SPC Benchmark 1/Energy™
Full Disclosure Report

NetApp, Inc.
NetApp FAS3270A

SPC-1/E™ V1.12

Submitted for Review: November 9, 2010
Submission Identifier: AE00004

Table of Contents

SPC BENCHMARK 1/ENERGY™ V1.12   FULL DISCLOSURE REPORT   Submission Identifier: AE00004
NetApp, Inc.   Submitted for Review: NOVEMBER 9, 2010
NetApp FAS3270A

AUDIT CERTIFICATION

Storage Performance Council

Gradient SYSTEMS

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

November 8, 2010

The SPC Benchmark 1/Energy™ Reported Data listed below for the NetApp FAS3270A were produced in compliance with the SPC Benchmark 1/Energy™ V1.12 Remote Audit requirements.

SPC Benchmark 1/Energy™ V1.12 Reported Data	
Tested Storage Configuration (TSC) Name:	
NetApp FAS3270A	
Metric	**Reported Result**
SPC-1 IOPS™	68,034.63
SPC-1 Price-Performance	$7.48/SPC-1 IOPS™
Total ASU Capacity	21,659.386 GB
Data Protection Level	Protected (RAID DP™)
Total TSC Price (including three-year maintenance)	$509,200.79

Power Environment

Average RMS Voltage: 208.28   Average Power Factor: 0.935

Usage Profile

	Hours of Use per Day			Nominal Power, W	Nominal Traffic, IOPS	Nominal IOPS/W	Nominal Heat, BTU/hr
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	2736.29	11332.97	4.14	9,333.07
Medium Daily Usage:	4	14	6	2755.83	28898.69	10.49	9,403.16
High Daily Usage:	18	6	0	2808.15	49296.67	17.55	9,581.67
			Composite Metrics:	2,766.42	29,842.78	10.79	

Annual Energy Use, kWh: 24,233.84
Energy Cost, $/kWh: $ 0.12   Annual Energy Cost, $: $ 2,908.06

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

AUDIT CERTIFICATION *(CONT.)*

NetApp FAS3270A   Page 2
SPC-1 Audit Certification

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

- A Letter of Good Faith, signed by a senior executive.

- The following Data Repository storage items were verified by 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/Tested Storage Configuration.

- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.

- SPC-1™ Workload Generator commands and parameters used for the audited SPC Test Runs.

- The following Host System requirements were verified by 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.
  - ✓ A valid SPC-1™ site license.
  - ✓ 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, 5, and 11 of the SPC Benchmark 1/Energy™ Specification:
  - ✓ Idle Test
    - o Conditioning Phase
    - o Application Idle Phase
    - o Recovery Phase
  - ✓ Primary Metrics Test:
    - o Sustainability Test Phase
    - o IOPS Test Phase
    - o Response Time Ramp Test Phase
  - ✓ Repeatability Test
  - ✓ Data Persistence Test

- The Yokogawa WT230 Digital Power Meter, used to record power consumption, was verified as an SPC approved "Power Extension apparatus" with a current calibration certificate.

- All power supplies present in the Tested Storage Configuration were verified as active.

- NetApp, Inc. provided documentation of the following:
  - ✓ Voltage *(220)*, amperage *(30)*, and phase characteristics *(single)* of the AC inputs used for powering the Tested Storage Configuration.
  - ✓ The configured power supplies were configured for mutual failover.

Storage Performance Council
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AUDIT CERTIFICATION *(CONT.)*
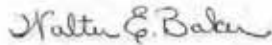
- Concurrent power measurements were taken at each active AC input so that the total power requirement of the Tested Storage Configuration was recorded.

- The ambient temperature was recorded at the following times in near proximity to the Tested Storage configuration with a precision of at least ±0.1°C:
    - ✓ During the first one minute of the Idle Test *(Initial Energy Extension temperature)*.
    - ✓ During the last one minute of the Primary Metrics Test *(Final Energy Extension temperature)*.

- The Benchmark Configuration/Tested Storage Configuration diagram included the electrical metering, which illustrates the measurement apparatus used and the relationship between the active AC inputs and the associated measurement apparatus inputs.

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

- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC Benchmark 1/Energy™ Specification.

- The Full Disclosure Report *(FDR)* met all of the requirements in Clauses 9 and 11 of the SPC Benchmark 1/Energy™ Specification.

- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,

Walter E. Baker

Walter E. Baker
SPC Auditor

Storage Performance Council
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LETTER OF GOOD FAITH

NetApp™

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  +1 408 822 4501 Fax   495 East Java Drive
  Sunnyvale, CA 94089

November 9, 2010

From:
Stephen Daniel
7301 Kit Creek Road
Building 1
Research Triangle Park, NC 27709

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

Subject: SPC-1E Letter of Good Faith for the NetApp FAS3270

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

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-1E benchmark specification.

Sincerely,

Daniel Morgan
Senior Director
Virtualization & Enterprise Applications Engineering

Date:

11/9/2010
Date of signature

Legal Reference

SPC BENCHMARK 1/ENERGY™ V1.12   FULL DISCLOSURE REPORT   Submission Identifier: AE00004
NetApp, Inc.   Submitted for Review: NOVEMBER 9, 2010
NetApp FAS3270A

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	NetApp, Inc. – http://www.netapp.com Stephen Daniel – daniel@netapp.com 7301 Kit Creek Road Building 1 Research Triangle Park, NC 27709 Phone: (919) 395-7099 FAX: (919) 476-4272
Test Sponsor Alternate Contact	NetApp, Inc. – http://www.netapp.com Bhavik Desai – bhavik@netapp.com 7301 Kit Creek Road Building 1 Research Triangle Park, NC 27709 Phone: (919) 476-5095 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	V1.12
SPC-1 Workload Generator revision number	V2.1.0
Date Results were first used publicly	November 9, 2010
Date the FDR was submitted to the SPC	November 9, 2010
Date the priced storage configuration is available for shipment to customers	November 9, 2010
Date the TSC completed audit certification	November 8, 2010

Tested Storage Product (TSP) Description

The NetApp(R) FAS3270 is the highest performing mid-range platform, with enhanced scalability and flexibility options, in the new FAS3200 family of storage systems with NetApp's unified storage architecture. The FAS3200 series 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. With the FAS3200 series and Data ONTAP 8.0.1 you can efficiently consolidate SAN, NAS, primary, and secondary storage on a single platform. Data ONTAP 8.0.1 is designed to provide customers with the next generation of features and functionality to ensure they are able to meet the demands of growing workloads. NetApp has designed systems to make them easy for you to install, configure, manage, and upgrade so you can quickly adapt your storage infrastructure to meet your changing business needs. Data center resources can be better utilized-by taking advantage of a comprehensive set of storage-saving software features in Data ONTAP like Deduplication and Thin Provisioning (FlexVols).

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: NetApp FAS3270A	
Metric	**Reported Result**
SPC-1 IOPS™	68,034.63
SPC-1 Price-Performance	$7.48/SPC-1 IOPS™
Total ASU Capacity	21,659.386 GB
Data Protection Level	Protected *(RAID DP™)*
Total TSC Price (including three-year maintenance)	$509,200.79

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

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

A **Data Protection Level** of **Protected** using 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, Relationships, and Utilization

The following diagram and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.
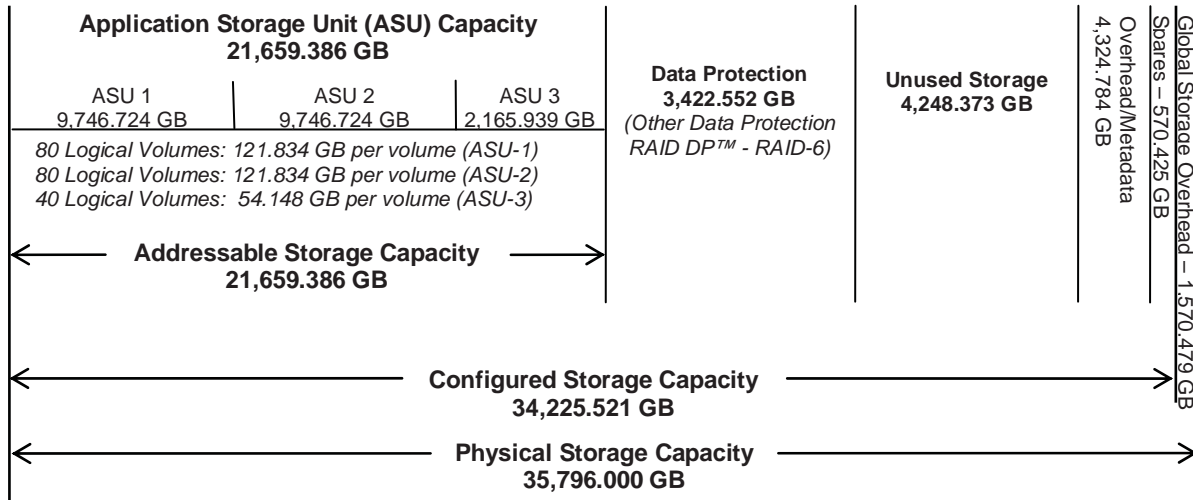
SPC-1 Storage Capacity Utilization	
Application Utilization	60.51%
Protected Application Utilization	70.07%
Unused Storage Ratio	11.87%

Application Utilization: Total ASU Capacity *21,659.386 GB)* divided by Physical Storage Capacity *(35,796.000 GB)*

Protected Application Utilization: (Total ASU Capacity *(21,659.386 GB)* plus total Data Protection Capacity *(3,422.552 GB)* minus unused Data Protection Capacity *(0.000 GB)* divided by Physical Storage Capacity *(35,796.000 GB)*

Unused Storage Ratio: Total Unused Capacity *(4,248.373 GB)* divided by Physical Storage Capacity *(35,796.000 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 25-26 in the Full Disclosure Report.

Response Time – Throughput Curve

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

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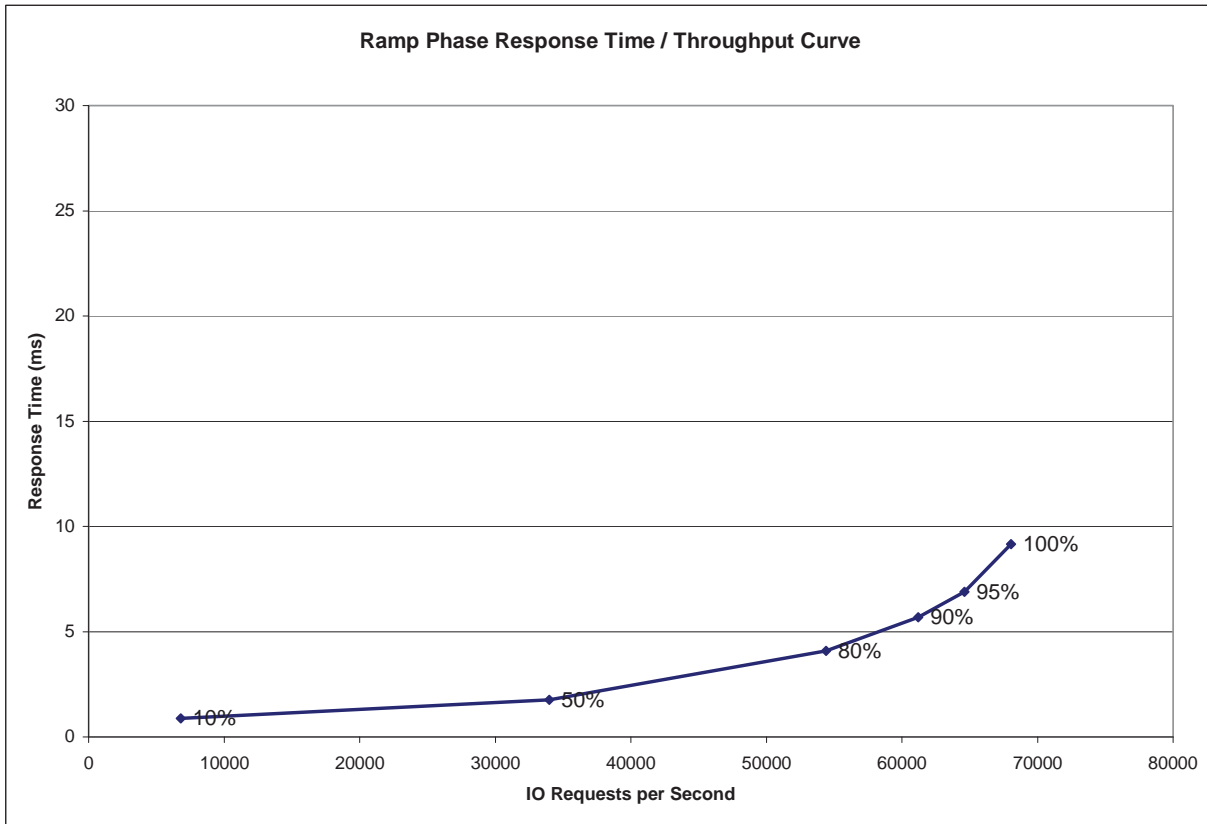
Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	6,806.31	33,998.92	54,395.92	61,212.00	64,599.52	68,034.63
Average Response Time (ms):						
All ASUs	0.88	1.75	4.09	5.68	6.88	9.16
ASU-1	0.88	1.80	4.36	6.13	7.54	10.24
ASU-2	1.43	3.00	6.29	8.30	9.58	11.89
ASU-3	0.65	1.09	2.56	3.56	4.32	5.66
Reads	1.25	2.73	6.24	8.50	10.19	13.38
Writes	0.65	1.11	2.69	3.84	4.73	6.41

SPC-1/E Reported Data

The initial SPC-1/E energy extension temperature, recorded during the first one minute of the Idle Test was 73.0F. The final SPC-1/E energy extension temperature, recorded during the last one minute of the Primary Metrics Test was 72.7F.

Power Environment

Average RMS Voltage:	208.28	Average Power Factor:	0.935

Usage Profile

	Hours of Use per Day			Nominal Power, W	Nominal Traffic, IOPS	Nominal IOPS/W	Nominal Heat, BTU/hr
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	2735.29	11332.97	4.14	9,333.07
Medium Daily Usage:	4	14	6	2755.83	28898.69	10.49	9,403.16
High Daily Usage:	18	6	0	2808.15	49296.67	17.55	9,581.67

	Composite Metrics:	2,766.42	29,842.78	10.79

Annual Energy Use, kWh:	24,233.84		
Energy Cost, $/kWh:	$ 0.12	Annual Energy Cost, $:	$ 2,908.06

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

HEAVY SPC-1 Workload: 2,828.83W at 80% of maximum reported performance *(54,395.92 SPC-1 IOPS)*.

MODERATE SPC-1 Workload: 2,745.08W at 50% of maximum reported performance *(33,998.92 SPC-1 IOPS)*.

IDLE SPC-1 Workload: 2,729.89W at 0% of maximum reported performance *(0.00 SPC-1 IOPS)*.

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

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

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

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

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

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

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

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

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

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

SPC-1/E Power/Performance Profile

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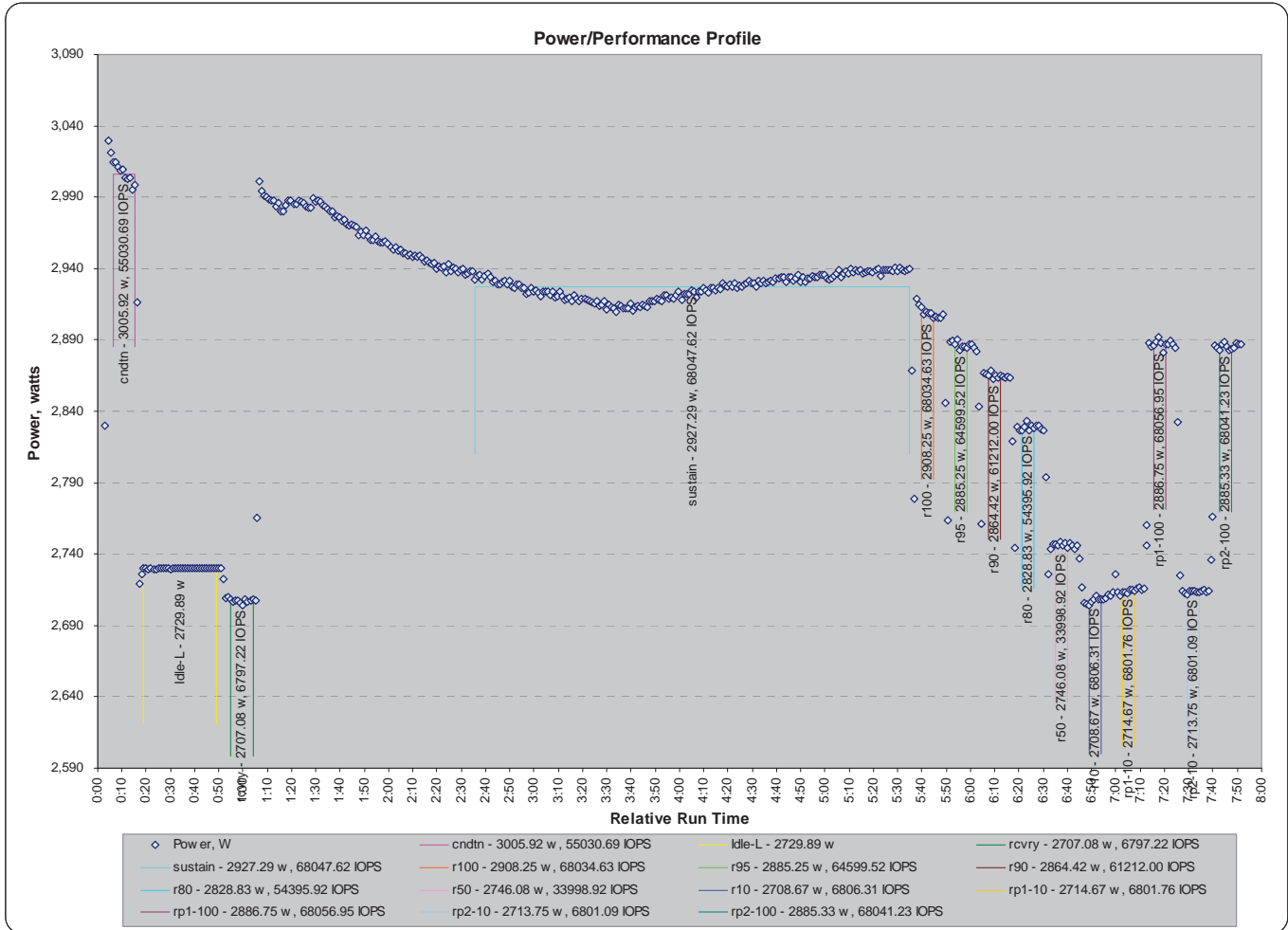
Priced Storage Configuration Pricing

Part Number	Description	Ext Qty	List Price	Disc %	Net Price	Ext Net Price
CS-A-INST-4R	SupportEdge Standard Replace 4hr, Hardware Support	1	$56,072.79	0	$0.00	$56,072.79
	Documents, 32xx,-C	1	$0.00	0	$0.00	$0.00
DS4243-1507-24S-R5-C	DSK SHLF, 24x300GB, 15K, 3Gb SAS, IOM3, -C, R5	5	$50,764.00	0	$50,764.00	$253,820.00
FAS-V32XX-CHASSIS-R6-C	FAS/V32XX, Chassis, AC PS, -C, R6	1	$0.00	0	$0.00	$0.00
FAS3270A-BASE-R6	FAS3270 HA System Dual Cntlr, includes SFPs and QSFPs	2	$42,000.00	0	$42,000.00	$84,000.00
SW-3270A-ONTAP8-C	SW, Standard Data ONTAP Features, 3270A, -C	2	$0	0	$0.00	$0.00
SW-3270A-PAMII-C	SW, PAMII, 3270AA, -C	2	$0	0	$0.00	$0.00
SW-FCP-C	SW, FCP, -C	2	$0.00	0	$0.00	$0.00
X-320-0008-R5-C	8-Pt Brocade 300 Full Fab FC 8Gbps, -C, R5, includes SFPs	2	$2,939.00	0	$2,939.00	$5,878.00
X1938A-R5-C	PAM II 512GB Perf Accel Module FLASH PCIe, -C	2	$49,000.00		$49,000.00	$98,000.00
X1089A-R6	HBA,QLogic QLE2462,2-Port,4Gb,PCIe,R6	2	$1,700.00	0	$1,700.00	$3,400.00
X6553-R6-C	Cable, Cntlr-Shelf/Switch, 2m, LC/LC, Op, -C	8	$125.00	0	$125.00	$1,000.00
X6557-R6-C	Cable, SAS Cntlr-Shelf/Shelf-Shelf/HA, 0.5m, -C	6	$0.00	0	$0.00	$0.00
X6558-R6-C	Cable, SAS Cntlr-Shelf/Shelf-Shelf/HA, 2m, -C	4	$125.00	0	$125.00	$500.00
X6559-R6-C	Cable, SAS Cntlr-Shelf/Shelf-Shelf/HA, 5m, -C	4	$170.00	0	$170.00	$680.00
X6560-R6-C	Cable, Ethernet, 0.5m RJ45 CAT6, -C	6	$0.00	0	$0.00	$0.00
X6561-R6-C	Cable, Ethernet, 2m RJ45 CAT6, -C	1	$0.00	0	$0.00	$0.00
X6562-R6-C	Cable, Ethernet, 5m RJ45 CAT6, -C	4	$0.00	0	$0.00	$0.00
X800-42U-R6-C	Cabinet Component Power Cable, -C, R6	26	$0.00	0	$0.00	$0.00
X8712C-R6-C	PDU, 1-Phase, 12 Outlet, 30A, NEMA, -C, R6	4	$550.00	0	$550.00	$2,200.00
X870C-R6-C	Cab, Deep, Empty, No PDU, No Rails, -C	1	$3,550.00	0	$3,550.00	$3,550.00
X8778-R6-C	Mounting Bracket, Tie-Down, 32X0, -C, R6	2	$50.00	0	$50.00	$100.00
X877B-R6-C	Rail Kit II, Cab, -C, R6	9	$0.00	0	$0.00	$0.00
SW-FAK-LINUX	FCP LINUX Host Utilities	1	$0.00	0	$0.00	$0.00
	Total					**$509,200.79**

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

- Acknowledgement of new and existing problems with four (4) hours.

