SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

NEC CORPORATION
NEC STORAGE M700

SPC-1 V1.13

Submitted for Review: April 26, 2013
Submission Identifier: A00132

First Edition – April 2013

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NEC Storage M700

AUDIT CERTIFICATION

Kentaro Yamamoto
NEC Corporation
1-10, Nisshin-Cho, Fucyu
Tokyo, 183-8501, Japan

April 24, 2013

The SPC Benchmark 1™ Reported Data listed below for the NEC Storage M700 was produced in compliance with the SPC Benchmark 1™ v1.13 Remote Audit requirements.

SPC Benchmark 1™ v1.13 Reported Data	
Tested Storage Product (TSP) Name:	
NEC Storage M700	
Metric	**Reported Result**
SPC-1 IOPS™	152,478.90
SPC-1 Price-Performance	$3.84/SPC-1 IOPS™
Total ASU Capacity	69,166.799 GB
Data Protection Level	Protected 1 (Mirroring)
Total Price (including three-year maintenance)	$586,215.30
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by information supplied by NEC Corporation:
  - ✓ Physical Storage Capacity and requirements.
  - ✓ Configured Storage Capacity and requirements.
  - ✓ Addressable Storage Capacity and requirements.
  - ✓ Capacity of each Logical Volume and requirements.
  - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- The total Application Storage Unit (ASU) Capacity was filled with random data, using an auditor approved tool, prior to execution of the SPC-1 Tests.

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

AUDIT CERTIFICATION *(CONT.)*

NEC Storage M700   Page 2
SPC-1 Audit Certification
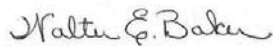
- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).

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

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

- The following Host System requirements were verified by information supplied by NEC Corporation:

  ✓ The type of each Host System including the number of processors and main memory.
  ✓ The presence and version number of the SPC-1 Workload Generator on each Host System.
  ✓ The TSC boundary within each Host System.

- The Test Results Files and resultant Summary Results Files received from NEC Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:

  ✓ Data Persistence Test
  ✓ Sustainability Test Phase
  ✓ IOPS Test Phase
  ✓ Response Time Ramp Test Phase
  ✓ Repeatability Test

- 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-1 Benchmark Specification.

- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.

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

Audit Notes:

There were no audit notes or exceptions.

Respectfully,

Walter E. Baker

Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

Empowered by Innovation **NEC**

NEC Corporation
1-10, Nisshin-Cho, Fucyu, Tokyo 183-8501, Japan

Date: April 15, 2013

From: NEC Corporation

To: Walter E. Baker, SPC Auditor
    Storage Performance Council (SPC)
    643 Bair Island Road, Suite 103
    Redwood City, CA 94063-2755

Subject: SPC-1 Letter of Good Faith for the NEC Storage M700

NEC Corporation is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V1.13 of the SPC-1 benchmark specification.
In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark that affected the reported results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specification.

Signed: Date:

Mitsugu Kato   *April 15, 2013*

Mitsugu Kato
Assistant General Manager
IT Platform Division

SPC BENCHMARK 1™ V1.13   FULL DISCLOSURE REPORT   Submission Identifier: A00132
NEC Corporation   Submitted for Review: APRIL 26, 2013
NEC Storage M700

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
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Test Sponsor Alternate Contact	NEC Corporation of America – http://www.necam.com Jim Hawes – jim.hawes@necam.com 2880 Scott Blvd. Santa Clara, CA 95050 Phone: (602) 237-9830
Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-1 Specification revision number	V1.13
SPC-1 Workload Generator revision number	V2.3.0
Date Results were first used publicly	April 26, 2013
Date the FDR was submitted to the SPC	April 26, 2013
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	April 24, 2013

Tested Storage Product (TSP) Description

NEC's M700 SAN storage arrays are a great choice for very scalable, mission-critical, high performance, primary or tiered storage. These SAN storage arrays are easy to operate, dependable and efficient.

They are also well-suited for use in virtualized environments by virtue of their great scalability, LUN lock stability, support for VMware APIs and flexibility.

NEC M700 SAN arrays feature host interfaces: 8 Gbps Fibre Channel, 10Gbps/1Gbps iSCSI. Both interfaces can be deployed concurrently.

M700 offers 3.5" and 2.5" drives. 2.5" drives are attractive due to their lower power and space consumption. 3.5" drives by contract offer the best storage density per spindle. M700 simultaneous supports SAS HDD, NearLine SAS HDD, and SSD in the same enclosures, enabling flexible tiered storage architecture.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: NEC Storage M700	
Metric	**Reported Result**
SPC-1 IOPS™	152,478.90
SPC-1 Price-Performance™	$3.84/SPC-1 IOPS™
Total ASU Capacity	69,166.799 GB
Data Protection Level	Protected 1 *(Mirroring)*
Total Price	$586,215.30
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

A **Data Protection Level** of **Protected 1** using *Mirroring* configures two or more identical copies of user data.

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

Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 15.

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

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

Storage Capacities, Relationships, and Utilization

The following diagram *(not to scale)* and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.
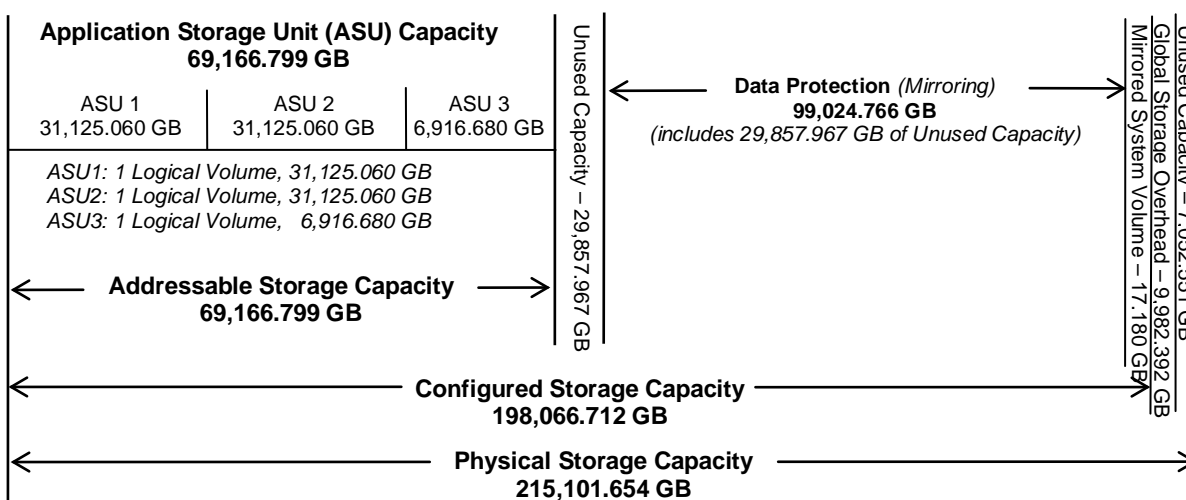
SPC-1 Storage Capacity Utilization	
Application Utilization	32.16%
Protected Application Utilization	64.31%
Unused Storage Ratio	31.04%

Application Utilization: Total ASU Capacity *(69,166.799 GB)* divided by Physical Storage Capacity *(215,101.654 GB)*

Protected Application Utilization: Total ASU Capacity *(69,166.799 GB)* plus total Data Protection Capacity *(99,024.766 GB)* minus unused Data Protection Capacity *(29,857.967 GB)* divided by Physical Storage Capacity *(215,101.654 GB)*

Unused Storage Ratio: Total Unused Capacity *(66,768.484 GB)* divided by Physical Storage Capacity *(215,101.654 GB)* and may not exceed 45%.

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

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.
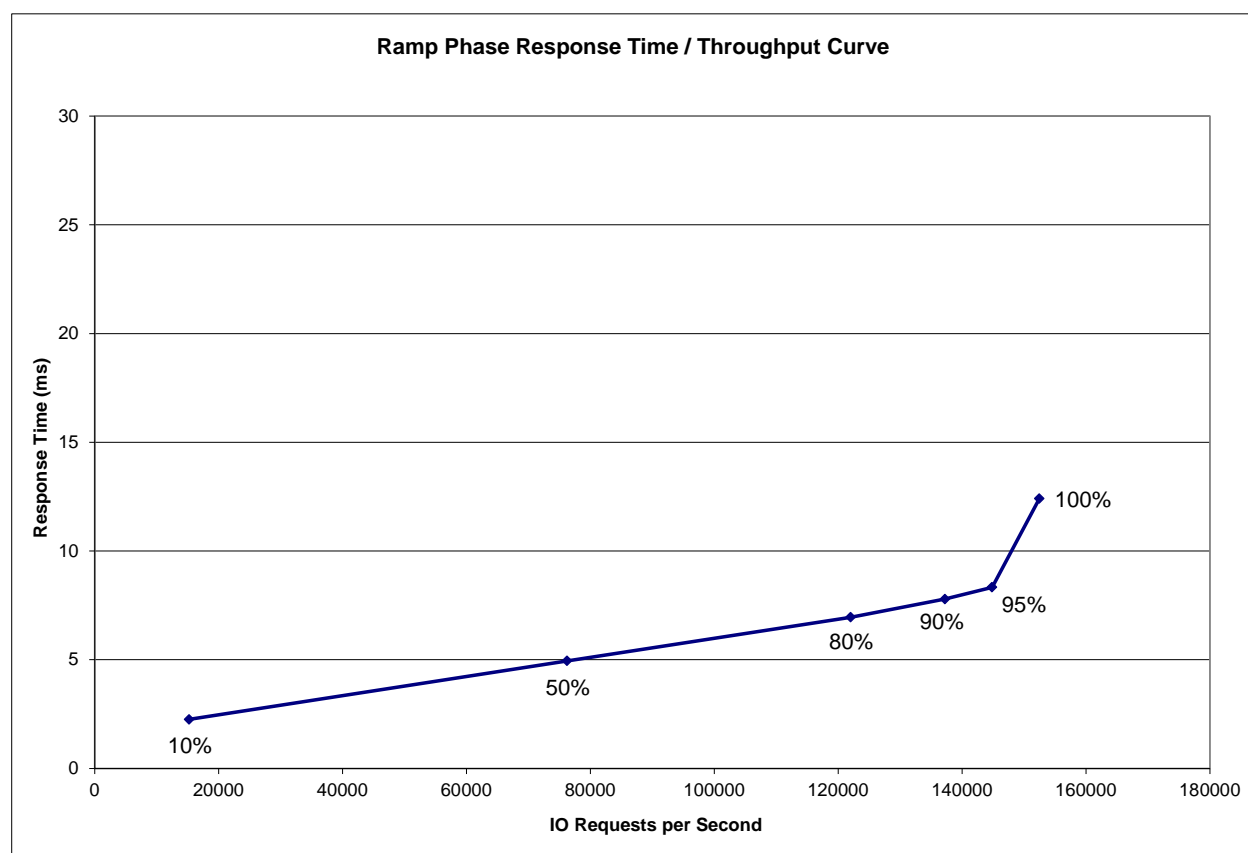
Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	15,246.10	76,248.14	122,017.26	137,238.82	144,845.98	152,478.90
Average Response Time (ms):						
All ASUs	2.25	4.95	6.95	7.79	8.33	12.41
ASU-1	2.99	6.29	8.63	9.54	10.07	13.63
ASU-2	2.91	7.80	11.19	12.46	13.19	17.20
ASU-3	0.41	0.85	1.54	2.03	2.52	7.73
Reads	4.93	11.00	15.00	16.38	17.04	19.67
Writes	0.51	1.00	1.71	2.19	2.66	7.68

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 Pricing

PART#	Product Name	Qty	Unit List Price	Extended LP	Discount	Discounted Price
NF5371-SB00E	M700 Disk Array Unit (includes 1 x NF5371-SD01WE (Disk Port Expansion), 8 x NF9120-SJ73 (Mini SAS Conversion cable(1m))	1	$108,096.00	$108,096.00	20.0%	$86,476.80
NF5371-SF02WE	M700 Host Port Expansion(2X8Gb FC 4-Port)	4	$4,686.00	$18,744.00	20.0%	$14,995.20
NF5371-SD01WE	M700 Disk Port Expansion (SAS 8Port)	3	$3,564.00	$10,692.00	20.0%	$8,553.60
NF5371-SC03E	M700 Standard Cache Memory(96GB)	1	$5,321.00	$5,321.00	20.0%	$4,256.80
NF5321-SM775E	SAS Disk Drive(2.5", 15krpm/300GB, 6Gbps)	384	$395.00	$151,680.00	20.0%	$121,344.00
NF5321-SE71E	Disk Enclosure(2.5", 6Gbps)	16	$3,383.00	$54,128.00	20.0%	$43,302.40
NF5321-SM725E	SAS Disk Drive(3.5", 15krpm/300GB, 6Gbps)	307	$440.00	$135,080.00	20.0%	$108,064.00
NF5321-SM728E	SAS Disk Drive(3.5", 15krpm/600GB, 6Gbps)	13	$540.00	$7,020.00	20.0%	$5,616.00
NF5321-SE70E	Disk Enclosure(3.5", 6Gbps)	32	$3,288.00	$105,216.00	20.0%	$84,172.80
NF9120-SJ73	Mini SAS conversion cable(3m)	12	$636.00	$7,632.00	20.0%	$6,105.60
N8190-154	8Gbps Dual Port Fibre Channel HBA	5	$1,355.00	$6,775.00	10.0%	$6,097.50
FC cable	FC cable	10	$100.00	$1,000.00	10.0%	$900.00
Power Cord	Power Cord (10 ft.)	100	$18.20	$1,820.00	10.0%	$1,638.00
Power Strips	Power Strips (8 outlets)	13	$78.00	$1,014.00	10.0%	$912.60
RACK	Rack 42U	3	$1,799.00	$5,397.00	10.0%	$4,857.30
UFSM01-700600AM	SW,STORAGE BASEPRODUCT M700	1	$0.00	$0.00	20.0%	$0.00
UFS206-0060W0AM	SW, PATH MANAGER FOR WINDOWS, M700	1	$1,123.00	$1,123.00	20.0%	$898.40
Q24-DN000000013775	3Years Upgraded Platinum Warranty for M700 Disk Array Unit	1	$14,417.00	$14,417.00	15.0%	$12,254.45
Q24-DN000000013782	3Years Upgraded Platinum Warranty for M700 Host Port(8Gb FC 8Port)	4	$1,640.00	$6,560.00	15.0%	$5,576.00
Q24-DN000000013803	3Years Upgraded Platinum Warranty for M700 Disk Port (SAS 8Port)	3	$1,247.00	$3,741.00	15.0%	$3,179.85
Q24-DN000000013856	3Years Upgraded Platinum Warranty for M700 Standard Cache Memory(96GB)	1	$1,862.00	$1,862.00	15.0%	$1,582.70
Q24-DN000000008386	3YR Upgraded to Platinum Warranty M100 HDD 2.5" 15K 300GB 6Gbps	16	$300.00	$4,800.00	15.0%	$4,080.00
Q24-DN000000006695	3YR Upgraded to Platinum Warranty M100 DiskExp2.5"6Gbps	16	$846.00	$13,536.00	15.0%	$11,505.60
Q24-DN000000006752	3YR Upgraded to Platinum Warranty M100 HDD 3.5" 15K 300GB 6Gbps	31	$300.00	$9,300.00	15.0%	$7,905.00
Q24-DN000000006754	3YR Upgraded to Platinum Warranty M100 HDD 3.5" 15K 600GB 6Gbps	2	$300.00	$600.00	15.0%	$510.00
Q24-DN000000006694	3YR Upgraded to Platinum Warranty M100 DiskExp3.5"6Gbps	32	$822.00	$26,304.00	15.0%	$22,358.40
Q24-DN000000061141	3 Years Upgraded Platinum Warranty for Mini SAS conversion cable (1m x 2)	4	$171.00	$684.00	15.0%	$581.40
Q24-DN000000061148	3 Years Upgraded Platinum Warranty for Mini SAS conversion cable (3m x 2)	6	$222.00	$1,332.00	15.0%	$1,132.20
Q24-DN000000013974	3 Years Upgraded Platinum SW Maintenance for M700 Storage Base SW	1	$20,071.00	$20,071.00	15.0%	$17,060.35
Q24-DN000000061692	3 Years Upgraded Platinum SW Maintenance for M-series PathManager_Windows	1	$351.00	$351.00	15.0%	$298.35
Total				$724,296.00		$586,215.30

