise Edition with SP2	SC-1/SC-2: NetApp FAS3170
Priced Host System Software: FCP Windows Host Utilities 4.0 for Native OS and Veritas Data ONTAP® DSM 3.2 for Windows MPIO	2 – FAS3170 Storage Controllers each with: 2 – AMD 2.6 GHz Opteron CPUs 16384 MB main memory 512 KB L2 cache 2 FCP front-end connections 8 FCP backend connections
PCIe	224 – 144 GB 15K RPM disk drives
WG	

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 9.2.4.4.1

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

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page 14 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

Storage Network Configuration

Clause 9.2.4.4.1

...

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 9.2.4.4.2.*

Clause 9.2.4.4.2

If a storage network was configured as a part of the Tested Storage Configuration and the Benchmark Configuration diagram described in Clause 9.2.4.4.1 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 Benchmark Configuration (BC)/Tested Storage Configuration (TSC), including the network configuration, is illustrated on page 14 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

Host System Configuration

Clause 9.2.4.4.3

The FDR shall minimally contain, for each Host System running the Workload Generator, a listing of the following:

1. *Number and type of CPUs.*
2. *Main memory capacity.*
3. *Cache memory capacity.*
4. *Number and type of disk controllers or Host Bus Adapters.*

The details of the Host System configuration may be found on page 14 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

Customer Tunable Parameters and Options

Clause 9.2.4.5.1

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 59 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

Tested Storage Configuration (TSC) Description

Clause 9.2.4.5.2

The FDR must include sufficient information to recreate the logical representation of the TSC. In addition to customer tunable parameters and options (Clause 4.2.4.5.3), that information must include, at a minimum:

- A diagram and/or description of the following:
 - All physical components that comprise the TSC. Those components are also illustrated in the BC Configuration Diagram in Clause 9.2.4.4.1 and/or the Storage Network Configuration Diagram in Clause 9.2.4.4.2.
 - The logical representation of the TSC, configured from the above components that will be presented to the Workload Generator.
- Listings of scripts used to create the logical representation of the TSC.
- If scripts were not used, a description of the process used with sufficient detail to recreate the logical representation of the TSC.

“Appendix C: Tested Storage Configuration (TSC) Creation” on page 60 contains the detailed information that describes how to create and configure the logical TSC.

SPC-1 Workload Generator Storage Configuration

Clause 9.2.4.5.3

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 69.

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 55 contains definitions of terms specific to the SPC-1 Data Repository.

Storage Capacities and Relationships

Clause 9.2.4.6.1

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

SPC-1 Storage Capacities

SPC-1 Storage Capacities		
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	19,628.500
Addressable Storage Capacity	Gigabytes (GB)	19,628.500
Configured Storage Capacity	Gigabytes (GB)	31,943.819
Physical Storage Capacity	Gigabytes (GB)	32,706.441
Data Protection (<i>Other Data Protection</i>)	Gigabytes (GB)	3,422.552
Required Storage (<i>spares/overhead</i>)	Gigabytes (GB)	3,112.649
Global Storage Overhead	Gigabytes (GB)	762.621
Total Unused Storage	Gigabytes (GB)	5,780.074

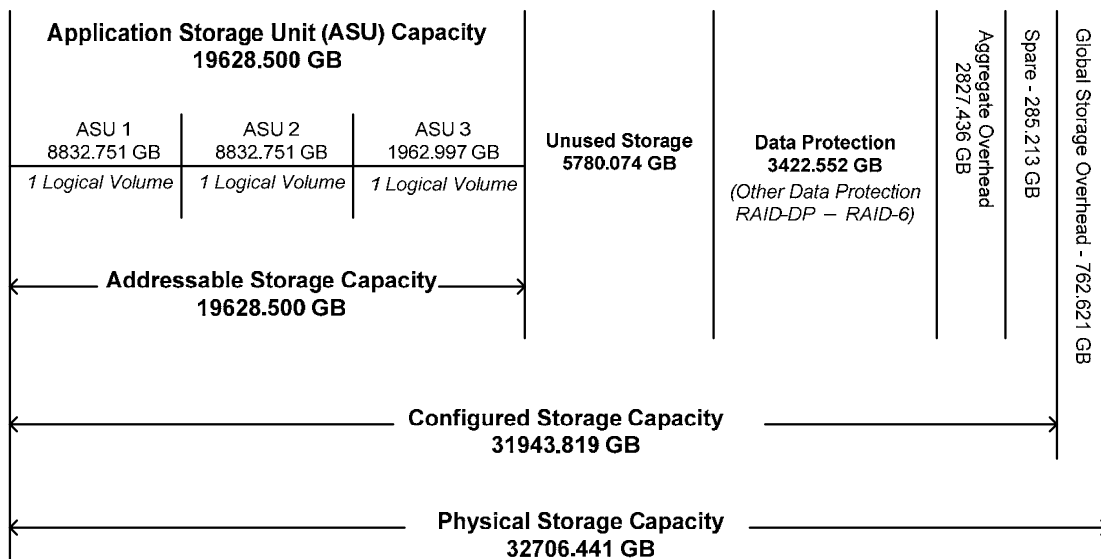
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	61.45%	60.01%
Required for Data Protection (Other)		10.71%	10.46%
Addressable Storage Capacity		61.45%	60.01%
Required Storage		9.74%	9.52%
Configured Storage Capacity			97.67%
Global Storage Overhead			2.33%
Unused Storage:			
Addressable	0.00%		
Configured		18.09%	
Physical			0.00%

The Physical Storage Capacity consisted of 32,706.441 GB distributed over 224 disk drives each with a formatted capacity of 146.011 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 762.621 GB (2.33%) of Physical Storage Capacity. There was 5,780.074 GB (18.09%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100.00% of the Addressable Storage Capacity resulting in 0.000 GB (0.00%) of Unused Storage within the Addressable Storage Capacity.

SPC-1 Storage Capacities and Relationships Illustration

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



Logical Volume Capacity and ASU Mapping

Clause 9.2.4.6.2

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 (8,832.751 GB)	ASU-2 (8,832.751 GB)	ASU-3 (1,962.997 GB)
1 Logical Volume 8,832.751 GB per Logical Volume (8,832.751 GB used per Logical Volume)	1 Logical Volume 8,832.751 GB per Logical Volume (8,832.751 GB used per Logical Volume)	1 Logical Volume 1,962.997 GB per Logical Volume (1,962.997 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was Other Data Protection 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. “SPC-1 Test Execution Definitions” on page 56 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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

SPC-1 Tests, Test Phases, and Test Runs

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

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

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

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

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

The Sustainability Test Phase has exactly one Test Run and shall demonstrate the maximum sustainable I/O Request Throughput within at least a continuous three (3) hour Measurement Interval. This Test Phase also serves to insure that the TSC has reached Steady State prior to reporting the final maximum I/O Request Throughput result (SPC-1 IOPS™).

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.2.4.7.1

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 70.

Sustainability Test Results File

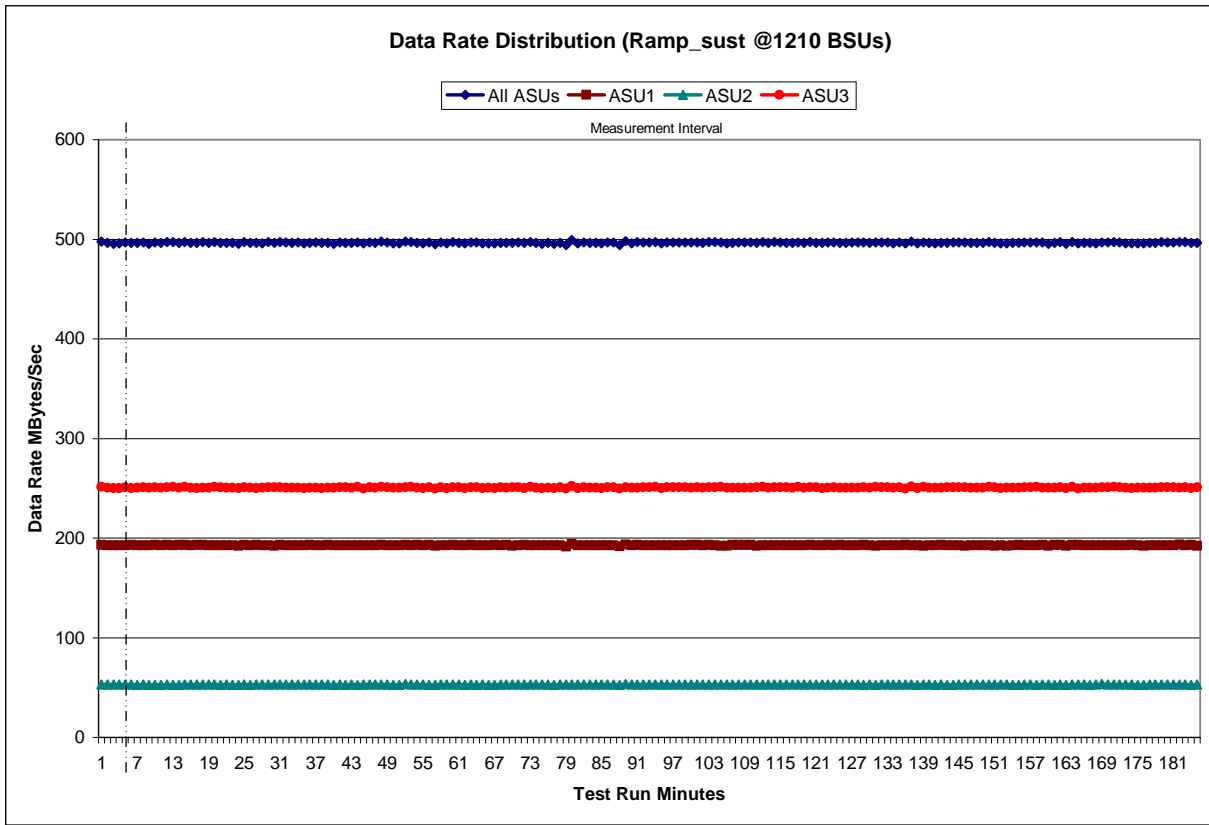
A link to the test results file generated from the Sustainability Test Run is listed below.

[Sustainability Test Results File](#)

Sustainability – Data Rate Distribution Data (MB/second)

Ramp-Up/Start-Up Measurement Interval		Start	Stop	Interval	Duration															
		8:08:42	8:13:42	0-4	0:05:00															
		8:13:42	11:13:42	4-184	3:00:00															
Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3						
0	497.42	192.89	53.03	251.50	63	496.80	192.76	52.90	251.14	126	496.60	192.85	53.25	250.51						
1	496.32	192.79	52.93	250.60	64	496.04	192.67	53.05	250.31	127	496.58	192.87	53.15	250.56						
2	495.65	192.60	53.03	250.02	65	496.09	192.68	52.90	250.51	128	496.82	193.04	52.76	251.02						
3	495.80	192.68	52.97	250.15	66	496.09	192.91	52.89	250.30	129	496.13	192.65	53.00	250.49						
4	496.61	192.75	53.03	250.84	67	496.35	192.62	52.96	250.76	130	496.59	192.34	52.84	251.41						
5	496.20	193.07	53.01	250.12	68	496.48	193.04	53.02	250.42	131	496.68	192.79	52.97	250.92						
6	496.22	192.83	52.91	250.48	69	496.11	192.39	52.94	250.79	132	496.82	192.82	52.99	251.02						
7	496.77	192.45	53.27	251.06	70	496.80	192.78	53.06	250.97	133	495.98	192.49	53.00	250.49						
8	495.57	192.45	52.77	250.36	71	496.15	192.89	53.06	250.20	134	496.61	192.54	53.05	251.01						
9	496.96	193.12	52.91	250.93	72	497.01	192.64	53.12	251.24	135	495.87	193.11	52.94	249.81						
10	496.27	192.75	52.89	250.63	73	496.35	192.87	53.05	250.43	136	497.43	192.85	52.93	251.65						
11	497.39	193.24	53.03	251.11	74	495.49	192.45	52.94	250.10	137	495.76	192.55	52.89	250.32						
12	497.04	192.63	52.91	251.50	75	496.45	192.79	53.32	250.35	138	496.64	192.37	52.99	251.29						
13	496.44	193.17	52.82	250.45	76	495.49	192.83	52.66	250.00	139	496.32	192.73	53.05	250.54						
14	497.22	192.88	53.08	251.26	77	496.50	192.62	53.06	250.82	140	496.00	192.81	52.83	250.36						
15	496.53	192.87	53.18	250.48	78	494.16	191.26	53.01	249.89	141	496.46	192.92	53.09	250.45						
16	496.33	193.05	53.02	250.26	79	499.38	194.07	53.18	252.13	142	496.51	192.52	52.81	251.19						
17	497.03	193.12	53.22	250.69	80	495.88	192.73	53.13	250.02	143	496.72	192.63	52.90	251.18						
18	496.29	192.71	53.08	250.51	81	496.90	192.83	53.14	250.93	144	496.92	192.85	53.02	251.04						
19	497.34	192.83	52.99	251.52	82	496.28	192.66	53.12	250.51	145	496.63	192.38	53.10	251.15						
20	496.30	192.52	52.78	251.01	83	496.24	192.48	53.00	250.75	146	496.19	192.58	53.16	250.45						
21	496.29	192.81	52.96	250.52	84	495.77	192.67	53.06	250.03	147	496.44	192.59	53.10	250.75						
22	496.13	192.68	52.84	250.61	85	496.88	192.78	52.98	251.12	148	496.42	192.73	53.14	250.55						
23	495.55	192.33	52.91	250.31	86	496.72	192.76	52.99	250.97	149	497.09	192.73	53.14	251.22						
24	497.39	193.14	53.18	251.07	87	494.07	191.97	52.57	249.54	150	496.27	192.36	53.00	250.91						
25	496.17	192.58	52.87	250.72	88	498.06	193.51	53.39	251.16	151	495.92	192.63	53.00	250.29						
26	496.22	192.94	53.24	250.04	89	496.09	192.68	52.98	250.43	152	496.04	192.33	53.17	250.53						
27	496.07	192.72	52.94	250.41	90	497.08	193.26	53.24	250.58	153	496.25	192.85	52.84	250.56						
28	497.03	192.84	53.04	251.16	91	496.57	192.64	53.06	250.87	154	496.45	193.06	52.85	250.53						
29	496.38	192.43	53.16	250.79	92	496.87	192.53	53.23	251.11	155	496.76	192.65	53.12	251.00						
30	497.10	192.98	53.11	251.02	93	497.26	192.81	53.25	251.20	156	496.74	192.81	53.08	250.85						
31	496.75	192.71	53.29	250.75	94	495.68	192.64	53.04	250.00	157	496.92	192.66	52.91	251.35						
32	496.29	192.78	52.97	250.53	95	496.82	192.75	53.00	251.07	158	496.81	193.04	53.17	250.60						
33	496.70	192.81	53.16	250.73	96	496.76	192.79	53.07	250.90	159	495.65	192.39	52.93	250.33						
34	495.91	192.70	53.12	250.09	97	496.91	192.76	53.22	250.92	160	496.46	193.16	52.78	250.52						
35	496.33	192.95	53.02	250.36	98	496.71	192.86	53.09	250.77	161	496.99	192.89	53.07	251.04						
36	496.85	192.79	53.33	250.74	99	496.62	193.07	52.99	250.56	162	495.52	192.43	52.83	250.26						
37	496.29	192.77	53.23	250.29	100	496.83	192.95	53.08	250.80	163	497.22	192.94	53.10	251.19						
38	496.30	192.89	53.06	250.35	101	496.13	192.55	53.19	250.39	164	495.86	192.93	53.15	249.78						
39	495.60	192.56	52.71	250.33	102	497.24	192.96	53.13	251.15	165	496.33	192.78	53.18	250.38						
40	496.75	192.63	53.28	250.84	103	497.20	192.85	53.29	251.07	166	496.19	192.75	52.89	250.56						
41	496.30	192.47	52.77	251.05	104	496.55	192.19	52.99	251.36	167	495.98	192.60	53.00	250.38						
42	496.49	192.62	53.12	250.75	105	495.98	192.40	53.22	250.36	168	496.83	192.49	53.35	250.99						
43	496.94	192.63	52.78	251.52	106	496.21	192.91	52.98	250.33	169	496.85	192.77	53.13	250.94						
44	495.75	192.66	53.31	249.79	107	496.68	192.89	53.05	250.74	170	497.16	192.76	53.18	251.23						
45	496.84	192.63	53.10	251.11	108	496.56	192.88	52.98	250.69	171	496.63	192.87	52.92	250.84						
46	496.28	192.59	53.01	250.68	109	496.60	193.04	52.93	250.62	172	496.09	192.50	53.22	250.37						
47	497.61	193.24	53.08	251.29	110	496.31	192.41	53.01	250.89	173	496.06	193.04	53.05	249.97						
48	496.76	192.86	52.98	250.92	111	497.11	192.75	53.15	251.21	174	496.08	192.67	52.85	250.56						
49	495.95	192.79	52.81	250.34	112	496.27	192.65	52.95	250.66	175	495.85	192.44	52.85	250.57						
50	495.75	192.44	52.83	250.48	113	497.08	192.83	53.09	251.16	176	496.53	192.86	52.93	250.73						
51	497.53	193.02	53.43	251.08	114	496.62	192.54	53.07	251.00	177	496.34	192.83	53.05	250.46						
52	497.31	192.76	53.19	251.36	115	496.46	192.65	52.94	250.87	178	496.99	192.79	53.16	251.04						
53	496.46	192.95	53.05	250.46	116	496.37	192.78	53.16	250.42	179	496.80	192.59	53.17	251.04						
54	495.71	192.47	53.15	250.10	117	496.84	192.63	52.92	251.29	180	496.82	192.60	53.09	251.12						
55	496.75	192.89	52.83	251.03	118	496.27	192.55	53.26	250.46	181	497.11	193.33	53.12	250.66						
56	495.10	192.37	52.90	249.83	119	497.01	193.11	52.94	250.97	182	496.98	192.64	53.25	251.09						
57	496.70	192.77	53.05	250.87	120	496.34	192.60	52.95	250.79	183	496.36	193.23	52.88	250.25						
58	495.90	192.74	52.95	250.22	121	496.17	192.80	53.23	250.14	184	496.37	192.39	53.00	250.99						
59	497.00	193.00	52.92	251.08	122	496.65	192.99	53.13	250.53											
60	496.33	192.55	53.01	250.77	123	496.88	192.77	53.03	251.08											
61	495.89	192.81	52.83	250.26	124	496.46	192.92	53.01	250.53											
62	496.97	192.91	52.99	251.07	125	496.41	192.62	53.09	250.71											