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

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

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

Priced Storage Configuration Diagram

dual-port PCIe HBA

hba1 port2

hba1 port1

dual-port PCIe HBA

hba2 port2

hba2 port1

Brocade 300 switch

Brocade 300 switch

0c
Controller 1

0d
Controller 1

0c
Controller 2

0d
Controller 2

FAS3270
Controller 1

FAS3270
Controller 2

SAS ports 0a
and 0b
Controller 1

SAS ports 0a
and 0b
Controller 2

5 – DS4243 shelves *(SAS Stack)*

120 – 300 GB, 15K RPM disks
(24 disks per shelf)
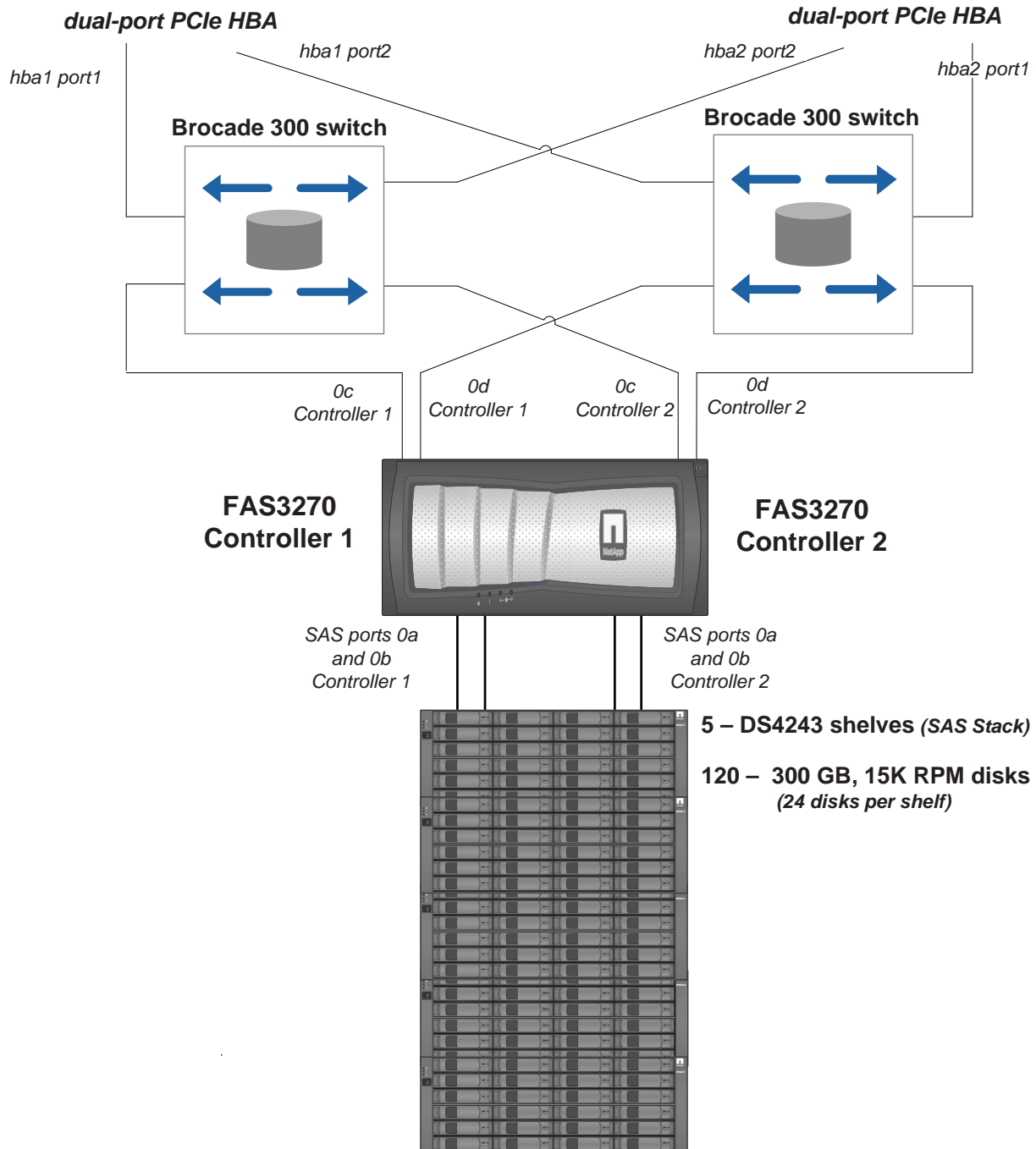
Priced Storage Configuration Components

Priced Storage Configuration
2 – Dual Port 4 Gb FC HBAs *(one per Host System)*

NetApp FAS3270A
  Single controller chassis with dual power supplies
  Dual Controllers each with:
       16 GB memory *(32 GB total)*
        6 MB L2 cache *(12 GB total)*
       512 GB FlashCache card *(1024 GB total)*
       2 FCP front-end connection *(4 total, 4 used)*
       2 SAS backend connections *(4 total, 4 used))*

Data ONTAP 8.0.1
2 – 16-port Brocade 300 FC 8 Gbps switches,   each switch licensed for 4 ports *(8 total)*
5 – DS4243 Disk Shelves
120 – 300 GB, 15K RPM SAS disk drives   24 disk drives per DS4243 Disk Shelf

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

CONFIGURATION INFORMATION

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

Clause 9.4.3.4.1

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

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page 22 *(Benchmark Configuration/Tested Storage Configuration Diagram)*.

Storage Network Configuration

Clause 9.4.3.4.1

…

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

Clause 9.4.3.4.2

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

The Tested Storage Configuration did not utilize network storage.

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

Clause 9.4.3.4.3

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

The Host System and Tested Storage Configuration (TSC) table of components is appears on page 23 *(Host Systems and Tested Storage Configuration Components)*.

Benchmark Configuration/Tested Storage Configuration Diagram

Fujitsu Primergy RX300 S5
Red Hat Enterprise Linux 5 Update 4
1 – dual-port PCIe HBA

Fujitsu Primergy RX300 S5
Red Hat Enterprise Linux 5 Update 4
1 – dual-port PCIe HBA

hba1 port2

hba2 port2

hba1 port1

hba2 port1

Brocade 300 switch

Brocade 300 switch

0c
Controller 1

0d
Controller 1

0c
Controller 2

0d
Controller 2

FAS3270
Controller 1

FAS3270
Controller 2

PDU1

SAS ports 0a
and 0b
Controller 1

SAS ports 0a
and 0b
Controller 2

5 – DS4243 shelves
(SAS Stack)

120 – 300 GB, 15K RPM disks
(24 disk per shelf)

PDU2

Power Cables:
4 per disk shelf
1 per controller
1 switch

Power Feed to
PDU1 and PDU2

Power Cables:
4 per disk shelf
1 switch

Power
Source

Yokogawa
WT230 Power
Meter

Host Systems and Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC)

2 – Fujitsu Primergy RX300 S5
    each with:
    1 – Intel Xeon quad-core X5550 processor
        2.66 GHz, SLC: 4x256 KB, TLC: 8 MB
	2 – Dual Port 4 Gb FC HBAs *(one per Host System)*

96 GB main memory per Host System	**NetApp FAS3270A**
	  Single controller chassis with dual power supplies
	  Dual Controllers each with:
	    16 GB memory *(32 GB total)*
	    6 MB L2 cache *(12 GB total)*
	    512 GB FlashCache card *(1024 GB total)*
	    2 FCP front-end connection *(4 total, 4 used)*
	    2 SAS backend connections *(4 total, 4 used)*

Red Hat Enterprise Linux 5 Update 4 (64-bit) kernel version: 2.6.18-164	
FCP Linux Host Utilities 5.2	
PCIe	Data ONTAP 8.0.1
Other BC components:	2 – 16-port Brocade 300 FC 8 Gbps switches, each switch licensed for 4 ports *(8 total)*
1 – Yokogawa WT230 Digital Power Meter	
2 – Power Distribution Units *(PDUs)*	5 – DS4243 Disk Shelves
	120 – 300 GB, 15K RPM SAS disk drives 24 disk drives per DS4243 Disk Shelf

Customer Tunable Parameters and Options

Clause 9.4.3.5.1

All Benchmark Configuration (BC) components with customer tunable parameter and options that have been altered from their default values must be listed in the FDR. The FDR entry for each of those components must include both the name of the component and the altered value of the parameter or option. If the parameter name is not self-explanatory to a knowledgeable practitioner, a brief description of the parameter's use must also be included in the FDR entry.

"Appendix B: Customer Tunable Parameters and Options" on page 64 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

Tested Storage Configuration (TSC) Description

Clause 9.4.3.5.2

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

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

"Appendix C: Tested Storage Configuration (TSC) Creation" on page 66 contains the detailed information that describes how to create and configure the logical TSC.

SPC-1 Workload Generator Storage Configuration

Clause 9.4.3.5.3

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

The SPC-1 Workload Generator storage configuration commands and parameters for this measurement appear in "Appendix D: SPC-1 Workload Generator Storage Commands and Parameters" on page 71.

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

Storage Capacities and Relationships

Clause 9.4.3.6.1

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

SPC-1 Storage Capacities

SPC-1 Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	21,659.386
Addressable Storage Capacity	Gigabytes (GB)	21,659.386
Configured Storage Capacity	Gigabytes (GB)	34,225.521
Physical Storage Capacity	Gigabytes (GB)	35.796.000
Data Protection _(RAID-6)_	Gigabytes (GB)	3,422.552
Required Storage _(metadata/overhead/spares)_	Gigabytes (GB)	4,895.210
Global Storage Overhead	Gigabytes (GB)	1,570.479
Total Unused Storage	Gigabytes (GB)	4,248.373

SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	63.28%	60.51%
Required for Data Protection _(RAID-6)_		10.00%	9.56%
Addressable Storage Capacity		63.28%	60.51%
Required Storage _(metadata/overhead/spares)_		14.30%	13.68%
Configured Storage Capacity			95.61%
Global Storage Overhead			4.39%
Unused Storage:			
Addressable	0.00%		
Configured		12.41%	
Physical			0.00%

The Physical Storage Capacity consisted of 35,796.000 GB distributed over 120 disk drives each with a formatted capacity of 298.300 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 1,570.479 GB (4.39%) of Physical Storage Capacity. There was 4,248.373 GB (12.41%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100.00% of the Addressable Storage Capacity resulting in 0.000 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(RAID-6)* capacity was 3,422.552 GB of which 3,422.552 GB was utilized. The total Unused Storage was 4,248.373 GB.

SPC-1 Storage Capacities and Relationships Illustration

The various storage capacities configured in the benchmark result are illustrated below (not to scale).
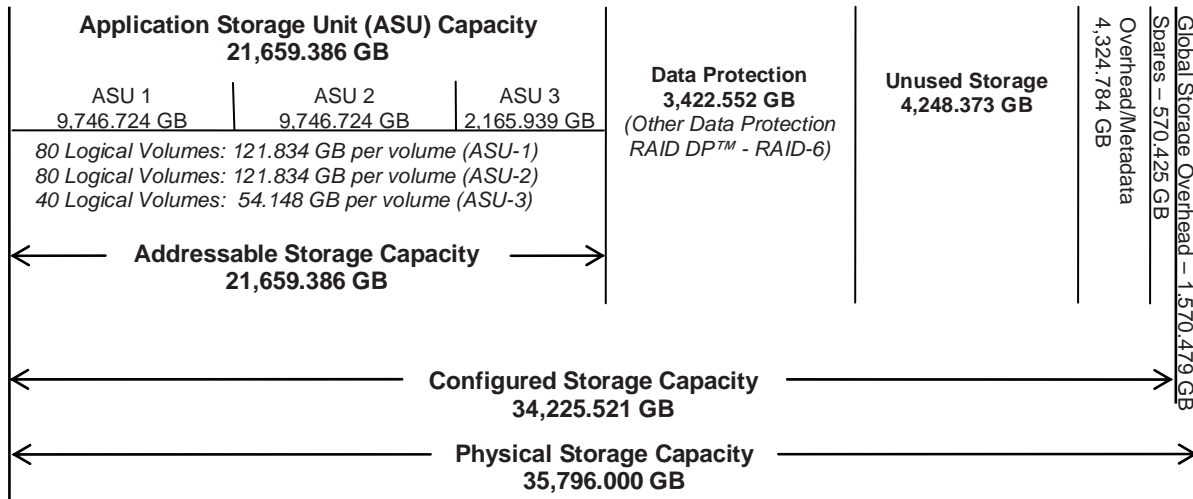
Logical Volume Capacity and ASU Mapping

Clause 9.4.3.6.3

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

Logical Volume Capacity and Mapping		
ASU-1 (9,746.724 GB)	**ASU-2 (9,746.724 GB)**	**ASU-3 (2,165.939 GB)**
80 Logical Volumes 121.834 GB per Logical Volume (121.834 GB used per Logical Volume)	80 Logical Volumes 121.834 GB per Logical Volume (121.834 GB used per Logical Volume)	40 Logical Volumes 54.148 GB per Logical Volume (54.148 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was **Protected** *(RAID-6)* as described on page 12. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

Storage Capacity Utilization

Clause 9.4.3.6.2

The FDR will include a table illustrating the storage capacity utilization values defined for Application Utilization (Clause 2.8.1), Protected Application Utilization (Clause 2.8.2), and Unused Storage Ratio (Clause 2.8.3).

Clause 2.8.1

Application Utilization is defined as Total ASU Capacity divided by Physical Storage Capacity.

Clause 2.8.2

Protected Application Utilization is defined as (Total ASU Capacity plus total Data Protection Capacity minus unused Data Protection Capacity) divided by Physical Storage Capacity.

Clause 2.8.3

Unused Storage Ratio is defined as Total Unused Capacity divided by Physical Storage Capacity and may not exceed 45%.

SPC-1 Storage Capacity Utilization	
Application Utilization	60.51%
Protected Application Utilization	70.07%
Unused Storage Ratio	11.87%

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 61 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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

SPC-1 Tests, Test Phases, and Test Runs

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

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

- **Repeatability Test**
  - Repeatability Test Phase 1
    - 10% of IOPS Test Run (LRT)
    - IOPS Test Run
  - Repeatability Test Phase 2
    - 10% of IOPS Test Run (LRT)
    - IOPS Test Run

- **Data Persistence Test**
  - Data Persistence Test Run 1
  - Data Persistence Test Run 2

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

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

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

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

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.4.3.7.1

For the Sustainability Test Phase the FDR shall contain:

1. *A Data Rate Distribution graph and data table.*
2. *I/O Request Throughput Distribution graph and data table.*
3. *A Response Time Frequency Distribution graph and table.*
4. *An Average Response Time Distribution graph and table.*
5. *The human readable Test Run Results File produced by the Workload Generator (may be included in an appendix).*
6. *A listing or screen image of all input parameters supplied to the Workload Generator (may be included in an appendix).*
7. *The Measured Intensity Multiplier for each I/O stream.*
8. *The variability of the Measured Intensity Multiplier, as defined in Clause 5.3.13.3.*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 82.

Sustainability Test Results File

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

Sustainability Test Results File

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

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

Sustainability Data Rate Table

Sustainability – Data Rate Distribution Graph
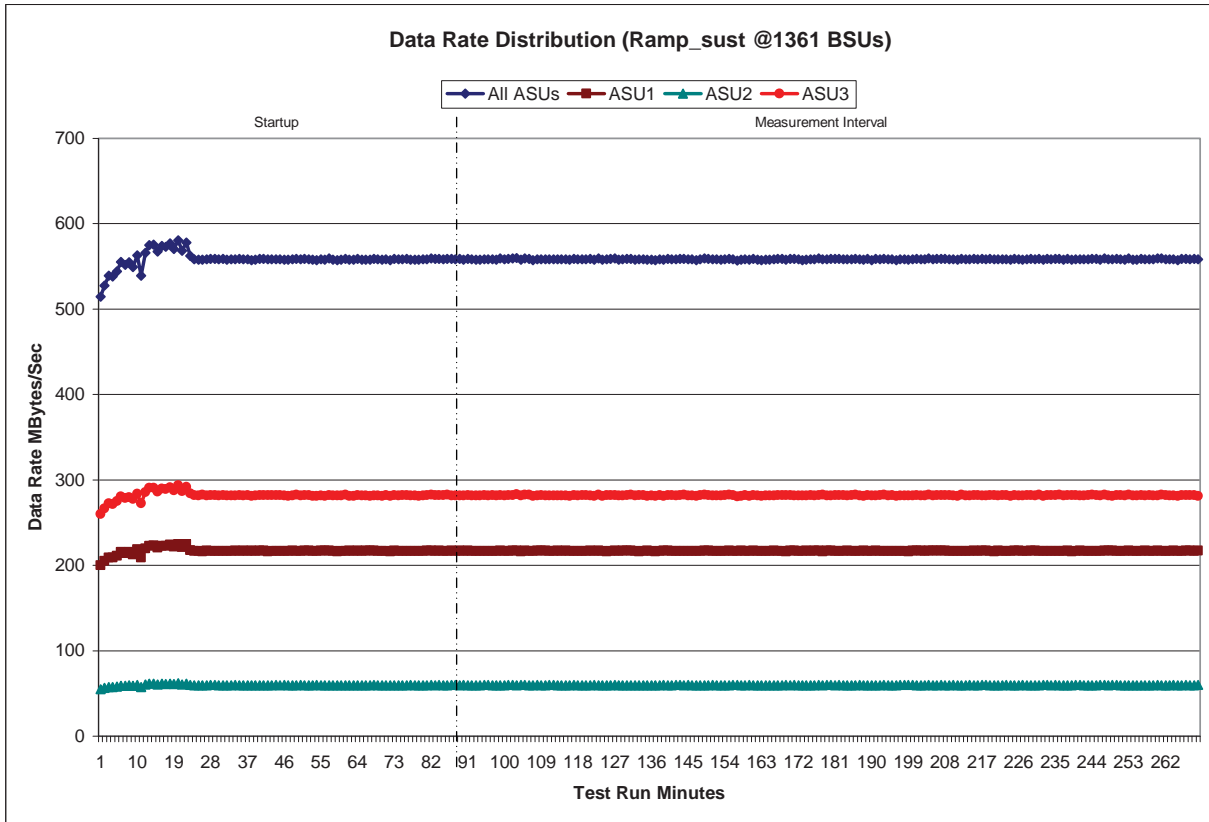
Sustainability – I/O Request Throughput Distribution Data