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

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

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

Priced Storage Configuration Diagram

NEC N8190-154
Dual 8 Gb/s FC HBA

NEC N8190-154
Dual 8 Gb/s FC HBA

NEC N8190-154
Dual 8 Gb/s FC HBA

NEC N8190-154
Dual 8 Gb/s FC HBA

NEC N8190-154
Dual 8 Gb/s FC HBA

NEC Storage M700
Dual-Active Controllers
96 GB cache, 48 GB/controller

DE00   DE20   DE40   DE60
DE01   DE21   DE41   DE61
DE02   DE22   DE42   DE62

DE08   DE28   DE48   DE68
DE09   DE29   DE49   DE69
DE0a   DE2a   DE4a   DE6a

DE10   DE30   DE50   DE70
DE11   DE31   DE51   DE71
DE12   DE32   DE52   DE72

DE18   DE38   DE58   DE78
DE19   DE39   DE59   DE79
DE1a   DE3a   DE5a   DE7a

48 – Disk Enclosures

704 – Disk Drives
691 – 300 GB, 15K RPM SAS disk drives
13 – 600 GB, 15K RPM SAS disk drives

The distribution of disk drives to disk enclosures is documented on page .

Priced Storage Configuration Components

Priced Storage Configuration:
5 – N8190-154 dual 8 Gb/s FC HBAs

NEC Storage M700
 dual controllers – Active-Active
    48 GB cache per controller *(96 GB total)*
    2 – FC 2x4-port Host Port Expansion per controller
       (8 Gbps, 4 Host Port Expansions total)
    16 – 8 Gbps front-end connections per controller
       (32 total, 10 used)
    2 – SAS 8 port Disk Port Expansion per controller
       (6 Gbps, 4 Disk Port Expansions total)
    16 –6 Gbps SAS backend connections per controller
       (32 total, 32 used)

48 – Disk Enclosures
    32 – enclosures, 6 Gbps *(3.5" disk drives)*
    16 – enclosures, 6 Gbps *(2.5" disk drives)*

704 – 15K RPM SAS disk drives
       384 – 2.5" 300 GB disk drives
       307 – 3.5" 300 GB disk drives
        13 – 3.5" 600 GB disk drives

3 – 42U Racks with 13 Power Strips *(8 outlets per strip)*

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 20 *(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 Benchmark Configuration (BC)/Tested Storage Configuration (TSC) was configured with local storage and, as such, did not employ a storage network.

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

Clause 9.4.3.4.3

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

The Host System(s) and TSC table of components may be found on page 21 *(Host Systems and Tested Storage Configuration Components).*

Benchmark Configuration/Tested Storage Configuration Diagram

5 – NEC Express5800/R120b-2 servers
Microsoft Windows Server 2003
Enterprise Edition (32-bit) SP2

5 – NEC N8190-154 Dual 8 Gb/s FC HBAs
(2 HBAs per server)

NEC Storage M700
Dual-Active Controllers
96 GB cache, 48 GB/controller

DE00	DE20	DE40	DE60
DE01	DE21	DE41	DE61
DE02	DE22	DE42	DE62

DE08	DE28	DE48	DE68
DE09	DE29	DE49	DE69
DE0a	DE2a	DE4a	DE6a

DE10	DE30	DE50	DE70
DE11	DE31	DE51	DE71
DE12	DE32	DE52	DE72

DE18	DE38	DE58	DE78
DE19	DE39	DE59	DE79
DE1a	DE3a	DE5a	DE7a

48 – Disk Enclosures

704 – Disk Drives
691 – 300 GB, 15K RPM SAS disk drives
13 – 600 GB, 15K RPM SAS disk drives

The distribution of disk drives to disk enclosures is documented on page .

Host Systems and Tested Storage Configuration Components

Host Systems:	Tested Storage Configuration (TSC):
5 – NEC Express5800/R120b-2 servers each server with: 1 – Intel Xeon X5650 6 core processor 2.66 GHz, 12 MB Intel Smart Cache 8 GB main memory Microsoft Windows 2003 Enterprise Edition (32-bit) with SP2 PCIe	Path Manager for Windows
	4 – N8190-154 dual 8 Gb/s FC HBAs

	NEC Storage M700
	  dual controllers – Active-Active
	    48 GB cache per controller *(96 GB total)*
	    2 – FC 2x4-port Disk Port Expansions per controller
	      (8 Gbps, 4 Host Port Expansions total)
	    16 – 8Gbps front-end connections per controller
	      (32 total, 1 used)
	    2 – SAS 8 port Disk Port Expansions per controller
	      (6 Gbps, 4 Disk Port Expansions per controller)
	    16 –6 Gbps SAS backend connections per controller *(32 total and 32 used)*

	48 – Disk Enclosures
	    32 – enclosures, 6 Gbps *(3.5" disk drives)*
	    16 – enclosures, 6 Gbps *(2.5" disk drives)*

	704 – 15K RPM SAS disk drives
	    384 – 2.5" 300 GB disk drives
	    307 – 3.5" 300 GB disk drives
	    13 – 3.5" 600 GB disk drives

	3 – 42U Racks with 13 Power Strips *(8 outlets per strip)*

Distribution of Disk Drives to Disk Enclosures

DE00 (2.5"): *24 - 300 GB disk drives*	**DE20 (2.5"):** *24 - 300 GB disk drives*	**DE40 (2.5"):** *24 - 300 GB disk drives*	**DE60 (2.5"):** *24 - 300 GB disk drives*
DE01 (3.5"): *12 - 300 GB disk drives*	**DE21 (3.5"):** *12 - 300 GB disk drives*	**DE41 (3.5"):** *12 - 300 GB disk drives*	**DE61 (3.5"):** *12 - 300 GB disk drives*
DE02 (3.5"): *8 - 300 GB disk drives*	**DE22 (3.5"):** *8 - 300 GB disk drives*	**DE42 (3.5"):** *8 - 300 GB disk drives*	**DE62 (3.5"):** *8 - 300 GB disk drives*
DE08 (2.5"): *24 - 300 GB disk drives*	**DE28 (2.5"):** *24 - 300 GB disk drives*	**DE48 (2.5"):** *24 - 300 GB disk drives*	**DE68 (2.5"):** *24 - 300 GB disk drives*
DE09 (3.5"): *12 - 300 GB disk drives*	**DE29 (3.5"):** *12 - 300 GB disk drives*	**DE49 (3.5"):** *12 - 300 GB disk drives*	**DE69 (3.5"):** *12 - 300 GB disk drives*
DE0A (3.5"): *8 - 300 GB disk drives*	**DE2A (3.5"):** *8 - 300 GB disk drives*	**DE4A (3.5"):** *8 - 300 GB disk drives*	**DE6A (3.5"):** *8 - 300 GB disk drives*
DE10 (2.5"): *24 - 300 GB disk drives*	**DE30 (2.5"):** *24 - 300 GB disk drives*	**DE50 (2.5"):** *24 - 300 GB disk drives*	**DE70 (2.5"):** *24 - 300 GB disk drives*
DE11 (3.5"): *12 - 300 GB disk drives*	**DE31 (3.5"):** *12 - 300 GB disk drives*	**DE51 (3.5"):** *12 - 300 GB disk drives*	**DE71 (3.5"):** *12 - 300 GB disk drives*
DE12 (3.5"): *8 - 300 GB disk drives*	**DE32 (3.5"):** *8 - 300 GB disk drives*	**DE52 (3.5"):** *8 - 300 GB disk drives*	**DE72 (3.5"):** *3 - 300 GB disk drives* *5 – 600 GB disk drives*
DE18 (2.5"): *24 - 300 GB disk drives*	**DE38 (2.5"):** *24 - 300 GB disk drives*	**DE58 (2.5"):** *24 - 300 GB disk drives*	**DE78 (2.5"):** *24 - 300 GB disk drives*
DE19 (3.5"): *12 - 300 GB disk drives*	**DE39 (3.5"):** *12 - 300 GB disk drives*	**DE59 (3.5"):** *12 - 300 GB disk drives*	**DE79 (3.5"):** *12 - 300 GB disk drives*
DE1A (3.5"): *8 - 300 GB disk drives*	**DE3A (3.5"):** *8 - 300 GB disk drives*	**DE5A (3.5"):** *8 - 300 GB disk drives*	**DE7A (3.5"):** *8 - 600 GB disk drives*
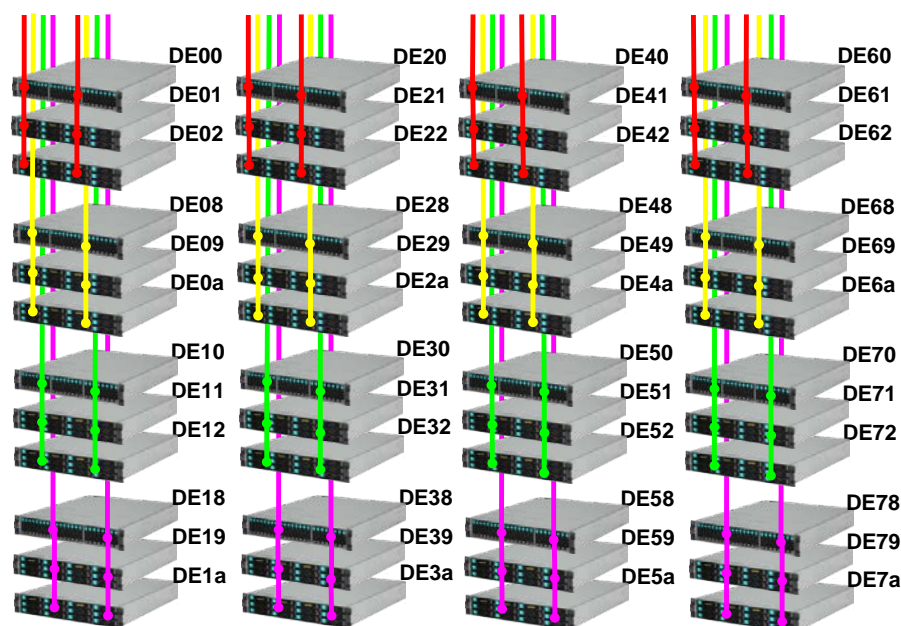
48 – Disk Enclosures
32 – enclosures *(3.5" disk drives)*
16 – enclosures *(2.5" disk drives)*

704 – Disk Drives
691 – 300 GB, 15K RPM SAS disk drives
13 – 600 GB, 15K RPM SAS disk drives

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 65 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 81.

ASU Pre-Fill

Clause 5.3.3

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

The configuration file used to complete the required ASU pre-fill appears in *Appendix D: SPC-1 Workload Generator Storage Commands and Parameters* on page 81.

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

The Physical Storage Capacity consisted of 215,101.654 GB distributed over 704 disk drives. That capacity was distributed between 691 disk drives with a formatted capacity of 300.00 GB per disk drive and 13 disk drives with a formatted capacity of 600.127 GB per disk drive. There was 7,052.551 GB (3.28%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 9,982.392 GB (4.64%) of the Physical Storage Capacity. There was 59,715.933 GB (30.15%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.00 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(Mirroring)* capacity was 99,024.766 GB of which 69,166.799 GB was utilized. The total Unused Storage capacity was 66,768.484 GB.