Sustainability – Data Rate Distribution Graph

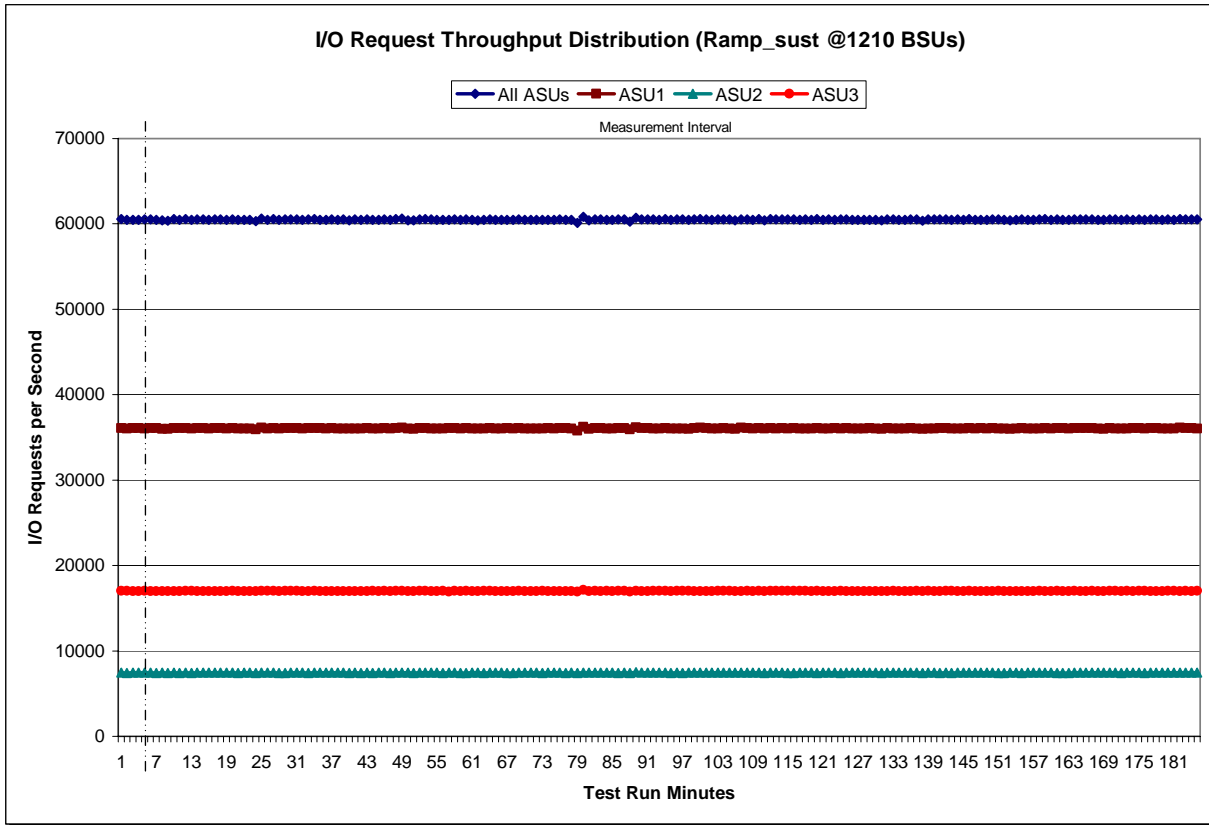


Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	8:08:42	8:13:42	0-4	0:05:00
Measurement Interval	8:13:42	11:13:42	5-184	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	60,582.65	36,096.43	7,449.20	17,037.02	63	60,540.60	36,077.02	7,439.27	17,024.32	126	60,490.60	36,034.60	7,462.80	16,993.20
1	60,496.07	36,058.18	7,426.78	17,011.10	64	60,466.63	36,048.13	7,445.20	16,973.30	127	60,480.50	36,049.62	7,452.72	16,978.17
2	60,493.45	36,062.35	7,448.80	16,982.30	65	60,467.98	36,033.17	7,439.32	16,995.50	128	60,491.73	36,068.15	7,436.27	16,987.32
3	60,499.78	36,083.48	7,440.33	16,975.97	66	60,464.88	36,089.90	7,416.20	16,958.78	129	60,496.18	36,054.97	7,441.92	16,999.30
4	60,513.95	36,043.97	7,455.23	17,014.75	67	60,481.78	36,044.13	7,430.18	17,007.47	130	60,425.55	35,993.82	7,425.57	17,006.17
5	60,506.78	36,089.33	7,439.80	16,977.65	68	60,538.28	36,079.25	7,443.47	17,015.57	131	60,506.05	36,063.65	7,440.25	17,002.15
6	60,471.72	36,067.65	7,416.40	16,987.67	69	60,472.15	36,029.48	7,443.82	16,998.85	132	60,525.22	36,057.23	7,450.78	17,017.20
7	60,434.08	36,001.27	7,441.87	16,990.95	70	60,478.68	36,035.70	7,436.62	17,006.37	133	60,456.75	36,017.47	7,443.65	16,995.63
8	60,394.17	36,003.57	7,430.10	16,960.50	71	60,482.27	36,043.27	7,442.62	16,996.38	134	60,477.02	36,037.17	7,442.07	16,997.78
9	60,558.50	36,099.17	7,452.42	17,006.92	72	60,475.50	36,011.58	7,429.93	17,033.98	135	60,514.62	36,074.55	7,451.03	16,989.03
10	60,493.32	36,084.47	7,422.57	16,986.28	73	60,495.35	36,065.75	7,447.83	16,981.77	136	60,534.97	36,049.73	7,453.88	17,031.35
11	60,584.52	36,107.60	7,462.12	17,014.80	74	60,470.87	36,026.17	7,440.62	17,004.08	137	60,392.37	35,987.57	7,416.57	16,988.23
12	60,461.65	36,009.43	7,431.73	17,020.48	75	60,510.75	36,072.88	7,439.48	16,998.38	138	60,511.25	36,032.77	7,435.28	17,043.20
13	60,505.08	36,076.45	7,433.62	16,995.02	76	60,466.43	36,069.80	7,426.40	16,970.23	139	60,514.55	36,055.70	7,457.48	17,001.37
14	60,514.23	36,077.87	7,442.72	16,993.65	77	60,465.08	36,035.43	7,436.00	16,993.65	140	60,513.88	36,080.75	7,424.85	17,008.28
15	60,494.35	36,047.77	7,449.87	16,996.72	78	60,147.13	35,792.08	7,409.85	16,945.20	141	60,535.08	36,067.20	7,457.32	17,010.57
16	60,513.98	36,068.57	7,448.10	16,997.32	79	60,836.13	36,252.55	7,472.82	17,110.77	142	60,467.32	36,037.08	7,415.03	17,015.20
17	60,506.53	36,077.97	7,449.17	16,979.40	80	60,428.72	36,004.30	7,451.15	16,973.27	143	60,500.70	36,049.33	7,443.57	17,007.80
18	60,482.65	36,051.83	7,452.68	16,978.13	81	60,534.38	36,070.28	7,452.02	17,012.08	144	60,480.38	36,038.67	7,443.72	16,998.00
19	60,549.02	36,072.70	7,445.53	17,030.78	82	60,524.27	36,075.07	7,448.43	17,000.77	145	60,555.40	36,080.45	7,452.13	17,022.82
20	60,451.60	36,023.58	7,427.67	17,000.35	83	60,479.48	36,027.85	7,439.47	17,012.17	146	60,462.35	36,031.97	7,441.70	16,988.68
21	60,458.15	36,019.90	7,444.55	16,993.70	84	60,497.33	36,056.42	7,443.18	16,997.73	147	60,495.03	36,062.42	7,456.78	16,975.83
22	60,475.00	36,052.33	7,437.40	16,985.27	85	60,540.43	36,090.97	7,432.43	17,017.03	148	60,487.12	36,036.72	7,446.03	17,004.37
23	60,333.97	35,951.48	7,423.92	16,958.57	86	60,525.57	36,066.00	7,442.20	17,017.37	149	60,529.68	36,087.63	7,437.70	17,004.35
24	60,619.55	36,136.73	7,459.75	17,023.07	87	60,265.18	35,925.15	7,398.08	16,941.95	150	60,502.20	36,041.53	7,430.65	17,030.02
25	60,489.40	36,034.75	7,444.03	17,010.62	88	60,712.43	36,168.42	7,485.72	17,058.30	151	60,478.00	36,051.25	7,430.10	16,996.65
26	60,552.05	36,090.07	7,452.35	17,009.63	89	60,514.90	36,073.72	7,455.63	16,985.55	152	60,447.32	35,987.17	7,452.57	17,007.58
27	60,478.55	36,052.42	7,424.05	17,002.08	90	60,533.73	36,071.68	7,459.10	17,002.95	153	60,477.92	36,046.12	7,435.95	16,995.85
28	60,544.00	36,094.97	7,433.35	17,015.68	91	60,504.58	36,051.40	7,442.30	17,010.88	154	60,512.78	36,103.82	7,432.55	16,976.42
29	60,524.73	36,062.58	7,445.00	17,017.15	92	60,484.10	36,036.38	7,436.03	17,011.68	155	60,496.83	36,048.07	7,448.47	17,000.30
30	60,545.27	36,059.95	7,465.83	17,019.48	93	60,554.73	36,089.18	7,453.38	17,012.17	156	60,485.27	36,044.98	7,440.05	17,000.23
31	60,462.17	36,030.52	7,452.67	16,978.98	94	60,469.45	36,047.32	7,433.22	16,988.92	157	60,547.43	36,051.80	7,450.35	17,045.28
32	60,514.77	36,084.88	7,431.82	16,998.07	95	60,528.43	36,053.28	7,442.28	17,032.87	158	60,559.58	36,098.12	7,456.02	17,005.45
33	60,568.93	36,085.72	7,462.92	17,020.30	96	60,502.95	36,037.98	7,432.02	17,032.95	159	60,488.90	36,040.23	7,449.65	16,999.02
34	60,487.47	36,069.18	7,452.38	16,965.90	97	60,495.65	36,006.28	7,462.50	17,026.87	160	60,530.97	36,096.32	7,423.75	17,010.90
35	60,462.98	36,033.18	7,445.35	16,984.45	98	60,512.22	36,076.57	7,441.33	16,994.32	161	60,472.45	36,061.40	7,442.45	16,987.60
36	60,516.05	36,060.85	7,459.85	16,995.35	99	60,571.18	36,109.67	7,464.87	16,996.65	162	60,454.13	36,054.45	7,427.13	16,972.55
37	60,498.77	36,052.42	7,454.68	16,991.67	100	60,511.95	36,079.77	7,443.22	16,988.97	163	60,521.95	36,074.00	7,434.13	17,013.82
38	60,513.12	36,056.92	7,451.37	17,004.83	101	60,450.73	36,025.22	7,440.67	16,984.85	164	60,532.02	36,092.78	7,448.30	16,990.93
39	60,448.38	36,036.17	7,420.53	16,991.68	102	60,522.85	36,039.92	7,438.93	17,044.00	165	60,526.67	36,065.00	7,459.47	17,002.20
40	60,504.75	36,054.15	7,458.48	16,992.12	103	60,530.35	36,067.75	7,448.73	17,013.87	166	60,523.83	36,079.92	7,433.65	17,010.27
41	60,465.38	36,033.17	7,433.32	16,998.90	104	60,546.78	36,054.67	7,436.33	17,055.78	167	60,455.32	36,023.93	7,451.78	16,979.60
42	60,524.82	36,089.72	7,455.48	16,979.62	105	60,430.48	36,006.87	7,433.63	16,989.98	168	60,454.73	35,988.48	7,458.40	17,007.85
43	60,479.63	36,032.33	7,429.87	17,017.43	106	60,539.35	36,111.87	7,441.52	16,985.97	169	60,534.60	36,084.25	7,441.27	17,009.08
44	60,477.82	36,020.45	7,454.10	17,003.27	107	60,545.83	36,072.75	7,464.38	17,008.70	170	60,518.92	36,035.40	7,450.02	17,033.50
45	60,530.98	36,072.68	7,438.07	17,020.23	108	60,461.33	36,016.83	7,441.32	17,003.18	171	60,487.40	36,057.40	7,432.50	16,997.50
46	60,467.00	36,047.47	7,432.88	16,986.65	109	60,551.85	36,091.13	7,436.85	17,023.87	172	60,519.13	36,048.57	7,457.37	17,013.20
47	60,559.78	36,087.30	7,447.97	17,024.52	110	60,444.98	36,016.43	7,432.12	16,996.43	173	60,468.93	36,064.67	7,433.63	16,970.63
48	60,601.22	36,120.12	7,451.47	17,029.63	111	60,563.70	36,084.42	7,461.73	17,017.55	174	60,519.62	36,065.43	7,440.25	17,013.93
49	60,423.43	36,013.18	7,433.67	16,976.58	112	60,520.43	36,035.78	7,458.08	17,026.57	175	60,485.03	36,044.70	7,428.28	17,012.05
50	60,411.80	36,002.85	7,429.42	16,979.53	113	60,548.85	36,073.08	7,452.32	17,023.45	176	60,505.80	36,058.32	7,443.50	17,003.98
51	60,546.92	36,085.28	7,449.60	17,012.03	114	60,511.53	36,050.37	7,432.70	17,028.47	177	60,507.87	36,064.30	7,450.37	16,993.20
52	60,566.80	36,071.63	7,459.62	17,035.55	115	60,504.95	36,060.85	7,433.30	17,010.80	178	60,467.50	36,023.20	7,448.47	16,995.83
53	60,506.45	36,056.77	7,444.02	17,005.67	116	60,486.55	36,036.77	7,440.13	17,009.65	179	60,524.02	36,052.88	7,447.83	17,023.30
54	60,464.62	36,041.78	7,444.25	16,978.58	117	60,521.68	36,037.53	7,441.53	17,042.62	180	60,483.67	36,028.23	7,443.18	17,012.25
55	60,495.67	36,035.38	7,422.63	17,037.65	118	60,487.45	36,025.13	7,456.03	17,006.28	181	60,551.18	36,123.25	7,437.67	16,990.27
56	60,455.40	36,058.33	7,440.45	16,956.62	119	60,554.22	36,107.68	7,422.17	17,024.37	182	60,534.57	36,067.93	7,447.73	17,018.90
57	60,512.80	36,058.75	7,439.88	17,014.17	120	60,492.07	36,048.88	7,444.35	16,998.83	183	60,542.93	36,103.03	7,449.40	16,990.50
58	60,451.98	36,036.68	7,420.63	16,994.67	121	60,517.43	36,055.40	7,466.38	16,995.65	184	60,531.67	36,043.58	7,443.60	17,044.48
59	60,508.28	36,065.05	7,414.58	17,028.65	122	60,476.98	36,065.85	7,441.45	16,969.68	Average	60,499.46	36,053.90	7,442.37	17,003.18
60	60,459.88	36,009.07	7,448.80	17,002.02	123	60,512.22	36,057.12	7,430.08	17,025.02					
61	60,428.93	36,011.05	7,441.23	16,976.65	124	60,534.03	36,091.73	7,449.68	16,992.62				</	

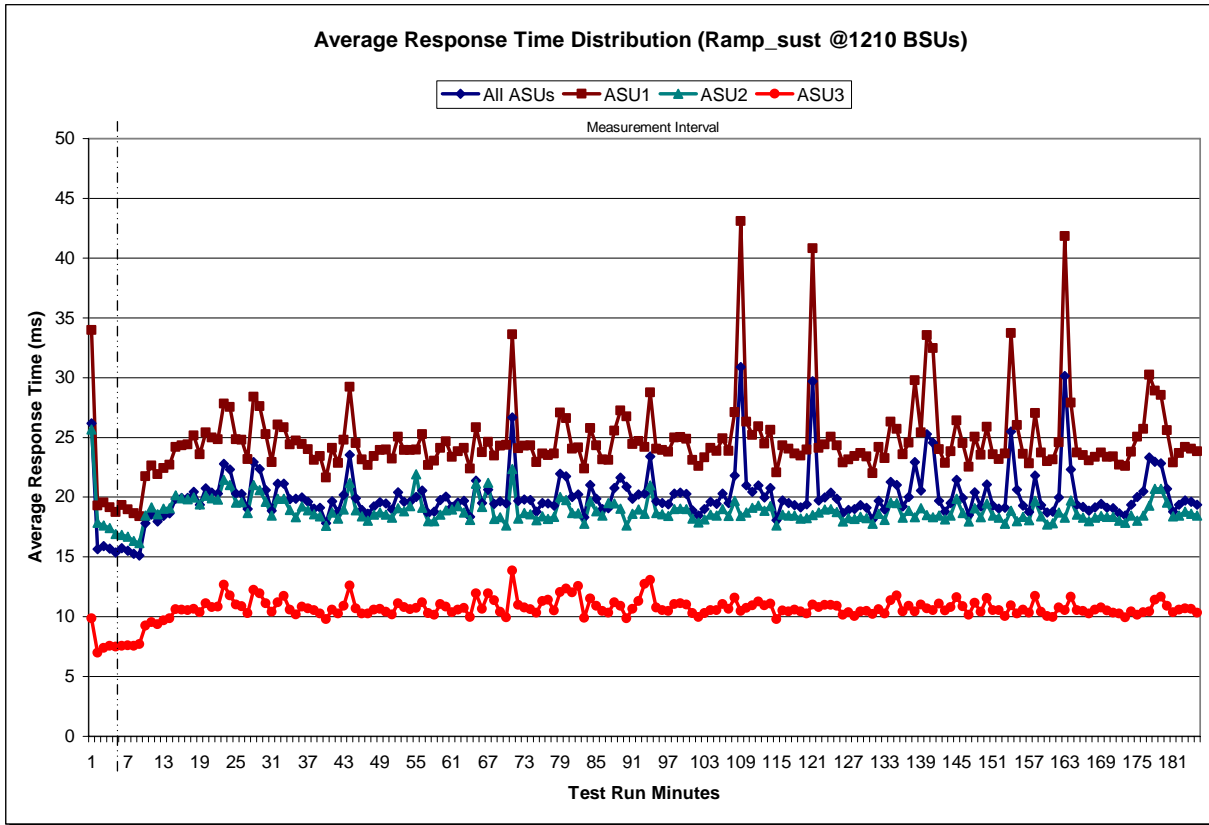
Sustainability – I/O Request Throughput Distribution Graph