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

Sustainability I/O Request Throughput Table

Sustainability – I/O Request Throughput Distribution Graph
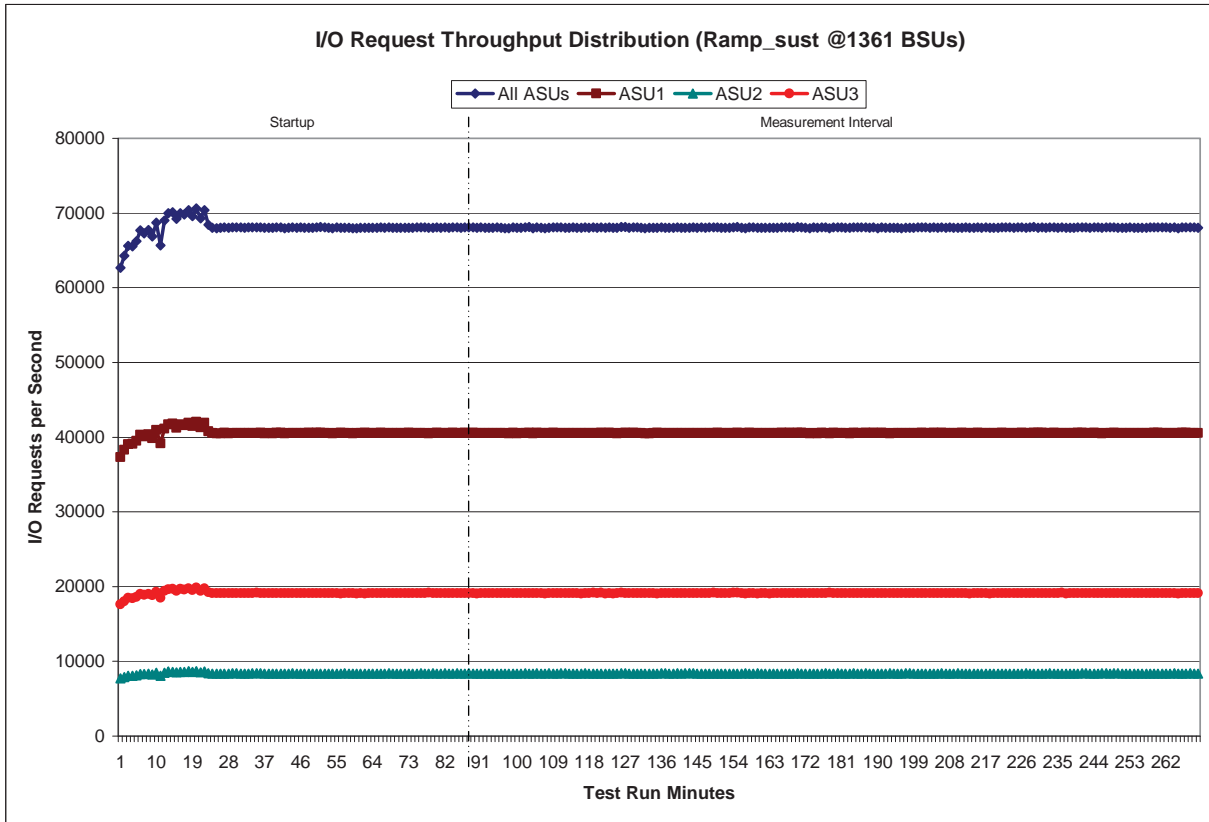
Sustainability – Average Response Time (ms) Distribution Data

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

Sustainability Average Response Time Table

Sustainability – Average Response Time (ms) Distribution Graph
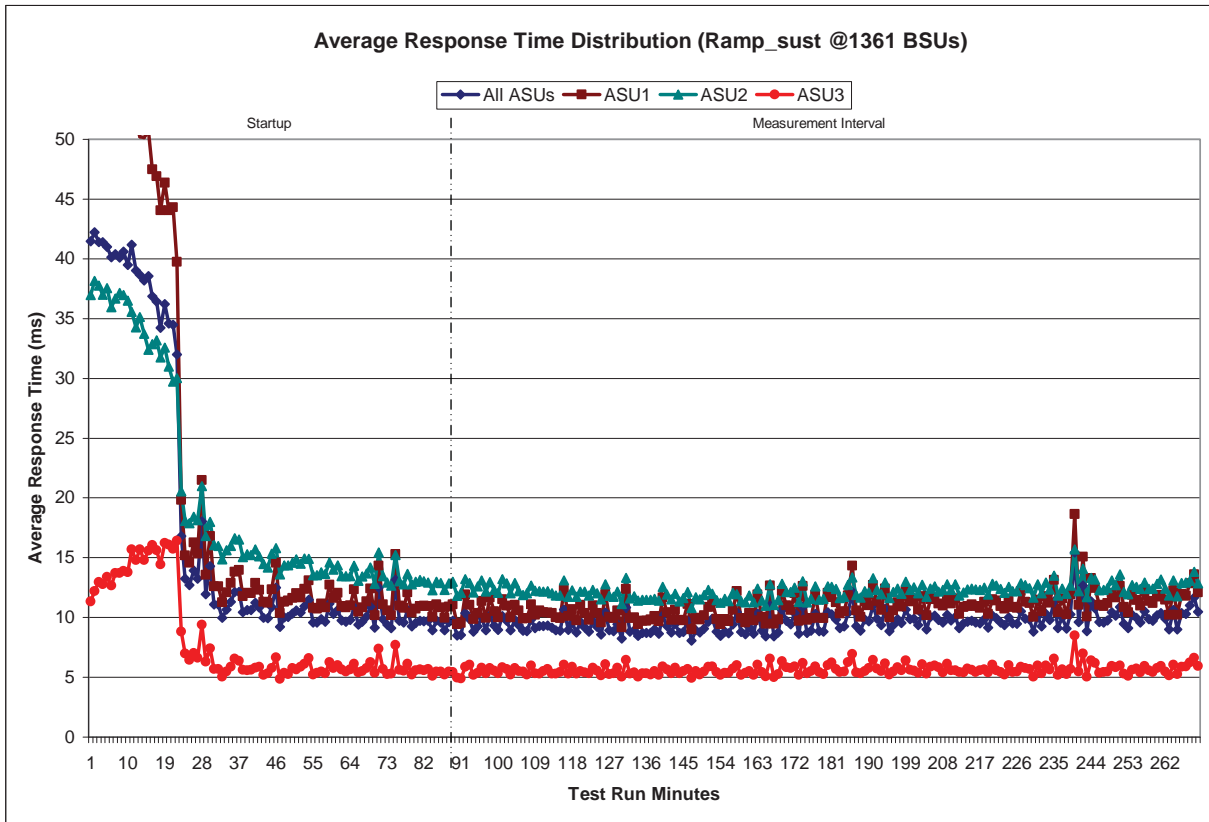
Sustainability – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	705,939	5,634,461	7,529,136	4,896,548	5,286,931	5,023,799	5,033,015	4,192,648
Write	368,416	13,728,653	18,862,501	13,685,535	16,475,075	17,900,308	18,908,654	15,775,541
All ASUs	1,074,355	19,363,114	26,391,637	18,582,083	21,762,006	22,924,107	23,941,669	19,968,189
ASU1	776,251	11,813,149	15,185,276	10,258,065	11,905,138	12,448,484	12,964,565	10,784,368
ASU2	179,325	2,080,492	2,670,313	1,910,479	2,219,494	2,311,104	2,389,072	1,972,883
ASU3	118,779	5,469,473	8,536,048	6,413,539	7,637,374	8,164,519	8,588,032	7,210,938

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	12,095,709	10,987,556	12,283,061	10,437,255	11,525,049	9,219,243	15,946,507	12,554,852
Write	44,255,971	37,389,666	34,319,071	23,772,756	21,571,326	14,708,464	22,239,064	16,754,245
All ASUs	56,351,680	48,377,222	46,602,132	34,210,011	33,096,375	23,927,707	38,185,571	29,309,097
ASU1	30,315,421	25,967,150	25,568,370	19,216,031	19,143,657	14,140,643	22,915,557	17,406,173
ASU2	5,422,413	4,569,924	4,429,000	3,299,786	3,278,292	2,478,734	4,222,533	3,530,152
ASU3	0	71,817	71,613	143,430	0	573,217	573,236	1,146,453

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	9,862,038	8,629,186	7,619,280	33,904,365	26,455,555	19,120,894	13,619,133	37,297,220
Write	13,977,342	12,839,414	11,033,914	37,092,967	16,524,391	7,682,980	4,219,985	10,968,176
All ASUs	23,839,380	21,468,600	18,653,194	70,997,332	42,979,946	26,803,874	17,839,118	48,265,396
ASU1	13,676,037	11,984,434	10,347,910	41,842,236	29,168,521	19,832,132	13,556,573	36,800,756
ASU2	3,036,348	2,834,760	2,555,743	10,605,013	7,119,461	4,790,371	3,358,340	9,135,409
ASU3	7,126,995	6,649,406	5,749,541	18,550,083	6,691,964	2,181,371	924,205	2,329,231

Sustainability – Response Time Frequency Distribution Graph
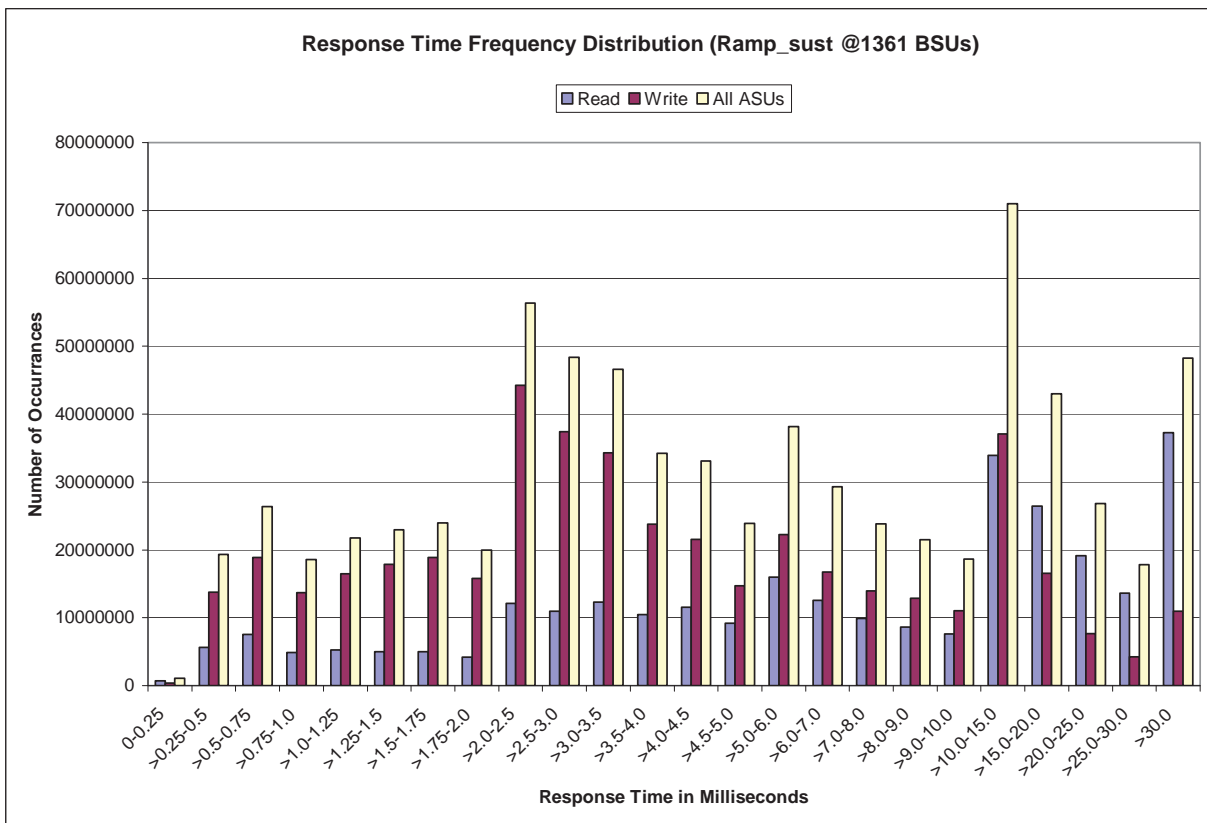
Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0-.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.002	0.001	0.004	0.002	0.002	0.001

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

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

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

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

Clause 9.4.3.7.2

For the IOPS Test Phase the FDR shall contain:

1. *I/O Request Throughput Distribution (data and graph).*
2. *A Response Time Frequency Distribution.*
3. *An Average Response Time Distribution.*
4. *The human readable Test Run Results File produced by the Workload Generator.*
5. *A listing or screen image of all input parameters supplied t 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 82.

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

1361 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:06:45	20:09:45	0-2	0:03:00
Measurement Interval	20:09:45	20:19:45	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	68,093.05	40,608.10	8,374.68	19,110.27
1	68,033.80	40,540.97	8,367.75	19,125.08
2	68,027.98	40,552.73	8,370.38	19,104.87
3	68,068.12	40,573.33	8,378.45	19,116.33
4	68,063.07	40,542.23	8,376.58	19,144.25
5	68,071.87	40,582.62	8,375.32	19,113.93
6	67,987.22	40,540.50	8,357.62	19,089.10
7	68,009.40	40,553.92	8,345.37	19,110.12
8	68,002.87	40,530.55	8,355.63	19,116.68
9	68,001.45	40,517.23	8,380.77	19,103.45
10	68,033.63	40,536.03	8,360.63	19,136.97
11	68,041.72	40,527.13	8,378.47	19,136.12
12	68,066.92	40,578.22	8,376.60	19,112.10
Average	*68,034.63*	*40,548.18*	*8,368.54*	*19,117.91*

IOPS Test Run – I/O Request Throughput Distribution Graph
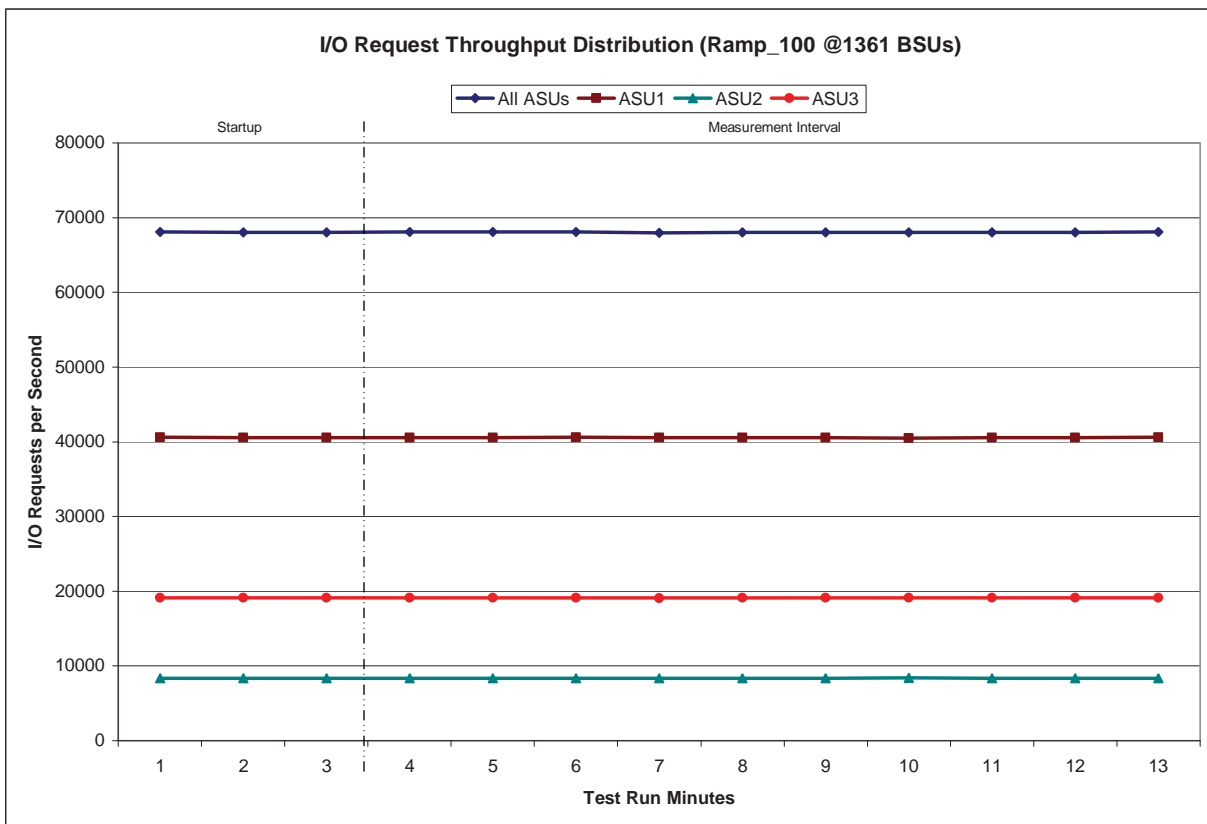
I/O Request Throughput Distribution (Ramp_100 @1361 BSUs)

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

1361 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:06:45	20:09:45	0-2	0:03:00
Measurement Interval	20:09:45	20:19:45	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9.51	10.79	12.06	5.67
1	8.24	9.13	11.19	5.06
2	9.68	10.92	12.30	5.91
3	8.42	9.33	11.22	5.26
4	9.18	10.22	12.00	5.75
5	10.25	11.54	12.79	6.40
6	8.14	9.04	11.11	4.95
7	8.96	9.97	11.64	5.64
8	8.67	9.64	11.58	5.33
9	8.94	9.97	11.70	5.53
10	8.84	9.84	11.75	5.43
11	9.24	10.39	12.05	5.59
12	10.92	12.45	13.04	6.74
Average	9.16	10.24	11.89	5.66

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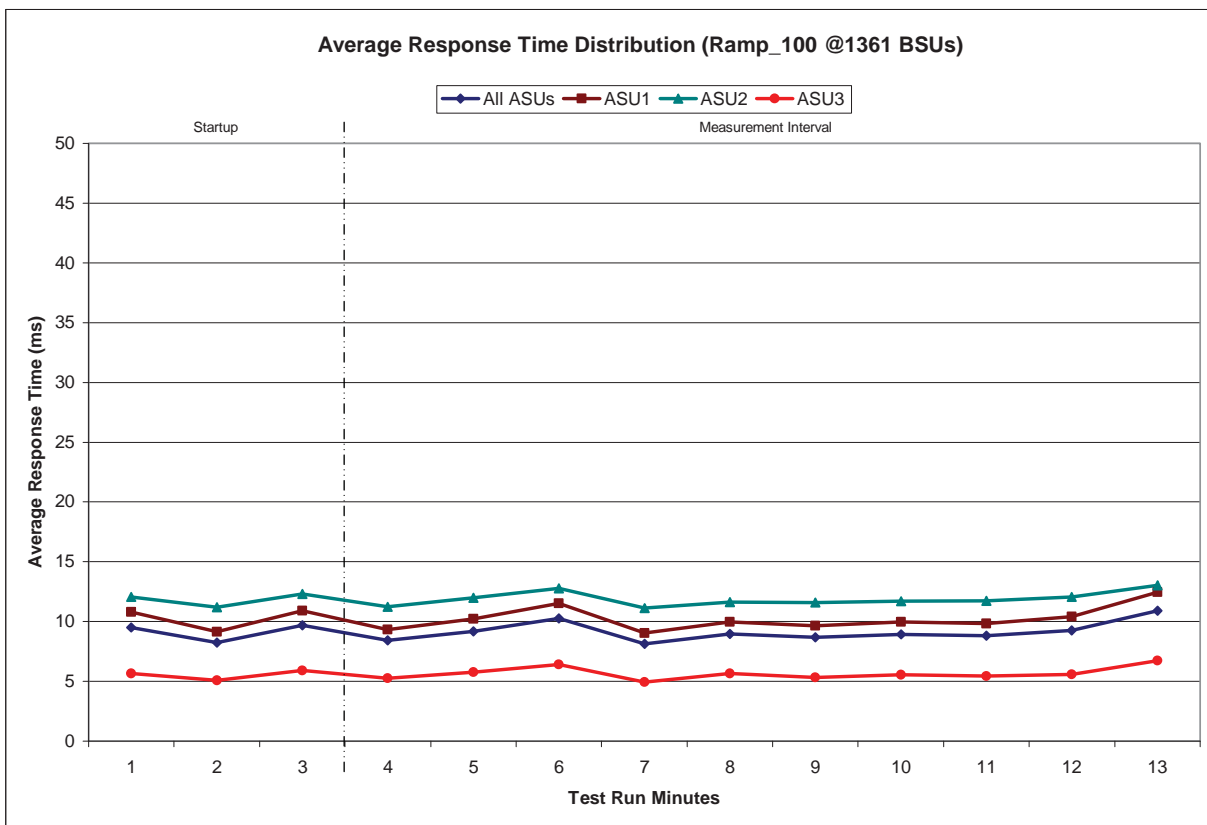
IOPS Test Run – Response Time Frequency Distribution Data

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	38,772	323,549	436,816	280,107	299,899	283,237	282,423	237,134
Write	20,807	764,335	1,030,685	743,299	892,549	968,812	1,019,005	863,921
All ASUs	59,579	1,087,884	1,467,501	1,023,406	1,192,448	1,252,049	1,301,428	1,101,055
ASU1	43,364	669,587	852,395	568,528	658,312	686,423	711,513	600,791
ASU2	9,519	113,470	145,428	103,776	119,222	124,098	128,003	107,589
ASU3	6,696	304,827	469,678	351,102	414,914	441,528	461,912	392,675