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

SPC-1 Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	69,166.799
Addressable Storage Capacity	Gigabytes (GB)	69.166.799
Configured Storage Capacity	Gigabytes (GB)	198,066.712
Physical Storage Capacity	Gigabytes (GB)	215,101.654
Data Protection *(Mirroring)*	Gigabytes (GB)	99,024.766
Required Storage *(mirrored system volume)*	Gigabytes (GB)	17.180
Global Storage Overhead	Gigabytes (GB)	9,982.392
Total Unused Storage	Gigabytes (GB)	66,768.484

SPC-1 Storage Capacities and Relationships Illustration

The various storage capacities configured in the benchmark result are illustrated below *(not to scale)*.
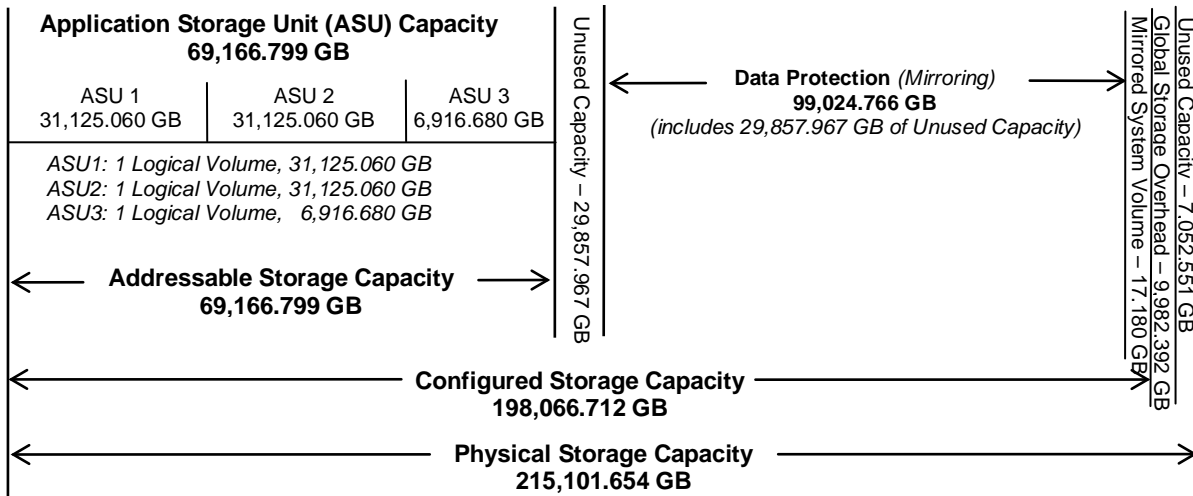
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	34.92%	32.16%
Required for Data Protection (*Mirroring*)		50.00%	46.04%
Addressable Storage Capacity		34.92%	32.16%
Required Storage (*mirrored system volume*)		0.01%	0.01%
Configured Storage Capacity			92.08%
Global Storage Overhead			4.64%
Unused Storage:			
Addressable	0.00%		
Configured		30.15%	
Physical			3.28%

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	32.16%
Protected Application Utilization	64.31%
Unused Storage Ratio	31.04%

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 (31,125.060 GB)	ASU-2 (31,125.060 GB)	ASU-3 (6,916.680 GB)
1 Logical Volume 31,125.060 GB per Logical Volume (31,125.060 GB used per Logical Volume)	1 Logical Volume 31,125.060 GB per Logical Volume (31,125.060 GB used per Logical Volume)	1 Logical Volume 6,916.680 GB per Logical Volume (6,916.680 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was **Protected 1** using *Mirroring* as described on page 12. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. *"Appendix A: SPC-1 Glossary"* 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
    - o 95% of IOPS Test Run
    - o 90% of IOPS Test Run
    - o 80% of IOPS Test Run
    - o 50% of IOPS Test Run
    - o 10% of IOPS Test Run (LRT)

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

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

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

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

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

The Sustainability Test Phase has exactly one Test Run and shall demonstrate the maximum sustainable I/O Request Throughput within at least a continuous eight (8) hour Measurement Interval. This Test Phase also serves to insure that the TSC has reached Steady State prior to reporting the final maximum I/O Request Throughput result (SPC-1 IOPS™).

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.4.3.7.1

For the Sustainability Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 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
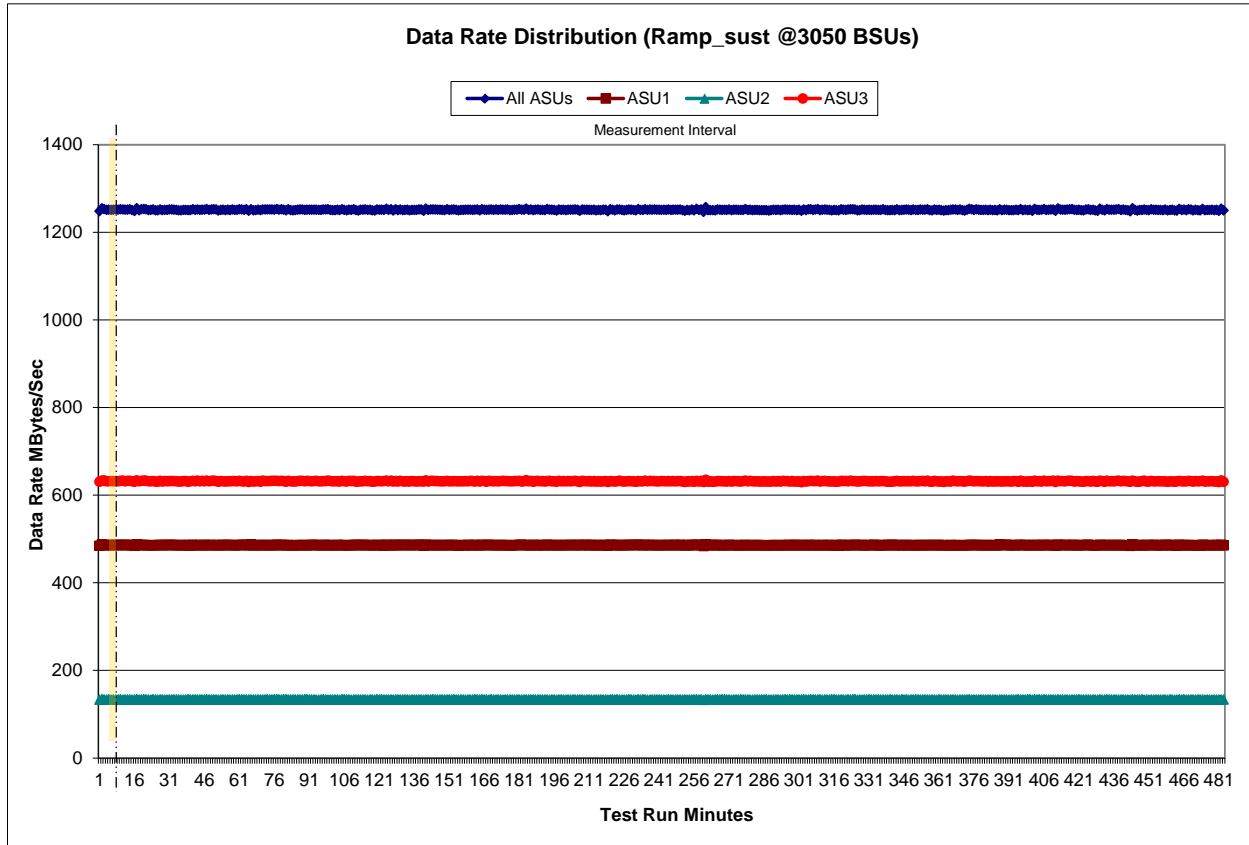
Sustainability – I/O Request Throughput Distribution Data

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
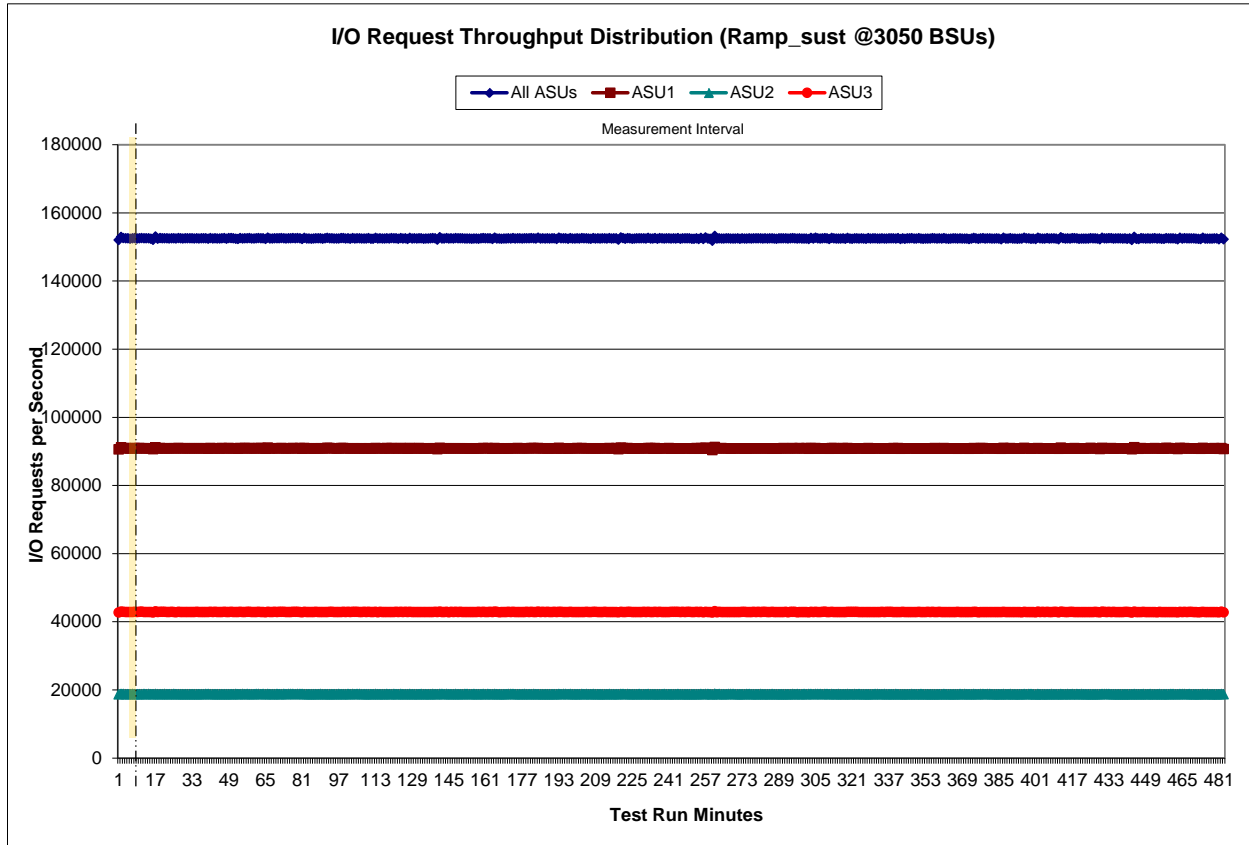
Sustainability – Average Response Time (ms) Distribution Data

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
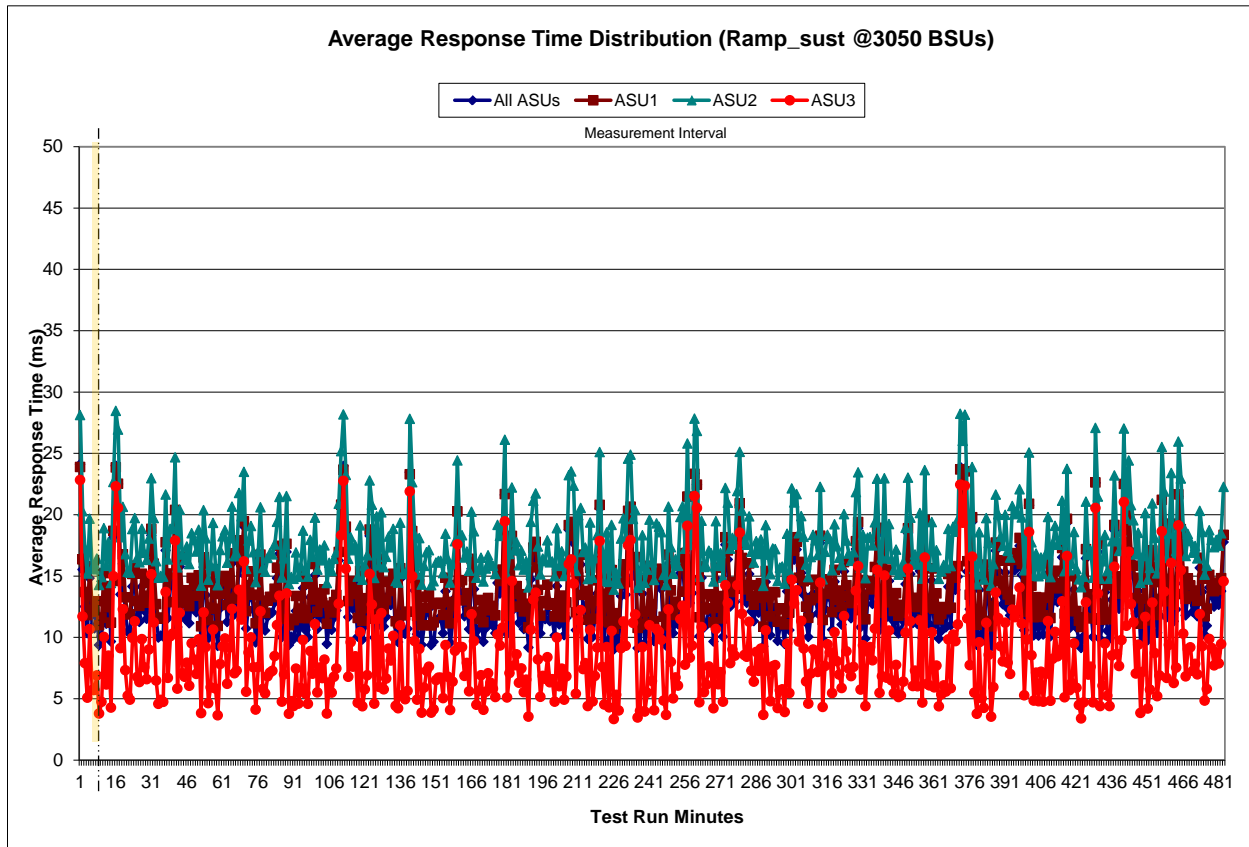
Sustainability – Response Time Frequency Distribution Data

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	17,496,600	62,689,783	31,749,329	9,260,314	5,429,604	6,046,102	7,784,897	9,108,103
Write	12	64,527,247	275,858,677	273,707,536	204,326,046	174,755,889	143,536,315	117,280,099
All ASUs	17,496,612	127,217,030	307,608,006	282,967,850	209,755,650	180,801,991	151,321,212	126,388,202
ASU1	16,274,017	80,220,315	151,289,047	128,439,949	93,070,208	80,218,889	68,507,879	58,437,301
ASU2	1,222,592	21,419,774	37,741,520	30,752,803	22,052,122	18,597,697	15,182,191	12,413,651
ASU3	3	25,576,941	118,577,439	123,775,098	94,633,320	81,985,405	67,631,142	55,537,250

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	23,428,269	30,720,134	40,114,500	52,090,291	65,708,113	73,867,630	146,599,553	132,496,058
Write	181,310,791	146,832,877	112,897,090	89,662,404	68,779,902	56,506,742	85,628,450	61,796,940
All ASUs	204,739,060	177,553,011	153,011,590	141,752,695	134,488,015	130,374,372	232,228,003	194,292,998
ASU1	98,654,013	90,205,035	83,608,017	84,593,215	87,701,823	89,405,655	163,685,457	139,408,367
ASU2	19,655,093	17,323,283	15,279,909	14,181,760	13,730,911	13,954,645	27,690,072	25,565,841
ASU3	86,429,954	70,024,693	54,123,664	42,977,720	33,055,281	27,014,072	40,852,474	29,318,790