Sustainability – Average Response Time (ms) Distribution Data

	Start	Stop	Interval	Duration										
Ramp-Up/Start-Up	8:08:42	8:13:42	0-4	0:05:00										
Measurement Interval	8:13:42	11:13:42	4-184	3:00:00										
Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	26.18	33.99	25.67	9.85	63	18.37	22.39	18.09	9.99	126	18.94	23.13	18.26	10.36
1	15.66	19.30	17.86	6.98	64	21.38	25.86	21.13	11.96	127	19.02	23.42	18.16	10.06
2	15.89	19.55	17.62	7.37	65	19.51	23.75	19.19	10.66	128	19.32	23.70	18.34	10.45
3	15.69	19.15	17.43	7.57	66	20.64	24.62	21.20	11.94	129	19.13	23.39	18.24	10.48
4	15.37	18.77	16.91	7.50	67	19.42	23.48	18.17	11.38	130	18.15	21.98	17.78	10.21
5	15.73	19.33	16.85	7.58	68	19.66	24.29	18.33	10.41	131	19.69	24.19	18.62	10.63
6	15.51	18.98	16.71	7.60	69	19.48	24.36	17.65	9.92	132	18.97	23.26	18.09	10.26
7	15.25	18.65	16.33	7.57	70	26.69	33.63	22.36	13.86	133	21.29	26.33	19.55	11.36
8	15.10	18.38	16.15	7.69	71	19.69	24.09	18.21	10.99	134	21.02	25.69	19.50	11.77
9	17.84	21.76	18.47	9.24	72	19.79	24.28	18.68	10.77	135	19.23	23.56	18.29	10.45
10	18.53	22.64	19.14	9.54	73	19.77	24.33	18.57	10.61	136	20.01	24.55	18.87	10.91
11	17.98	21.91	18.57	9.37	74	18.80	22.93	18.09	10.35	137	22.93	29.78	18.33	10.45
12	18.42	22.43	19.04	9.67	75	19.53	23.64	18.39	11.29	138	20.57	25.40	19.06	11.02
13	18.66	22.70	19.09	9.88	76	19.46	23.50	18.18	11.42	139	25.27	33.54	18.50	10.69
14	19.88	24.19	20.15	10.60	77	19.30	23.64	18.37	10.50	140	24.57	32.46	18.34	10.54
15	19.93	24.34	19.90	10.60	78	21.97	27.06	20.03	12.08	141	19.70	24.01	18.48	11.10
16	19.95	24.41	19.84	10.53	79	21.74	26.59	19.76	12.34	142	18.80	22.84	18.15	10.51
17	20.45	25.15	19.99	10.67	80	20.00	24.04	18.69	12.01	143	19.50	23.83	18.46	10.79
18	19.36	23.59	19.39	10.36	81	20.22	24.15	18.63	12.57	144	21.45	26.42	19.86	11.62
19	20.74	25.40	20.11	11.13	82	18.32	22.39	17.78	9.92	145	19.96	24.51	18.69	10.87
20	20.37	24.99	19.90	10.79	83	21.02	25.79	19.65	11.50	146	18.50	22.54	17.96	10.14
21	20.29	24.85	19.82	10.84	84	19.88	24.33	18.82	10.91	147	20.41	25.05	19.08	11.15
22	22.78	27.83	21.44	12.66	85	19.01	23.13	18.46	10.49	148	19.22	23.56	18.33	10.42
23	22.30	27.54	21.01	11.76	86	19.08	23.12	19.51	10.34	149	21.06	25.87	19.47	11.54
24	20.30	24.83	19.56	11.01	87	20.77	25.55	19.48	11.19	150	19.28	23.59	18.45	10.53
25	20.25	24.82	19.59	10.87	88	21.65	27.25	19.03	10.92	151	19.02	23.18	18.27	10.54
26	19.00	23.17	18.67	10.30	89	20.87	26.73	17.62	9.86	152	19.10	23.66	17.77	10.05
27	22.94	28.39	21.01	12.25	90	19.85	24.44	18.63	10.66	153	25.49	33.71	18.87	10.93
28	22.34	27.59	20.58	11.96	91	20.22	24.69	18.96	11.29	154	20.62	26.04	18.01	10.26
29	20.59	25.26	19.60	11.13	92	20.29	24.21	18.61	12.73	155	19.30	23.62	18.37	10.57
30	18.86	22.94	18.45	10.39	93	23.41	28.77	21.00	13.08	156	18.74	22.83	18.08	10.35
31	21.13	26.08	19.87	11.19	94	19.66	24.04	18.68	10.78	157	21.82	27.04	19.71	11.72
32	21.14	25.83	19.85	11.73	95	19.50	23.93	18.58	10.54	158	19.33	23.74	18.38	10.39
33	19.84	24.39	18.94	10.57	96	19.39	23.79	18.42	10.49	159	18.72	23.02	17.72	10.03
34	19.86	24.72	18.32	10.20	97	20.32	24.98	19.01	11.04	160	18.80	23.16	17.82	9.99
35	19.98	24.45	19.23	10.82	98	20.39	25.03	19.04	11.12	161	19.98	24.59	18.70	10.76
36	19.63	24.00	18.89	10.68	99	20.27	24.88	18.99	11.02	162	30.15	41.82	18.30	10.53
37	19.03	23.12	18.58	10.55	100	18.92	23.13	18.20	10.29	163	22.33	27.89	19.71	11.68
38	19.11	23.42	18.41	10.27	101	18.48	22.61	17.88	9.98	164	19.38	23.70	18.54	10.56
39	17.82	21.65	17.61	9.81	102	19.02	23.33	18.16	10.28	165	19.20	23.51	18.28	10.47
40	19.64	24.11	18.72	10.58	103	19.61	24.11	18.55	10.55	166	18.84	23.07	18.01	10.25
41	18.74	22.85	18.23	10.25	104	19.45	23.87	18.48	10.54	167	19.15	23.37	18.30	10.57
42	20.19	24.81	18.96	10.90	105	20.30	24.92	19.01	11.07	168	19.42	23.72	18.44	10.78
43	23.55	29.21	21.20	12.59	106	19.49	23.87	18.44	10.66	169	19.13	23.36	18.35	10.50
44	19.92	24.50	18.89	10.68	107	21.82	27.09	19.69	11.59	170	19.09	23.39	18.34	10.33
45	18.94	23.15	18.39	10.26	108	30.88	43.09	18.43	10.47	171	18.65	22.73	18.03	10.26
46	18.62	22.67	18.04	10.27	109	20.99	26.30	18.73	10.72	172	18.47	22.62	17.87	9.94
47	19.23	23.45	18.56	10.58	110	20.45	25.21	19.11	10.96	173	19.38	23.78	18.47	10.43
48	19.57	23.95	18.72	10.65	111	20.98	25.90	19.29	11.27	174	20.01	25.06	18.04	10.16
49	19.49	23.96	18.55	10.40	112	19.98	24.49	18.86	10.93	175	20.50	25.70	18.47	10.37
50	18.95	23.23	18.29	10.18	113	20.75	25.62	19.27	11.10	176	23.31	30.22	19.29	10.43
51	20.41	25.06	19.07	11.13	114	18.06	22.06	17.64	9.78	177	22.97	28.89	20.71	11.41
52	19.61	23.93	18.81	10.81	115	19.73	24.32	18.54	10.52	178	22.84	28.55	20.71	11.67
53	19.63	23.95	19.26	10.61	116	19.53	24.03	18.45	10.45	179	20.71	25.58	19.54	10.90
54	20.01	23.98	21.94	10.74	117	19.33	23.66	18.47	10.57	180	18.81	22.88	18.38	10.37
55	20.56	25.29	19.11	11.21	118	19.15	23.47	18.23	10.43	181	19.38	23.69	18.48	10.60
56	18.64	22.69	17.99	10.30	119	19.42	23.97	18.25	10.27	182	19.74	24.20	18.79	10.69
57	18.79	23.04	17.99	10.14	120	29.71	40.83	18.52	11.01	183	19.61	24.03	18.60	10.66
58	19.75	24.10	18.53	11.04	121	19.72	24.13	18.72	10.80	184	19.37	23.84	18.46	10.32
59	20.06	24.64	18.91	10.85	122	19.97	24.42	18.96	10.96	Average	20.08	24.77	18.81	10.70
60	19.17	23.37	18.98	10.37	123	20.36	25.07	18.99	10.99					
61	19.54	23.83	19.25	10.58	124	19.88	24.33	18.76	10.92					
62	19.68	24.11	18.70	10.72	125	18.70	22.88	17.95	10.16					

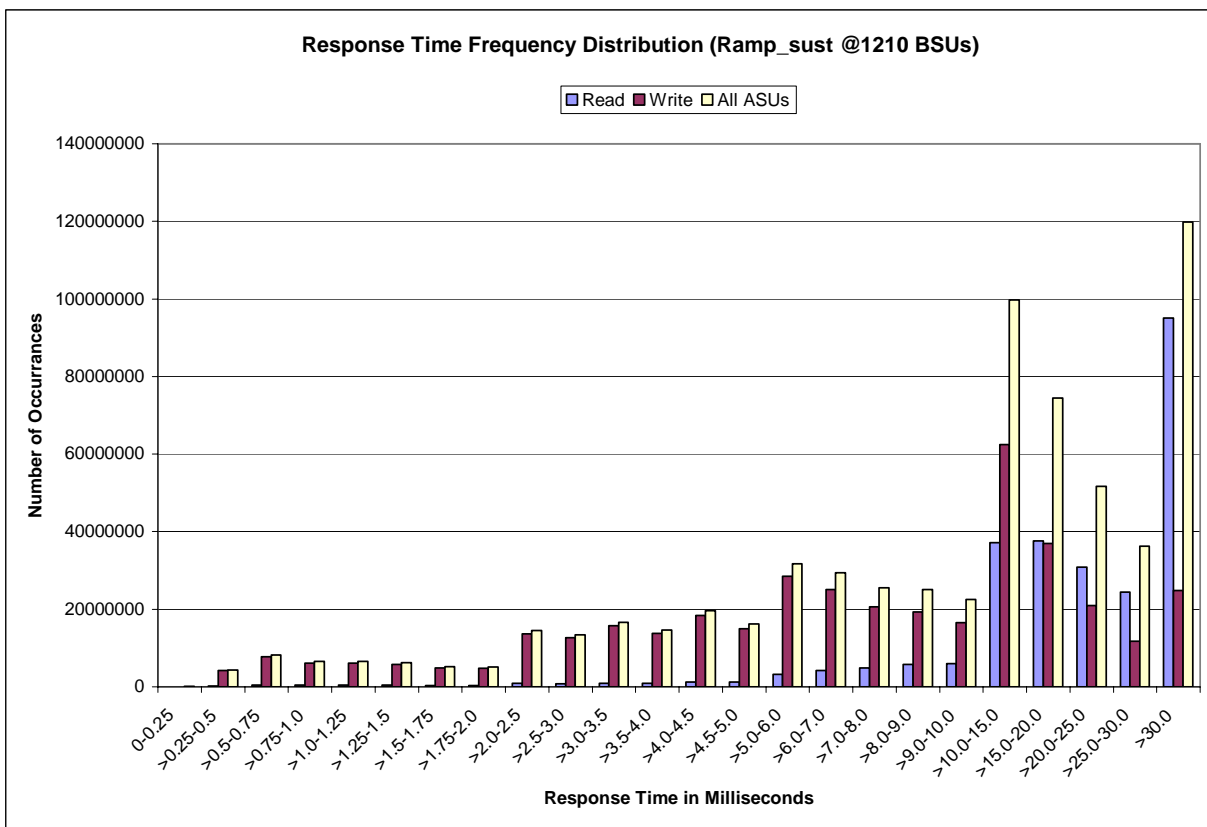
Sustainability – Average Response Time (ms) Distribution Graph



Sustainability – Response Time Frequency Distribution Data

Response	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	33,858	176,604	412,500	455,521	483,287	441,297	355,682	333,691
Write	55,189	4,203,709	7,746,824	6,129,641	6,088,730	5,768,916	4,828,765	4,735,744
All ASUs	89,047	4,380,313	8,159,324	6,585,162	6,572,017	6,210,213	5,184,447	5,069,435
ASU1	62,674	2,310,317	3,918,227	3,040,551	3,046,749	2,909,572	2,444,310	2,388,076
ASU2	10,209	511,788	914,870	727,876	729,979	694,484	580,798	568,629
ASU3	16,164	1,558,208	3,326,227	2,816,735	2,795,289	2,606,157	2,159,339	2,112,730
Response	>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	854,591	731,267	895,259	842,138	1,231,546	1,222,473	3,203,092	4,266,944
Write	13,641,013	12,676,380	15,711,093	13,774,874	18,389,240	14,959,914	28,475,950	25,102,679
All ASUs	14,495,604	13,407,647	16,606,352	14,617,012	19,620,786	16,182,387	31,679,042	29,369,623
ASU1	6,824,134	6,289,456	7,746,765	6,802,257	9,101,537	7,529,245	14,924,885	14,227,476
ASU2	1,612,028	1,480,525	1,818,712	1,597,543	2,141,549	1,777,180	3,539,822	3,393,360
ASU3	6,059,442	5,637,666	7,040,875	6,217,212	8,377,700	6,875,962	13,214,335	11,748,787
Response	>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	4,908,927	5,730,663	5,986,031	37,206,089	37,587,844	30,796,514	24,455,374	95,061,843
Write	20,584,396	19,348,405	16,567,301	62,502,469	36,901,781	20,940,106	11,787,674	24,799,909
All ASUs	25,493,323	25,079,068	22,553,332	99,708,558	74,489,625	51,736,620	36,243,048	119,861,752
ASU1	12,743,373	12,803,246	11,773,399	56,062,800	45,898,427	34,086,159	25,397,131	97,051,059
ASU2	3,021,060	3,007,543	2,729,021	12,317,315	9,554,061	6,940,574	5,083,582	15,625,052
ASU3	9,728,890	9,268,279	8,050,912	31,328,443	19,037,137	10,709,887	5,762,335	7,185,641

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 5.1.0 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.002	0.001	0.004	0.002	0.003	0.001

Primary Metrics Test – IOPS Test Phase

Clause 5.4.2.2

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 9.2.4.7.2

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 70.

IOPS Test Results File

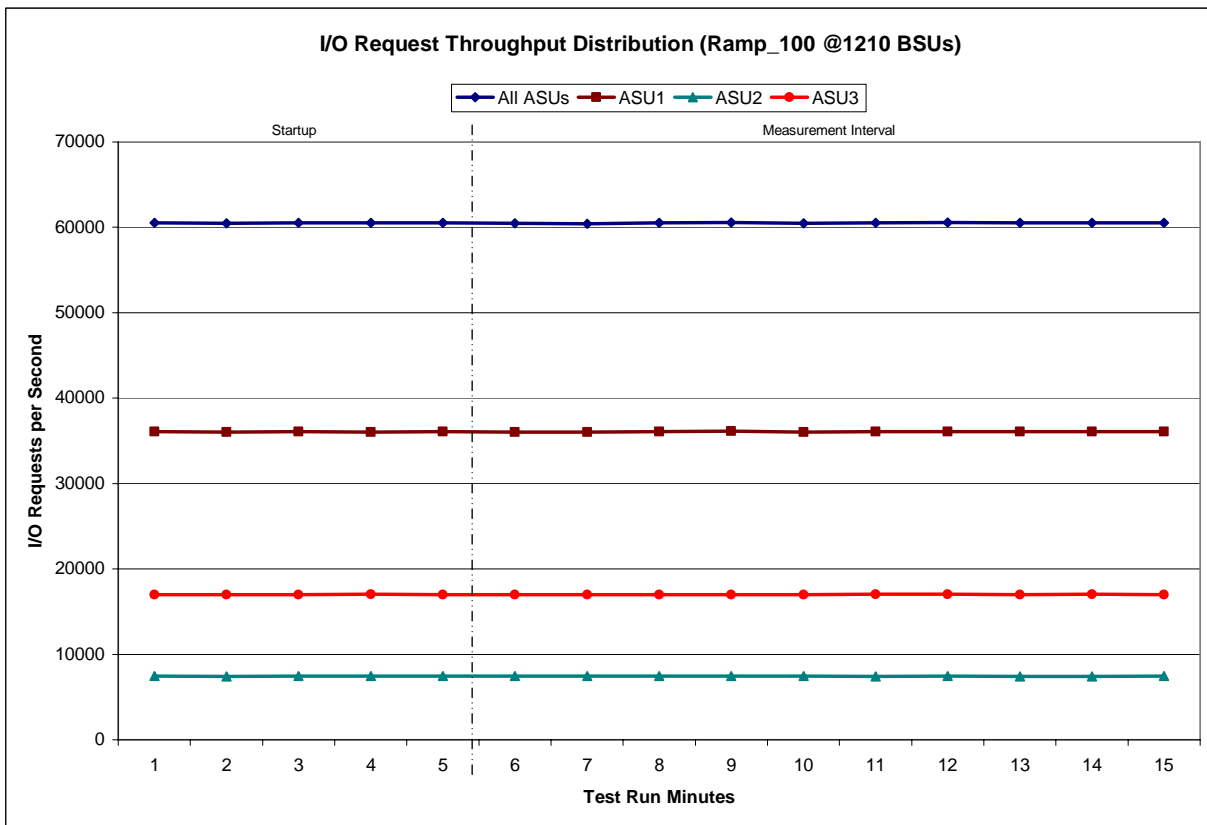
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

IOPS Test Run – I/O Request Throughput Distribution Data

1210 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	11:14:11	11:19:12	0-4	0:05:01
<i>Measurement Interval</i>	11:19:12	11:29:12	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	60,531.65	36,093.10	7,433.42	17,005.13
1	60,493.35	36,054.00	7,430.88	17,008.47
2	60,513.50	36,072.88	7,434.75	17,005.87
3	60,503.20	36,028.50	7,459.20	17,015.50
4	60,541.53	36,092.13	7,448.25	17,001.15
5	60,478.75	36,055.40	7,433.67	16,989.68
6	60,449.65	36,017.12	7,455.33	16,977.20
7	60,531.15	36,076.42	7,447.18	17,007.55
8	60,559.40	36,113.02	7,447.52	16,998.87
9	60,470.60	36,056.80	7,433.98	16,979.82
10	60,513.92	36,070.52	7,430.57	17,012.83
11	60,562.68	36,087.05	7,444.12	17,031.52
12	60,507.97	36,068.93	7,430.82	17,008.22
13	60,542.60	36,084.43	7,425.73	17,032.43
14	60,536.63	36,096.10	7,435.05	17,005.48
Average	60,515.34	36,072.58	7,438.40	17,004.36