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	691,266	634,369	720,022	615,885	689,639	553,194	959,707	750,911
Write	2,449,818	2,094,387	1,954,283	1,357,238	1,233,427	835,677	1,262,052	940,572
All ASUs	3,141,084	2,728,756	2,674,305	1,973,123	1,923,066	1,388,871	2,221,759	1,691,483
ASU1	1,705,312	1,477,862	1,480,446	1,119,066	1,126,073	833,386	1,355,804	1,024,200
ASU2	298,790	254,823	251,030	188,149	187,698	141,519	243,930	202,567
ASU3	1,136,982	996,071	942,829	665,908	609,295	413,966	622,025	464,716

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	577,786	495,123	427,514	1,851,929	1,425,692	1,011,447	705,372	1,802,946
Write	775,860	710,384	611,535	2,048,504	915,594	420,892	228,468	583,031
All ASUs	1,353,646	1,205,507	1,039,049	3,900,433	2,341,286	1,432,339	933,840	2,385,977
ASU1	791,032	682,016	580,775	2,283,479	1,564,667	1,039,301	695,887	1,778,095
ASU2	171,972	160,399	144,070	599,755	402,744	267,952	184,080	470,416
ASU3	390,642	363,092	314,204	1,017,199	373,875	125,086	53,873	137,466

IOPS Test Run –Response Time Frequency Distribution Graph
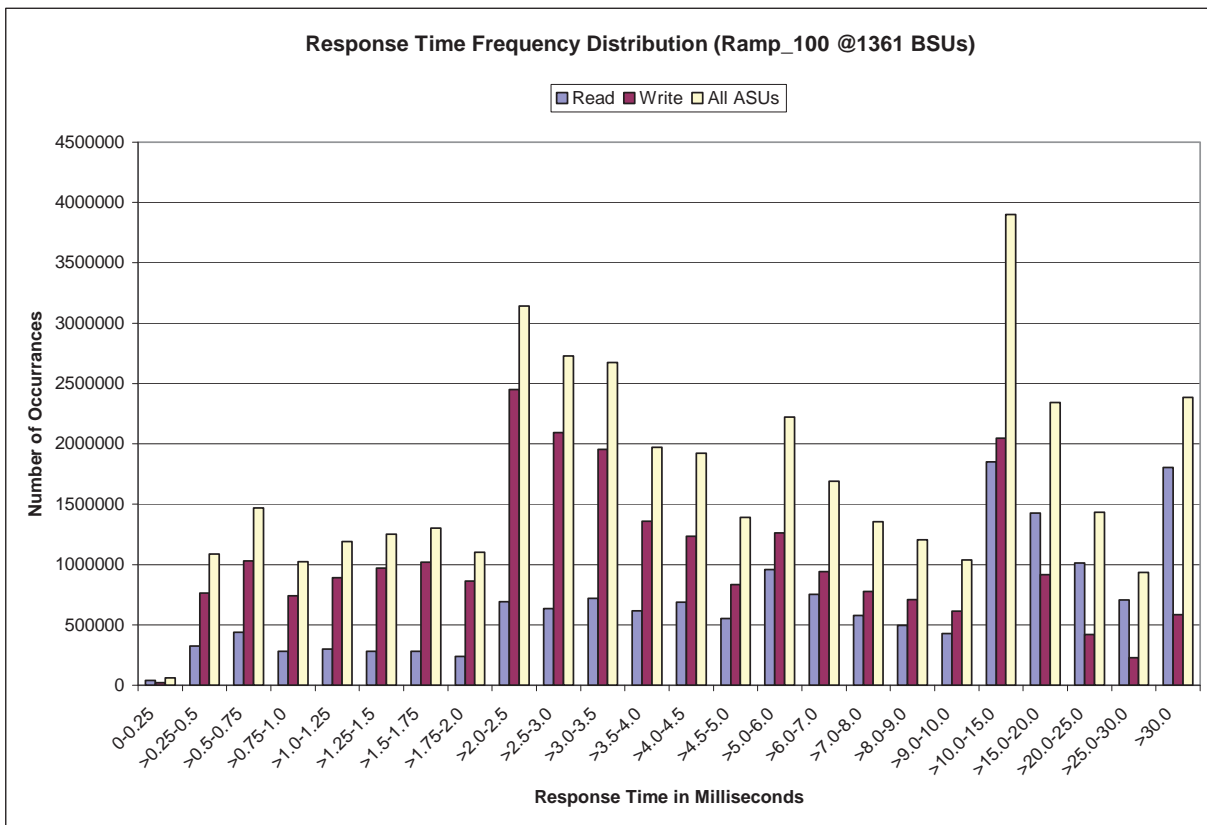
IOPS Test Run – I/O Request Information

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
40,819,874	38,433,897	2,385,977

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2809	0.0700	0.2101	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.001	0.001	0.004	0.002	0.003	0.001

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.4.3

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

The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 14.

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

Clause 9.4.3.7.3

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 82.

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 - 1361 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:06:45	20:09:45	0-2	0:03:00
Measurement Interval	20:09:45	20:19:45	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	68,093.05	40,608.10	8,374.68	19,110.27
1	68,033.80	40,540.97	8,367.75	19,125.08
2	68,027.98	40,552.73	8,370.38	19,104.87
3	68,068.12	40,573.33	8,378.45	19,116.33
4	68,063.07	40,542.23	8,376.58	19,144.25
5	68,071.87	40,582.62	8,375.32	19,113.93
6	67,987.22	40,540.50	8,357.62	19,089.10
7	68,009.40	40,553.92	8,345.37	19,110.12
8	68,002.87	40,530.55	8,355.63	19,116.68
9	68,001.45	40,517.23	8,380.77	19,103.45
10	68,033.63	40,536.03	8,360.63	19,136.97
11	68,041.72	40,527.13	8,378.47	19,136.12
12	68,066.92	40,578.22	8,376.60	19,112.10
Average	68,034.63	40,548.18	8,368.54	19,117.91

95% Load Level - 1292 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:20:33	20:23:33	0-2	0:03:00
Measurement Interval	20:23:33	20:33:33	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	64,627.65	38,505.62	7,959.48	18,162.55
1	64,603.43	38,526.65	7,950.28	18,126.50
2	64,633.93	38,545.73	7,943.50	18,144.70
3	64,628.55	38,480.57	7,977.13	18,170.85
4	64,617.50	38,494.80	7,928.57	18,194.13
5	64,573.03	38,496.28	7,930.50	18,146.25
6	64,628.95	38,529.80	7,942.62	18,156.53
7	64,556.15	38,446.93	7,947.68	18,161.53
8	64,584.48	38,493.42	7,949.43	18,141.63
9	64,565.62	38,463.27	7,951.93	18,150.42
10	64,642.17	38,521.62	7,963.38	18,157.17
11	64,591.05	38,479.13	7,973.65	18,138.27
12	64,607.68	38,504.28	7,953.08	18,150.32
Average	64,599.52	38,491.01	7,951.80	18,156.71

90% Load Level - 1224 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:34:21	20:37:21	0-2	0:03:00
Measurement Interval	20:37:21	20:47:21	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	61,222.43	36,487.07	7,518.35	17,217.02
1	61,155.35	36,449.22	7,516.58	17,189.55
2	61,201.28	36,474.83	7,525.05	17,201.40
3	61,227.40	36,504.95	7,542.87	17,179.58
4	61,288.77	36,514.47	7,547.98	17,226.32
5	61,224.68	36,497.53	7,542.77	17,184.38
6	61,175.58	36,453.93	7,542.03	17,179.62
7	61,180.38	36,464.73	7,530.13	17,185.52
8	61,242.28	36,481.70	7,544.95	17,215.63
9	61,223.90	36,483.32	7,529.05	17,211.53
10	61,186.23	36,461.72	7,530.37	17,194.15
11	61,239.23	36,468.73	7,544.73	17,225.77
12	61,131.52	36,422.48	7,514.20	17,194.83
Average	61,212.00	36,475.36	7,536.91	17,199.73

80% Load Level - 1088 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:48:09	20:51:09	0-2	0:03:00
Measurement Interval	20:51:09	21:01:09	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	54,366.02	32,425.73	6,695.58	15,244.70
1	54,404.15	32,430.23	6,704.80	15,269.12
2	54,425.32	32,442.87	6,702.40	15,280.05
3	54,395.92	32,410.95	6,679.32	15,305.65
4	54,385.68	32,398.53	6,696.73	15,290.42
5	54,382.92	32,396.77	6,693.10	15,293.05
6	54,399.13	32,436.95	6,687.80	15,274.38
7	54,433.47	32,414.67	6,712.68	15,306.12
8	54,333.97	32,361.60	6,685.20	15,287.17
9	54,449.67	32,440.65	6,710.70	15,298.32
10	54,394.12	32,410.72	6,689.33	15,294.07
11	54,373.45	32,416.97	6,688.08	15,268.40
12	54,410.88	32,428.42	6,689.88	15,292.58
Average	54,395.92	32,411.62	6,693.28	15,291.02

50% Load Level - 680 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:01:56	21:04:56	0-2	0:03:00
Measurement Interval	21:04:56	21:14:56	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	34,012.22	20,249.75	4,185.75	9,576.72
1	33,982.27	20,253.77	4,182.82	9,545.68
2	34,005.62	20,274.18	4,170.58	9,560.85
3	33,998.87	20,259.80	4,180.73	9,558.33
4	34,013.90	20,278.67	4,181.78	9,553.45
5	33,992.22	20,259.02	4,188.63	9,544.57
6	34,011.87	20,287.73	4,174.55	9,549.58
7	33,928.50	20,222.37	4,163.72	9,542.42
8	34,046.80	20,304.73	4,188.98	9,553.08
9	33,996.83	20,276.25	4,172.72	9,547.87
10	33,992.15	20,257.57	4,196.07	9,538.52
11	33,963.40	20,247.83	4,167.37	9,548.20
12	34,044.65	20,294.48	4,177.63	9,572.53
Average	33,998.92	20,268.85	4,179.22	9,550.86

10% Load Level - 136 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:15:43	21:18:43	0-2	0:03:00
Measurement Interval	21:18:43	21:28:43	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	6,805.33	4,049.43	836.38	1,919.52
1	6,803.38	4,052.30	837.65	1,913.43
2	6,785.00	4,060.65	830.03	1,894.32
3	6,800.07	4,051.45	837.98	1,910.63
4	6,805.72	4,058.02	834.37	1,913.33
5	6,797.07	4,051.45	837.78	1,907.83
6	6,797.18	4,043.97	843.42	1,909.80
7	6,795.03	4,052.83	838.77	1,903.43
8	6,807.33	4,056.12	838.62	1,912.60
9	6,794.97	4,058.53	836.58	1,899.85
10	6,825.18	4,066.83	837.98	1,920.37
11	6,825.97	4,064.03	841.08	1,920.85
12	6,814.53	4,061.83	838.73	1,913.97
Average	6,806.31	4,056.51	838.53	1,911.27

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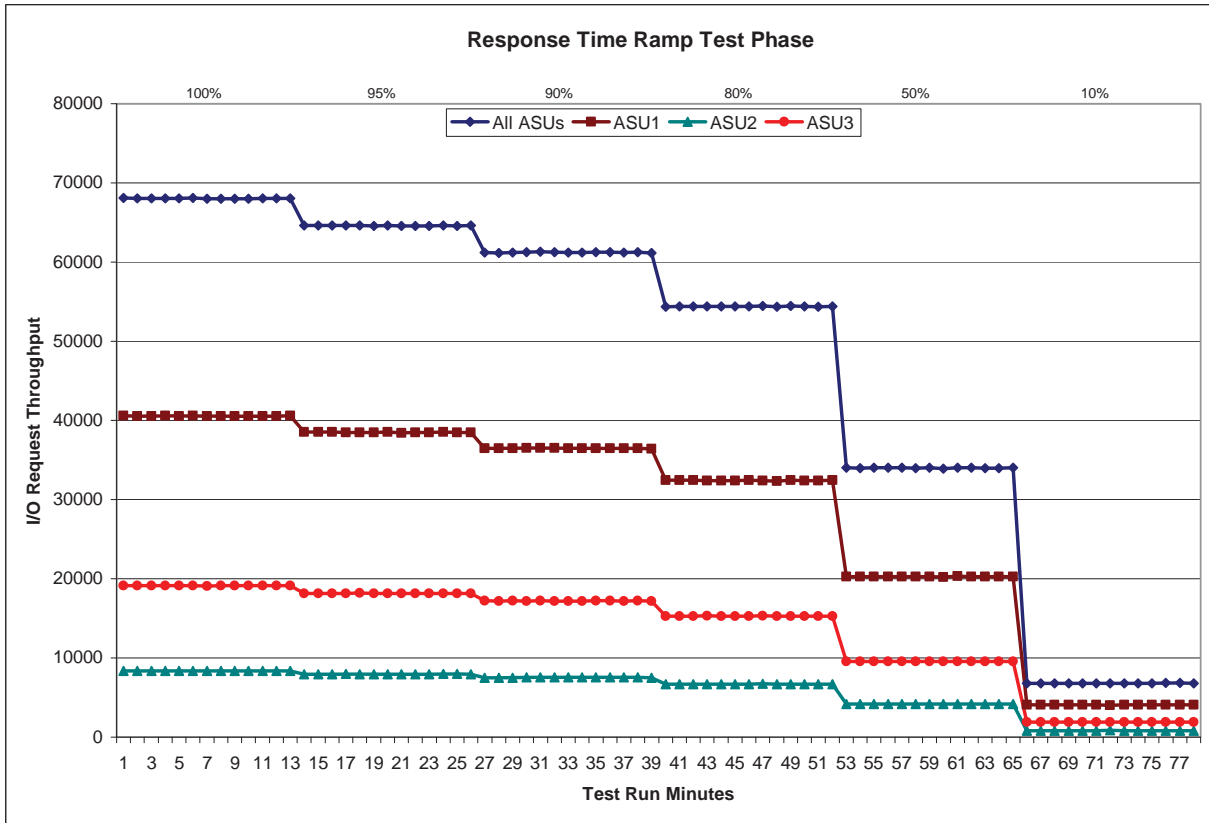
SPC-1 LRT™ Average Response Time (ms) Distribution Data

136 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:15:43	21:18:43	0-2	0:03:00
Measurement Interval	21:18:43	21:28:43	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.85	0.84	1.39	0.64
1	0.86	0.85	1.39	0.65
2	0.87	0.85	1.46	0.65
3	0.86	0.86	1.37	0.63
4	0.89	0.88	1.46	0.66
5	0.90	0.89	1.42	0.68
6	0.89	0.89	1.44	0.64
7	0.89	0.89	1.44	0.65
8	0.88	0.88	1.43	0.65
9	0.89	0.88	1.44	0.64
10	0.88	0.87	1.45	0.64
11	0.90	0.90	1.46	0.66
12	0.87	0.87	1.41	0.64
Average	*0.88*	*0.88*	*1.43*	*0.65*

SPC-1 LRT™ Average Response Time (ms) Distribution Graph
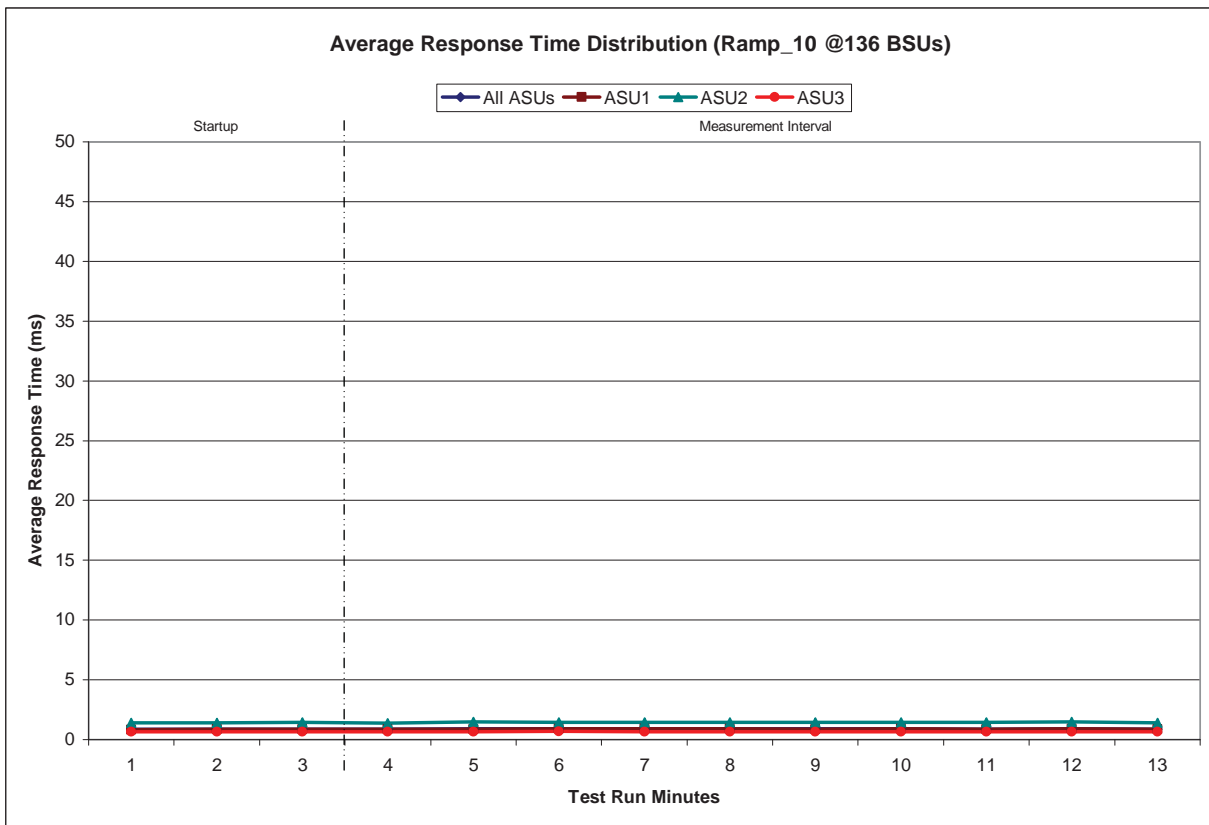
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0349	0.2811	0.0699	0.2100	0.0181	0.0701	0.0350	0.2808
COV	0.010	0.002	0.006	0.003	0.015	0.005	0.013	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% or less than the SPC-1 LRT™ metric plus one (1) millisecond (ms).

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

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

Clause 9.4.3.7.4

The following content shall appear in the FDR for each Test Run in the two Repeatability Test Phases:

1. _A table containing the results of the Repeatability Test._
2. _An I/O Request Throughput Distribution graph and table._
3. _An Average Response Time Distribution graph and table._
4. _The human readable Test Run Results File produced by the Workload Generator._
5. _A listing or screen image of all input parameters supplied to the Workload Generator._

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 82.

Repeatability Test Results File

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

	SPC-1 IOPS™
Primary Metrics	*68,034.63*
Repeatability Test Phase 1	68,056.95
Repeatability Test Phase 2	68,041.23

The SPC-1 IOPS™ values in the above table were generated using 100% of the specified Business Scaling Unit (BSU) load level. Each of the Repeatability Test Phase values for SPC-1 IOPS™ must greater than 95% of the reported SPC-1 IOPS™ Primary Metric.