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	108,545,695	76,348,425	59,770,605	194,153,049	112,548,001	80,204,858	61,593,522	324,421,868
Write	48,098,098	39,235,829	33,354,957	131,162,213	112,445,690	76,647,494	32,409,350	128,947,962
All ASUs	156,643,793	115,584,254	93,125,562	325,315,262	224,993,691	156,852,352	94,002,872	453,369,830
ASU1	112,929,345	80,771,004	65,153,629	222,683,105	144,614,205	101,183,156	66,035,127	310,444,265
ASU2	21,032,371	16,400,112	12,356,023	41,205,119	27,288,150	19,354,612	12,737,598	83,092,072
ASU3	22,682,077	18,413,138	15,615,910	61,427,038	53,091,336	36,314,584	15,230,147	59,833,493

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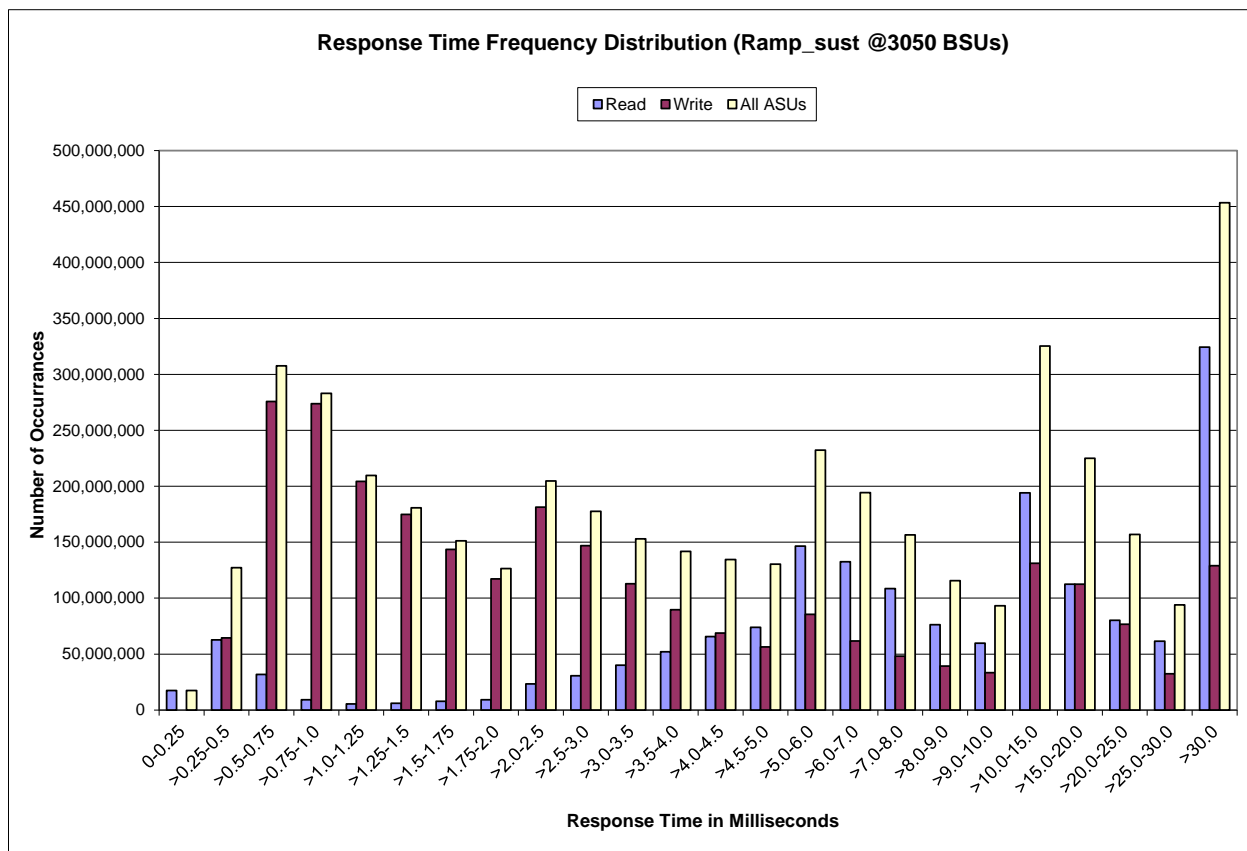
Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

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

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

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

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

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

Clause 9.4.3.7.2

For the IOPS Test Phase the FDR shall contain:

1. *I/O Request Throughput Distribution (data and graph).*
2. *A Response Time Frequency Distribution.*
3. *An Average Response Time Distribution.*
4. *The human readable Test Run Results File produced by the Workload Generator.*
5. *A listing or screen image of all input parameters supplied to the Workload Generator.*
6. *The total number of I/O Requests completed in the Measurement Interval as well as the number of I/O Requests with a Response Time less than or equal to 30 milliseconds and the number of I/O Requests with a Response Time greater than 30 milliseconds.*

SPC-1 Workload Generator Input Parameters

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

3,050 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:04:09	0:07:10	0-2	0:03:01
Measurement Interval	0:07:10	0:17:10	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	151,246.37	90,169.83	18,606.15	42,470.38
1	153,156.88	91,291.07	18,863.13	43,002.68
2	153,173.63	91,282.77	18,833.88	43,056.98
3	152,375.67	90,781.23	18,764.98	42,829.45
4	152,574.00	90,933.30	18,773.62	42,867.08
5	152,605.13	90,952.58	18,764.83	42,887.72
6	152,476.05	90,918.97	18,762.40	42,794.68
7	152,503.68	90,920.35	18,749.92	42,833.42
8	152,523.73	90,906.23	18,773.23	42,844.27
9	152,533.85	90,897.88	18,753.32	42,882.65
10	152,501.22	90,898.68	18,748.25	42,854.28
11	152,372.93	90,853.93	18,719.60	42,799.40
12	152,322.73	90,777.00	18,716.65	42,829.08
Average	*152,478.90*	*90,884.02*	*18,752.68*	*42,842.20*

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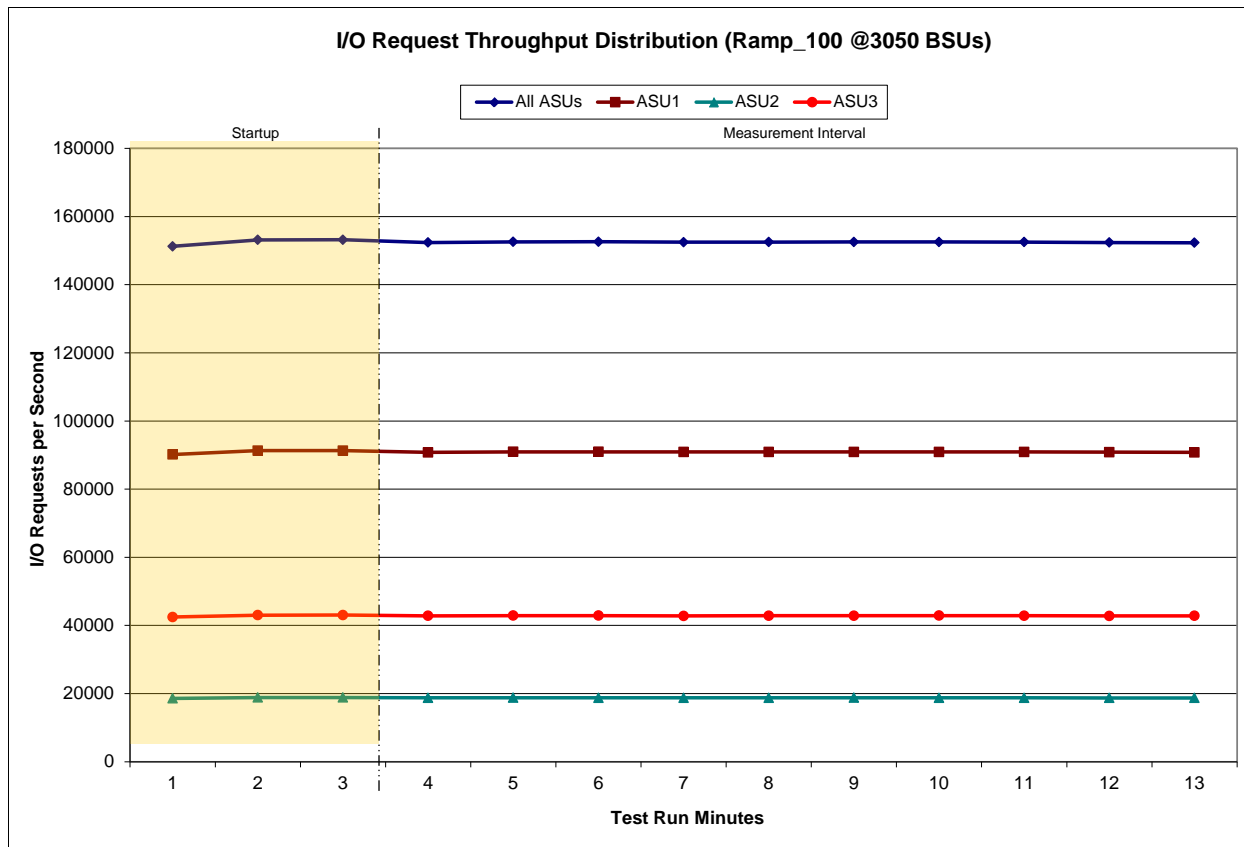
IOPS Test Run – Average Response Time (ms) Distribution Data

3,050 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:04:09	0:07:10	0-2	0:03:01
Measurement Interval	0:07:10	0:17:10	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	28.18	27.58	31.99	27.79
1	23.37	23.25	27.64	21.73
2	19.89	20.26	24.46	17.11
3	9.43	11.03	14.40	3.86
4	15.88	16.69	20.48	12.14
5	16.58	17.27	21.11	13.13
6	13.68	14.69	18.32	9.49
7	13.16	14.29	17.91	8.68
8	9.91	11.46	14.83	4.45
9	9.96	11.46	14.83	4.66
10	12.86	14.00	17.55	8.39
11	10.79	12.19	15.71	5.66
12	11.89	13.25	16.81	6.85
Average	***12.41***	***13.63***	***17.20***	***7.73***

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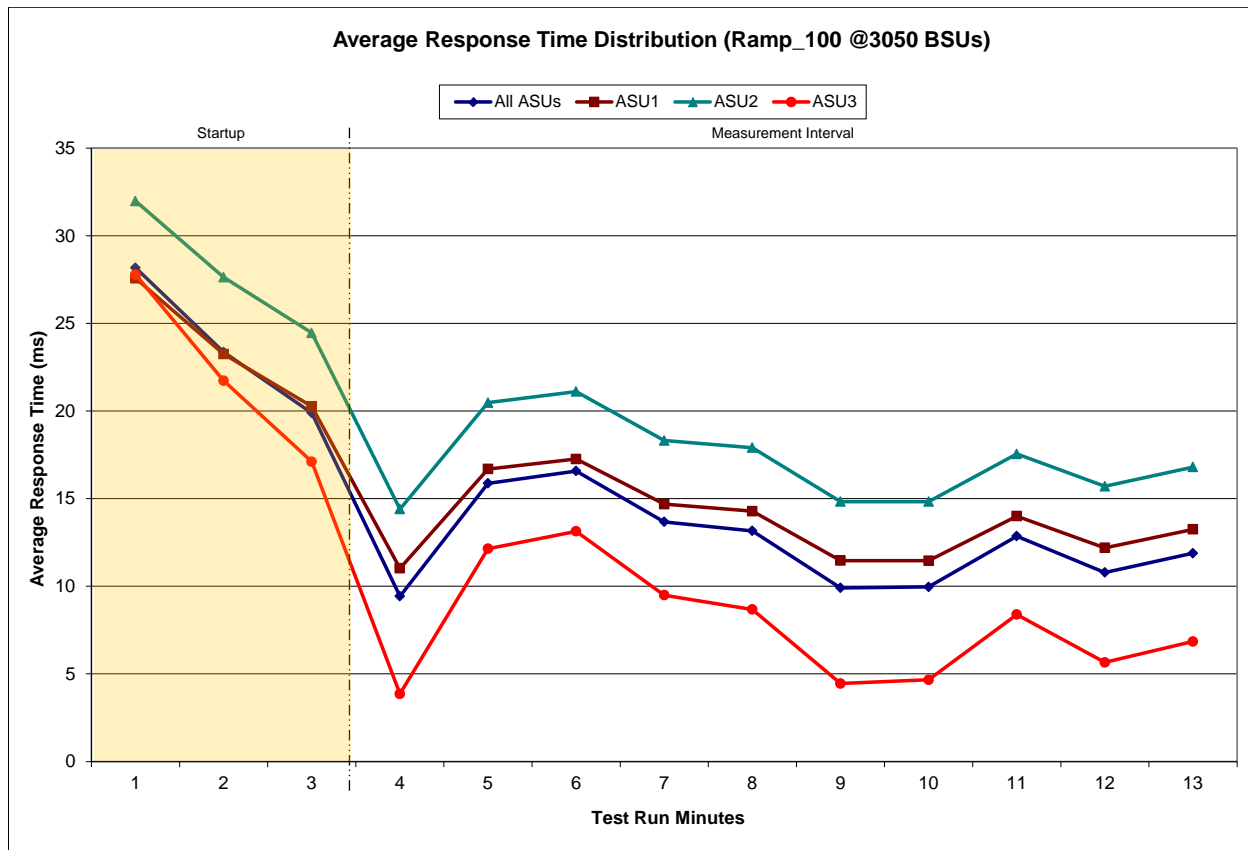
IOPS Test Run – Response Time Frequency Distribution Data

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	394,884	1,328,642	667,346	193,830	112,734	126,364	162,734	189,395
Write	2	1,377,129	6,149,968	6,180,597	4,502,399	3,798,832	3,119,003	2,526,198
All ASUs	394,886	2,705,771	6,817,314	6,374,427	4,615,133	3,925,196	3,281,737	2,715,593
ASU1	368,859	1,707,188	3,344,554	2,885,015	2,039,338	1,731,332	1,479,014	1,248,183
ASU2	26,026	454,104	831,276	690,431	483,014	402,701	328,240	266,209
ASU3	1	544,479	2,641,484	2,798,981	2,092,781	1,791,163	1,474,483	1,201,201