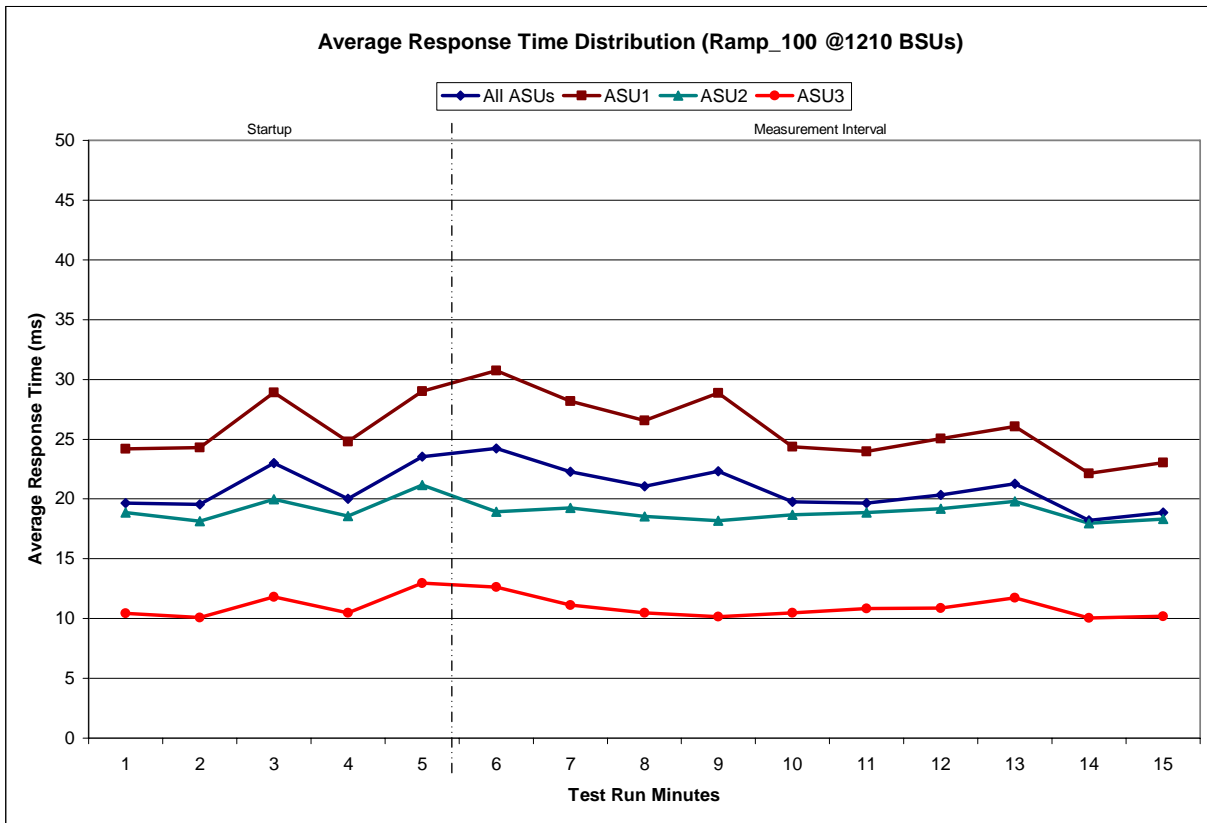
IOPS Test Run – I/O Request Throughput Distribution Graph



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

1210 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	11:14:11	11:19:12	0-4	0:05:01
<i>Measurement Interval</i>	11:19:12	11:29:12	3-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	19.67	24.19	18.86	10.43
1	19.54	24.29	18.15	10.06
2	23.00	28.89	20.00	11.81
3	20.00	24.79	18.59	10.47
4	23.54	29.01	21.15	12.96
5	24.22	30.76	18.93	12.65
6	22.30	28.20	19.25	11.12
7	21.05	26.56	18.52	10.47
8	22.31	28.87	18.18	10.17
9	19.76	24.37	18.67	10.46
10	19.65	23.96	18.88	10.84
11	20.34	25.04	19.19	10.89
12	21.26	26.05	19.81	11.73
13	18.23	22.15	17.96	10.04
14	18.85	23.03	18.34	10.20
Average	20.80	25.90	18.77	10.86

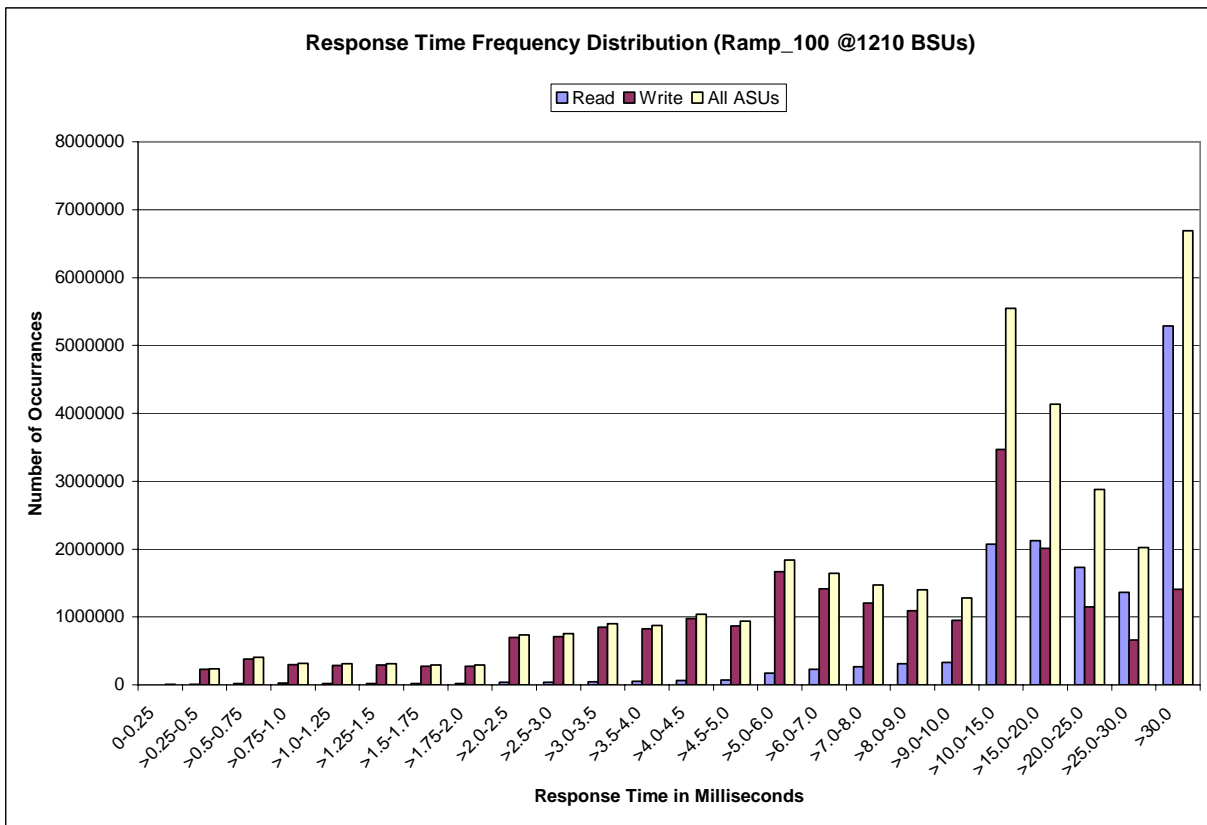
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	1557	8,010	21,958	22,495	21,439	20,737	19,048	17,780
Write	2694	227,991	383,502	295,080	286,537	290,086	274,594	274,722
All ASUs	4251	236,001	405,460	317,575	307,976	310,823	293,642	292,502
ASU1	2979	123,672	193,297	146,938	143,684	146,414	138,386	137,789
ASU2	478	27,675	45,755	35,611	34,573	34,724	32,860	32,658
ASU3	794	84,654	166,408	135,026	129,719	129,685	122,396	122,055
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	40,702	39,148	45,814	48,262	62,059	66,610	173,816	226,425
Write	696,460	713,104	851,348	826,598	977,937	869,049	1,664,426	1,415,500
All ASUs	737,162	752,252	897,162	874,860	1,039,996	935,659	1,838,242	1,641,925
ASU1	347,552	352,505	418,049	406,898	481,825	435,011	863,397	790,684
ASU2	81,891	83,526	98,254	95,904	114,115	102,050	204,262	189,198
ASU3	307,719	316,221	380,859	372,058	444,056	398,598	770,583	662,043
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	269,149	309,407	332,121	2,074,964	2,121,125	1,730,129	1,362,560	5,285,539
Write	1,202,036	1,089,234	949,786	3,469,863	2,011,925	1,149,563	660,471	1,404,380
All ASUs	1,471,185	1,398,641	1,281,907	5,544,827	4,133,050	2,879,692	2,023,031	6,689,919
ASU1	730,751	710,303	666,310	3,121,543	2,565,011	1,902,182	1,414,444	5,402,822
ASU2	173,133	166,440	154,295	683,040	529,966	386,802	283,782	871,876
ASU3	567,301	521,898	461,302	1,740,244	1,038,073	590,708	324,805	415,221

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
36,307,740	29,617,821	6,689,919

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 5.1.0 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2812	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.002	0.001	0.004	0.002	0.003	0.001

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.2.3

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 12.

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 9.2.4.7.3

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 70.

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](#)

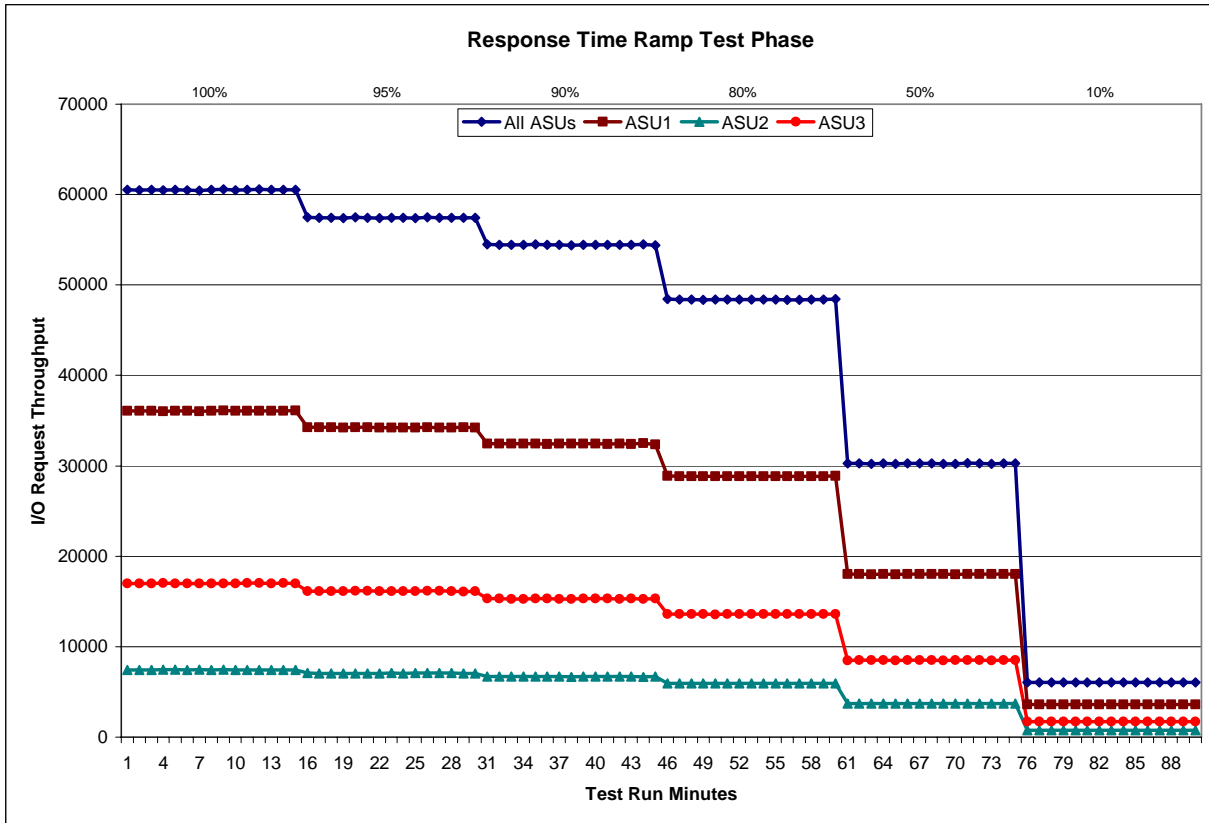
[10% Load Level](#)

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 - 1210 BSUs					95% Load Level - 1149 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:14:11	11:19:12	0-4	0:05:01	Start-Up/Ramp-Up	11:29:45	11:34:46	0-4	0:05:01
Measurement Interval	11:19:12	11:29:12	5-14	0:10:00	Measurement Interval	11:34:46	11:44:46	5-14	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	60,531.65	36,093.10	7,433.42	17,005.13	0	57,493.35	34,261.07	7,087.90	16,144.38
1	60,493.35	36,054.00	7,430.88	17,008.47	1	57,438.53	34,241.58	7,054.27	16,142.68
2	60,513.50	36,072.88	7,434.75	17,005.87	2	57,441.07	34,245.48	7,066.37	16,129.22
3	60,503.20	36,028.50	7,459.20	17,015.50	3	57,378.18	34,212.45	7,049.50	16,116.23
4	60,541.53	36,092.13	7,448.25	17,001.15	4	57,469.15	34,245.85	7,054.63	16,168.67
5	60,478.75	36,055.40	7,433.67	16,989.68	5	57,447.75	34,241.98	7,048.45	16,157.32
6	60,449.65	36,017.12	7,455.33	16,977.20	6	57,410.82	34,211.50	7,065.50	16,133.82
7	60,531.15	36,076.42	7,447.18	17,007.55	7	57,426.13	34,215.02	7,082.28	16,128.83
8	60,559.40	36,113.02	7,447.52	16,998.87	8	57,432.20	34,224.40	7,059.98	16,147.82
9	60,470.60	36,056.80	7,433.98	16,979.82	9	57,393.17	34,193.08	7,067.12	16,132.97
10	60,513.92	36,070.52	7,430.57	17,012.83	10	57,498.72	34,244.40	7,087.02	16,167.30
11	60,562.68	36,087.05	7,444.12	17,031.52	11	57,455.22	34,224.62	7,070.97	16,159.63
12	60,507.97	36,068.93	7,430.82	17,008.22	12	57,430.15	34,206.25	7,069.02	16,154.88
13	60,542.60	36,084.43	7,425.73	17,032.43	13	57,415.82	34,245.68	7,063.65	16,106.48
14	60,536.63	36,096.10	7,435.05	17,005.48	14	57,440.68	34,227.05	7,060.85	16,152.78
Average	60,515.34	36,072.58	7,438.40	17,004.36	Average	57,435.07	34,223.40	7,067.48	16,144.18
90% Load Level - 1089 BSUs					80% Load Level - 968 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:45:46	11:50:47	0-4	0:05:01	Start-Up/Ramp-Up	12:00:55	12:05:56	0-4	0:05:01
Measurement Interval	11:50:47	12:00:47	5-14	0:10:00	Measurement Interval	12:05:56	12:15:56	5-14	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	54,493.58	32,464.62	6,713.03	15,315.93	0	48,454.60	28,892.47	5,962.18	13,599.95
1	54,459.38	32,437.50	6,708.68	15,313.20	1	48,418.28	28,839.12	5,968.42	13,610.75
2	54,426.62	32,446.48	6,701.12	15,279.02	2	48,407.13	28,860.02	5,944.20	13,602.92
3	54,441.30	32,464.50	6,691.95	15,284.85	3	48,364.90	28,814.70	5,938.50	13,611.70
4	54,496.82	32,454.55	6,714.28	15,327.98	4	48,385.50	28,850.05	5,950.28	13,585.17
5	54,448.83	32,418.55	6,703.53	15,326.75	5	48,380.15	28,845.10	5,946.02	13,589.03
6	54,443.67	32,449.20	6,701.53	15,292.93	6	48,371.88	28,821.68	5,960.92	13,589.28
7	54,411.90	32,448.12	6,680.28	15,283.50	7	48,390.60	28,843.42	5,945.25	13,601.93
8	54,462.43	32,441.17	6,709.75	15,311.52	8	48,382.52	28,836.85	5,945.05	13,600.62
9	54,446.57	32,450.83	6,696.40	15,299.33	9	48,378.48	28,839.12	5,943.28	13,596.08
10	54,430.63	32,428.47	6,697.28	15,304.88	10	48,351.07	28,824.75	5,935.32	13,591.00
11	54,450.78	32,472.27	6,691.47	15,287.05	11	48,350.55	28,828.65	5,932.07	13,589.83
12	54,434.60	32,421.68	6,691.90	15,321.02	12	48,378.28	28,839.95	5,947.30	13,591.03
13	54,464.90	32,484.48	6,682.97	15,297.45	13	48,418.72	28,852.00	5,963.90	13,602.82
14	54,385.45	32,382.05	6,700.93	15,302.47	14	48,422.37	28,872.40	5,946.88	13,603.08
Average	54,437.98	32,439.68	6,695.61	15,302.69	Average	48,382.46	28,840.39	5,946.60	13,595.47
50% Load Level - 605 BSUs					10% Load Level - 121 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:16:04	12:21:05	0-4	0:05:01	Start-Up/Ramp-Up	12:31:12	12:36:13	0-4	0:05:01
Measurement Interval	12:21:05	12:31:05	5-14	0:10:00	Measurement Interval	12:36:13	12:46:13	5-14	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	30,249.02	18,040.45	3,717.63	8,490.93	0	6,045.52	3,600.28	744.90	1,700.33
1	30,253.62	18,034.03	3,712.67	8,506.92	1	6,048.08	3,602.67	742.87	1,702.55
2	30,237.80	18,006.68	3,723.27	8,507.85	2	6,032.05	3,596.90	742.28	1,692.87
3	30,252.90	18,023.90	3,726.72	8,502.28	3	6,060.53	3,611.30	745.70	1,703.53
4	30,222.17	18,011.53	3,722.80	8,487.83	4	6,038.03	3,602.78	738.58	1,696.67
5	30,250.05	18,029.23	3,724.80	8,496.02	5	6,044.83	3,600.50	741.78	1,702.55
6	30,282.03	18,056.15	3,719.60	8,506.28	6	6,059.72	3,611.42	747.27	1,701.03
7	30,264.07	18,029.32	3,723.95	8,510.80	7	6,051.85	3,611.78	742.22	1,697.85
8	30,238.78	18,031.07	3,718.90	8,488.82	8	6,053.45	3,607.53	740.32	1,705.60
9	30,240.55	18,007.78	3,732.42	8,500.35	9	6,047.90	3,602.32	742.63	1,702.95
10	30,294.28	18,053.87	3,725.15	8,515.27	10	6,045.13	3,604.07	742.85	1,698.22
11	30,271.17	18,043.12	3,714.93	8,513.12	11	6,052.23	3,602.58	744.05	1,705.60
12	30,218.47	18,029.28	3,708.53	8,480.65	12	6,056.87	3,615.92	739.93	1,701.02
13	30,271.98	18,032.73	3,718.93	8,520.32	13	6,047.65	3,592.80	747.23	1,707.62
14	30,267.28	18,046.68	3,716.12	8,504.48	14	6,056.87	3,613.47	743.10	1,700.30
Average	30,259.87	18,035.92	3,720.33	8,503.61	Average	6,051.65	3,606.24	743.14	1,702.27