	SPC-1 LRT™
Primary Metrics	*0.88 ms*
Repeatability Test Phase 1	0.89 ms
Repeatability Test Phase 2	0.91 ms

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

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

Repeatability Test Phase 1, Test Run 1 (LRT)
Repeatability Test Phase 1, Test Run 2 (IOPS)
Repeatability Test Phase 2, Test Run 1 (LRT)
Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

136 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:29:31	21:32:31	0-2	0:03:00
Measurement Interval	21:32:31	21:42:31	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	6,806.62	4,059.60	837.22	1,909.80
1	6,813.17	4,065.40	832.93	1,914.83
2	6,795.27	4,045.72	837.32	1,912.23
3	6,819.77	4,067.15	838.73	1,913.88
4	6,796.25	4,055.45	832.15	1,908.65
5	6,807.02	4,047.67	836.15	1,923.20
6	6,804.68	4,057.78	830.83	1,916.07
7	6,801.78	4,069.37	827.15	1,905.27
8	6,814.15	4,064.68	837.22	1,912.25
9	6,805.42	4,059.15	834.92	1,911.35
10	6,779.62	4,043.33	829.65	1,906.63
11	6,793.35	4,044.18	838.40	1,910.77
12	6,795.58	4,048.28	837.48	1,909.82
Average	*6,801.76*	*4,055.71*	*834.27*	*1,911.79*

Repeatability 1 LRT – I/O Request Throughput Distribution Graph
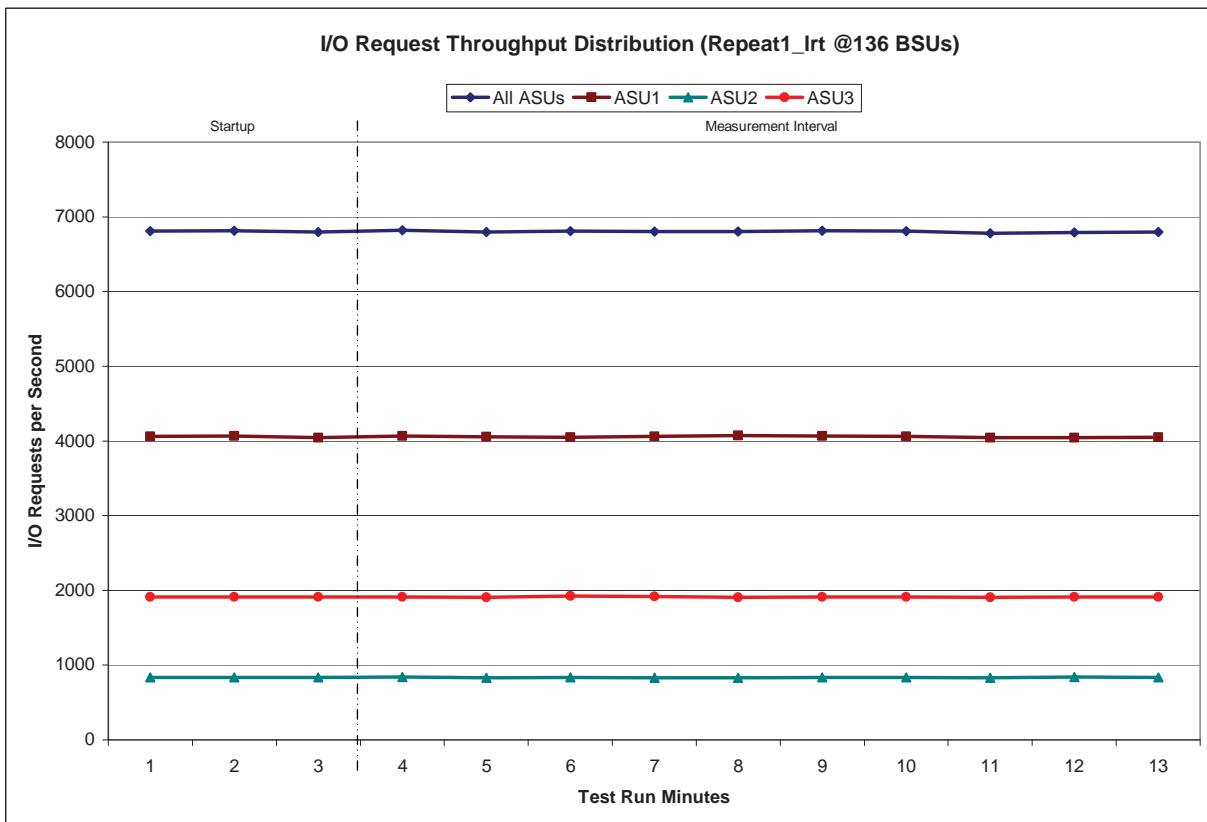
Repeatability 1 LRT –Average Response Time (ms) Distribution Data

136 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:29:31	21:32:31	0-2	0:03:00
Measurement Interval	21:32:31	21:42:31	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.88	0.85	1.53	0.66
1	0.86	0.83	1.49	0.64
2	0.87	0.85	1.45	0.65
3	0.86	0.83	1.47	0.65
4	0.88	0.86	1.48	0.65
5	0.88	0.86	1.49	0.65
6	0.90	0.89	1.49	0.67
7	0.88	0.87	1.48	0.64
8	0.88	0.87	1.50	0.64
9	0.92	0.91	1.53	0.68
10	0.88	0.86	1.50	0.64
11	0.88	0.87	1.50	0.64
12	0.90	0.89	1.53	0.66
Average	*0.89*	*0.87*	*1.50*	*0.65*

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

Repeatability 1 IOPS – I/O Request Throughput Distribution Data

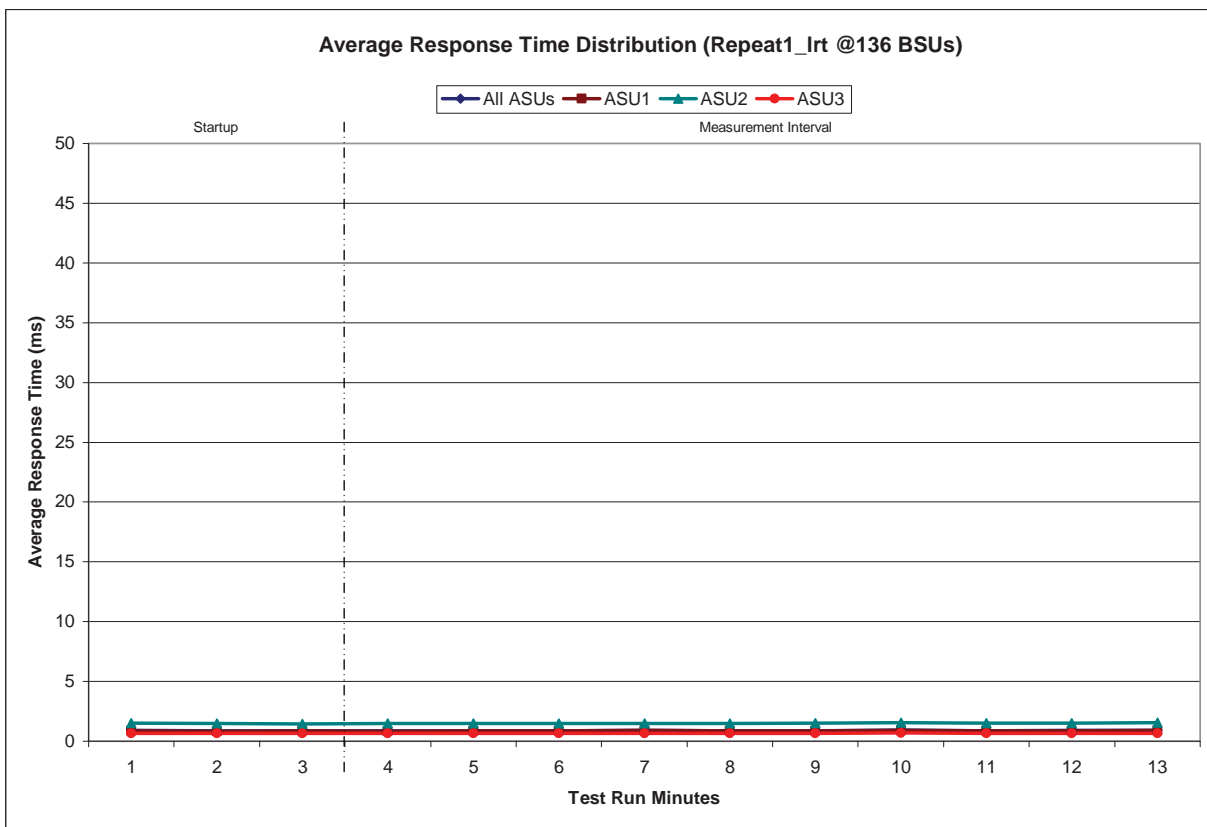| 1361 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:42:38	21:45:39	0-2	0:03:01
Measurement Interval	21:45:39	21:55:39	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	68,063.27	40,532.70	8,361.22	19,169.35
1	68,052.95	40,541.68	8,381.27	19,130.00
2	68,046.50	40,554.72	8,370.30	19,121.48
3	68,076.08	40,571.35	8,373.25	19,131.48
4	68,073.48	40,558.13	8,368.77	19,146.58
5	68,007.57	40,550.48	8,348.47	19,108.62
6	68,064.78	40,570.92	8,385.43	19,108.43
7	68,087.67	40,587.22	8,378.45	19,122.00
8	68,042.72	40,542.75	8,376.25	19,123.72
9	68,036.57	40,560.42	8,358.17	19,117.98
10	68,058.17	40,545.20	8,376.92	19,136.05
11	68,067.43	40,571.70	8,351.23	19,144.50
12	68,055.05	40,584.53	8,357.60	19,112.92
Average	*68,056.95*	*40,564.27*	*8,367.45*	*19,125.23*

Repeatability 1 IOPS – I/O Request Throughput Distribution Graph

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

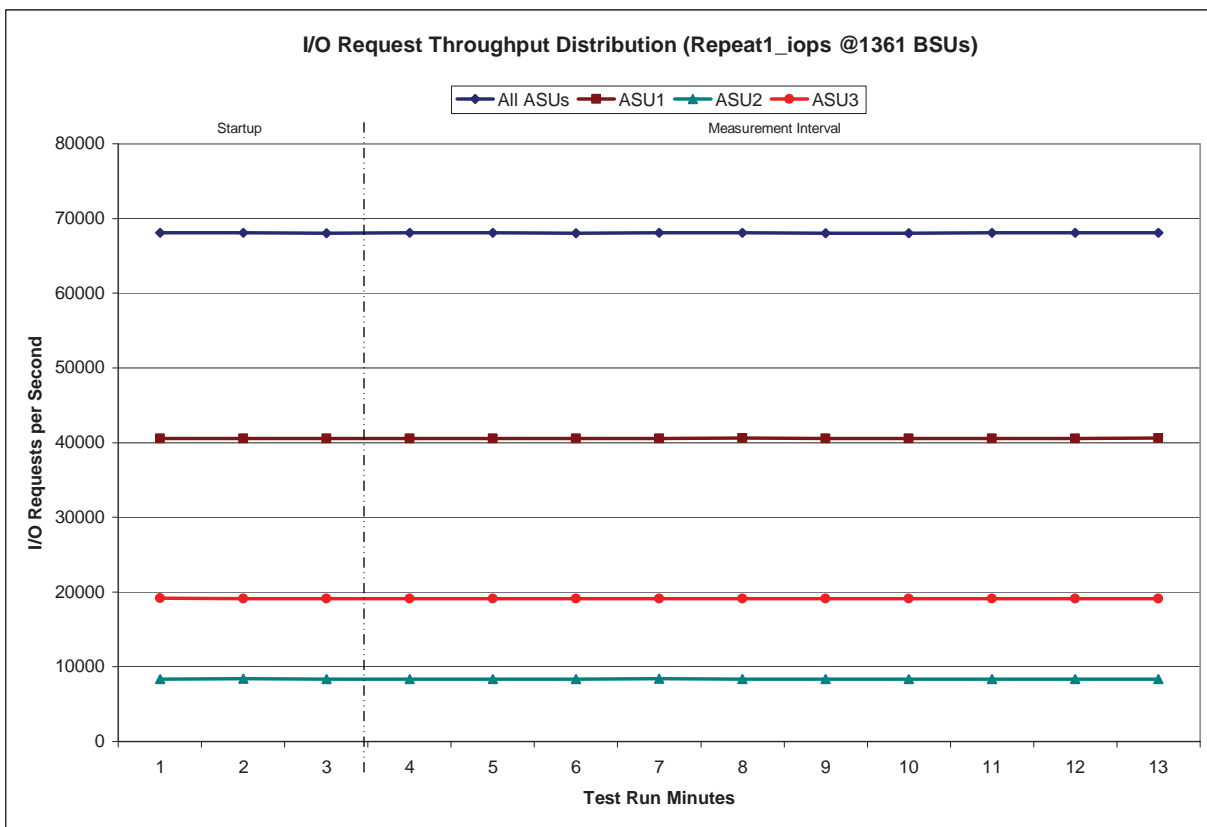| 1361 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:42:38	21:45:39	0-2	0:03:01
Measurement Interval	21:45:39	21:55:39	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	10.29	11.77	12.30	6.28
1	8.09	8.87	10.88	5.23
2	8.94	9.94	11.50	5.69
3	9.84	10.97	12.67	6.21
4	8.31	9.10	11.34	5.32
5	9.04	10.10	11.79	5.57
6	8.53	9.42	11.11	5.52
7	8.49	9.34	11.23	5.47
8	8.33	9.18	11.07	5.31
9	9.62	10.81	12.20	5.99
10	9.43	10.53	11.90	6.04
11	10.21	11.65	12.28	6.25
12	8.41	9.25	11.02	5.49
Average	*9.02*	*10.04*	*11.66*	*5.72*

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

Repeatability 2 LRT – I/O Request Throughput Distribution Data

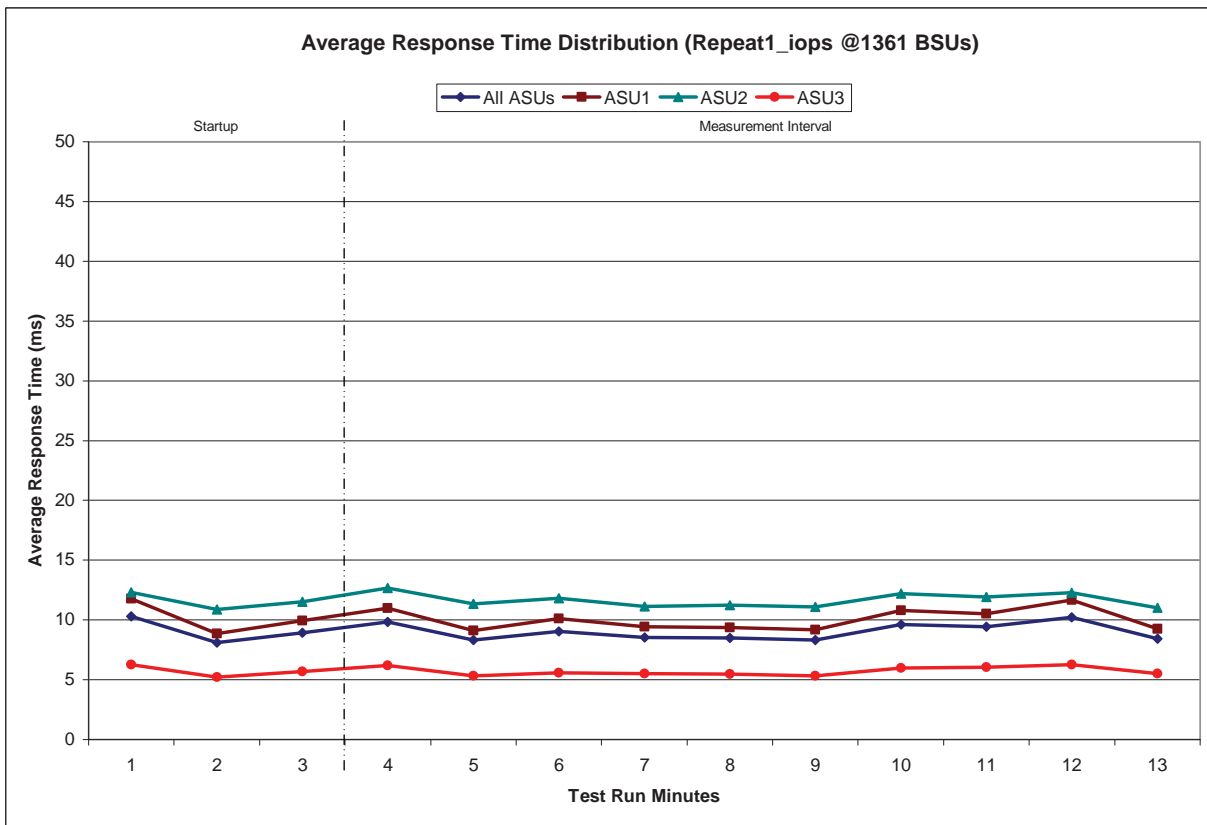| 136 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:56:28	21:59:28	0-2	0:03:00
Measurement Interval	21:59:28	22:09:28	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	6,795.77	4,060.72	826.30	1,908.75
1	6,795.33	4,041.37	841.30	1,912.67
2	6,809.95	4,049.60	843.05	1,917.30
3	6,802.95	4,060.05	840.17	1,902.73
4	6,804.50	4,062.50	833.73	1,908.27
5	6,802.20	4,053.83	836.90	1,911.47
6	6,796.30	4,054.43	835.30	1,906.57
7	6,810.05	4,061.77	827.85	1,920.43
8	6,799.33	4,050.92	837.57	1,910.85
9	6,787.57	4,031.43	840.80	1,915.33
10	6,806.68	4,062.35	841.62	1,902.72
11	6,808.18	4,058.47	839.57	1,910.15
12	6,793.17	4,037.33	836.77	1,919.07
Average	*6,801.09*	*4,053.31*	*837.03*	*1,910.76*

Repeatability 2 LRT – I/O Request Throughput Distribution Graph

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

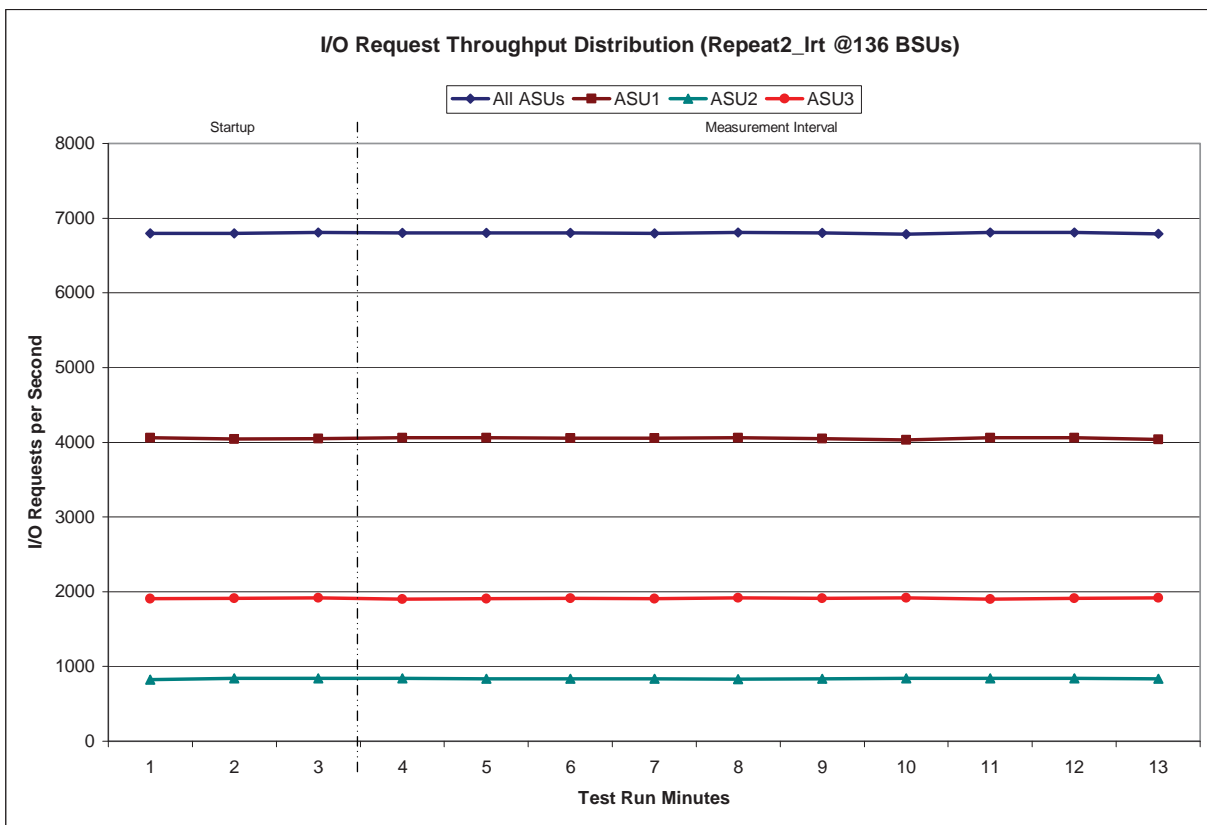| 136 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:56:28	21:59:28	0-2	0:03:00
Measurement Interval	21:59:28	22:09:28	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.87	0.86	1.46	0.65
1	0.88	0.87	1.44	0.63
2	0.86	0.86	1.45	0.63
3	0.91	0.89	1.56	0.66
4	0.89	0.88	1.51	0.63
5	0.90	0.90	1.53	0.64
6	0.94	0.93	1.53	0.68
7	0.90	0.90	1.56	0.63
8	0.93	0.93	1.53	0.65
9	0.90	0.90	1.52	0.64
10	0.91	0.91	1.53	0.65
11	0.91	0.90	1.56	0.64
12	0.90	0.89	1.53	0.65
Average	*0.91*	*0.90*	*1.53*	*0.65*