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	491,539	644,675	843,482	1,094,285	1,383,318	1,553,456	3,079,530	2,782,672
Write	3,816,002	3,071,537	2,326,233	1,849,886	1,393,362	1,148,634	1,726,692	1,241,947
All ASUs	4,307,541	3,716,212	3,169,715	2,944,171	2,776,680	2,702,090	4,806,222	4,024,619
ASU1	2,067,848	1,883,244	1,734,448	1,760,806	1,821,640	1,862,630	3,404,833	2,902,591
ASU2	411,720	362,762	315,325	294,307	282,429	289,152	574,034	530,911
ASU3	1,827,973	1,470,206	1,119,942	889,058	672,611	550,308	827,355	591,117

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	2,269,904	1,593,492	1,245,667	4,034,528	2,327,624	1,658,003	1,271,025	6,635,367
Write	964,446	785,588	664,976	2,458,820	1,973,289	1,364,550	589,846	2,367,760
All ASUs	3,234,350	2,379,080	1,910,643	6,493,348	4,300,913	3,022,553	1,860,871	9,003,127
ASU1	2,344,692	1,670,855	1,344,989	4,514,233	2,844,025	1,999,781	1,331,364	6,235,941
ASU2	435,421	339,492	254,297	830,496	531,216	380,530	255,187	1,681,641
ASU3	454,237	368,733	311,357	1,148,619	925,672	642,242	274,320	1,085,545

IOPS Test Run – Response Time Frequency Distribution Graph

Response Time Frequency Distribution (Ramp_100 @3050 BSUs)
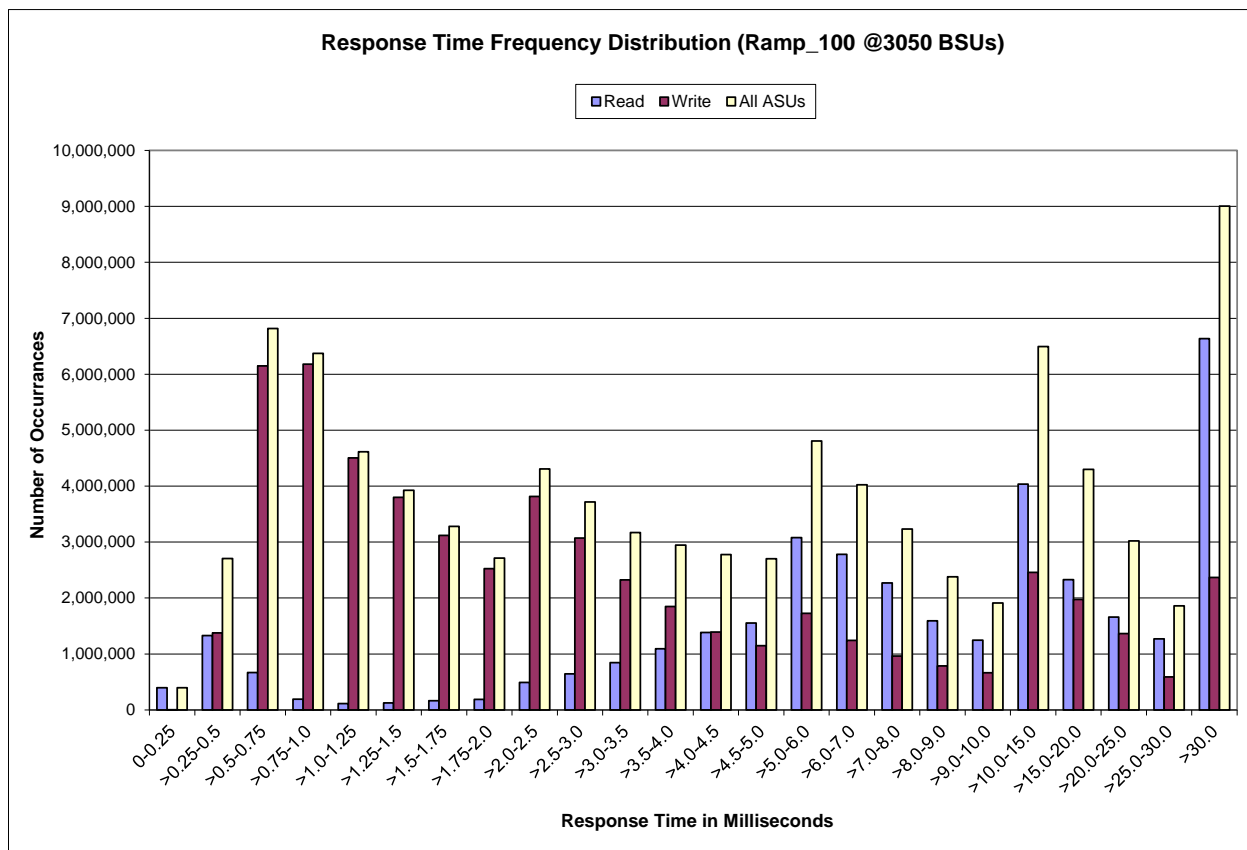
IOPS Test Run – I/O Request Information

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
91,482,192	82,479,065	9,003,127

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.001	0.001	0.003	0.001	0.001	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 - 3,050 BSUs	Start	Stop	Interval	Duration	95% Load Level - 2,897 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:04:09	0:07:10	0-2	0:03:01	Start-Up/Ramp-Up	0:22:34	0:25:35	0-2	0:03:01
Measurement Interval	0:07:10	0:17:10	3-12	0:10:00	Measurement Interval	0:25:35	0:35:35	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	151,246.37	90,169.83	18,606.15	42,470.38	0	144,901.20	86,382.25	17,806.55	40,712.40
1	153,156.88	91,291.07	18,863.13	43,002.68	1	144,900.47	86,371.98	17,817.72	40,710.77
2	153,173.63	91,282.77	18,833.88	43,056.98	2	144,915.97	86,356.70	17,824.75	40,734.52
3	152,375.67	90,781.23	18,764.98	42,829.45	3	144,808.62	86,295.28	17,797.42	40,715.92
4	152,574.00	90,933.30	18,773.62	42,867.08	4	144,821.47	86,286.28	17,809.57	40,725.62
5	152,605.13	90,952.58	18,764.83	42,887.72	5	144,820.30	86,339.58	17,800.90	40,679.82
6	152,476.05	90,918.97	18,762.40	42,794.68	6	144,966.35	86,378.18	17,852.58	40,735.58
7	152,503.68	90,920.35	18,749.92	42,833.42	7	144,804.75	86,304.78	17,835.10	40,664.87
8	152,523.73	90,906.23	18,773.23	42,844.27	8	144,909.92	86,292.50	17,857.75	40,759.67
9	152,533.85	90,897.88	18,753.32	42,882.65	9	144,878.68	86,355.50	17,837.73	40,685.45
10	152,501.22	90,898.68	18,748.25	42,854.28	10	144,811.18	86,308.72	17,793.95	40,708.52
11	152,372.93	90,853.93	18,719.60	42,799.40	11	144,868.17	86,341.27	17,822.40	40,704.50
12	152,322.73	90,777.00	18,716.65	42,829.08	12	144,770.40	86,242.02	17,815.87	40,712.52
Average	152,478.90	90,884.02	18,752.68	42,842.20	Average	144,845.98	86,314.41	17,822.33	40,709.25
90% Load Level - 2,745 BSUs	**Start**	**Stop**	**Interval**	**Duration**	**80% Load Level - 2,440 BSUs**	**Start**	**Stop**	**Interval**	**Duration**
Start-Up/Ramp-Up	0:40:55	0:43:56	0-2	0:03:01	Start-Up/Ramp-Up	0:59:18	1:02:19	0-2	0:03:01
Measurement Interval	0:43:56	0:53:56	3-12	0:10:00	Measurement Interval	1:02:19	1:12:19	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	137,239.75	81,788.98	16,871.40	38,579.37	0	121,959.40	72,666.42	15,007.52	34,285.47
1	137,277.17	81,805.88	16,887.90	38,583.38	1	121,971.40	72,729.78	14,968.32	34,273.30
2	137,262.63	81,810.45	16,906.63	38,545.55	2	122,075.72	72,792.58	15,005.22	34,277.92
3	137,177.82	81,739.97	16,870.00	38,567.85	3	122,045.77	72,750.60	15,023.20	34,271.97
4	137,260.72	81,790.98	16,877.98	38,591.75	4	122,065.97	72,774.77	15,002.05	34,289.15
5	137,192.72	81,708.48	16,880.40	38,603.83	5	122,126.08	72,759.35	15,022.93	34,343.80
6	137,148.65	81,772.77	16,846.02	38,529.87	6	122,019.47	72,716.50	14,995.80	34,307.17
7	137,295.72	81,778.20	16,901.62	38,615.90	7	121,888.23	72,670.73	14,980.87	34,236.63
8	137,230.88	81,787.87	16,876.57	38,566.45	8	121,939.65	72,714.25	14,986.47	34,238.93
9	137,239.33	81,778.07	16,876.67	38,584.60	9	121,963.80	72,653.48	15,018.92	34,291.40
10	137,328.02	81,827.48	16,888.98	38,611.55	10	121,975.27	72,693.78	15,006.97	34,274.52
11	137,222.60	81,819.10	16,871.23	38,532.27	11	122,056.48	72,773.82	15,022.60	34,260.07
12	137,291.70	81,835.32	16,898.57	38,557.82	12	122,091.92	72,737.72	15,039.52	34,314.68
Average	137,238.82	81,783.82	16,878.80	38,576.19	Average	122,017.26	72,724.50	15,009.93	34,282.83
50% Load Level - 1,525 BSUs	**Start**	**Stop**	**Interval**	**Duration**	**10% Load Level - 305 BSUs**	**Start**	**Stop**	**Interval**	**Duration**
Start-Up/Ramp-Up	1:17:41	1:20:42	0-2	0:03:01	Start-Up/Ramp-Up	1:36:10	1:39:11	0-2	0:03:01
Measurement Interval	1:20:42	1:30:42	3-12	0:10:00	Measurement Interval	1:39:11	1:49:11	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	76,264.80	45,457.83	9,406.22	21,400.75	0	15,254.95	9,081.90	1,871.83	4,301.22
1	76,231.28	45,429.70	9,365.47	21,436.12	1	15,261.50	9,099.55	1,866.58	4,295.37
2	76,189.25	45,422.07	9,375.13	21,392.05	2	15,263.25	9,092.08	1,875.28	4,295.88
3	76,279.10	45,453.87	9,377.75	21,447.48	3	15,254.10	9,091.17	1,868.33	4,294.60
4	76,205.13	45,435.70	9,381.18	21,388.25	4	15,237.78	9,092.73	1,871.65	4,273.40
5	76,216.87	45,424.27	9,386.73	21,405.87	5	15,249.63	9,102.45	1,871.87	4,275.32
6	76,198.23	45,400.15	9,370.02	21,428.07	6	15,271.13	9,088.55	1,884.30	4,298.28
7	76,230.63	45,433.30	9,378.67	21,418.67	7	15,242.93	9,083.53	1,870.70	4,288.70
8	76,277.75	45,441.98	9,402.62	21,433.15	8	15,222.92	9,068.33	1,875.85	4,278.73
9	76,228.50	45,446.65	9,368.03	21,413.82	9	15,253.88	9,074.67	1,882.90	4,296.32
10	76,316.58	45,511.48	9,384.22	21,420.88	10	15,241.48	9,093.90	1,871.67	4,275.92
11	76,246.90	45,434.07	9,387.42	21,425.42	11	15,215.12	9,070.63	1,877.35	4,267.13
12	76,281.73	45,441.05	9,374.53	21,466.15	12	15,272.00	9,100.57	1,875.30	4,296.13
Average	76,248.14	45,442.25	9,381.12	21,424.78	Average	15,246.10	9,086.65	1,874.99	4,284.45

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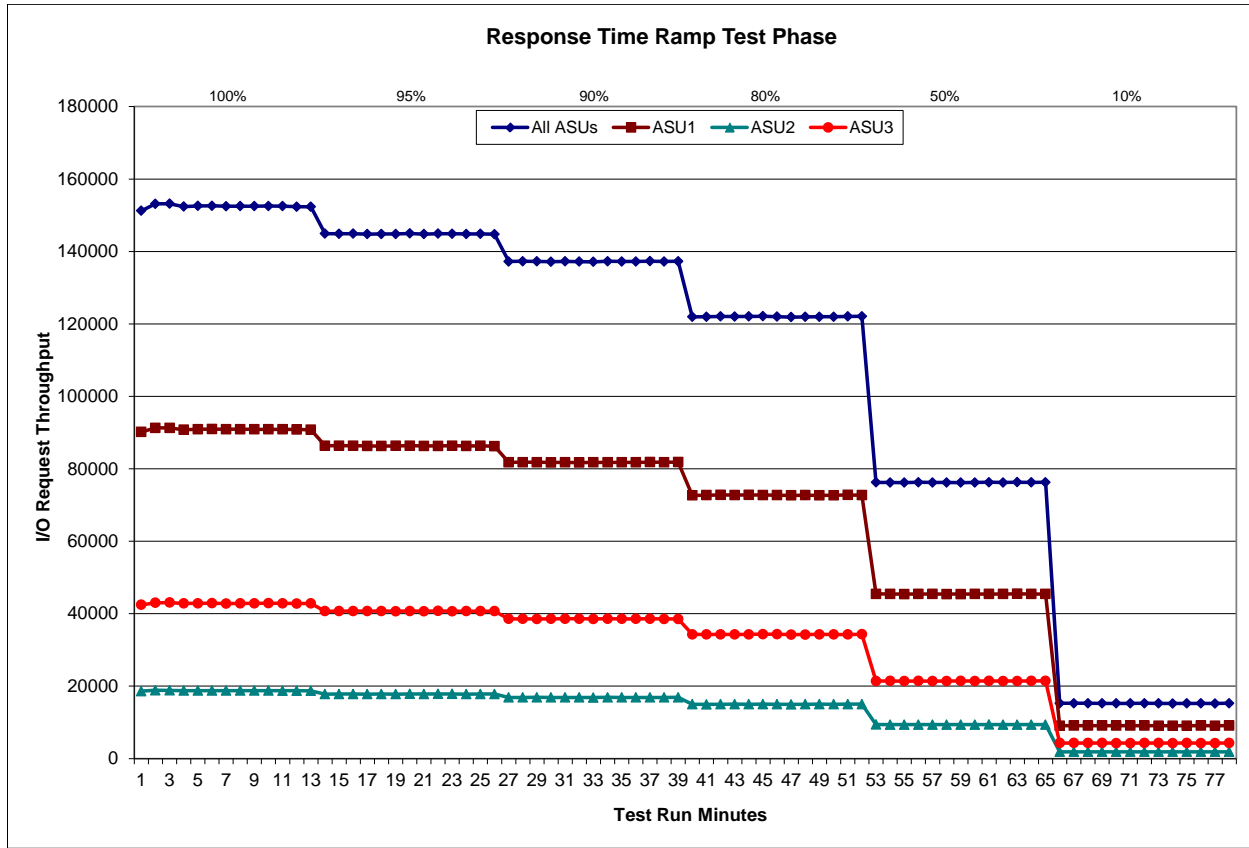
SPC-1 LRT™ Average Response Time (ms) Distribution Data