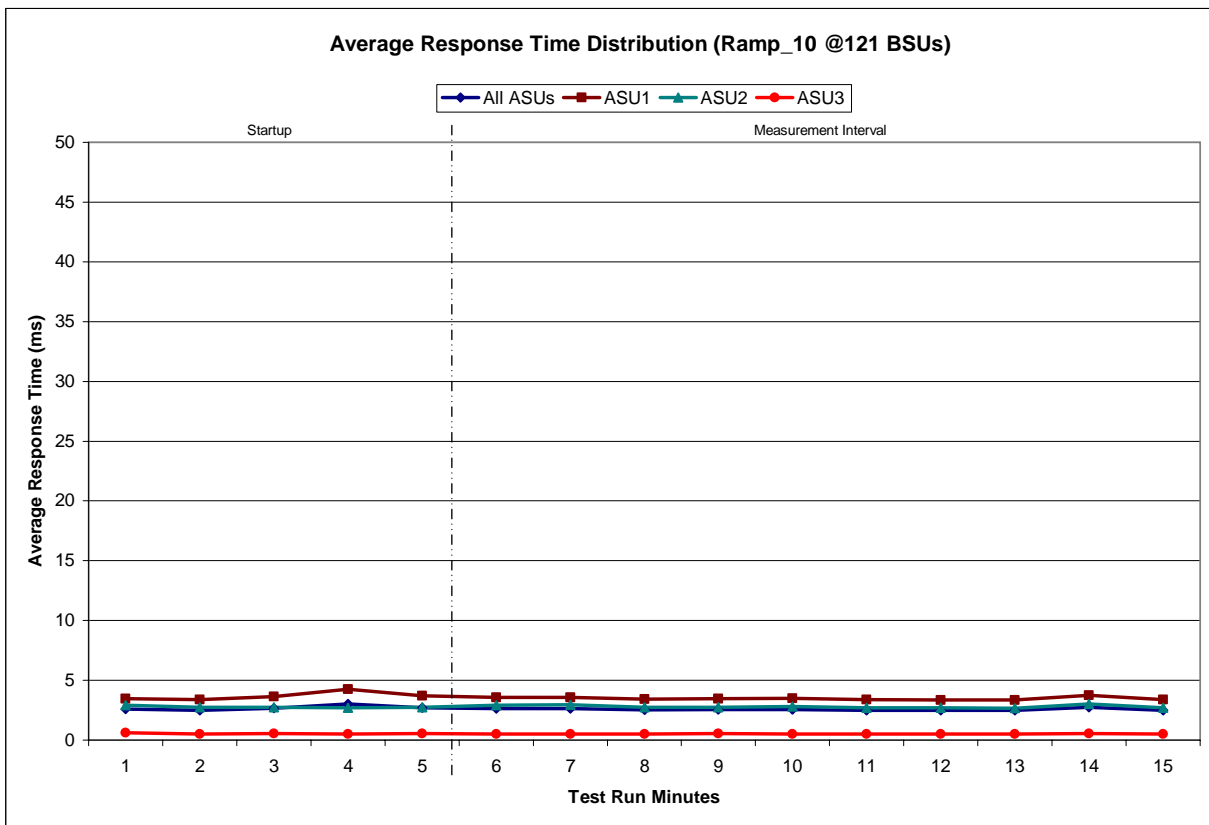
Response Time Ramp Distribution (IOPS) Graph



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

121 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	12:31:12	12:36:13	0-4	0:05:01
<i>Measurement Interval</i>	12:36:13	12:46:13	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.58	3.45	2.90	0.60
1	2.50	3.39	2.74	0.51
2	2.65	3.64	2.73	0.52
3	3.01	4.25	2.71	0.51
4	2.71	3.72	2.74	0.53
5	2.62	3.55	2.93	0.52
6	2.63	3.55	2.94	0.52
7	2.52	3.43	2.75	0.51
8	2.55	3.47	2.74	0.52
9	2.57	3.49	2.79	0.52
10	2.50	3.39	2.69	0.52
11	2.47	3.35	2.71	0.51
12	2.48	3.36	2.67	0.52
13	2.74	3.73	3.02	0.53
14	2.50	3.39	2.71	0.51
Average	2.56	3.47	2.79	0.52

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 5.1.0 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0351	0.2806	0.0698	0.2104	0.0179	0.0700	0.0348	0.2813
COV	0.006	0.001	0.007	0.002	0.012	0.004	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 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%.

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 9.2.4.7.4

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 70.

Repeatability Test Results File

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

	SPC-1 IOPS™	SPC-1 LRT™
<i>Primary Metrics</i>	60,515.34	2.56
Repeatability Test Phase 1	60,496.56	2.57
Repeatability Test Phase 2	60,509.69	2.56

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

[Repeatability Test Phase 1, Test Run 1 \(LRT\)](#)

[Repeatability Test Phase 1, Test Run 2 \(IOPS\)](#)

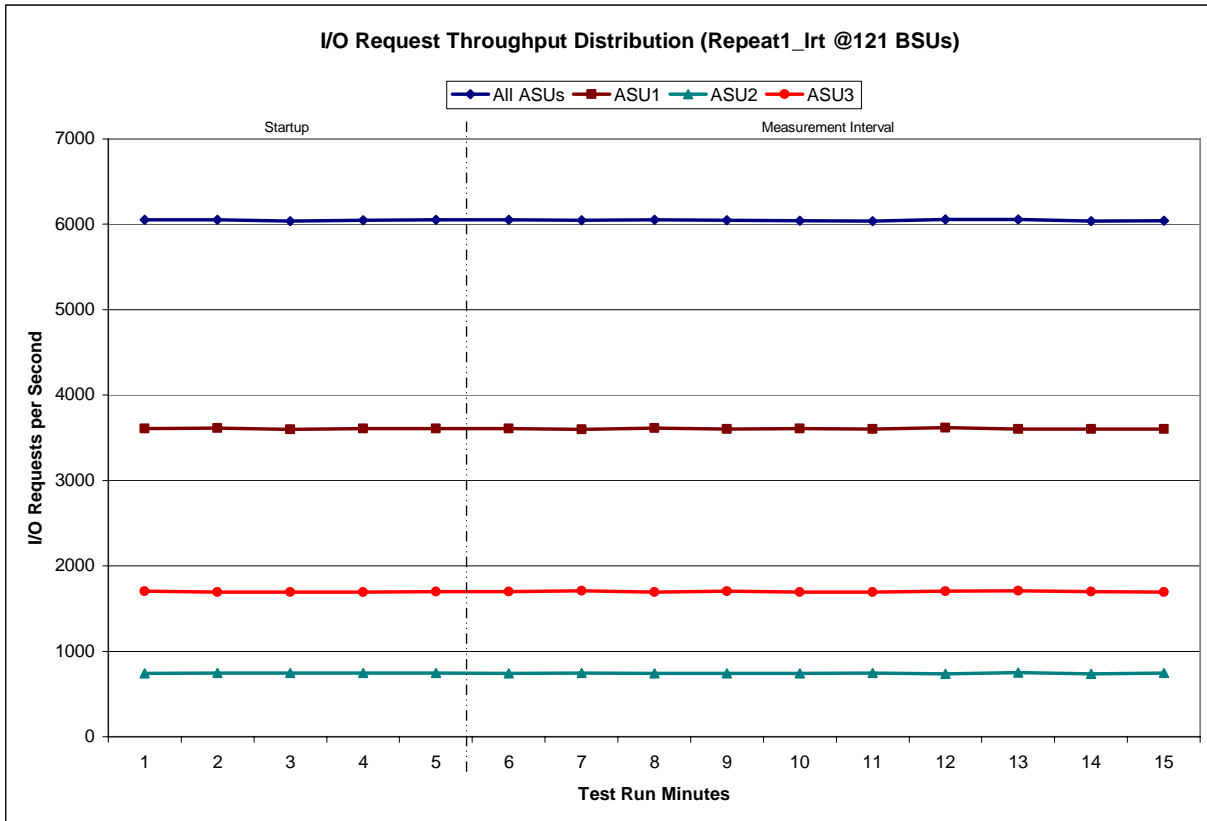
[Repeatability Test Phase 2, Test Run 1 \(LRT\)](#)

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

Repeatability 1 LRT - I/O Request Throughput Distribution Data

121 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	12:46:24	12:51:24	0-4	0:05:00
<i>Measurement Interval</i>	12:51:24	13:01:24	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6,053.68	3,608.25	740.62	1,704.82
1	6,052.37	3,611.40	746.52	1,694.45
2	6,037.50	3,598.38	743.85	1,695.27
3	6,047.12	3,609.48	745.97	1,691.67
4	6,053.15	3,610.42	745.97	1,696.77
5	6,050.18	3,610.08	743.33	1,696.77
6	6,049.80	3,597.92	745.77	1,706.12
7	6,051.47	3,614.58	742.20	1,694.68
8	6,045.12	3,602.35	738.67	1,704.10
9	6,040.70	3,606.03	741.72	1,692.95
10	6,039.95	3,601.68	744.43	1,693.83
11	6,056.93	3,617.82	737.12	1,702.00
12	6,059.23	3,603.70	749.15	1,706.38
13	6,036.68	3,604.08	736.22	1,696.38
14	6,043.57	3,602.37	746.83	1,694.37
Average	6,047.36	3,606.06	742.54	1,698.76

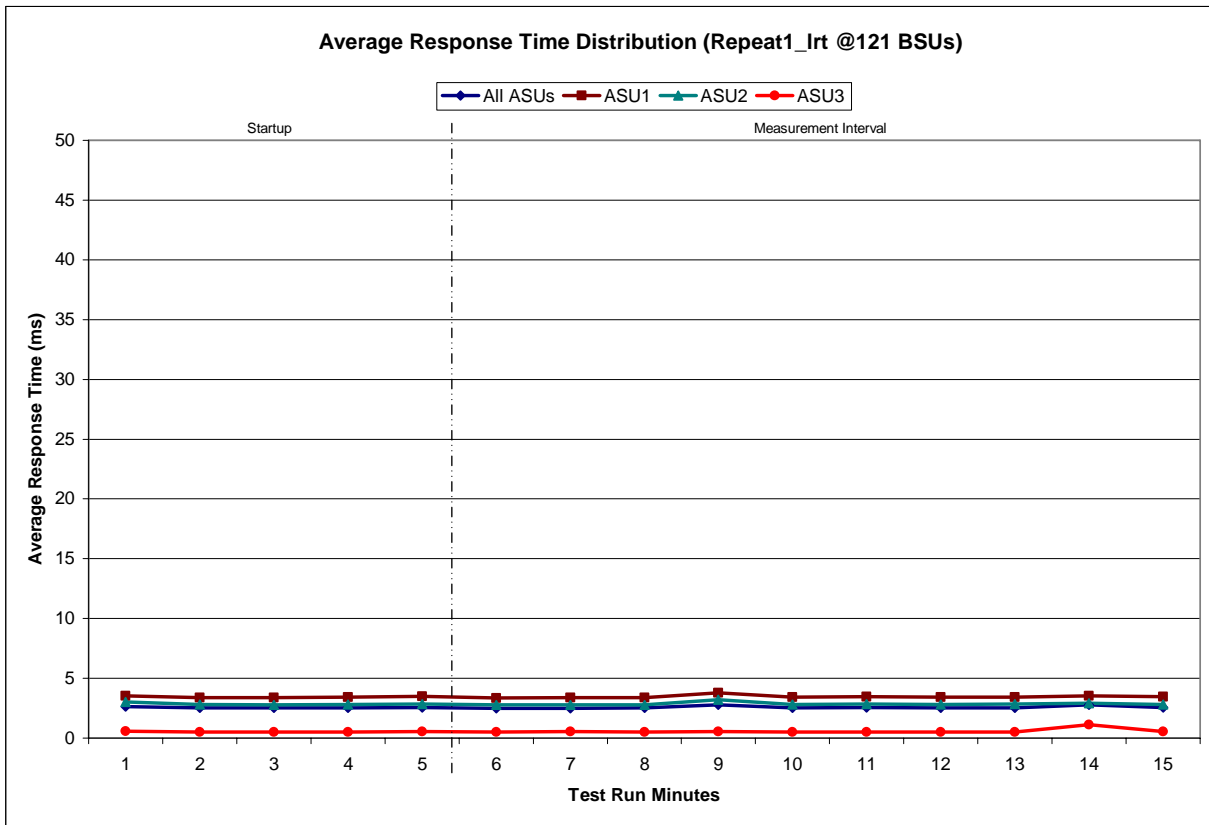
Repeatability 1 LRT - I/O Request Throughput Distribution Graph



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

121 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	12:46:24	12:51:24	0-4	0:05:00
<i>Measurement Interval</i>	12:51:24	13:01:24	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.64	3.53	3.03	0.57
1	2.51	3.39	2.81	0.52
2	2.50	3.39	2.77	0.51
3	2.54	3.42	2.82	0.51
4	2.57	3.47	2.84	0.53
5	2.49	3.36	2.76	0.51
6	2.50	3.38	2.78	0.53
7	2.51	3.39	2.76	0.51
8	2.78	3.77	3.19	0.53
9	2.52	3.41	2.82	0.50
10	2.56	3.46	2.84	0.51
11	2.52	3.41	2.79	0.52
12	2.54	3.43	2.84	0.52
13	2.78	3.53	2.93	1.10
14	2.56	3.45	2.82	0.55
Average	2.57	3.46	2.85	0.58

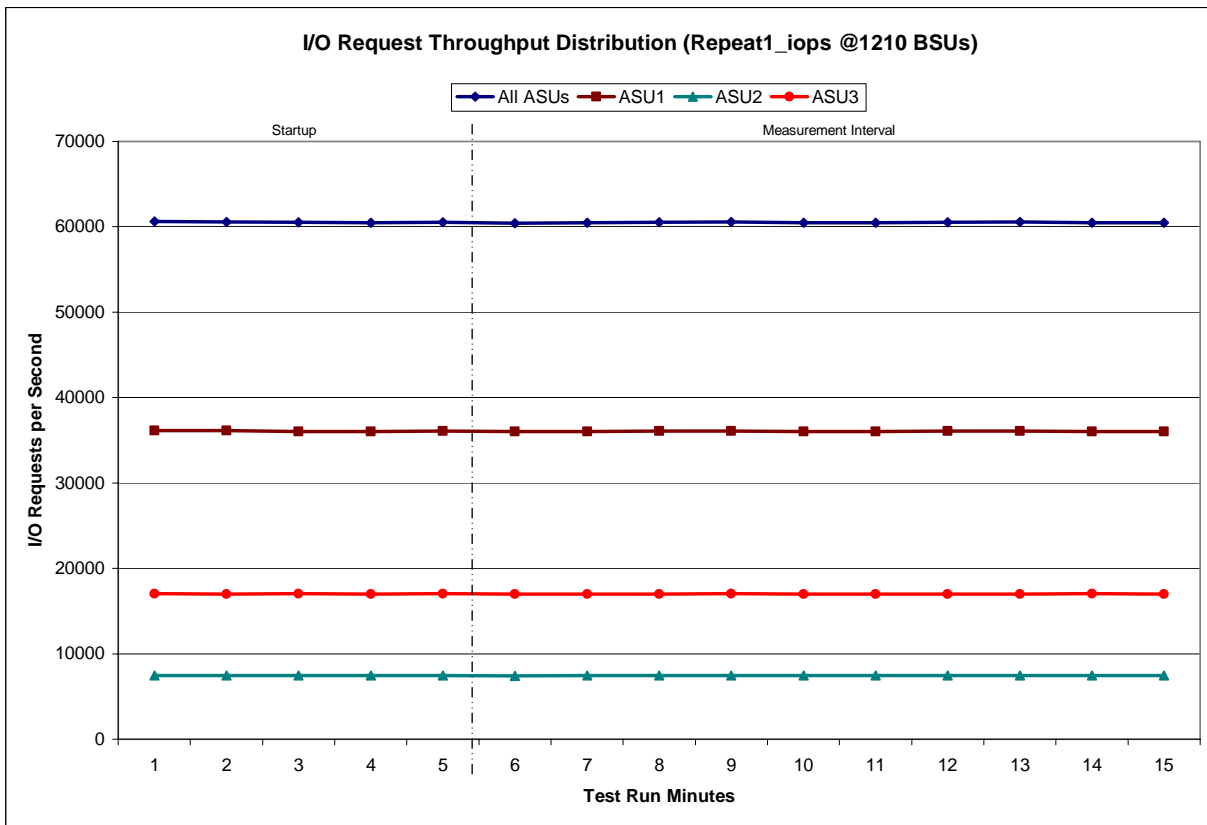
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS - I/O Request Throughput Distribution Data