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

Repeatability 2 IOPS – I/O Request Throughput Distribution Data

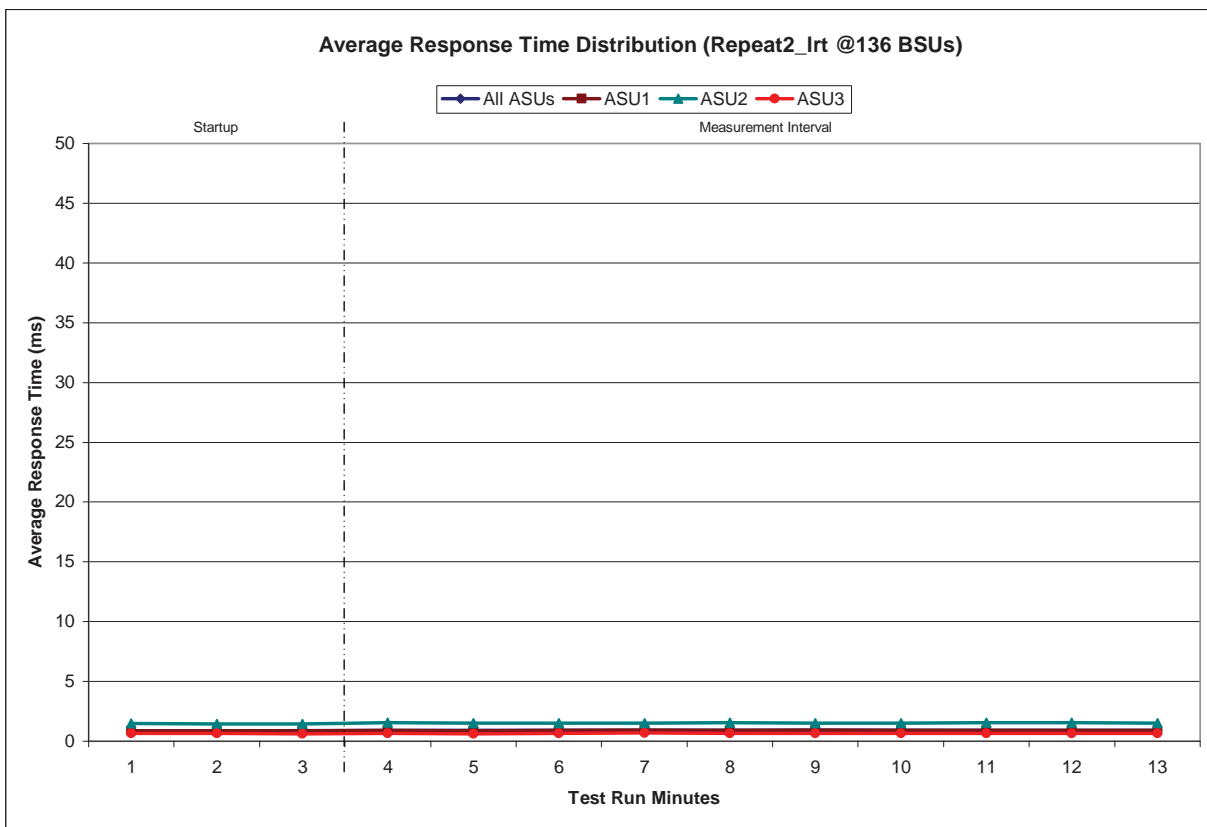| 1361 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:09:35	22:12:36	0-2	0:03:01
Measurement Interval	22:12:36	22:22:36	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	68,067.22	40,545.05	8,381.62	19,140.55
1	68,036.45	40,545.45	8,370.50	19,120.50
2	68,026.23	40,562.18	8,369.22	19,094.83
3	68,019.67	40,521.10	8,381.23	19,117.33
4	67,998.47	40,539.65	8,362.02	19,096.80
5	68,052.97	40,552.57	8,372.62	19,127.78
6	68,019.02	40,521.98	8,359.42	19,137.62
7	68,075.40	40,584.80	8,374.73	19,115.87
8	68,019.60	40,563.42	8,369.57	19,086.62
9	68,093.45	40,602.00	8,380.25	19,111.20
10	68,043.38	40,543.02	8,375.17	19,125.20
11	68,013.28	40,537.13	8,366.97	19,109.18
12	68,077.03	40,593.57	8,360.15	19,123.32
Average	*68,041.23*	*40,555.92*	*8,370.21*	*19,115.09*

Repeatability 2 IOPS – I/O Request Throughput Distribution Graph
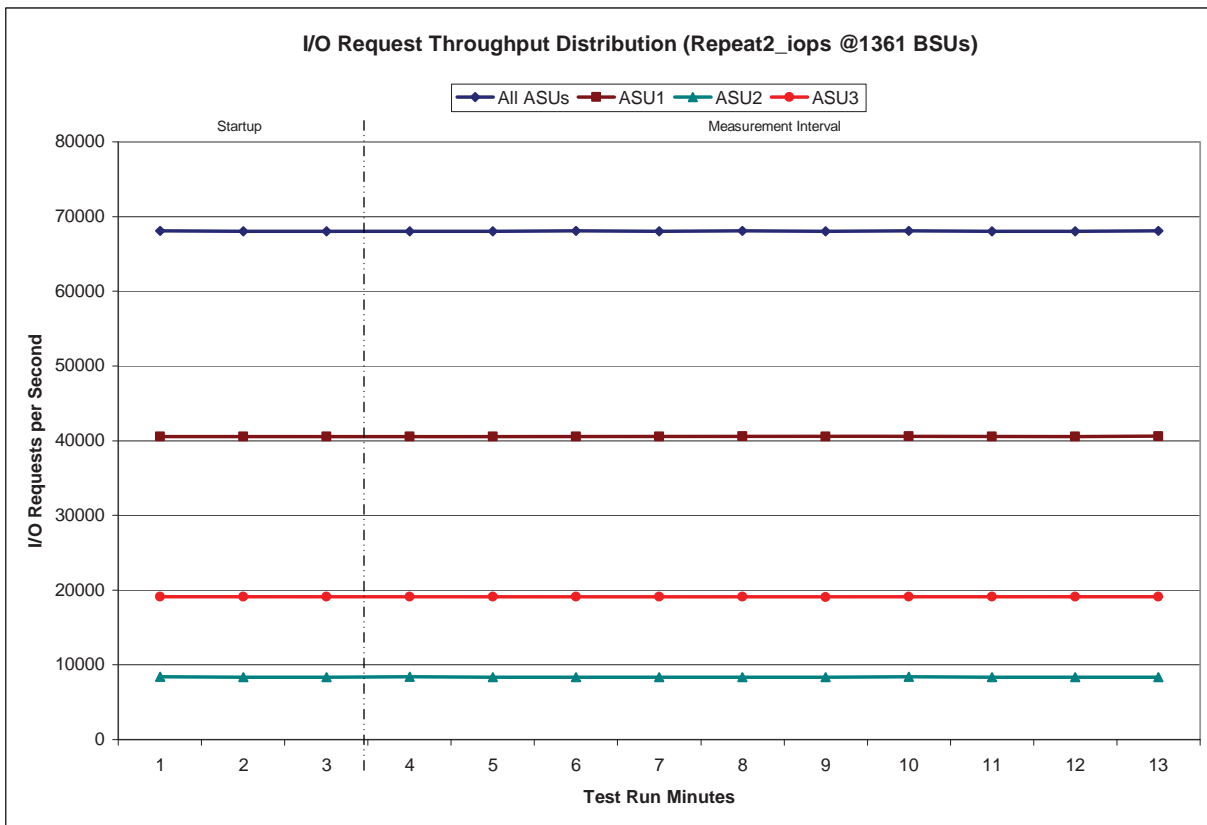
Repeatability 2 IOPS –Average Response Time (ms) Distribution Data

1361 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:09:35	22:12:36	0-2	0:03:01
Measurement Interval	22:12:36	22:22:36	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9.10	10.07	11.78	5.88
1	7.69	8.37	10.47	5.01
2	9.15	10.10	11.64	6.05
3	8.80	9.76	11.41	5.62
4	8.86	9.79	11.65	5.64
5	8.61	9.53	11.43	5.42
6	9.50	10.72	11.53	6.05
7	9.42	10.58	11.78	5.93
8	8.22	9.07	10.74	5.30
9	9.25	10.29	11.93	5.86
10	8.64	9.62	11.33	5.39
11	8.11	8.97	10.83	5.10
12	9.56	10.78	11.86	5.97
Average	*8.90*	*9.91*	*11.45*	*5.63*

Repeatability 2 IOPS –Average Response Time (ms) Distribution Graph
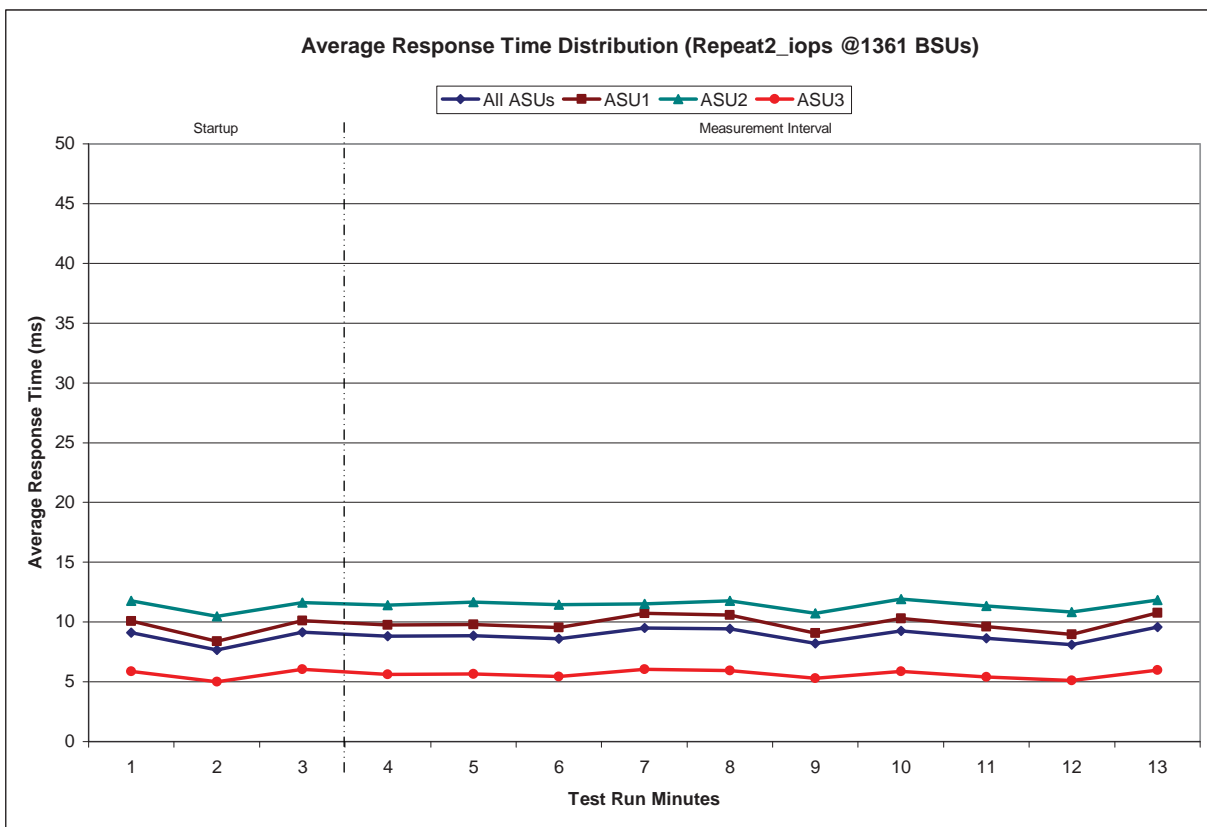
Repeatability 1 (LRT)
Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2812	0.0700	0.2100	0.0180	0.0698	0.0349	0.2811
COV	0.007	0.002	0.006	0.004	0.008	0.005	0.010	0.002

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	0.2101	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.002	0.001	0.004	0.002	0.004	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	0.0350	0.2811	0.0698	0.2100	0.0181	0.0701	0.0349	0.2809
COV	0.010	0.003	0.007	0.003	0.012	0.006	0.011	0.004

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2812	0.0700	0.2099	0.0180	0.0700	0.0350	0.2809
COV	0.002	0.001	0.001	0.001	0.004	0.002	0.004	0.001

Data Persistence Test

Clause 6

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

- *Is capable of maintaining data integrity across a power cycle.*

- *Ensures the transfer of data between Logical Volumes and host systems occurs without corruption or loss.*

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

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

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

Clause 9.4.3.8

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

1. *A listing or screen image of all input parameters supplied to the Workload Generator (may optionally be referenced in an appendix).*

2. *For the successful Data Persistence Test Run, a table illustrating key results. The content, appearance, and format of this table are specified in Table 9-16. Information displayed in this table shall be obtained from the Test Run Results File referenced below in #3.*

3. *For the successful Data Persistence Test Run, the human readable Test Run Results File produced by the Workload Generator.*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 82.

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	163,144,272
Total Number of Logical Blocks Verified	118,249,728
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in Bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 9.2.4.9

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

The NetApp FAS3270A as documented in this Full Disclosure Report will become available on November 9, 2010 for customer purchase and shipment.

PRICING INFORMATION

Clause 9.4.3.3.6

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

Pricing information may found in the Priced Storage Configuration Pricing section on page 15.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.7

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

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

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the NetApp FAS3270A .

APPENDIX A: SPC-1 GLOSSARY

"Decimal" *(powers of ten)* Measurement Units

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

A kilobyte (KB) is equal to 1,000 (10^3) bytes.

A megabyte (MB) is equal to 1,000,000 (10^6) bytes.

A gigabyte (GB) is equal to 1,000,000,000 (10^9) bytes.

A terabyte (TB) is equal to 1,000,000,000,000 (10^{12}) bytes.

A petabyte (PB) is equal to 1,000,000,000,000,000 (10^{15}) bytes

An exabyte (EB) is equal to 1,000,000,000,000,000,000 (10^{18}) bytes

"Binary" *(powers of two)* Measurement Units

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

A kibibyte (KiB) is equal to 1,024 (2^{10}) bytes.

A mebibyte (MiB) is equal to 1,048,576 (2^{20}) bytes.

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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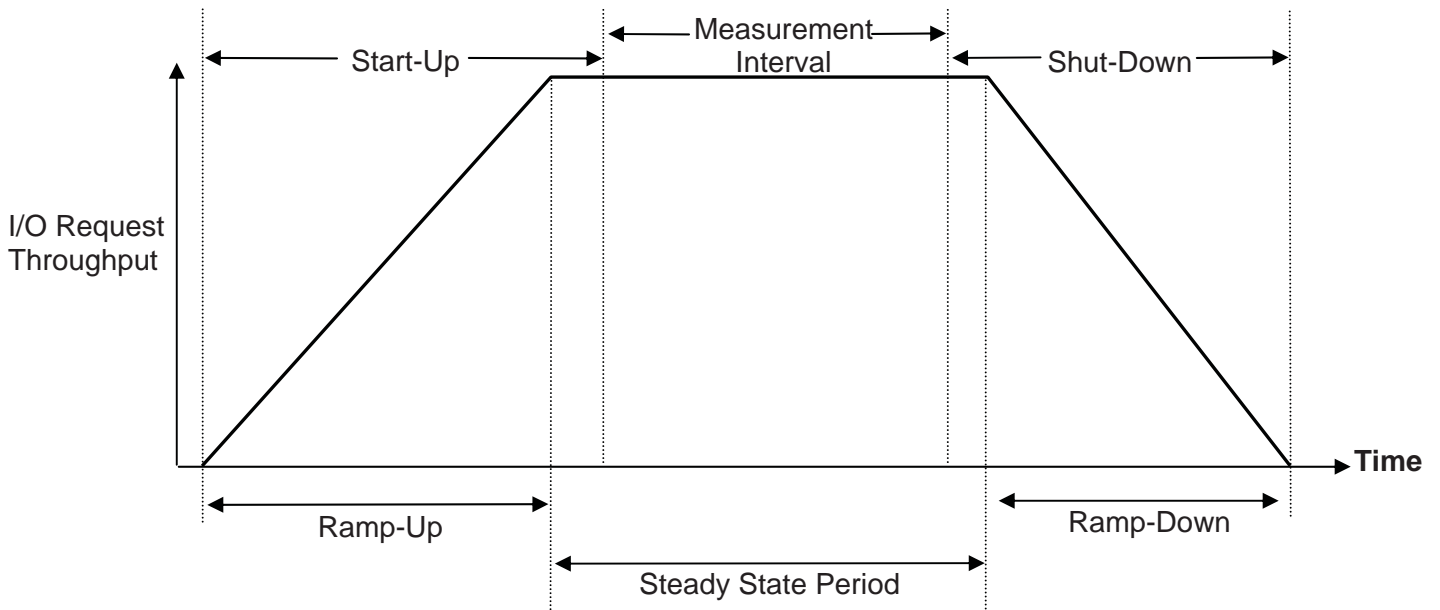
period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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

I/O Completion Types
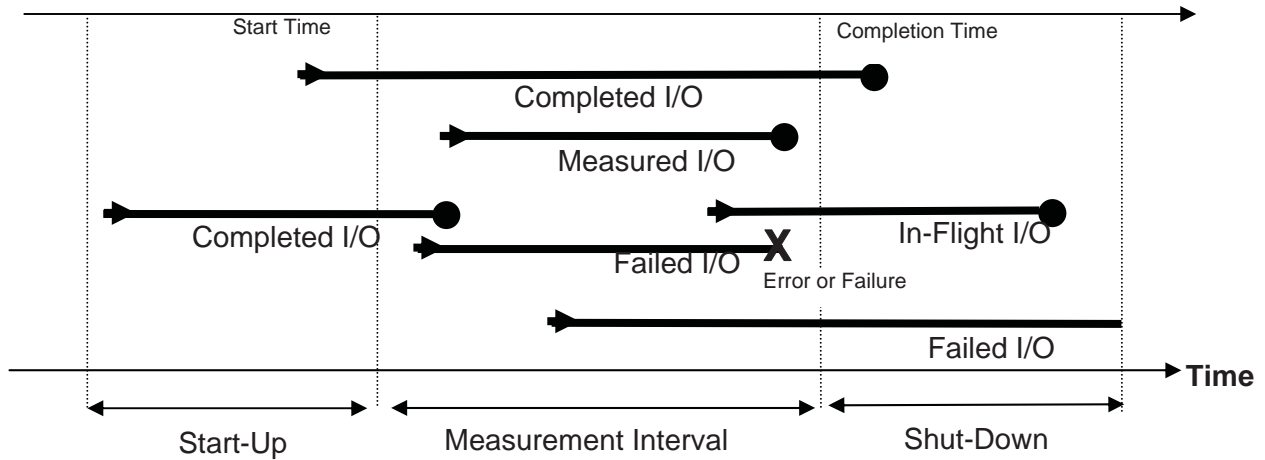
SPC-1 Test Run Components

APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

The following customer tunable parameter and options were changed from their default values for the audit measurements. The method for changing each parameter/option is documented in Appendix C: Tested Storage Configuration (TSC) Creation.

Host System

Change the I/O scheduler from default **cfq** to **noop** on each Host System, which will result in all incoming I/O request inserted into a simple, unordered FIFO queue.

FAS3270 Storage Controllers

The following parameters/options were changed on each controller:

Root Aggregate

- Change RAID type *(aggregate option **raidtype**)* of the root aggregate from default RAID-DP to RAID-4.

- Change the aggregate Snapshot reserve, **snap reserve**, to 0 bytes so that no space is reserved for snapshots.

- Change the aggregate option **nosnap** from its default value of **off** to **on**. This disables the automatic creation of snapshots.

SPC Data Aggregate

- Change the aggregate Snapshot reserve, **snap reserve**, to 0 bytes so that no space is reserved for snapshots.

- Change the aggregate option **nosnap** from its default value of **off** to **on**. This disables the automatic creation of snapshots.

Volume Options – SPC Volumes *(vol_asu1_base, vol_asu2_base, vol_asu3_base, vol_asu1_hs, vol_asu2_hs)*

- Change the volume options **nosnap** to **on** from default **off**. This disables automatic creation of Snapshot copies.

- Change the volume **snap reserve** to 0 bytes so that no space is reserved for snapshots.

- Create the volumes *(**-s** parameter of the **vol create** command)* with a space reservation requirement of **none** instead of default volume. Because all LUNs in volume are pre-allocated there is no need to reserve space in volume.