305 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:36:10	1:39:11	0-2	0:03:01
Measurement Interval	1:39:11	1:49:11	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.00	2.59	2.42	0.55
1	2.36	3.11	3.05	0.46
2	2.26	3.01	2.92	0.39
3	2.32	3.07	3.07	0.41
4	2.20	2.91	2.87	0.38
5	2.27	3.01	2.88	0.44
6	2.29	3.03	2.94	0.44
7	2.29	3.03	2.95	0.44
8	2.20	2.92	2.86	0.39
9	2.26	3.00	2.93	0.40
10	2.25	2.99	2.84	0.42
11	2.23	2.97	2.88	0.38
12	2.23	2.97	2.83	0.39
Average	*2.25*	*2.99*	*2.91*	*0.41*

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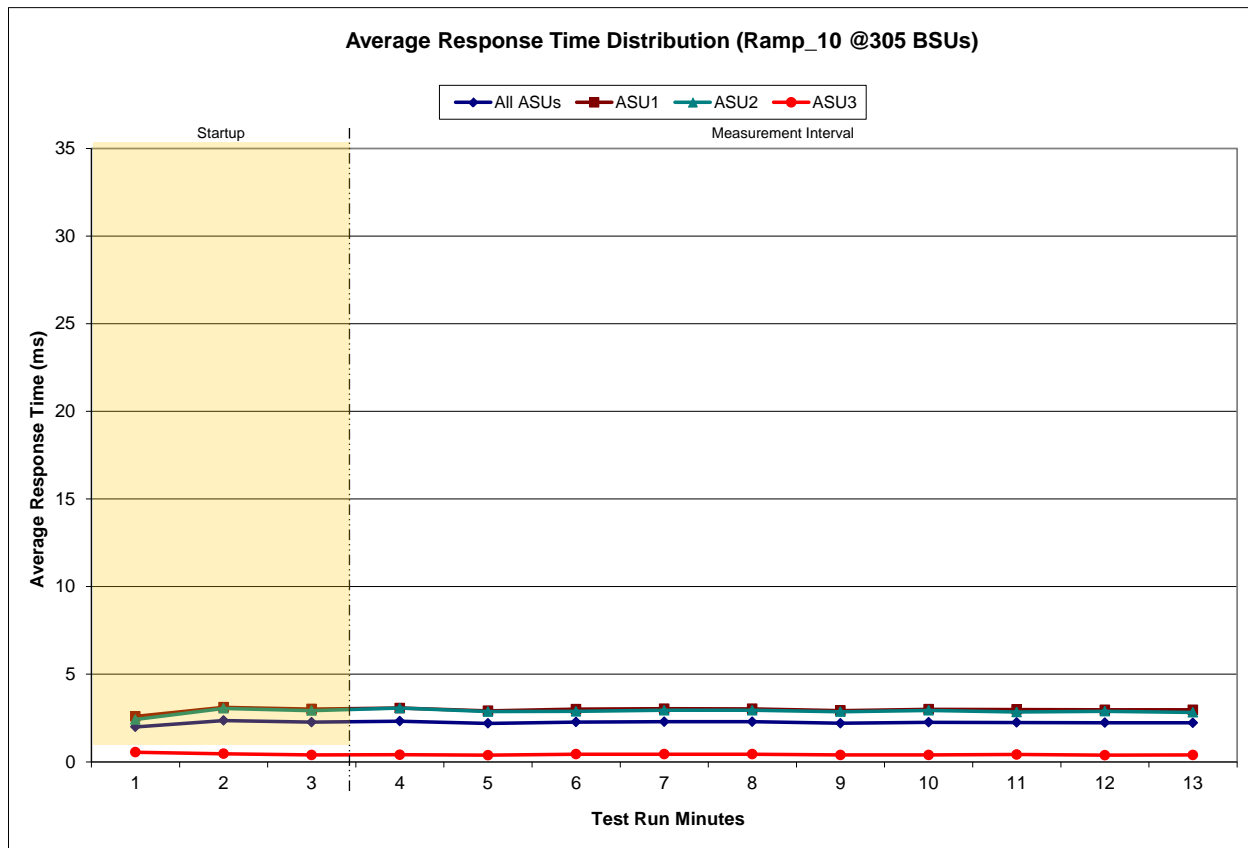
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2811	0.0700	0.2099	0.0180	0.0700	0.0349	0.2810
COV	0.005	0.001	0.005	0.003	0.007	0.004	0.006	0.002

Repeatability Test

Clause 5.4.5

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

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

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

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

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

Clause 9.4.3.7.4

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 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	*152,478.90*
Repeatability Test Phase 1	152,496.49
Repeatability Test Phase 2	152,509.66

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	*2.25 ms*
Repeatability Test Phase 1	2.25 ms
Repeatability Test Phase 2	2.25 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

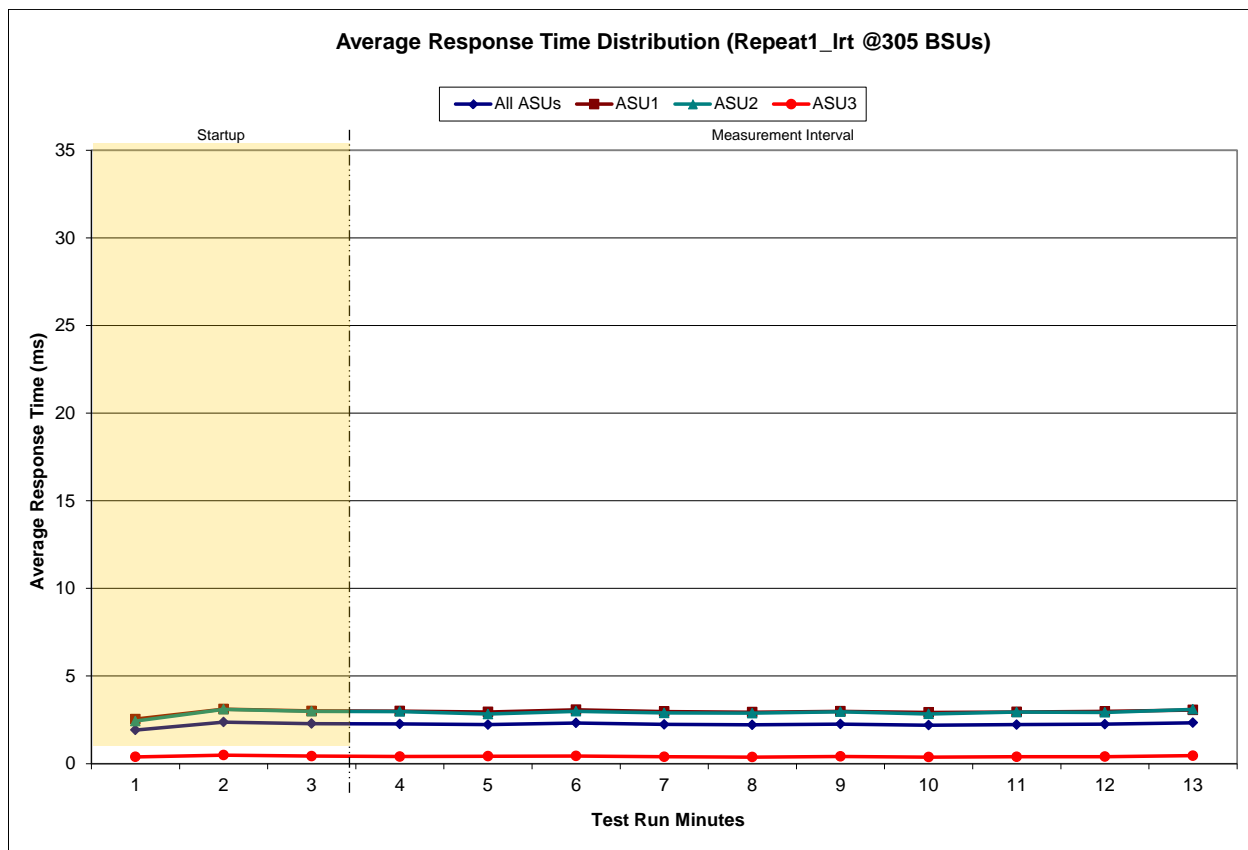| 305 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:54:49	1:57:49	0-2	0:03:00
Measurement Interval	1:57:49	2:07:49	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	15,240.13	9,079.47	1,874.20	4,286.47
1	15,237.93	9,074.02	1,877.87	4,286.05
2	15,236.53	9,083.98	1,879.27	4,273.28
3	15,223.22	9,070.37	1,868.88	4,283.97
4	15,269.80	9,104.25	1,875.73	4,289.82
5	15,205.42	9,051.68	1,865.62	4,288.12
6	15,239.35	9,093.07	1,865.62	4,280.67
7	15,256.77	9,117.17	1,869.92	4,269.68
8	15,270.25	9,103.05	1,882.55	4,284.65
9	15,263.10	9,102.08	1,872.43	4,288.58
10	15,236.25	9,078.80	1,876.10	4,281.35
11	15,275.82	9,114.48	1,881.92	4,279.42
12	15,265.73	9,097.27	1,877.28	4,291.18
Average	*15,250.57*	*9,093.22*	*1,873.61*	*4,283.74*

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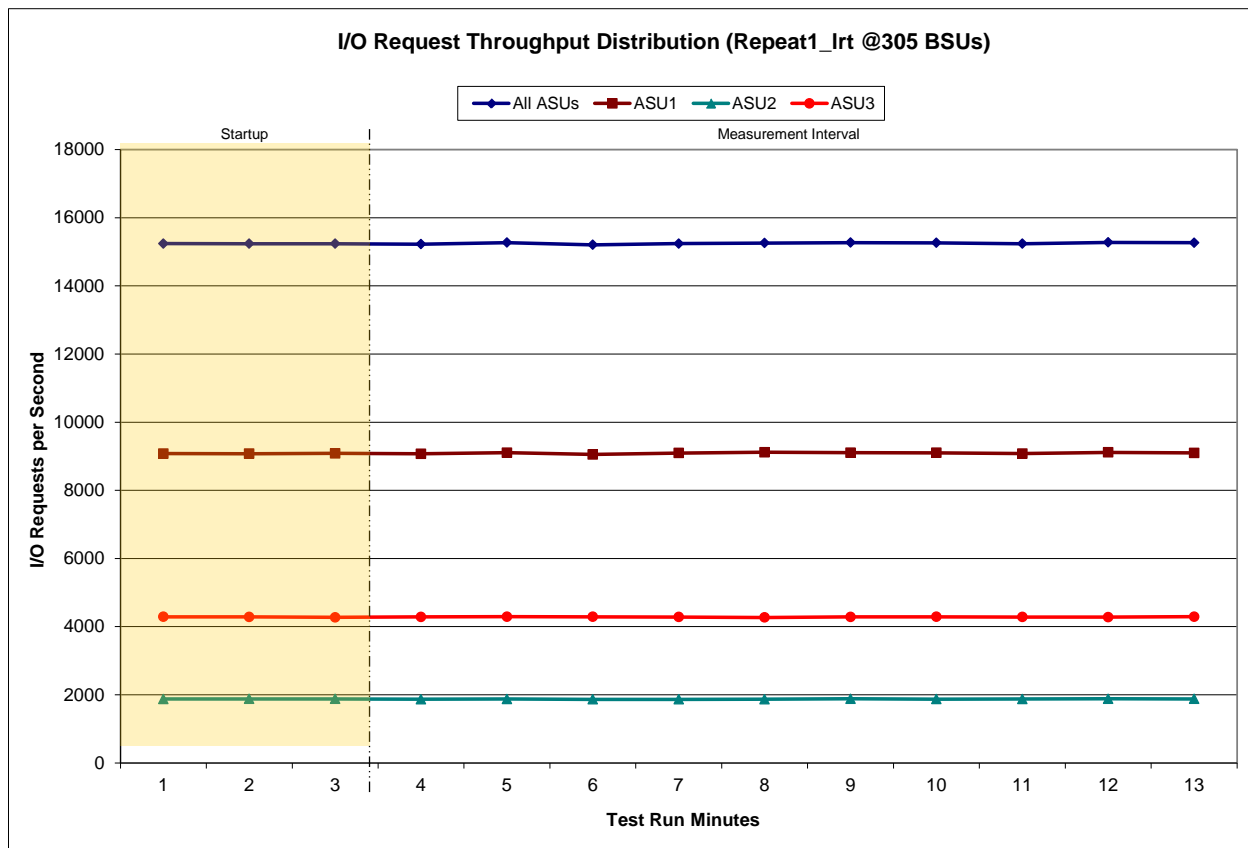
Repeatability 1 LRT –Average Response Time (ms) Distribution Data

305 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:54:49	1:57:49	0-2	0:03:00
Measurement Interval	1:57:49	2:07:49	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.92	2.54	2.43	0.38
1	2.37	3.11	3.10	0.49
2	2.28	3.01	2.99	0.43
3	2.27	3.00	2.97	0.41
4	2.22	2.95	2.83	0.43
5	2.32	3.08	2.99	0.44
6	2.24	2.97	2.89	0.39
7	2.21	2.93	2.88	0.37
8	2.26	2.98	2.96	0.41
9	2.20	2.93	2.84	0.38
10	2.23	2.95	2.94	0.39
11	2.25	2.98	2.93	0.40
12	2.33	3.06	3.10	0.45
Average	*2.25*	*2.98*	*2.93*	*0.41*