1210 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:01:57	13:06:58	0-4	0:05:01
Measurement Interval	13:06:58	13:16:58	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	60,605.03	36,109.58	7,460.87	17,034.58
1	60,572.25	36,123.07	7,453.25	16,995.93
2	60,511.05	36,046.28	7,448.43	17,016.33
3	60,486.78	36,039.87	7,455.18	16,991.73
4	60,532.70	36,062.42	7,447.98	17,022.30
5	60,445.73	36,010.25	7,431.10	17,004.38
6	60,455.58	36,038.08	7,441.37	16,976.13
7	60,507.73	36,081.40	7,436.12	16,990.22
8	60,563.92	36,072.32	7,440.37	17,051.23
9	60,484.95	36,028.43	7,456.53	16,999.98
10	60,478.38	36,044.47	7,438.68	16,995.23
11	60,514.80	36,075.07	7,450.88	16,988.85
12	60,553.18	36,074.25	7,473.78	17,005.15
13	60,492.92	36,038.70	7,438.65	17,015.57
14	60,468.40	36,033.80	7,456.53	16,978.07
Average	60,496.56	36,049.68	7,446.40	17,000.48

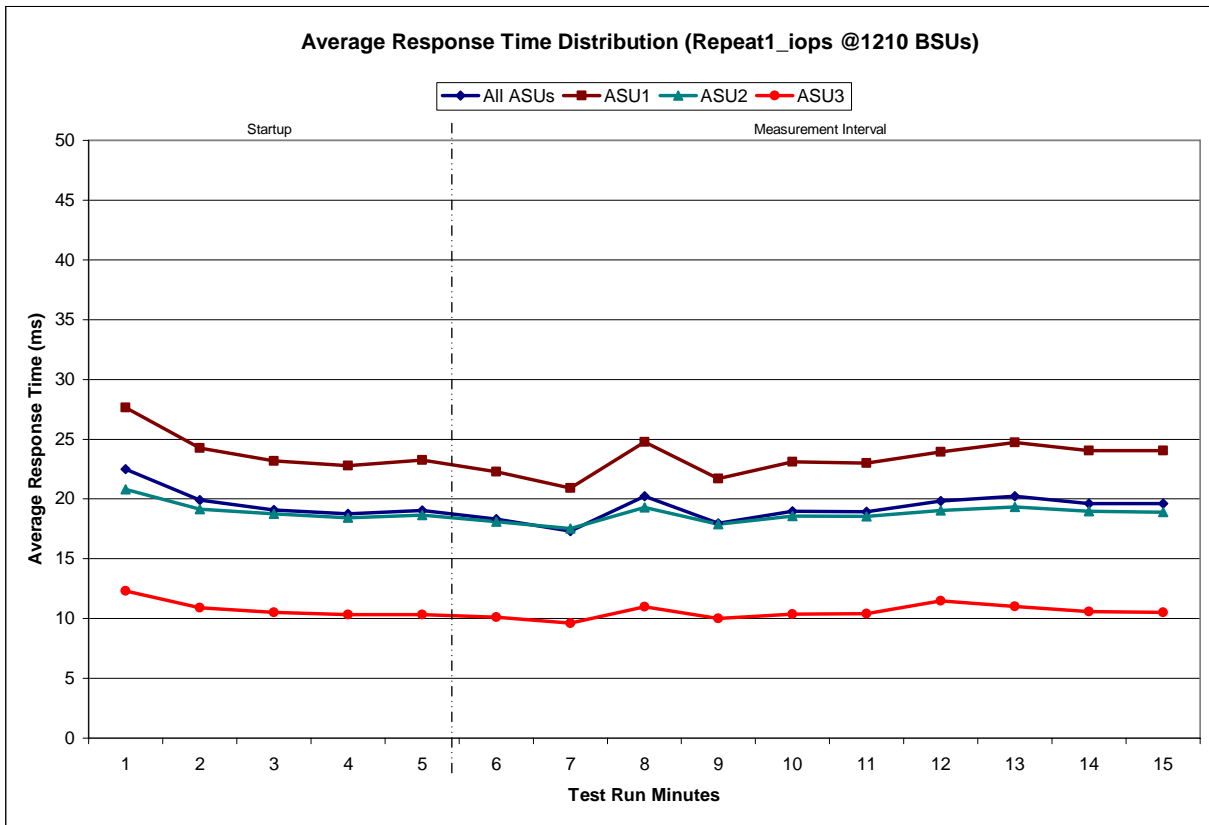
Repeatability 1 IOPS - I/O Request Throughput Distribution Graph



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

1210 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:01:57	13:06:58	0-4	0:05:01
<i>Measurement Interval</i>	13:06:58	13:16:58	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	22.49	27.63	20.80	12.32
1	19.90	24.27	19.16	10.91
2	19.08	23.19	18.76	10.51
3	18.74	22.77	18.45	10.32
4	19.05	23.25	18.65	10.33
5	18.34	22.27	18.11	10.10
6	17.32	20.90	17.54	9.62
7	20.22	24.77	19.30	10.98
8	17.95	21.72	17.89	10.01
9	18.97	23.10	18.56	10.38
10	18.92	23.02	18.54	10.39
11	19.83	23.92	19.04	11.47
12	20.22	24.74	19.34	11.03
13	19.64	24.05	18.96	10.59
14	19.62	24.05	18.92	10.50
Average	19.10	23.25	18.62	10.51

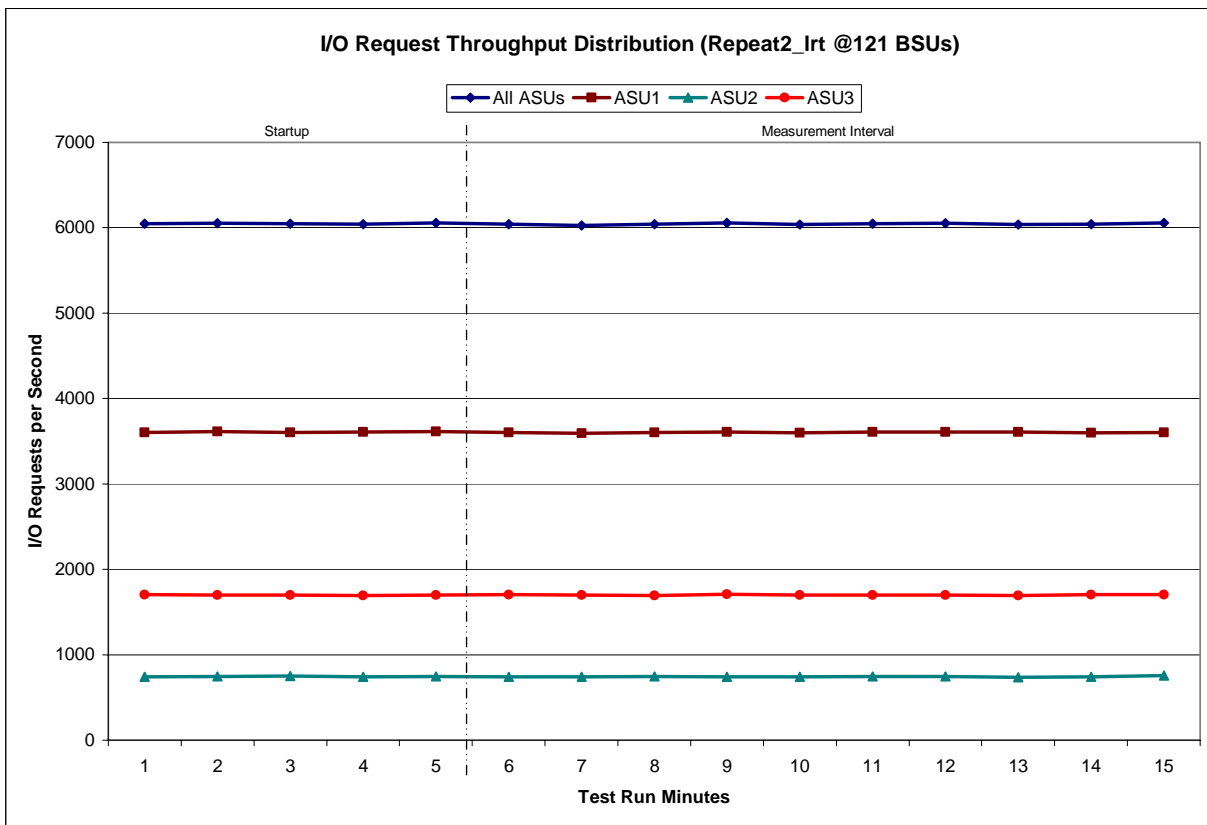
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT - I/O Request Throughput Distribution Data

121 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:17:22	13:22:22	0-4	0:05:00
<i>Measurement Interval</i>	13:22:22	13:32:22	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6,049.22	3,605.18	741.03	1,703.00
1	6,054.23	3,612.90	744.22	1,697.12
2	6,049.13	3,600.90	749.35	1,698.88
3	6,040.25	3,608.02	738.92	1,693.32
4	6,058.75	3,614.58	745.50	1,698.67
5	6,043.18	3,601.53	739.73	1,701.92
6	6,029.53	3,592.47	740.42	1,696.65
7	6,041.80	3,602.82	743.65	1,695.33
8	6,059.98	3,606.42	742.67	1,710.90
9	6,038.17	3,597.45	742.60	1,698.12
10	6,048.62	3,606.05	744.10	1,698.47
11	6,052.72	3,608.02	744.50	1,700.20
12	6,037.17	3,606.12	738.15	1,692.90
13	6,040.75	3,597.73	741.63	1,701.38
14	6,058.73	3,601.22	755.33	1,702.18
Average	6,045.07	3,601.98	743.28	1,699.81

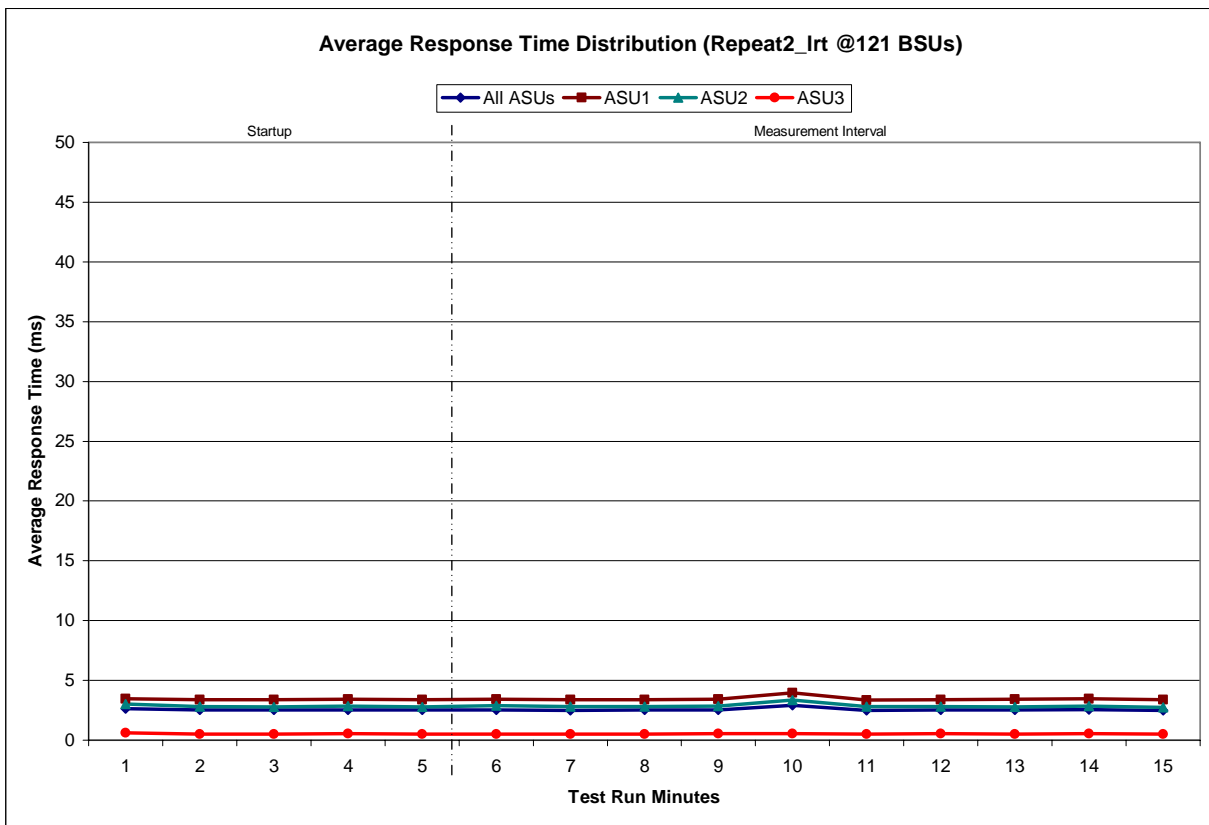
Repeatability 2 LRT - I/O Request Throughput Distribution Graph



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

121 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:17:22	13:22:22	0-4	0:05:00
<i>Measurement Interval</i>	13:22:22	13:32:22	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.61	3.47	3.03	0.60
1	2.52	3.39	2.82	0.52
2	2.50	3.39	2.78	0.51
3	2.53	3.41	2.84	0.52
4	2.50	3.38	2.78	0.51
5	2.53	3.40	2.87	0.52
6	2.49	3.37	2.79	0.51
7	2.52	3.40	2.80	0.51
8	2.53	3.42	2.84	0.53
9	2.93	3.97	3.36	0.54
10	2.49	3.36	2.79	0.50
11	2.52	3.40	2.82	0.52
12	2.53	3.42	2.77	0.51
13	2.55	3.45	2.85	0.53
14	2.49	3.37	2.75	0.51
Average	2.56	3.46	2.86	0.52

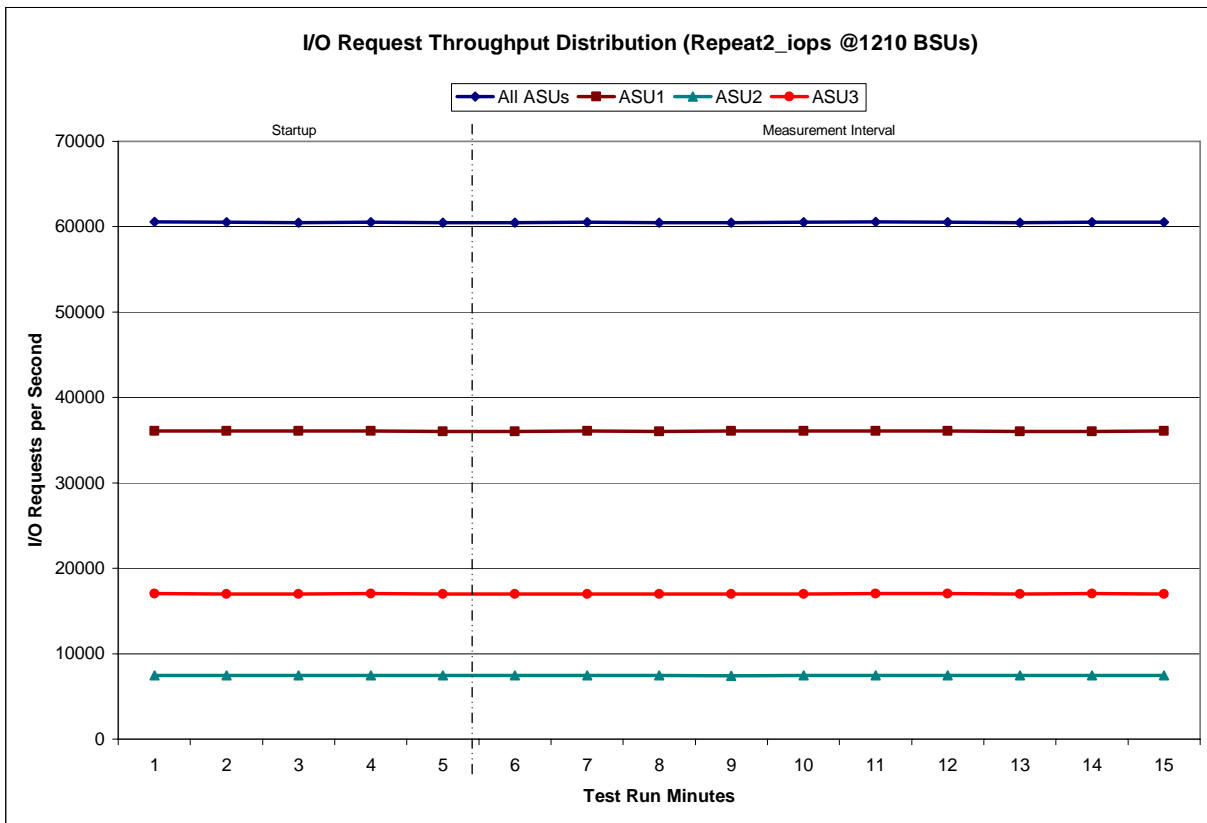
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS - I/O Request Throughput Distribution Data

1210 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	13:32:31	13:37:32	0-4	0:05:01
<i>Measurement Interval</i>	13:37:32	13:47:32	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	60,553.82	36,099.63	7,444.80	17,009.38
1	60,518.50	36,079.08	7,438.95	17,000.47
2	60,497.72	36,066.35	7,435.72	16,995.65
3	60,545.68	36,082.62	7,447.78	17,015.28
4	60,485.08	36,047.00	7,442.77	16,995.32
5	60,482.03	36,046.15	7,437.47	16,998.42
6	60,543.22	36,099.28	7,455.90	16,988.03
7	60,468.07	36,028.35	7,443.77	16,995.95
8	60,468.40	36,064.17	7,417.72	16,986.52
9	60,546.73	36,103.97	7,457.57	16,985.20
10	60,553.93	36,085.00	7,459.35	17,009.58
11	60,547.15	36,087.68	7,446.65	17,012.82
12	60,456.38	36,014.88	7,445.58	16,995.92
13	60,504.97	36,039.10	7,451.18	17,014.68
14	60,525.98	36,076.78	7,444.43	17,004.77
Average	60,509.69	36,064.54	7,445.96	16,999.19