- Change volume option **read_realloc** to **on** from default **off**. This improves the on-disk layout of data that has been sequentially read.

- Change the memory policy *(**cache=** parameter of the **set volume** command)* for vol_asu1_base, vol_asu2_base and vol_asu3_base volumes from default to **reuse**. This tells the management system to expect a low cache hit rate for user data in

buffer cache. The effect of this change is to increase the priority of systems metadata in buffer cache relative to application data.

- Change **max_write_alloc_blocks** to *256* from default *64* for vol_asu1_base, vol_asu2_base, vol_asu1_hs, vol_asu2_hs volumes. This option changes the number of blocks written to a spindle before write allocator changes to new spindle. This provides a better on-disk layout for long sequential reads.

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.

System Options

wafl.optimize_write_once: change default value of *on* to *off*. This option affects the initial layout of data within a newly created aggregate. The default data layout favors applications which do not overwrite their data.

wafl.downgrade_target: change default value of *on* to *off*. This option changes the runtime 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.

flexscale.enable: change default off value to *on*. This is to enable the FlashCache card.

flexscale.lopri_blocks: change default off value to *on*. This is to enable caching of sequential and recently written data.

System Flags

wafl_read_ahead_hipri_once: change the value from default *0 (off)* to *1 (on)* to enable caching of blocks that have been speculatively read ahead.

wafl_waffinity_read_ahead_chunk: change the value from default *64* to *16*. This reduces the amount of speculative read-ahead. This is useful for workloads such as SPC-1 that use lots of concurrent sequential read streams, no one of which consumes data very rapidly.

wafl_waffinity_read_ahead_offset: change the value from the default *0* to -*1*. This reduces the distance (in blocks) from the current read point to the current speculative read ahead point. This change is useful for workloads such as SPC-1 that use lots of concurrent sequential read streams, no one of which consumes data very rapidly.

wafl_read_ahead_readset_threshold: set this to *1*. This is the minimum size of a LUN (in GB) that will have additional read sets allocated to it.

wafl_read_ahead_variable_size_reset: Change to *0 (disable)* from *1 (default)*. Normally the read ahead engine assumes that all reads in a sequential read stream are the same size. This change removes that assumption. SPC-1 sequential read streams use variable read sizes.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

Host Systems

- Install and setup two Qlogic 2462 HBAs, one in each Host System, using the NetApp certified Qlogic driver.

- Install NetApp Linux Host Utilities 5.2. Follow the instructions in the documentation, at the following URL *(login required)*, to install Host Utilities and also to setup multipathing.

  http://now.netapp.com/NOW/knowledge/docs/hba/linux/rellinuxhu52/pdfs/setup.pdf

- On each Host System set the I/O scheduler to **noop** by changing the **grub.conf** file.

Storage Controllers

The NetApp FAS3270A includes two storage controllers. The following sections document how to configure the storage controllers and create the RAID groups, aggregates, volumes and LUNs that comprise the SPC-1 data repository.

To do the initial setup of the controllers and storage, commands are issued to the storage controllers by establishing a telnet console session from Putty to the appropriate storage controller by providing a console ip address and port number for the controller.

Initializing Disk Ownership

The first step is to establish ownership of the individual disks as follows:

- The 5 DS4243 disk shelves are setup in a SAS stack in a Multi-Path High Availability (MPHA) configuration. Each disk shelf contains 24 disks. Each controller is connected to the top shelf and bottom shelf in the SAS stack with the other shelves daisy-chained between the top and bottom shelves. For more details refer to the documentation, at the following URL *(login required)*, to setup DS4243 shelves.

  http://now.netapp.com/NOW/knowledge/docs/hardware/filer/210-04708_B0.pdf

- Once the controllers and disk shelves are physically connected, we have to assign ownership of disks to each controller. To do this,

  o Power ON the controllers and disk shelves.

  o Press CTRL C during the boot process when prompted for special boot menu.

  o Once at the special boot menu, select option 5 to enter Maintenance mode boot.

  o At the prompt type the following command at each controller: **disk assign –n 60.** This will automatically assign ownership of a group of 60 disks to one controller and other group of 60 disks to the other controller.

  o Type **halt** to go back to **LOADER>** prompt

After the SAS backend connections and disk ownership have been established, zero *(initialize)* all disks by executing the following steps on each NetApp controller.

- Boot each controller either by power cycling or typing **boot** at the **LOADER>** prompt on the console screen.

- Press **CTRL C** during the boot process when prompted for the special boot menu on the console screen.

- Once at the special boot menu, select option **4a** to zero *(initialize)* all disks and install a flexible root volume.

- After zeroing *(initialization)* of all disks is completed, complete the basic setup of each controller which includes providing the following information during a series of subsequent prompts:

  o A host-name for each storage controller.

  o Setup networking information for each controller by configuring a specific network port like e0a with IP address, subnet mask and gateway.

  o Accept the default values for remainder of the prompts and select NO to setup the RLM LAN interface. These can be changed later based on user requirements.

  o Type **reboot** for changes to take effect.

After zeroing *(initialization)* of all disks and basic setup is completed, install NetApp Data ONTAP 8.0.1 on each controller by executing the following steps:

- Download Data ONTAP 8.0.1 system files for the FAS3270 platform from NetApp's NOW site *(http://now.netapp.com/NOW/cgi-bin/software/, login required)* to a directory location that can be accessed via an http URL.

- Establish a telnet console session to each controller as **root** and at the command prompt type: **software install <http URL of Data ONTAP 8.0.1 system files>**.

- Once the installation of system files is completed, type **download** at the command prompt.

- Once the **download** command completes, reboot the NetApp controller, type **reboot** command for the changes to take effect.

Installing Licenses

The following licenses must be installed after NetApp Data ONTAP 8.0.1 system software installation has completed:

- **cluster**

- **fcp**

- **pamii** *(virgo)*

To install the licenses, execute the following command on each controller's console at the command prompt:

license add <license key>

After the licenses are installed change the RAID type of the root aggregate from RAID-DP to RAID4 by running the following command at the command prompt on each controller:

> ***aggr options aggr0 raidtype raid4***

To zero the spare disk created as a result of changing the raid-type of root aggregate, run the following command at the command prompt on each controller:

> ***disk zero spares***

Enable **rsh** on the controllers by running the following command at the command prompt on each controller:

> ***options rsh.enable on***

Base Setup Script – FAS3270 Controllers

Once licenses are installed and both FAS3270 controllers rebooted, the **perl** script below is run from one of the Host Systems to configure both FAS3270 controllers and create the required SPC-1 ASUs. The script is invoked using the following syntax:

> ***master_spc1_setup.pl –f controller_1,controller_2 –l***
> ***wwpn_1,wwpn_2,wwpn_3,wwpn_4***

where controller_1 and controller_2 are the IP addresses or hostnames of controllers and wwpn_1,wwpn_2,wwpn_3 and wwpn_4 are the WWPNs of host HBAs.

The following describes the actions of the script:

- set timezone to EST5EDT

- changes the following **setflags**, as described in Appendix B, to appropriate settings:
  - ➢ **setflag wafl_read_ahead_hipri_once 1**
  - ➢ **setflag wafl_waffinity_read_ahead_chunk 16**
  - ➢ **setflag wafl_waffinity_read_ahead_offset -1**
  - ➢ **setflag wafl_read_ahead_readset_threshold 1**
  - ➢ **setflag wafl_read_ahead_variable_size_reset 0**

The **/etc/rc** file is modified to make the above flag settings persist across a system reboot.

- set the following options, as described in Appendix B, to appropriate settings:
  - ➢ **options wafl.downgrade_target off**
  - ➢ **options wafl.optimize_write_once off**
  - ➢ **options flexscale.enable on**
  - ➢ **options flexscale.lopri_blocks on**

- Configure the root aggregate, **aggr0**, and create the SPC data aggregate, **spc_aggr**, with the following settings:
  - ➢ Root aggregate **aggr0** options:
    - o **nosnap=on**
    - o **set snap reserve = 0**
    - o **set snap sched to 0 0 0**

- ➢ SPC aggregate **spc_aggr** settings: 64bit, 3 raid groups, raid group size (3x19), 1 spare
- ➢ SPC aggregate **spc_aggr** options:
  - o **nosnap=on**
  - o **set snap reserve = 0**
  - o **set snap sched to 0 0 0**

- Configure the root flexible volume **vol0** within **aggr0** and create the SPC-1 volumes within **spc_aggr** with the following settings:
  - ➢ Root flexible volume **vol0**:
    - o **nosnap=on**
    - o **snap reserve = 0**
    - o **snap sched to 0 0 0**

  - ➢ Create SPC-1 volumes **vol_asu1_base**, **vol_asu2_base**, **vol_asu3_base**, **vol_asu1_hs** and **vol_asu2_hs** with their respective volume sizes and following settings:
    - o **nosnap=on**
    - o **snap reserve = 0**
    - o **snap sched to 0 0 0**
    - o space reservation (guarantee) to **none**
    - o **read_realloc = on**

  - ➢ set **max write allocation blocks** to **256** for **vol_asu1_base**, **vol_asu2_base**, **vol_asu1_hs** and **vol_asu2_hs** volumes.

  - ➢ Set memory policy to *cache=reuse* for **vol_asu1_base**, **vol_asu2_base** and **vol_asu3_base** volumes.

- Create fcp portset to contain controller ports 0c and 0d. Then, create linux igroup which contains the fcp port set and the wwpn of FCP HBAs initiators in the Linux hosts.

- Create zeroed LUNs with no space reservation on each controller with the following sizes and then map them to the linux igroup created earlier assigning each LUN a unique LUN ID.
  - ➢ 80 LUNs for ASU1 of size 118963146 KB each
  - ➢ 80 LUNs for ASU2 of size 118963146 KB each
  - ➢ 40 LUNs for ASU3 of size 52872509 KB each
- Start **fcp** service on both controllers.

Once the ASU LUNs are configured:

- Start the multipath daemon on both Host Systems by running the following command on the host systems: **/etc/init.d/multipathd start**.

- Use the rescan script **rescan-scsi-bus.sh** to get the LUNs to show up on both Host Systems. The rescan script is available with the sg3_utils package.

- Verify that multipath is working fine and the same LUN is accessible from multiple paths by running the following command: **/sbin/multipath -ll**.

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

Primary Metrics Test

The content of each SPC-1 Workload Generator command and parameter file, used in this benchmark to execute the Primary Metrics Test, is listed below. The first set of content is common to each of the files. The content listed after each Test Run heading is specific to the Test Run.

```
javaparms="-Xms1536m -Xmx2048m -Xss256k"
host=master
slaves=(host1_slave1,host1_slave2,host1_slave3,host1_slave4,host1_slave5,host1_slave
6,host1_slave7,host2_slave1,host2_slave2,host2_slave3,host2_slave4,host2_slave5,host
2_slave6,host2_slave7)

sd=asu1_0,lun=/spc1/test/disks/asu1_0,size=121834045440
sd=asu1_1,lun=/spc1/test/disks/asu1_1,size=121834045440
sd=asu1_2,lun=/spc1/test/disks/asu1_2,size=121834045440
sd=asu1_3,lun=/spc1/test/disks/asu1_3,size=121834045440
sd=asu1_4,lun=/spc1/test/disks/asu1_4,size=121834045440
sd=asu1_5,lun=/spc1/test/disks/asu1_5,size=121834045440
sd=asu1_6,lun=/spc1/test/disks/asu1_6,size=121834045440
sd=asu1_7,lun=/spc1/test/disks/asu1_7,size=121834045440
sd=asu1_8,lun=/spc1/test/disks/asu1_8,size=121834045440
sd=asu1_9,lun=/spc1/test/disks/asu1_9,size=121834045440
sd=asu1_10,lun=/spc1/test/disks/asu1_10,size=121834045440
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sd=asu1_41,lun=/spc1/test/disks/asu1_41,size=121834045440
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```

```
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```

```
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```

```
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sd=asu3_185,lun=/spc1/test/disks/asu3_185,size=54148464640
sd=asu3_186,lun=/spc1/test/disks/asu3_186,size=54148464640
sd=asu3_187,lun=/spc1/test/disks/asu3_187,size=54148464640
sd=asu3_188,lun=/spc1/test/disks/asu3_188,size=54148464640
sd=asu3_189,lun=/spc1/test/disks/asu3_189,size=54148464640
sd=asu3_190,lun=/spc1/test/disks/asu3_190,size=54148464640
sd=asu3_191,lun=/spc1/test/disks/asu3_191,size=54148464640
sd=asu3_192,lun=/spc1/test/disks/asu3_192,size=54148464640
sd=asu3_193,lun=/spc1/test/disks/asu3_193,size=54148464640
sd=asu3_194,lun=/spc1/test/disks/asu3_194,size=54148464640
sd=asu3_195,lun=/spc1/test/disks/asu3_195,size=54148464640
sd=asu3_196,lun=/spc1/test/disks/asu3_196,size=54148464640
sd=asu3_197,lun=/spc1/test/disks/asu3_197,size=54148464640
sd=asu3_198,lun=/spc1/test/disks/asu3_198,size=54148464640
sd=asu3_199,lun=/spc1/test/disks/asu3_199,size=54148464640
```

Sustainability Test Run

```
rd=ramp_sust,bsus=1361,startup=5400,elapsed=10800,interval=60
```

IOPS Test Run

```
rd=ramp_100,bsus=1361,startup=180,elapsed=600,interval=60
```

Ramp 95 Test Run

```
rd=ramp_95,bsus=1292,startup=180,elapsed=600,interval=60
```

Ramp 90 Test Run

```
rd=ramp_90,bsus=1224,startup=180,elapsed=600,interval=60
```

Ramp 80 Test Run

```
rd=ramp_80,bsus=1224,startup=180,elapsed=600,interval=60
```

Ramp 50 Test Run

```
rd=ramp_50,bsus=1224,startup=180,elapsed=600,interval=60
```

Ramp 10 Test Run

```
rd=ramp_10,bsus=1224,startup=180,elapsed=600,interval=60
```

Repeatability Test

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

```
javaparms="-Xms1536m -Xmx2048m -Xss256k"
host=master
slaves=(host1_slave1,host1_slave2,host1_slave3,host1_slave4,host1_slave5,host1_slave
6,host1_slave7,host2_slave1,host2_slave2,host2_slave3,host2_slave4,host2_slave5,host
2_slave6,host2_slave7)

sd=asu1_0,lun=/spc1/test/disks/asu1_0,size=121834045440
sd=asu1_1,lun=/spc1/test/disks/asu1_1,size=121834045440
sd=asu1_2,lun=/spc1/test/disks/asu1_2,size=121834045440
sd=asu1_3,lun=/spc1/test/disks/asu1_3,size=121834045440
sd=asu1_4,lun=/spc1/test/disks/asu1_4,size=121834045440
sd=asu1_5,lun=/spc1/test/disks/asu1_5,size=121834045440
sd=asu1_6,lun=/spc1/test/disks/asu1_6,size=121834045440
sd=asu1_7,lun=/spc1/test/disks/asu1_7,size=121834045440
sd=asu1_8,lun=/spc1/test/disks/asu1_8,size=121834045440
sd=asu1_9,lun=/spc1/test/disks/asu1_9,size=121834045440
sd=asu1_10,lun=/spc1/test/disks/asu1_10,size=121834045440
sd=asu1_11,lun=/spc1/test/disks/asu1_11,size=121834045440
sd=asu1_12,lun=/spc1/test/disks/asu1_12,size=121834045440
sd=asu1_13,lun=/spc1/test/disks/asu1_13,size=121834045440
sd=asu1_14,lun=/spc1/test/disks/asu1_14,size=121834045440
sd=asu1_15,lun=/spc1/test/disks/asu1_15,size=121834045440
sd=asu1_16,lun=/spc1/test/disks/asu1_16,size=121834045440
sd=asu1_17,lun=/spc1/test/disks/asu1_17,size=121834045440
sd=asu1_18,lun=/spc1/test/disks/asu1_18,size=121834045440
sd=asu1_19,lun=/spc1/test/disks/asu1_19,size=121834045440
sd=asu1_20,lun=/spc1/test/disks/asu1_20,size=121834045440
sd=asu1_21,lun=/spc1/test/disks/asu1_21,size=121834045440
sd=asu1_22,lun=/spc1/test/disks/asu1_22,size=121834045440
sd=asu1_23,lun=/spc1/test/disks/asu1_23,size=121834045440
sd=asu1_24,lun=/spc1/test/disks/asu1_24,size=121834045440
sd=asu1_25,lun=/spc1/test/disks/asu1_25,size=121834045440
sd=asu1_26,lun=/spc1/test/disks/asu1_26,size=121834045440
sd=asu1_27,lun=/spc1/test/disks/asu1_27,size=121834045440
sd=asu1_28,lun=/spc1/test/disks/asu1_28,size=121834045440
sd=asu1_29,lun=/spc1/test/disks/asu1_29,size=121834045440
sd=asu1_30,lun=/spc1/test/disks/asu1_30,size=121834045440
sd=asu1_31,lun=/spc1/test/disks/asu1_31,size=121834045440
sd=asu1_32,lun=/spc1/test/disks/asu1_32,size=121834045440
sd=asu1_33,lun=/spc1/test/disks/asu1_33,size=121834045440
sd=asu1_34,lun=/spc1/test/disks/asu1_34,size=121834045440
sd=asu1_35,lun=/spc1/test/disks/asu1_35,size=121834045440
sd=asu1_36,lun=/spc1/test/disks/asu1_36,size=121834045440
sd=asu1_37,lun=/spc1/test/disks/asu1_37,size=121834045440
sd=asu1_38,lun=/spc1/test/disks/asu1_38,size=121834045440
sd=asu1_39,lun=/spc1/test/disks/asu1_39,size=121834045440
sd=asu1_40,lun=/spc1/test/disks/asu1_40,size=121834045440
sd=asu1_41,lun=/spc1/test/disks/asu1_41,size=121834045440
sd=asu1_42,lun=/spc1/test/disks/asu1_42,size=121834045440
sd=asu1_43,lun=/spc1/test/disks/asu1_43,size=121834045440
sd=asu1_44,lun=/spc1/test/disks/asu1_44,size=121834045440
sd=asu1_45,lun=/spc1/test/disks/asu1_45,size=121834045440
sd=asu1_46,lun=/spc1/test/disks/asu1_46,size=121834045440
sd=asu1_47,lun=/spc1/test/disks/asu1_47,size=121834045440
sd=asu1_48,lun=/spc1/test/disks/asu1_48,size=121834045440
sd=asu1_49,lun=/spc1/test/disks/asu1_49,size=121834045440
sd=asu1_50,lun=/spc1/test/disks/asu1_50,size=121834045440
```