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

Repeatability 1 IOPS – I/O Request Throughput Distribution Data

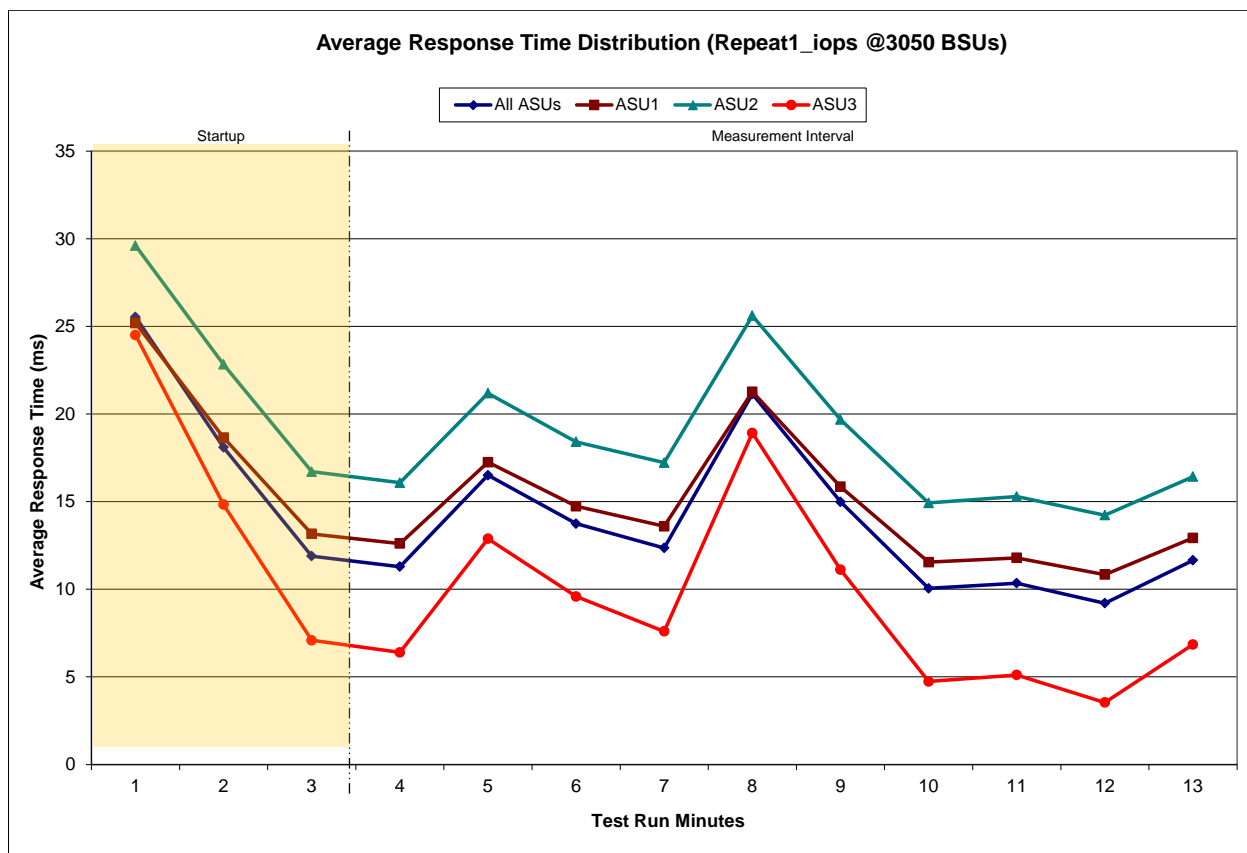| 3,050 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:13:10	2:16:11	0-2	0:03:01
Measurement Interval	2:16:11	2:26:11	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	151,983.52	90,565.25	18,688.70	42,729.57
1	153,013.87	91,178.90	18,834.70	43,000.27
2	152,416.20	90,794.17	18,778.35	42,843.68
3	152,559.60	90,924.17	18,778.17	42,857.27
4	152,458.72	90,861.13	18,734.42	42,863.17
5	152,412.27	90,837.02	18,751.63	42,823.62
6	152,508.23	90,919.13	18,743.22	42,845.88
7	152,298.58	90,778.35	18,735.82	42,784.42
8	152,769.57	91,063.70	18,802.05	42,903.82
9	152,480.03	90,876.60	18,776.68	42,826.75
10	152,462.92	90,900.60	18,755.32	42,807.00
11	152,556.90	90,943.03	18,756.68	42,857.18
12	152,458.08	90,873.17	18,740.97	42,843.95
Average	*152,496.49*	*90,897.69*	*18,757.50*	*42,841.31*

Repeatability 1 IOPS – I/O Request Throughput Distribution Graph

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

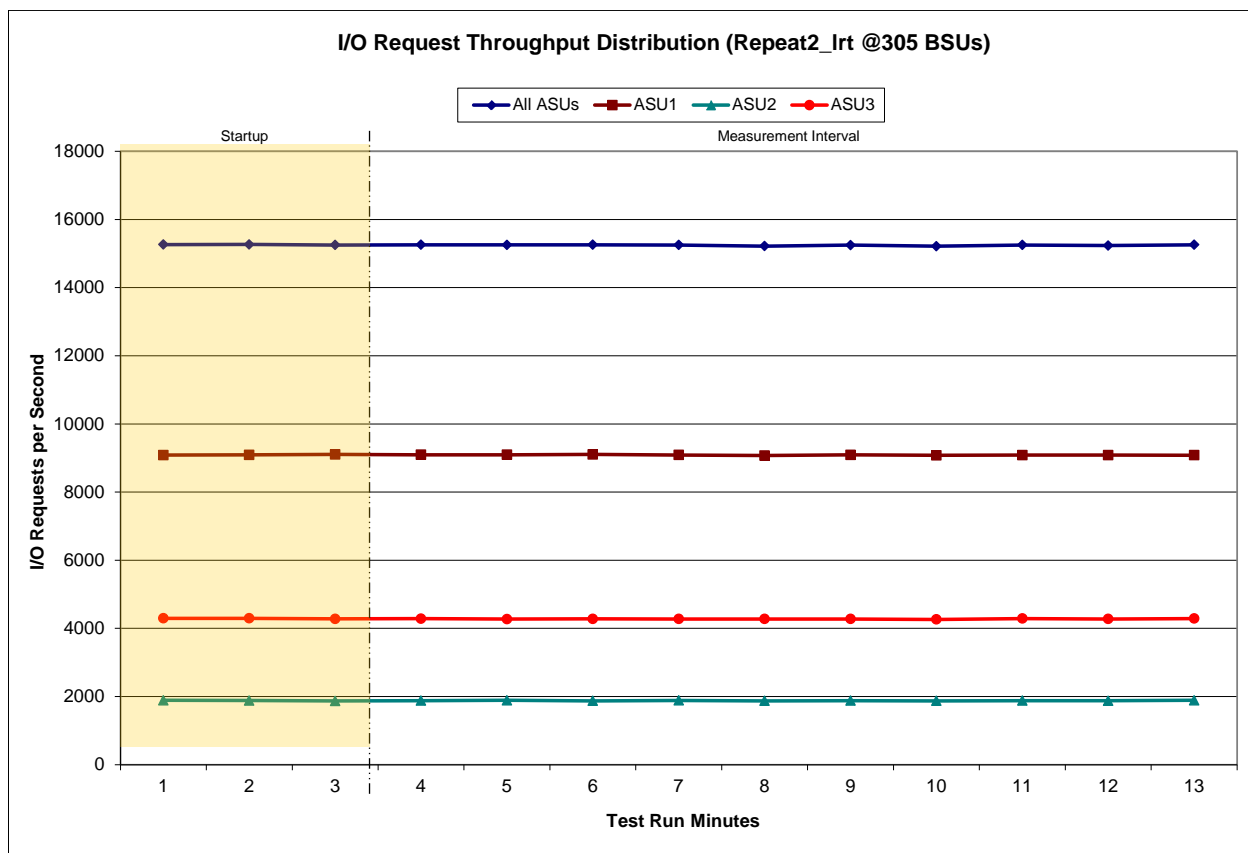| 3,050 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:13:10	2:16:11	0-2	0:03:01
Measurement Interval	2:16:11	2:26:11	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	25.54	25.19	29.61	24.51
1	18.10	18.66	22.83	14.83
2	11.89	13.16	16.71	7.09
3	11.29	12.61	16.08	6.40
4	16.51	17.25	21.19	12.88
5	13.74	14.74	18.41	9.59
6	12.36	13.60	17.23	7.59
7	21.14	21.27	25.61	18.92
8	14.99	15.85	19.68	11.11
9	10.05	11.55	14.93	4.74
10	10.34	11.79	15.29	5.11
11	9.21	10.84	14.23	3.54
12	11.65	12.93	16.43	6.85
Average	*13.13*	*14.24*	*17.91*	*8.67*

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

Repeatability 2 LRT – I/O Request Throughput Distribution Data

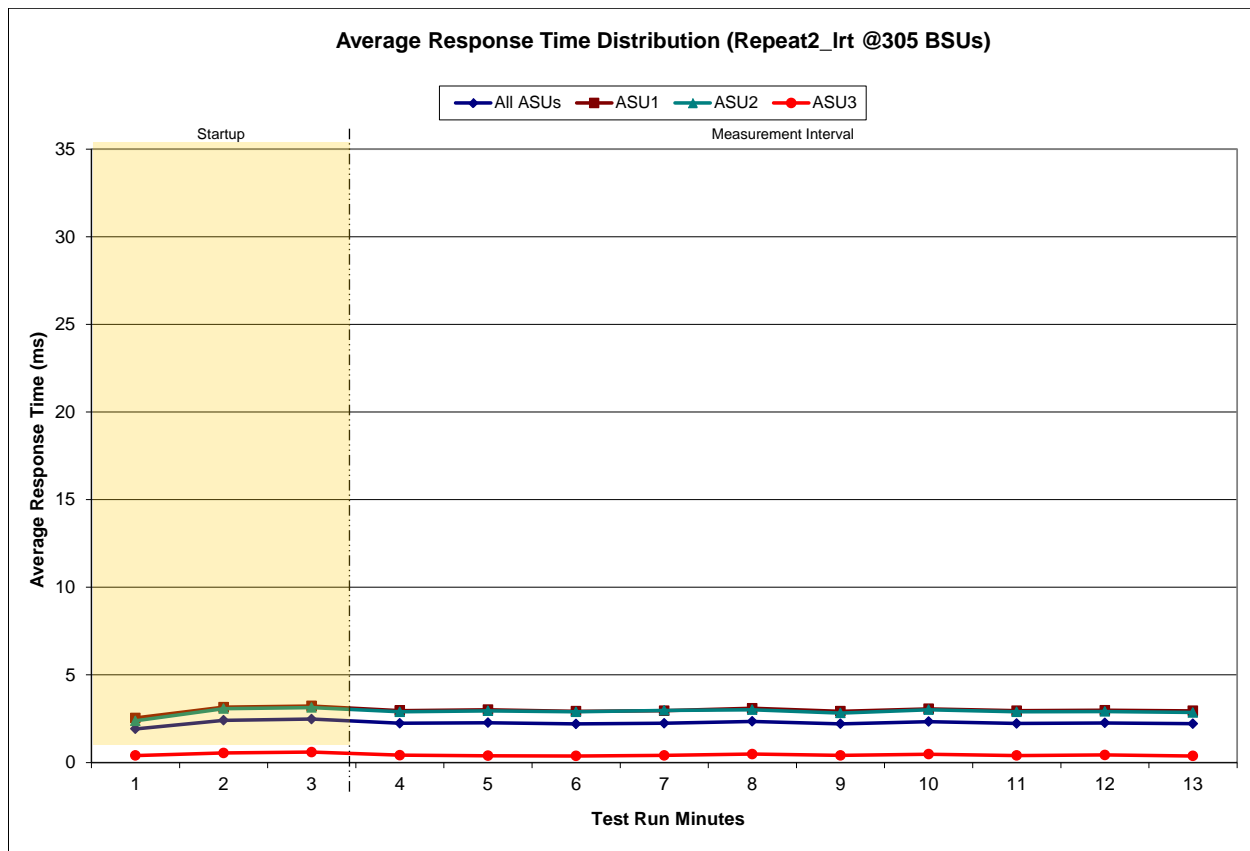| 305 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:31:45	2:34:45	0-2	0:03:00
Measurement Interval	2:34:45	2:44:45	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	15,264.78	9,083.83	1,887.70	4,293.25
1	15,267.30	9,090.38	1,881.97	4,294.95
2	15,250.67	9,103.20	1,867.78	4,279.68
3	15,256.28	9,095.10	1,877.03	4,284.15
4	15,253.17	9,093.42	1,887.28	4,272.47
5	15,256.27	9,104.18	1,872.60	4,279.48
6	15,249.82	9,088.02	1,885.87	4,275.93
7	15,217.95	9,070.63	1,873.12	4,274.20
8	15,247.35	9,091.98	1,879.23	4,276.13
9	15,214.07	9,077.92	1,873.32	4,262.83
10	15,251.38	9,083.93	1,877.98	4,289.47
11	15,233.83	9,084.07	1,876.27	4,273.50
12	15,256.70	9,080.53	1,889.52	4,286.65
Average	*15,243.68*	*9,086.98*	*1,879.22*	*4,277.48*