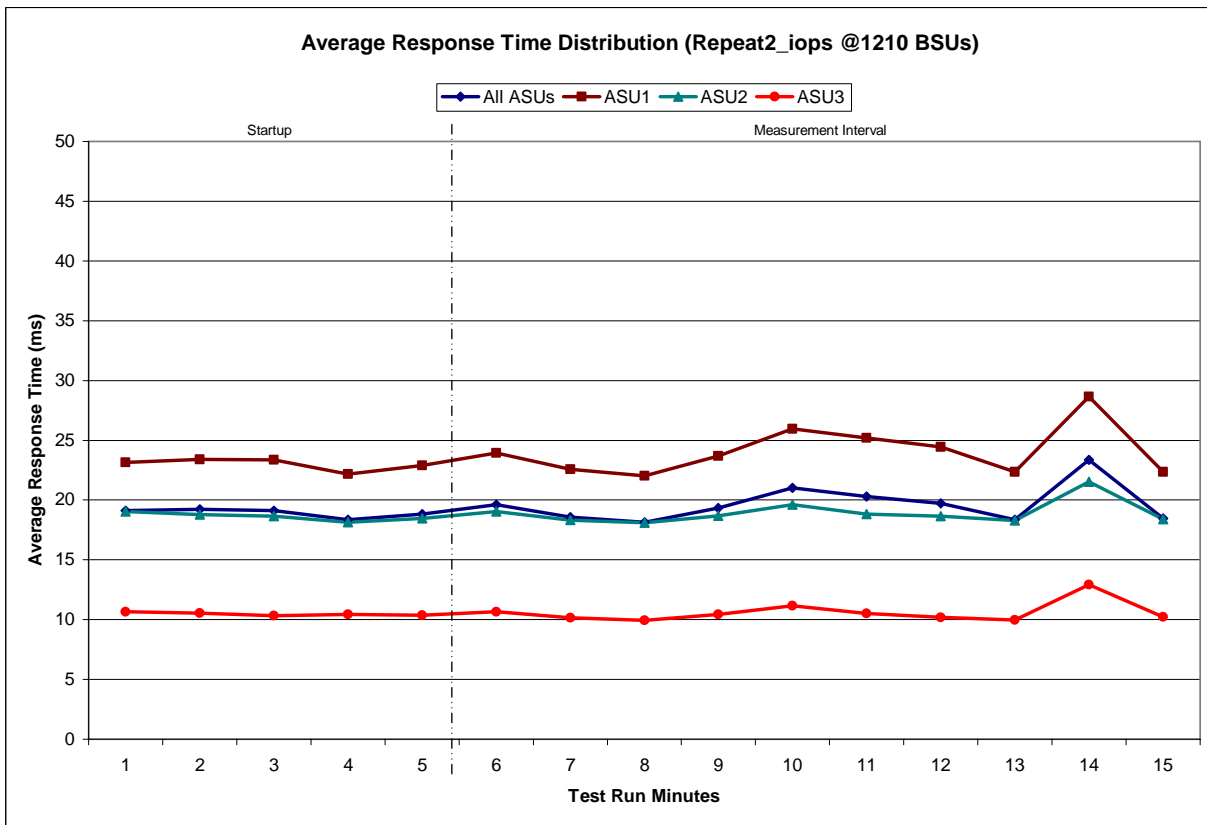
Repeatability 2 IOPS - I/O Request Throughput Distribution Graph



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

1210 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	13:32:31	13:37:32	0-4	0:05:01
Measurement Interval	13:37:32	13:47:32	5-14	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	19.13	23.14	19.05	10.66
1	19.22	23.40	18.78	10.54
2	19.12	23.36	18.65	10.35
3	18.37	22.16	18.14	10.45
4	18.83	22.90	18.46	10.35
5	19.60	23.94	19.05	10.65
6	18.57	22.58	18.32	10.17
7	18.13	22.01	18.10	9.92
8	19.35	23.68	18.67	10.44
9	21.03	25.97	19.61	11.16
10	20.29	25.20	18.82	10.52
11	19.72	24.43	18.65	10.20
12	18.37	22.34	18.28	9.98
13	23.35	28.66	21.52	12.92
14	18.46	22.34	18.40	10.24
Average	19.69	24.12	18.94	10.62

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



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

Clause 3.4.3

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

Clauses 5.1.0 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0351	0.2811	0.0699	0.2102	0.0179	0.0699	0.0350	0.2809
COV	0.010	0.003	0.006	0.003	0.012	0.007	0.008	0.003

**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	0.2098	0.0180	0.0701	0.0350	0.2810
COV	0.002	0.001	0.001	0.001	0.004	0.002	0.003	0.001

**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	0.0348	0.2814	0.0701	0.2096	0.0180	0.0699	0.0350	0.2812
COV	0.005	0.003	0.006	0.003	0.012	0.006	0.009	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
<i>IM</i>	<i>0.0350</i>	<i>0.2810</i>	<i>0.0700</i>	<i>0.2100</i>	<i>0.0180</i>	<i>0.0700</i>	<i>0.0350</i>	<i>0.2810</i>
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2809
COV	0.003	0.001	0.001	0.001	0.003	0.003	0.003	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 IOP™ 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 Benchmark Configuration 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 9.2.4.8

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.*

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 70.

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	144,584,816
Total Number of Logical Blocks Verified	45,297,168
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in Bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 9.2.4.9

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

The FDR shall state: "The Priced Storage Configuration, as documented in this Full Disclosure Report will be available for shipment to customers on MMMM DD, YYYY." Where Priced Storage Configuration is the TSC Configuration Name as described in Clause 9.2.4.3.3 and MMMM is the alphanumeric month, DD is the numeric day, and YYYY is the numeric year of the date that the Priced Storage Configuration, as documented, is available for shipment to customers as described above.

The NetApp FAS3170 as documented in this Full Disclosure Report became available for customer purchase and shipment on June 10, 2008.

PRICING INFORMATION

Clause 9.2.4.11

A statement of the respective calculations for pricing must be included.

Clause 9.2.4.11.3

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration must be included.

Pricing information may found in the Tested Storage Configuration Pricing section on page 13. 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 13.

ANOMALIES OR IRREGULARITIES

Clause 9.2.4.10

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the NetApp FAS3170.

APPENDIX A: SPC-1 GLOSSARY

“Decimal” (*powers of ten*) Measurement Units

In the storage industry, the terms “kilo”, “mega”, “giga”, “tera”, “peta”, and “exa” are commonly used prefixes for computing performance and capacity. For the purposes of the SPC workload definitions, all of the following terms are defined in “powers of ten” measurement units.

- A kilobyte (KB) is equal to 1,000 (10^3) bytes.
- A megabyte (MB) is equal to 1,000,000 (10^6) bytes.
- A gigabyte (GB) is equal to 1,000,000,000 (10^9) bytes.
- A terabyte (TB) is equal to 1,000,000,000,000 (10^{12}) bytes.
- A petabyte (PB) is equal to 1,000,000,000,000,000 (10^{15}) bytes
- An exabyte (EB) is equal to 1,000,000,000,000,000,000 (10^{18}) bytes

“Binary” (*powers of two*) Measurement Units

The sizes reported by many operating system components use “powers of two” measurement units rather than “power of ten” units. The following standardized definitions and terms are also valid and may be used in this document.

- A kibibyte (KiB) is equal to 1,024 (2^{10}) bytes.
- A mebibyte (MiB) is equal to 1,048,576 (2^{20}) bytes.
- A gibibyte (GiB) is equal to 1,073,741,824 (2^{30}) bytes.
- A tebibyte (TiB) is equal to 1,099,511,627,776 (2^{40}) bytes.
- A pebibyte (PiB) is equal to 1,125,899,906,842,624 (2^{50}) bytes.
- An exbibyte (EiB) is equal to 1,152,921,504,606,846,967 (2^{60}) bytes.

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

RAID5: User data is distributed across the disks in the array. Check data corresponding to user data is distributed across multiple disks in the form of bit-by-bit parity.

Mirroring: Two or more identical copies of user data are maintained on separate disks.

Other Protection Level: Any data protection other than **RAID5** or **Mirroring**.

Unprotected: There is no data protection provided.

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.

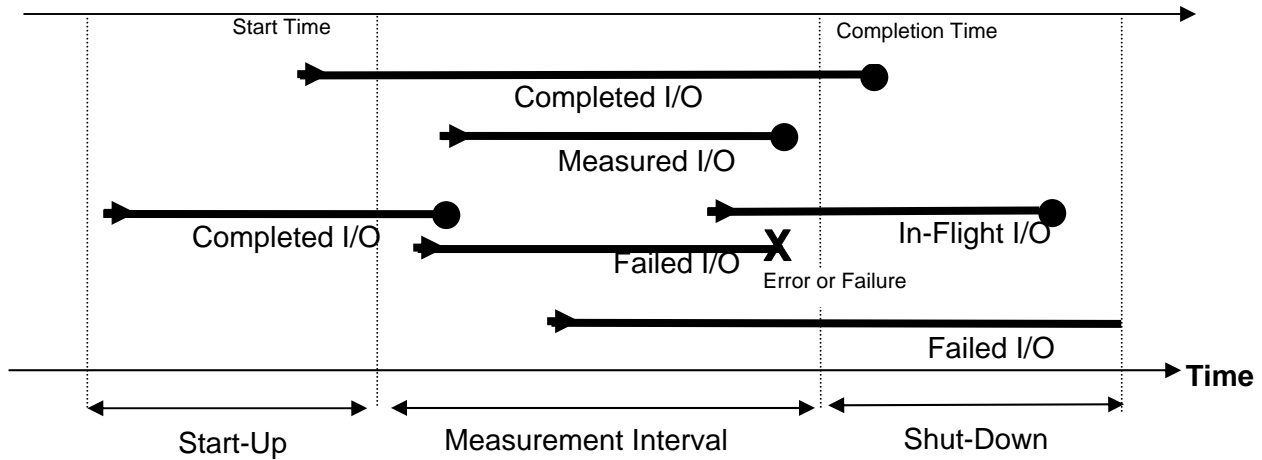
Test: A collection of Test Phases and or Test Runs sharing a common objective.

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

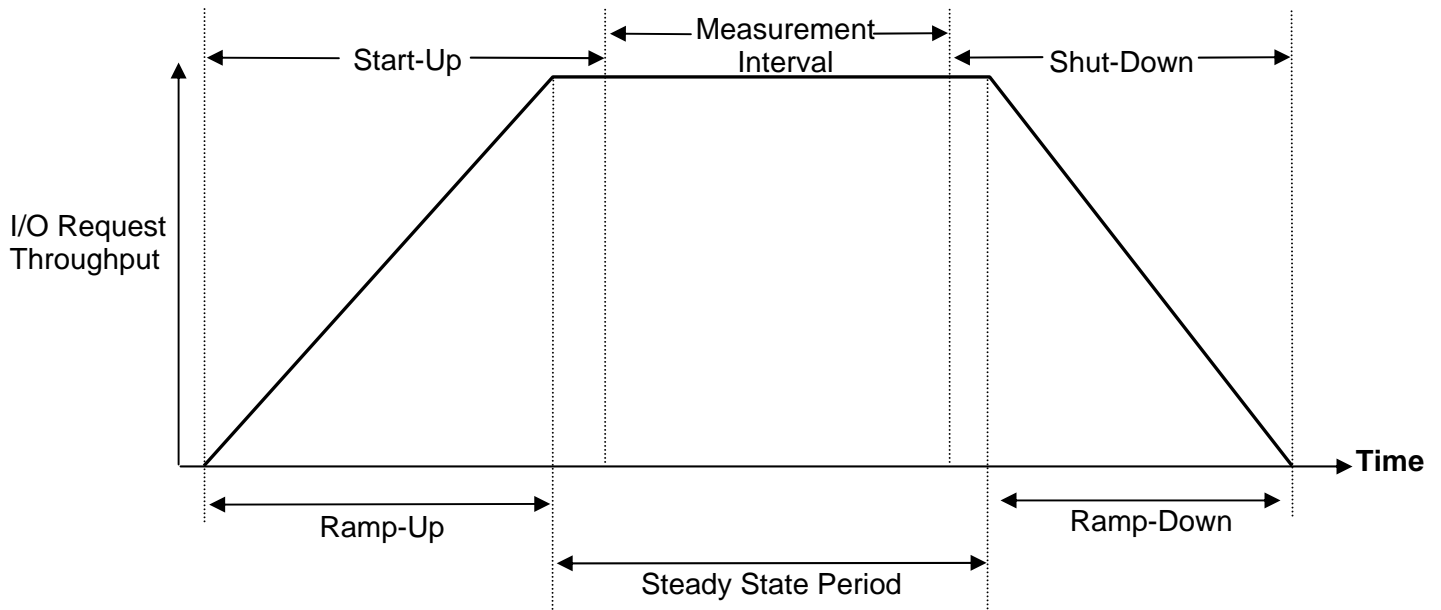
period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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

Windows 2003 Server

For each HBA in the system, change the execution throttle (queue depth) from the default value of 16 to 256.

FAS3170 Storage Controllers

The following changes must be made on each controller:

- **LUN options:** Create the LUNs without space reservations. By default, the “lun create” command creates LUNs with space reservations. Instead of reserving space for the LUNs, the LUN create script pre-allocates space for all of the LUNs by overwriting every block of each LUN (see Appendix C), as required by the SPC-1 specification.
- **Volume Options (applied to vol0, the ONTAP root volume):**
 - Change the volume option “nosnap” from its default value of “off” to “on”. This disables the automatic creation of Snapshot copies.
- **Volume Options (applied to vol1, the SPC data set volume):**
 - Change the memory policy for each volume from “default” to “reuse”. This tells the memory management system to expect a low cache hit rate for user data in the buffer cache. The effect of this change is to increase the priority of system metadata in the buffer cache relative to application data.
 - Create the volumes with a space reservation requirement of “none” rather than the default value of “volume”. Because all of the LUNs in the volume are preallocated there is no need to reserve space in the volume.
 - Change the volume option “nosnap” from its default value of “off” to “on”. This disables the automatic creation of Snapshot™ copies.
- **Aggregate Options (applied to aggr0, the only aggregate in the system)**
 - Change the aggregate Snapshot reserve to 0 bytes.
 - Change the aggregate option “nosnap” from its default value of “off” to “on”.
These changes disable automatic Snapshot copies at the aggregate level.
- **System Flags:**
 - **waf1_optimize_write_once:** change default value of 1 to 0. This flag affects the initial layout of data within a newly created aggregate. The default data layout favors applications which do not overwrite their data.
 - **waf1_downgrade_target:** change default value of 1 to 0. This flag changes the run-time priority of the process that handles the SCSI protocol for incoming Fibre-Channel requests. For storage systems that are not also servicing NAS requests this change to the process priority is recommended.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

Host System

- Install Microsoft Windows Server 2003 Service Pack 2.
- Install and setup two Qlogic 2462 HBAs using NetApp certified Qlogic driver.
- Install NetApp FCP Windows Host Utilities 4.0 for Native OS and Veritas
- Install Qlogic SANsurfer HBA management software.
- Install Data ONTAP DSM 3.2 for Windows MPIO
- Set the “Execution Throttle” (also known as HBA queue depth) setting on each FCP port from default of 16 to 256 using SANsurfer HBA management software.

Brocade FCP Switches

Connect the physical connections from the Host System to the FAS3170 as illustrated on page 14 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

Storage Controllers

The following sections document how to set up the storage controllers and create the raid-groups, aggregates, volumes and LUNs that comprise the SPC-1 data repository.

Initializing Disk Ownership

The NetApp FAS3170 system consists of two storage controllers. Before the systems are installed the ownership of the individual disks must be established in the following fashion:

- Each controller should be setup with 4 active and 4 passive FCAL connections to the disk shelves
- Each controller should be setup with 8 active shelves (total 16 disk shelves between the two controllers). Each controller should own all disks in its 8 active shelves.

After the FCAL connections to disk shelves and disk ownership has been established, zero (initialize) all disks by executing the following steps on each NetApp controller:

1. Boot the NetApp controllers either by power cycling or typing “boot” at the “LOADER>” prompt on the console screen
2. Hit “CTRL C” during the boot process when prompted for the special boot menu on the console screen
3. Once at special boot menu, select option “4a” to zero (initialize) all disks and install a flexible root volume
4. After zeroing (initialization) of all disks are completed, follow the remaining prompts to complete the basic setup of NetApp controller.

After zeroing (initialization) of all disks and basic setup is completed, install NetApp Data ONTAP 7.3 by executing the following steps:

1. Download Data ONTAP 7.3 system files for FAS3170 platform from NetApp's NOW site to a directory location that can be accessed via an http URL.
2. Login to NetApp controller as root and at the command prompt type:
`software install <http URL of Data ONTAP 7.3 system files>`
3. Once the installation of system files is completed, type "download" at the command prompt of NetApp controllers
4. Once "download" command completes, reboot the NetApp controller for changes to take effect.

Installing Licenses

The following licenses must be installed after NetApp ONTAP 7.3 system software installation has completed:

- cluster
- fcp

To install the licenses, execute the following command at NetApp controller's command prompt:

```
license add <license key>
```

Base Setup Script – FAS3170 Controllers

Once licenses are installed and both FAS3170 controllers rebooted, the perl script below should be run to setup both FAS3170 controllers with appropriate storage sizes for SPC-1 ASUs. The script is invoked using the following syntax:

```
ntap_spc1_cfg.pl -f controller_a,controller_b -i wwpn_1,wwpn_2,wwpn_3,wwpn_4 -t timehost_ip_addr -s spc1
```

The script does the following on each FAS3170 controller:

- modify /etc/rc file with the following setflags so these are persistent across reboots:
 - setflag waf1_optimize_write_once 0
 - setflag waf1_downgrade_target 0
- set timezone to EST5EDT
- sets the following setflags to appropriate settings:
 - waf1_optimize_write_once 0
 - waf1_downgrade_target 0
- create aggregate with the following configuration:
 - aggr0 settings, 6 rgs, rg sizes (3x18 + 3x19), 1 spare
 - aggr0 options:
 - nosnap=on
 - set snap reserve = 0 on aggregate aggr0

- set snap sched to 0 0 0 on the aggregate aggr0
- Configure the flexible volumes within aggregate with the following configuration:
 - Root flexible volume (vol0)
 - set volume options on vol0
 - nosnap=on
 - nosnapdir=off
 - set snap reserve = 0 on vol0
 - set snap sched to 0 0 0 on vol0
 - spc1 data flexible volume (vol1):
 - create vol1 of size 12831 GB
 - set volume options on vol1:
 - nosnap=on
 - nosnapdir=off
 - set snap reserve = 0 on vol1
 - set snap sched to 0 0 0 on vol1
 - set space reservation (guarantee) to “none”
 - set the memory policy to cache=reuse on vol1
- Create fcp portset to contain NetApp controller ports 0a and 0c. Then, create windows igroup which contains the fcp portset and the wwpn of FCP HBAs initiators in the SPC-1 Windows Host System
- Create zeroed luns with no space reservation on each NetApp controller with the following sizes and then map them to the windows igroup created earlier assigning each lun a unique lun id.
 - 6 lun files for ASU1 of size 718798080 KB each
 - 6 lun files for ASU2 of size 718798080 KB each
 - 6 lun files for ASU3 of size 159732907 KB each
- Verify fcp is started on both NetApp controllers.