```
sd=asu1_51,lun=/spc1/test/disks/asu1_51,size=121834045440
sd=asu1_52,lun=/spc1/test/disks/asu1_52,size=121834045440
sd=asu1_53,lun=/spc1/test/disks/asu1_53,size=121834045440
sd=asu1_54,lun=/spc1/test/disks/asu1_54,size=121834045440
sd=asu1_55,lun=/spc1/test/disks/asu1_55,size=121834045440
sd=asu1_56,lun=/spc1/test/disks/asu1_56,size=121834045440
sd=asu1_57,lun=/spc1/test/disks/asu1_57,size=121834045440
sd=asu1_58,lun=/spc1/test/disks/asu1_58,size=121834045440
sd=asu1_59,lun=/spc1/test/disks/asu1_59,size=121834045440
sd=asu1_60,lun=/spc1/test/disks/asu1_60,size=121834045440
sd=asu1_61,lun=/spc1/test/disks/asu1_61,size=121834045440
sd=asu1_62,lun=/spc1/test/disks/asu1_62,size=121834045440
sd=asu1_63,lun=/spc1/test/disks/asu1_63,size=121834045440
sd=asu1_64,lun=/spc1/test/disks/asu1_64,size=121834045440
sd=asu1_65,lun=/spc1/test/disks/asu1_65,size=121834045440
sd=asu1_66,lun=/spc1/test/disks/asu1_66,size=121834045440
sd=asu1_67,lun=/spc1/test/disks/asu1_67,size=121834045440
sd=asu1_68,lun=/spc1/test/disks/asu1_68,size=121834045440
sd=asu1_69,lun=/spc1/test/disks/asu1_69,size=121834045440
sd=asu1_70,lun=/spc1/test/disks/asu1_70,size=121834045440
sd=asu1_71,lun=/spc1/test/disks/asu1_71,size=121834045440
sd=asu1_72,lun=/spc1/test/disks/asu1_72,size=121834045440
sd=asu1_73,lun=/spc1/test/disks/asu1_73,size=121834045440
sd=asu1_74,lun=/spc1/test/disks/asu1_74,size=121834045440
sd=asu1_75,lun=/spc1/test/disks/asu1_75,size=121834045440
sd=asu1_76,lun=/spc1/test/disks/asu1_76,size=121834045440
sd=asu1_77,lun=/spc1/test/disks/asu1_77,size=121834045440
sd=asu1_78,lun=/spc1/test/disks/asu1_78,size=121834045440
sd=asu1_79,lun=/spc1/test/disks/asu1_79,size=121834045440
sd=asu2_80,lun=/spc1/test/disks/asu2_80,size=121834045440
sd=asu2_81,lun=/spc1/test/disks/asu2_81,size=121834045440
sd=asu2_82,lun=/spc1/test/disks/asu2_82,size=121834045440
sd=asu2_83,lun=/spc1/test/disks/asu2_83,size=121834045440
sd=asu2_84,lun=/spc1/test/disks/asu2_84,size=121834045440
sd=asu2_85,lun=/spc1/test/disks/asu2_85,size=121834045440
sd=asu2_86,lun=/spc1/test/disks/asu2_86,size=121834045440
sd=asu2_87,lun=/spc1/test/disks/asu2_87,size=121834045440
sd=asu2_88,lun=/spc1/test/disks/asu2_88,size=121834045440
sd=asu2_89,lun=/spc1/test/disks/asu2_89,size=121834045440
sd=asu2_90,lun=/spc1/test/disks/asu2_90,size=121834045440
sd=asu2_91,lun=/spc1/test/disks/asu2_91,size=121834045440
sd=asu2_92,lun=/spc1/test/disks/asu2_92,size=121834045440
sd=asu2_93,lun=/spc1/test/disks/asu2_93,size=121834045440
sd=asu2_94,lun=/spc1/test/disks/asu2_94,size=121834045440
sd=asu2_95,lun=/spc1/test/disks/asu2_95,size=121834045440
sd=asu2_96,lun=/spc1/test/disks/asu2_96,size=121834045440
sd=asu2_97,lun=/spc1/test/disks/asu2_97,size=121834045440
sd=asu2_98,lun=/spc1/test/disks/asu2_98,size=121834045440
sd=asu2_99,lun=/spc1/test/disks/asu2_99,size=121834045440
sd=asu2_100,lun=/spc1/test/disks/asu2_100,size=121834045440
sd=asu2_101,lun=/spc1/test/disks/asu2_101,size=121834045440
sd=asu2_102,lun=/spc1/test/disks/asu2_102,size=121834045440
sd=asu2_103,lun=/spc1/test/disks/asu2_103,size=121834045440
sd=asu2_104,lun=/spc1/test/disks/asu2_104,size=121834045440
sd=asu2_105,lun=/spc1/test/disks/asu2_105,size=121834045440
sd=asu2_106,lun=/spc1/test/disks/asu2_106,size=121834045440
sd=asu2_107,lun=/spc1/test/disks/asu2_107,size=121834045440
sd=asu2_108,lun=/spc1/test/disks/asu2_108,size=121834045440
sd=asu2_109,lun=/spc1/test/disks/asu2_109,size=121834045440
sd=asu2_110,lun=/spc1/test/disks/asu2_110,size=121834045440
sd=asu2_111,lun=/spc1/test/disks/asu2_111,size=121834045440
sd=asu2_112,lun=/spc1/test/disks/asu2_112,size=121834045440
sd=asu2_113,lun=/spc1/test/disks/asu2_113,size=121834045440
```

```
sd=asu2_114,lun=/spc1/test/disks/asu2_114,size=121834045440
sd=asu2_115,lun=/spc1/test/disks/asu2_115,size=121834045440
sd=asu2_116,lun=/spc1/test/disks/asu2_116,size=121834045440
sd=asu2_117,lun=/spc1/test/disks/asu2_117,size=121834045440
sd=asu2_118,lun=/spc1/test/disks/asu2_118,size=121834045440
sd=asu2_119,lun=/spc1/test/disks/asu2_119,size=121834045440
sd=asu2_120,lun=/spc1/test/disks/asu2_120,size=121834045440
sd=asu2_121,lun=/spc1/test/disks/asu2_121,size=121834045440
sd=asu2_122,lun=/spc1/test/disks/asu2_122,size=121834045440
sd=asu2_123,lun=/spc1/test/disks/asu2_123,size=121834045440
sd=asu2_124,lun=/spc1/test/disks/asu2_124,size=121834045440
sd=asu2_125,lun=/spc1/test/disks/asu2_125,size=121834045440
sd=asu2_126,lun=/spc1/test/disks/asu2_126,size=121834045440
sd=asu2_127,lun=/spc1/test/disks/asu2_127,size=121834045440
sd=asu2_128,lun=/spc1/test/disks/asu2_128,size=121834045440
sd=asu2_129,lun=/spc1/test/disks/asu2_129,size=121834045440
sd=asu2_130,lun=/spc1/test/disks/asu2_130,size=121834045440
sd=asu2_131,lun=/spc1/test/disks/asu2_131,size=121834045440
sd=asu2_132,lun=/spc1/test/disks/asu2_132,size=121834045440
sd=asu2_133,lun=/spc1/test/disks/asu2_133,size=121834045440
sd=asu2_134,lun=/spc1/test/disks/asu2_134,size=121834045440
sd=asu2_135,lun=/spc1/test/disks/asu2_135,size=121834045440
sd=asu2_136,lun=/spc1/test/disks/asu2_136,size=121834045440
sd=asu2_137,lun=/spc1/test/disks/asu2_137,size=121834045440
sd=asu2_138,lun=/spc1/test/disks/asu2_138,size=121834045440
sd=asu2_139,lun=/spc1/test/disks/asu2_139,size=121834045440
sd=asu2_140,lun=/spc1/test/disks/asu2_140,size=121834045440
sd=asu2_141,lun=/spc1/test/disks/asu2_141,size=121834045440
sd=asu2_142,lun=/spc1/test/disks/asu2_142,size=121834045440
sd=asu2_143,lun=/spc1/test/disks/asu2_143,size=121834045440
sd=asu2_144,lun=/spc1/test/disks/asu2_144,size=121834045440
sd=asu2_145,lun=/spc1/test/disks/asu2_145,size=121834045440
sd=asu2_146,lun=/spc1/test/disks/asu2_146,size=121834045440
sd=asu2_147,lun=/spc1/test/disks/asu2_147,size=121834045440
sd=asu2_148,lun=/spc1/test/disks/asu2_148,size=121834045440
sd=asu2_149,lun=/spc1/test/disks/asu2_149,size=121834045440
sd=asu2_150,lun=/spc1/test/disks/asu2_150,size=121834045440
sd=asu2_151,lun=/spc1/test/disks/asu2_151,size=121834045440
sd=asu2_152,lun=/spc1/test/disks/asu2_152,size=121834045440
sd=asu2_153,lun=/spc1/test/disks/asu2_153,size=121834045440
sd=asu2_154,lun=/spc1/test/disks/asu2_154,size=121834045440
sd=asu2_155,lun=/spc1/test/disks/asu2_155,size=121834045440
sd=asu2_156,lun=/spc1/test/disks/asu2_156,size=121834045440
sd=asu2_157,lun=/spc1/test/disks/asu2_157,size=121834045440
sd=asu2_158,lun=/spc1/test/disks/asu2_158,size=121834045440
sd=asu2_159,lun=/spc1/test/disks/asu2_159,size=121834045440
sd=asu3_160,lun=/spc1/test/disks/asu3_160,size=54148464640
sd=asu3_161,lun=/spc1/test/disks/asu3_161,size=54148464640
sd=asu3_162,lun=/spc1/test/disks/asu3_162,size=54148464640
sd=asu3_163,lun=/spc1/test/disks/asu3_163,size=54148464640
sd=asu3_164,lun=/spc1/test/disks/asu3_164,size=54148464640
sd=asu3_165,lun=/spc1/test/disks/asu3_165,size=54148464640
sd=asu3_166,lun=/spc1/test/disks/asu3_166,size=54148464640
sd=asu3_167,lun=/spc1/test/disks/asu3_167,size=54148464640
sd=asu3_168,lun=/spc1/test/disks/asu3_168,size=54148464640
sd=asu3_169,lun=/spc1/test/disks/asu3_169,size=54148464640
sd=asu3_170,lun=/spc1/test/disks/asu3_170,size=54148464640
sd=asu3_171,lun=/spc1/test/disks/asu3_171,size=54148464640
sd=asu3_172,lun=/spc1/test/disks/asu3_172,size=54148464640
sd=asu3_173,lun=/spc1/test/disks/asu3_173,size=54148464640
sd=asu3_174,lun=/spc1/test/disks/asu3_174,size=54148464640
sd=asu3_175,lun=/spc1/test/disks/asu3_175,size=54148464640
sd=asu3_176,lun=/spc1/test/disks/asu3_176,size=54148464640
```

```
sd=asu3_177,lun=/spc1/test/disks/asu3_177,size=54148464640
sd=asu3_178,lun=/spc1/test/disks/asu3_178,size=54148464640
sd=asu3_179,lun=/spc1/test/disks/asu3_179,size=54148464640
sd=asu3_180,lun=/spc1/test/disks/asu3_180,size=54148464640
sd=asu3_181,lun=/spc1/test/disks/asu3_181,size=54148464640
sd=asu3_182,lun=/spc1/test/disks/asu3_182,size=54148464640
sd=asu3_183,lun=/spc1/test/disks/asu3_183,size=54148464640
sd=asu3_184,lun=/spc1/test/disks/asu3_184,size=54148464640
sd=asu3_185,lun=/spc1/test/disks/asu3_185,size=54148464640
sd=asu3_186,lun=/spc1/test/disks/asu3_186,size=54148464640
sd=asu3_187,lun=/spc1/test/disks/asu3_187,size=54148464640
sd=asu3_188,lun=/spc1/test/disks/asu3_188,size=54148464640
sd=asu3_189,lun=/spc1/test/disks/asu3_189,size=54148464640
sd=asu3_190,lun=/spc1/test/disks/asu3_190,size=54148464640
sd=asu3_191,lun=/spc1/test/disks/asu3_191,size=54148464640
sd=asu3_192,lun=/spc1/test/disks/asu3_192,size=54148464640
sd=asu3_193,lun=/spc1/test/disks/asu3_193,size=54148464640
sd=asu3_194,lun=/spc1/test/disks/asu3_194,size=54148464640
sd=asu3_195,lun=/spc1/test/disks/asu3_195,size=54148464640
sd=asu3_196,lun=/spc1/test/disks/asu3_196,size=54148464640
sd=asu3_197,lun=/spc1/test/disks/asu3_197,size=54148464640
sd=asu3_198,lun=/spc1/test/disks/asu3_198,size=54148464640
sd=asu3_199,lun=/spc1/test/disks/asu3_199,size=54148464640
```

Persistence Test

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

```
javaparms="-Xms1536m -Xmx2048m -Xss256k"

sd=asu1_0,lun=/spc1/test/disks/asu1_0,size=121834045440
sd=asu1_1,lun=/spc1/test/disks/asu1_1,size=121834045440
sd=asu1_2,lun=/spc1/test/disks/asu1_2,size=121834045440
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```

```
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```

```
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```

```
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```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

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

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

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

#Sub-routines and variables for host and storage profile collection

$RSH="/usr/bin/rsh -l root";

@CONTROLLER_LIST=("10.61.172.231","10.61.172.232");

sub do_rsh($$) {

    my ($filer, $cmd) = @_;

    print "\nCommand:$cmd\n";
    $TIME_CMD1=`date`;
    chomp ($TIME_CMD1);
    print "Timestamp:$TIME_CMD1\n";
    system("/usr/bin/rsh -l root -n $filer \"$cmd\"");
    $TIME_CMD2=`date`;
    chomp ($TIME_CMD2);
    print "Timestamp:$TIME_CMD2\n";
}

sub do_information {

#Saving STDOUT
open(SAVEOUT,">&STDOUT");

open (STDOUT, ">physical_device_listing_before_tests.txt");
foreach $controller (@CONTROLLER_LIST) {
print "\n\n--Controller:$controller---Physical Device Listing---\n";
print "\nThis command gives information about all the physical devices on the
controllers";
do_rsh($controller, "sysconfig -av");
print "\nThis command gives information about RAID groups";
do_rsh($controller, "sysconfig -r");
}
close (STDOUT);

open (STDOUT, ">aggregate_information_before_tests.txt");
foreach $controller (@CONTROLLER_LIST) {
print "\n\n--Controller:$controller---Aggregate Information---\n";
print "\n**Aggregate Space Usage**\n";
print "This command gives space usage information at aggregate level";
do_rsh($controller, "df -A");
print "\n**Aggregate Status**\n";
print "This command gives information about the aggregates";
do_rsh($controller, "aggr status -v");
print "\n**Aggregate Disk Status**\n";
print "This command gives RAID group and disk information for aggregates";
```

```perl
  do_rsh($controller, "aggr status -r");
  }
  close (STDOUT);

  open (STDOUT, ">volume_information_before_tests.txt");
  foreach $controller (@CONTROLLER_LIST) {
  print "\n\n--Controller:$controller---Volume Information---\n";
  print "\n**Volume Space Usage**\n";
  print "This command gives space usage information at volume level";
  do_rsh($controller, "df");
  print "\n**Volume Status**\n";
  print "This command gives information about the volumes";
  do_rsh($controller, "vol status -v");
  }
  close (STDOUT);

  open (STDOUT, ">lun_information_before_tests.txt");
  foreach $controller (@CONTROLLER_LIST) {
  print "\n\n--Controller:$controller---LUN Information---\n";
  print "\n**LUN Status**\n";
  print "This command gives information about the LUNs";
  do_rsh($controller, "lun show");
  }
  close (STDOUT);

  open (STDOUT, ">host_device_listing_before_tests.txt");
  print "\n---Host Device Listing---\n";
  print "\n**Device Listing**\n";
  $TIME_CMD=`date`;
  chomp ($TIME_CMD);
  print "Timestamp:$TIME_CMD\n";
  system("/opt/netapp/santools/sanlun lun show");
  print "\n\n";
  system("/sbin/multipath -ll");
  close (STDOUT);

  #Restoring STDOUT
  open (STDOUT, ">&SAVEOUT");
  }

  #Collecting host and storage profile information
  do_information();

  #Start SPC1-E tests
  $date =`date +%m%d%y%H%M%S`;
  `mkdir audit_results/spc_audit.$date`;
  $dir = "audit_results/spc_audit.$date";


  #Doing range test
  print "Starting Conditioning Phase\n";
  system("java -Xms1536m -Xmx2048m -Xss256k range -t 600 -b 1361");
  sleep 1;
  `mv rangetest/ conditioning/`;
  print "\n\nStarting Idle Phase-L:Sleeping 35 minutes";
  sleep 2100;
  print "\nStarting Recovery Phase\n";
  system("java -Xms1536m -Xmx2048m -Xss256k range -t 600 -b 136");
  sleep 1;
  `mv rangetest/ recovery/`;

  print "\nStarting Metrics Phase\n";
  system("java -Xms1536m -Xmx2048m -Xss256k spc1 -f sustain.txt -o sustain SPCOut");
```

```
sleep 1;
system("java -Xms1536m -Xmx2048m -Xss256k spc1 -f iops.txt -o iops SPCOut");
sleep 1;
system("java -Xms1536m -Xmx2048m -Xss256k spc1 -f ramp095.txt -o ramp095 SPCOut");
sleep 1;
system("java -Xms1536m -Xmx2048m -Xss256k spc1 -f ramp090.txt -o ramp090 SPCOut");
sleep 1;
system("java -Xms1536m -Xmx2048m -Xss256k spc1 -f ramp080.txt -o ramp080 SPCOut");
sleep 1;
system("java -Xms1536m -Xmx2048m -Xss256k spc1 -f ramp050.txt -o ramp050 SPCOut");
sleep 1;
system("java -Xms1536m -Xmx2048m -Xss256k spc1 -f ramp010.txt -o ramp010 SPCOut");
sleep 1;

print "\nStarting Repeatability1 Phase\n";
system("java -Xms1536m -Xmx2048m -Xss256k repeat1 -b 1361");
sleep 1;
print "\nStarting Repeatability2 Phase\n";
system("java -Xms1536m -Xmx2048m -Xss256k repeat2 -b 1361");
sleep 1;



#Saving config files for multi-host
`cp SPC1.cfg $dir/SPC1.cfg.multi_host`;
`cp SPC1.parm $dir/SPC1.parm.multi_host`;

#Copying config files for single host
`cp SPC1_persist.cfg SPC1.cfg`;

print "Starting Persistence1 Phase\n";
system("java -Xms1536m -Xmx2048m -Xss256k persist1 -b 1361");
```

Persistence Test Run 2

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

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

#Sub-routines and variables for host and storage profile collection

$RSH="/usr/bin/rsh -l root";

@CONTROLLER_LIST=("10.61.172.231","10.61.172.232");

sub do_rsh($$) {

    my ($filer, $cmd) = @_;

    print "\nCommand:$cmd\n";
    $TIME_CMD1=`date`;
    chomp ($TIME_CMD1);
    print "Timestamp:$TIME_CMD1\n";
    system("/usr/bin/rsh -l root -n $filer \"$cmd\"");
    $TIME_CMD2=`date`;
    chomp ($TIME_CMD2);
    print "Timestamp:$TIME_CMD2\n";
}
```

```perl
sub do_information {

#Saving STDOUT
open(SAVEOUT,">&STDOUT");

open (STDOUT, ">physical_device_listing_after_tests.txt");
foreach $controller (@CONTROLLER_LIST) {
print "\n\n--Controller:$controller---Physical Device Listing---\n";
print "\nThis command gives information about all the physical devices on the
controllers";
do_rsh($controller, "sysconfig -av");
print "\nThis command gives information about RAID groups";
do_rsh($controller, "sysconfig -r");
}
close (STDOUT);

open (STDOUT, ">aggregate_information_after_tests.txt");
foreach $controller (@CONTROLLER_LIST) {
print "\n\n--Controller:$controller---Aggregate Information---\n";
print "\n**Aggregate Space Usage**\n";
print "This command gives space usage information at aggregate level";
do_rsh($controller, "df -A");
print "\n**Aggregate Status**\n";
print "This command gives information about the aggregates";
do_rsh($controller, "aggr status -v");
print "\n**Aggregate Disk Status**\n";
print "This command gives RAID group and disk information for aggregates";
do_rsh($controller, "aggr status -r");
}
close (STDOUT);

open (STDOUT, ">volume_information_after_tests.txt");
foreach $controller (@CONTROLLER_LIST) {
print "\n\n--Controller:$controller---Volume Information---\n";
print "\n**Volume Space Usage**\n";
print "This command gives space usage information at volume level";
do_rsh($controller, "df");
print "\n**Volume Status**\n";
print "This command gives information about the volumes";
do_rsh($controller, "vol status -v");
}
close (STDOUT);

open (STDOUT, ">lun_information_after_tests.txt");
foreach $controller (@CONTROLLER_LIST) {
print "\n\n--Controller:$controller---LUN Information---\n";
print "\n**LUN Status**\n";
print "This command gives information about the LUNs";
do_rsh($controller, "lun show");
}
close (STDOUT);

open (STDOUT, ">host_device_listing_after_tests.txt");
print "\n---Host Device Listing---\n";
print "\n**Device Listing**\n";
$TIME_CMD=`date`;
chomp ($TIME_CMD);
print "Timestamp:$TIME_CMD\n";
system("/opt/netapp/santools/sanlun lun show");
print "\n\n";
system("/sbin/multipath -ll");
close (STDOUT);
```

```
#Restoring STDOUT
open (STDOUT, ">&SAVEOUT");
}


$out = `ls audit_results`;
$dir = "audit_results/$out";
print "\n\n\n$dir\n";

print "Starting Persistence2 Phase\n";
system("java -Xms1536m -Xmx2048m -Xss256k persist2");
sleep 5;

print "$dir\n";
`mv conditioning/ $dir`;
sleep 5;
`mv recovery/ $dir`;
sleep 5;
`mv sustain/ $dir`;
sleep 5;
`mv iops/ $dir`;
sleep 5;
`mv ramp095/ $dir`;
sleep 5;
`mv ramp090/ $dir`;
sleep 5;
`mv ramp080/ $dir`;
sleep 5;
`mv ramp050/ $dir`;
sleep 5;
`mv ramp010/ $dir`;
sleep 5;
`mv repeatability1/ $dir`;
sleep 5;
`mv repeatability2/ $dir`;
sleep 5;
`mv persistence1/ $dir`;
sleep 5;
`mv persistence2/ $dir`;
sleep 5;
`mv SPCOut/ $dir`;

#Collecting host and storage profile information
do_information();
```