Host Disk Stripe Setup

Once the ASU LUNs are visible on the Windows host, execute the following steps to stripe the appropriate ASU LUNs together and assign a drive letter:

- In Windows disk management MMC, initialize each disk associated with the ASU luns.
- Convert each of the same disks to dynamic disks
- Create three striped volumes for ASU1, ASU2, and ASU3.
 - Stripe each volume across all 12 luns associated with each respective ASU.
 - Assign drive letter “E” for ASU1
 - Assign drive letter “F” for ASU2
 - Assign drive letter “G” for ASU3

ntap_spc1_cfg.pl

```
#!/usr/local/bin/perl
use Getopt::Std;

# ----- #
# Global Definition Section

# Set up some host-specific variables
$TEST=`VER 2>&l`;
$SPC_VERSION="spc1";
$RSH="";
$TIME_CMD="";
$WINDOWS=0;
if ( $TEST eq "" ) {
    $RSH="/usr/bin/rsh -l root -n";
    $TIME_CMD="date";
} else {
    $WINDOWS=1;
    $RSH="rsh.exe";
    $TIME_CMD="time /T";
}

$INITIATOR_WWN_LIST="";
# controller-specific stuff
$LUN_TYPE = "windows";
$USE_WIN_RAW_DEVICES = 0;
$LUN_COUNT = 36;
$ASU1_2_LUN_SIZE = "718798080k";
$ASU3_LUN_SIZE = "159732907k";
$IGROUP_TYPE = "windows";
$TIMEHOST="";
$AGGR_NAME="aggr0";
$TARGET_VOL="voll";
@CONTROLLER_LIST=();

# ----- #
# Helper function definition section

sub usage {
    printf STDOUT "\
SPC-1 setup script for FAS3170 cluster:\
> %s [-h] [-r] -f controller_a,controller_b -t timehost_ip_addr [-i\
wnw_1,wnw_2,...,wnw_n]\
Options                               Semantics\
  -h                                   Display help menu and exit\
\
  -r                                   Create setup for Windows raw\
                                   devices (default is to setup for\
                                   Windows volume manager)\
  -f controller_a,controller_b        Comma-separated list of controller\
                                   hostnames or ip-addr to setup for\
                                   SPC-1 test.\
                                   *NOTE* We split lun creation\
                                   evenly between controller_a and\
                                   controller_b, with controller_a\
                                   getting the odd numbered lun names\
                                   (but even numbered lun ids) and\

```

```

controller_b getting the even\
numbered lun names and odd\
numbered lun ids.\
\
-i wwpn_1,wwpn_2,...,wwpn_n      Comma-separated list of WWPNs of\
client-side initiator ports.\
\
-t timehost_ip_addr              IP address of the timehost to\
synchronize controller times.\
\
-s [spc1|spc2]                   Specifies SPC version to do setup\
for.\
", $0;
}
# Print msg with timestamp to STDOUT
sub log_msg {
    my $msg = shift(@_);
    $timestamp = ` $TIME_CMD`;
    chomp($timestamp);
    printf "%s -- %s\n", $timestamp, $msg;
}
# Small subroutine that sends an rsh command to $controller and returns the output
sub do_rsh($$) {
    my ($controller, $cmd) = @_;
    log_msg("Controller: ".$controller.: sending command \"priv set -q diag;
\".$cmd.\"");

    if ($WINDOWS eq 1) {
        return(`CMD \\/C \\/$RSH $controller -l root priv set -q diag; $cmd\`);
    } else {
        return(`$RSH $controller "priv set -q diag; $cmd`);
    }
}

# ----- #
# Check options

getopts("rhf:i:t:s:");
if ($opt_h) {
    usage();
    exit 0;
}
if ($opt_s =~ "spc2") {
    $SPC_VERSION = $opt_s;
    # Update lun size and count for SPC-2
    $LUN_COUNT = 12;
    $ASU1_2_LUN_SIZE = $ASU3_LUN_SIZE = "1000222m";
    printf STDERR "SPC-2\n";
}
elseif ($opt_s && $opt_s !~ "spc1") {
    printf STDERR "ERROR: Only valid values to -s are 'spc1' or 'spc2'\n";
    exit 1;
}

if (!$opt_f) {
    printf STDERR "ERROR: Please provide comma-separated list of controller
hostnames or controller ip addresses!\n";
    usage();
    exit 1;
}
else {
    $opt_f =~ s/\\s+//;
    @CONTROLLER_LIST = split(",", $opt_f);
}

```



```
if ($opt_r) {
    $USE_WIN_RAW_DEVICES = 1;
    $LUN_TYPE = "linux";
    # Lun count and lun sizes will already be set for spc2 tests if '-s spc2' was
    specified
    if ($SPC_VERSION !~ "spc2") {
        $LUN_COUNT=100;
        $ASU1_2_LUN_SIZE="135030m";
        $ASU3_SIZE="60013m";
    }
}
if (!$opt_t) {
    printf STDERR "ERROR: Please provide a timehost ip to synchronize the controller
    clocks!\n";
    usage();
    exit 1;
} else {
    $TIMEHOST = $opt_t;
}
if (!$opt_i) {
    printf STDERR "ERROR: Please provide a comma-separated list of host initiator
    WWPNS!\n";
    usage();
    exit 1;
} else {
    $INITIATOR_WWN_LIST="";
    $opt_i =~ s/\s+//;
    @wwn_list = split(",", $opt_i);
    foreach $wwn (@wwn_list) {
        $INITIATOR_WWN_LIST .= $wwn.' ';
    }
}
# ----- #
# Functions for setting / configuring ONTAP options

# Routine for setting the two flags -- NOTE: Simply using setflag does not guarantee
# persistence across reboots
sub do_setflags {
    foreach $controller (@CONTROLLER_LIST) {
        do_rsh($controller, "setflag wafld_optimize_write_once 0");
        do_rsh($controller, "setflag wafld_downgrade_target 0");
    }
}
# Routine for adding the 2 setflags and default gateway to each controller's rc file
# so that they remain persistent across reboots
sub modify_rc_files {
    foreach $controller (@CONTROLLER_LIST) {
        do_rsh($controller, "wrfile -a /etc/rc \\\\\"priv set -q diag; setflag
        wafld_optimize_write_once 0\\\\");
        do_rsh($controller, "wrfile -a /etc/rc \\\\\"priv set -q diag; setflag
        wafld_downgrade_target 0\\\\");
    }
}
# Set timezone and rdate to timehost
sub set_timezone {
    foreach $controller (@CONTROLLER_LIST) {
        do_rsh($controller, "timezone EST5EDT");
        do_rsh($controller, "rdate $TIMEHOST");
    }
}
# Routine for creating an aggregate with:
# - snapshots disabled
# - no snap reserve
```

```
# - 6 raid_dp raid groups:
#   - 3 x 18 disk raid group
#   - 3 x 19 disk raid group
sub create_aggrs {
  foreach $controller (@CONTROLLER_LIST) {
    # Disable aggregate snapshots
    do_rsh($controller, "aggr options $AGGR_NAME nosnap on");
    do_rsh($controller, "snap sched -A $AGGR_NAME 0 0 0");
    # Turn off snap reserve in the aggregate
    do_rsh($controller, "snap reserve -A $AGGR_NAME 0");
    # Create the first 3 raidgroups of size 18
    do_rsh($controller, "aggr options $AGGR_NAME raidsize 18");
    do_rsh($controller, "aggr add $AGGR_NAME 51");
    sleep 30; # aggr add commands are async, so provide some sleep time
    # Now create the remaining 3 raid groups of size 19
    do_rsh($controller, "aggr options $AGGR_NAME raidsize 19");
    do_rsh($controller, "aggr add $AGGR_NAME 57");
    sleep 60; # aggr add commands are async, so provide some sleep time
  }
}
# Set options on root volume
sub do_root_vol_options {
  foreach $controller (@CONTROLLER_LIST) {
    # Disable snapshots
    do_rsh($controller, "vol options vol0 nosnap on");
    do_rsh($controller, "snap sched vol0 0 0 0");
    # Turn off snap reserve
    do_rsh($controller, "snap reserve vol0 0");
    do_rsh($controller, "vol options vol0 nosnapdir off");
  }
}
# Create a target flexible volume with snapshots off and snap reserve 0 that is 84%
of the containing aggregate
sub create_target_vols {
  foreach $controller (@CONTROLLER_LIST) {
    # Create a flexvol in $AGGR_NAME that is roughly 82% of all free space in
the aggr
    # Over-subscribe target vol to be +1 TB of aggr size
    do_rsh($controller, "vol create $TARGET_VOL -s none $AGGR_NAME 12831g");
    sleep 60; # vol create commands are async, so provide some time
    # Disable snapshots in target volume
    do_rsh($controller, "vol options $TARGET_VOL nosnap on");
    do_rsh($controller, "snap sched $TARGET_VOL 0 0 0");
    do_rsh($controller, "vol options $TARGET_VOL nosnapdir off");
    do_rsh($controller, "snap reserve $TARGET_VOL 0");
  }
}
# Set caching policy on the target vol to prefer caching meta data
sub set_target_vol_cache_policy {
  foreach $controller (@CONTROLLER_LIST) {
    do_rsh($controller, "priority set enabled_components=cache");
    do_rsh($controller, "priority set volume $TARGET_VOL cache=reuse");
    do_rsh($controller, "priority on");
  }
}
# Setup FCP settings
sub setup_fcp {
  foreach $controller (@CONTROLLER_LIST) {
    do_rsh($controller, "cf enable");
    do_rsh($controller, "fcp start");
    # Set the cfmode to SSI
    do_rsh($controller, "fcp set cfmode -f single_image");
    # Configure targets
  }
}
```

```

        do_rsh($controller, "fcg config 0a up");
        do_rsh($controller, "fcg config 0c up");
        do_rsh($controller, "fcg stop");
    }
}
# Setup portsets
sub create_portsets {
    foreach $controller (@CONTROLLER_LIST) {
        do_rsh($controller, "portset create -f portset1 0a 0c");
    }
}
# Setup igroups
sub create_igroups {
    foreach $controller (@CONTROLLER_LIST) {
        do_rsh($controller, "igroup create -t $IGROUP_TYPE -a portset1 -f igroup1
$INITIATOR_WWN_LIST");
    }
}
# Routine for writing out zeroed luns sequentially on one partner controller
sub do_controller_luns {
    my ($controller, $file_count, $starting_index) = @_;
    my $file_index = $starting_index;
    my $asu_num = 1;
    my $file_size = $ASU1_2_LUN_SIZE;

    do_rsh($controller, "exportfs -i -o anon=0 /vol/$TARGET_VOL");
    for ($i = 0; $i < $file_count; $i++) {
        # Check to see if it's time to switch to a new asu number only if we're
setting up dataset for SPC-1 test
        if ($SPC_VERSION =~ "spc1") {
            if (($i == 20 && $LUN_COUNT == 100) || ($i == 6 && $LUN_COUNT == 36)) {
                $asu_num = 2;
            } elsif (($i == 40 && $LUN_COUNT == 100) || ($i == 12 && $LUN_COUNT ==
36)) {
                $asu_num = 3;
                $file_size = $ASU3_LUN_SIZE;
            }
        }
        $file_name = "file-".$file_index;
        do_rsh($controller, "mkfile $file_size /vol/$TARGET_VOL/$file_name");
        $file_index+=2;
    }
}
# This routine will fork off a child proc so that zeroed luns can be created in
parallel across both controllers
sub create_zeroed_luns {
    $pid = fork();

    if($pid == 0) {
        # Child proc -- Start odd-numbered lun creations on controller at index 0
do_controller_luns(@CONTROLLER_LIST[0], $LUN_COUNT/2, 1);
        exit 0;
    } else {
        # Parent proc -- Start even-numbered lun creations on controller at index 1
if (@CONTROLLER_LIST[1] ne "") {
            do_controller_luns(@CONTROLLER_LIST[1], $LUN_COUNT/2, 2);
        }
        waitpid($pid,0);
    }
}
# Routine that creates luns and maps them to igroup1
sub create_and_map_luns {
    my $lun_id = 0;

```

```

my $controller = "";
my $asu_num = 1;
my $file_index = 1;

for ($i = 0; $i < $LUN_COUNT; $i++) {
    # Alternate lun creation...
    $controller = @CONTROLLER_LIST[$i%2];

    # Check to see if it's time to switch to a new asu number only if we're
    setting up dataset for SPC-1 test
    if ($SPC_VERSION =~ "spc1") {
        if (($file_index == 41 && $LUN_COUNT == 100) || ($file_index == 13 &&
    $LUN_COUNT == 36)) {
            $asu_num = 2;
        } elsif (($file_index == 81 && $LUN_COUNT == 100) || ($file_index == 25
    && $LUN_COUNT == 36)) {
            $asu_num = 3;
        }
    }

    $lun_name='asu'.$asu_num.'_'.$file_index;
    $lun_path="/vol/$TARGET_VOL/"$lun_name;
    $file_name="/vol/$TARGET_VOL/file-".$file_index;
    do_rsh($controller, "lun create -t $LUN_TYPE -f $file_name -o noreserve
    $lun_path");
    sleep 1;
    do_rsh($controller, "lun map $lun_path igroup1 $lun_id");
    sleep 1;
    $lun_id++;
    $file_index++;
}
}
# Routine for executing the final batch of commands before leaving setup
sub final_tasks {
    foreach $controller (@CONTROLLER_LIST) {
        # Make sure fcp service is running before leaving
        do_rsh($controller, "fcp start");
    }
}
# ----- #
# Main execution entry point
# ----- #
log_msg("Starting setup on cluster: '@CONTROLLER_LIST[0].',
"@CONTROLLER_LIST[1].");
modify_rc_files();
set_timezone();
do_setflags();
create_aggrs();
do_root_vol_options();
create_target_vols();
set_target_vol_cache_policy();
setup_fcp();
create_portsets();
create_igroups();
create_zeroed_luns();
create_and_map_luns();
final_tasks();
log_msg("Setup finished on cluster: '@CONTROLLER_LIST[0].',
"@CONTROLLER_LIST[1].");
exit 0;

```

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

The content of SPC-1 Workload Generator command and parameter file, used in this benchmark, is listed below.

```
javaparms="-Xmx1024m -Xms512m -Xss256k"  
sd=asu1_1,lun=\\.\\E:  
sd=asu2_1,lun=\\.\\F:  
sd=asu3_1,lun=\\.\\G:
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

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

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

```
REM metrics test
java -Xmx1024m -Xms512m -Xss256k metrics -b 1210 -s 300

REM repeatability1 test
java -Xmx1024m -Xms512m -Xss256k repeat1 -b 1210 -s 300

REM repeatability2 test
java -Xmx1024m -Xms512m -Xss256k repeat2 -b 1210 -s 300

REM persistencel test
java -Xmx1024m -Xms512m -Xss256k persist1 -b 1210
c:\sleep.exe 30

REM move the results directories to appropriate locations
mkdir 1210.audit
c:\sleep.exe 30

move /Y metrics 1210.audit\metrics.1210.audit
c:\sleep.exe 30

move /Y repeatability1 1210.audit\repeat1.1210.audit
c:\sleep.exe 30

move /Y repeatability2 1210.audit\repeat2.1210.audit
c:\sleep.exe 30

move /Y persistencel 1210.audit\persist1.1210.audit
c:\sleep.exe 30
```

Persistence Test Run 2

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

```
REM persistence2 test
java -Xmx1024m -Xms512m -Xss256k persist2
c:\sleep.exe 30

REM move the results directories to appropriate locations
move /Y persistence2 1210.audit\persist2.1210.audit
c:\sleep.exe 30

move /Y SPCOut 1210.audit\SPCOut.1210.audit
c:\sleep.exe 30
```

```
::: Begin device listing and other data collection
@ECHO OFF

set i=
:loop
set i=%i%!
  if %i%==! set CONTROLLER=startrek
  if %i%==!! set CONTROLLER=pulaski
  if %i%==!!! goto EndLoop

  SET OUTPUT=.\r1.txt
  SET MSG=Physical Device Listing for %CONTROLLER%
  CALL :Print_Header
  SET CMD=sysconfig -av
  CALL :Do_RSH
  SET CMD=sysconfig -r
  CALL :Do_RSH
  SET OUTPUT=.\r2.txt
  SET MSG=Aggregate Information for %CONTROLLER%
  CALL :Print_Header
  echo Aggregate Space Usage >> %OUTPUT%
  SET CMD=df -A
  CALL :Do_RSH
  echo Aggregate Status >> %OUTPUT%
  SET CMD=aggr status -v
  CALL :Do_RSH
  echo Aggregate Disk Status >> %OUTPUT%
  SET CMD=aggr status -r
  CALL :Do_RSH
  SET OUTPUT=.\r3.txt
  SET MSG=Volume Information for %CONTROLLER%
  CALL :Print_Header
  echo Volume Space Usage >> %OUTPUT%
  SET CMD=df
  CALL :Do_RSH
  echo Volume Status >> %OUTPUT%
  SET CMD=vol status -v
  CALL :Do_RSH
  SET OUTPUT=.\r4.txt
  SET MSG=Lun Information for %CONTROLLER%
  CALL :Print_Header
  echo Lun Status >> %OUTPUT%
  SET CMD=lun show
  CALL :Do_RSH
  goto loop

:Print_Header
echo. >> %OUTPUT%
echo ===== %MSG% ===== >> %OUTPUT%
GOTO :EOF

:Do_RSH
echo Executed command: %CMD% >> %OUTPUT%
echo Timestamp: %DATE:~% %TIME:~% >> %OUTPUT%
echo. >> %OUTPUT%
```

```
rsh.exe %CONTROLLER% -l root %CMD% >> %OUTPUT% 2>&1
echo. >> %OUTPUT%
GOTO :EOF

:EndLoop

echo LIST VOLUME >> .\diskpart.input.txt
echo SELECT VOLUME E >> .\diskpart.input.txt
echo DETAIL VOLUME >> .\diskpart.input.txt
echo SELECT VOLUME F >> .\diskpart.input.txt
echo DETAIL VOLUME >> .\diskpart.input.txt
echo SELECT VOLUME G >> .\diskpart.input.txt
echo DETAIL VOLUME >> .\diskpart.input.txt
echo EXIT >> .\diskpart.input.txt
echo Timestamp: %DATE:~% %TIME:~% >> .\win_host_logical_device.txt
diskpart.exe /s .\diskpart.input.txt >> .\win_host_logical_device.txt
```