Repeatability 2 LRT – I/O Request Throughput Distribution Graph

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

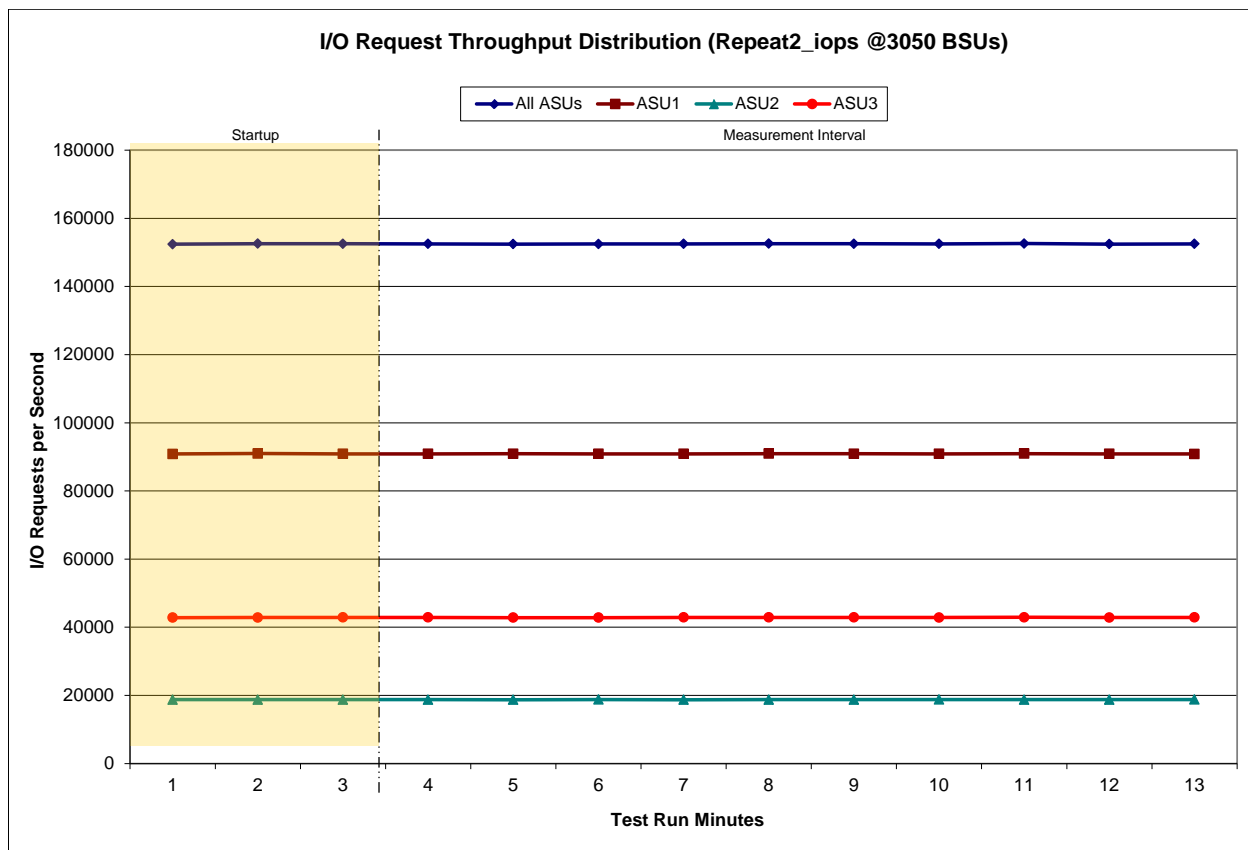| 305 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:31:45	2:34:45	0-2	0:03:00
Measurement Interval	2:34:45	2:44:45	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.92	2.54	2.38	0.40
1	2.41	3.15	3.08	0.54
2	2.48	3.23	3.14	0.59
3	2.24	2.96	2.89	0.42
4	2.27	3.01	2.95	0.39
5	2.20	2.92	2.89	0.37
6	2.24	2.95	2.97	0.41
7	2.35	3.09	3.01	0.48
8	2.21	2.93	2.82	0.40
9	2.33	3.06	3.01	0.47
10	2.23	2.95	2.89	0.40
11	2.26	2.98	2.91	0.43
12	2.21	2.95	2.85	0.38
Average	*2.25*	*2.98*	*2.92*	*0.41*

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

Repeatability 2 IOPS – I/O Request Throughput Distribution Data

| 3,050 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:50:09	2:53:10	0-2	0:03:01
Measurement Interval	2:53:10	3:03:10	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	152,414.02	90,853.62	18,748.95	42,811.45
1	152,576.78	90,966.17	18,766.38	42,844.23
2	152,534.40	90,892.07	18,750.12	42,892.22
3	152,514.17	90,887.95	18,759.45	42,866.77
4	152,431.62	90,913.72	18,712.47	42,805.43
5	152,456.55	90,876.67	18,769.25	42,810.63
6	152,503.10	90,880.80	18,735.97	42,886.33
7	152,574.63	90,950.33	18,755.05	42,869.25
8	152,549.72	90,918.87	18,763.17	42,867.68
9	152,520.38	90,888.52	18,778.50	42,853.37
10	152,587.28	90,930.07	18,743.15	42,914.07
11	152,456.32	90,868.73	18,750.05	42,837.53
12	152,502.85	90,848.27	18,783.20	42,871.38
Average	*152,509.66*	*90,896.39*	*18,755.03*	*42,858.25*

Repeatability 2 IOPS – I/O Request Throughput Distribution Graph

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

3,050 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:50:09	2:53:10	0-2	0:03:01
Measurement Interval	2:53:10	3:03:10	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	24.45	24.12	28.55	23.35
1	17.73	18.30	22.46	14.44
2	17.14	17.73	21.70	13.92
3	11.12	12.43	15.86	6.26
4	11.50	12.82	16.29	6.61
5	14.19	15.12	18.76	10.21
6	14.25	15.19	18.77	10.30
7	11.33	12.64	16.10	6.49
8	11.09	12.46	15.98	6.04
9	11.05	12.40	15.84	6.08
10	10.41	11.84	15.21	5.28
11	10.10	11.63	15.04	4.69
12	14.98	15.87	19.70	11.02
Average	*12.00*	*13.24*	*16.76*	*7.30*

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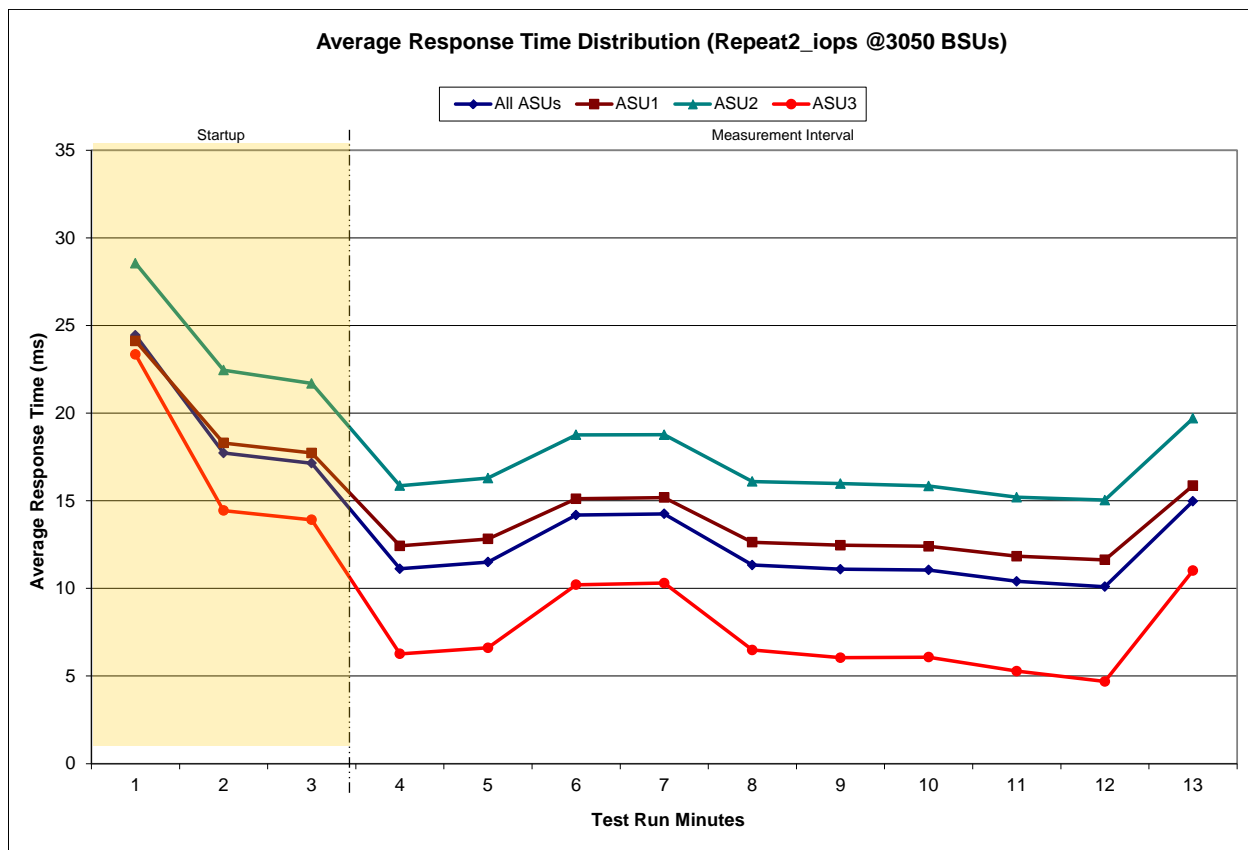
Repeatability 1 (LRT)
Measured Intensity Multiplier and Coefficient of Variation

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 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2810	0.0701	0.2101	0.0179	0.0699	0.0350	0.2809
COV	0.005	0.002	0.004	0.002	0.007	0.003	0.004	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	0.2811	0.0700	0.2100	0.0180	0.0700	0.0350	0.2809
COV	0.002	0.000	0.001	0.001	0.003	0.001	0.001	0.000

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0349	0.2811	0.0700	0.2101	0.0180	0.0701	0.0351	0.2806
COV	0.005	0.002	0.005	0.002	0.005	0.005	0.005	0.001

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	0.0349	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001

Data Persistence Test

Clause 6

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

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

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

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

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

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

Clause 9.4.3.8

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

1. *A listing or screen image of all input parameters supplied to the Workload Generator.*

2. *For the successful Data Persistence Test Run, a table illustrating key results. The content, appearance, and format of this table are specified in Table 9-12. Information displayed in this table shall be obtained from the Test Run Results File referenced below in #3.*

3. *For the successful Data Persistence Test Run, the human readable Test Run Results file produced by the Workload Generator (may be contained in an appendix).*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 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	151,199,600
Total Number of Logical Blocks Verified	79,790,800
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 9.4.3.9

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

The NEC Storage M700 as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

PRICING INFORMATION

Clause 9.4.3.3.6

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

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

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.8

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

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration may be found in the Executive Summary portion of this document on page 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 NEC Storage M700.

APPENDIX A: SPC-1 GLOSSARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

I/O Completion Types
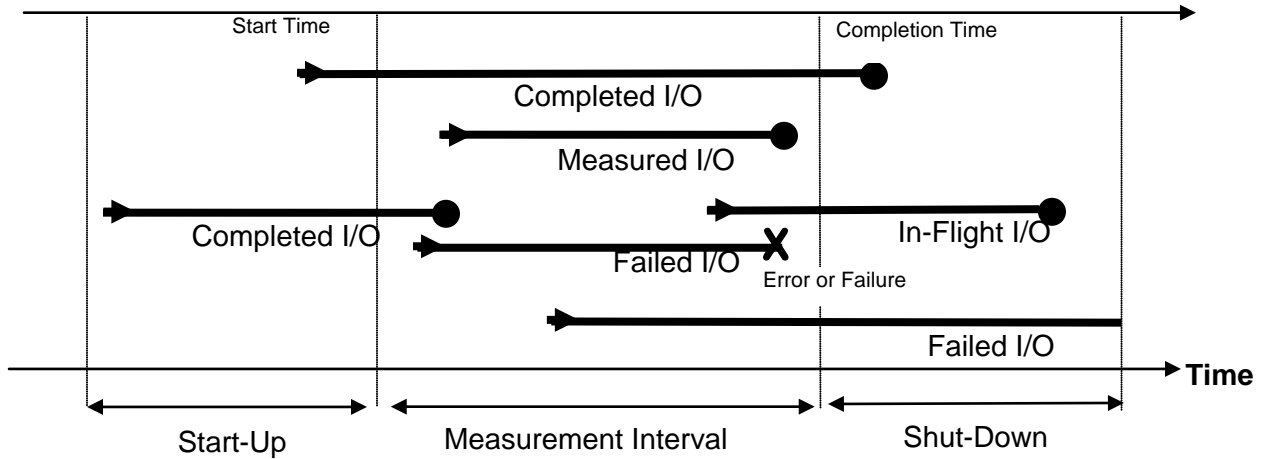
SPC-1 Test Run Components
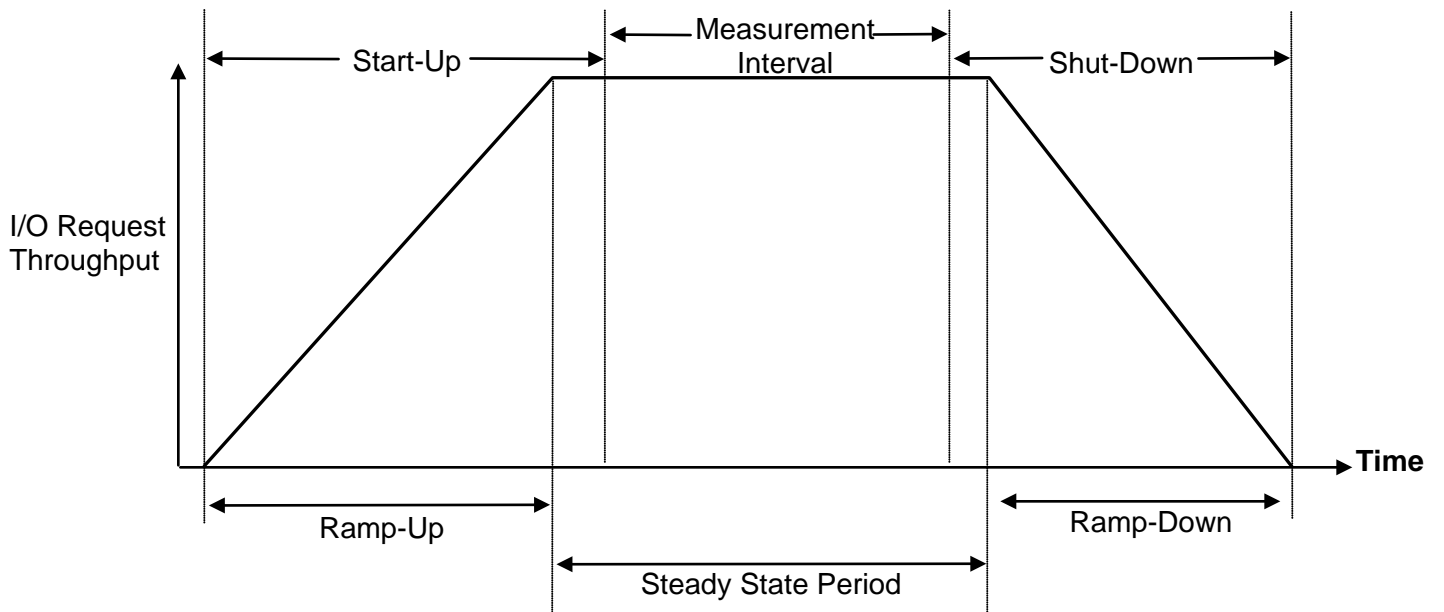
APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

There were no customer tunable parameters or options changed from their default values for the benchmark measurements.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The NEC Storage Manager was used to create and configure the Tested Storage Configuration. That storage management utility was installed and used from one of the two Host Systems.

Starting the NEC Storage Manager Client

The NEC Storage Manager client is started as follows:

1. Start a web browser on the Host System where the NEC Storage Manager client is installed.

2. Start the NEC Storage Manager client by entering the IP address of the NEC Storage M500 in the address bar of the web browser.

3. Perform the following to logon to the NEC Storage Manager client:

   a) Enter **sysadmin** in the **User Name** box

   b) Enter **sys123** *(default value)* in the **Password** box

4. Click **Login** to open the client main menu.
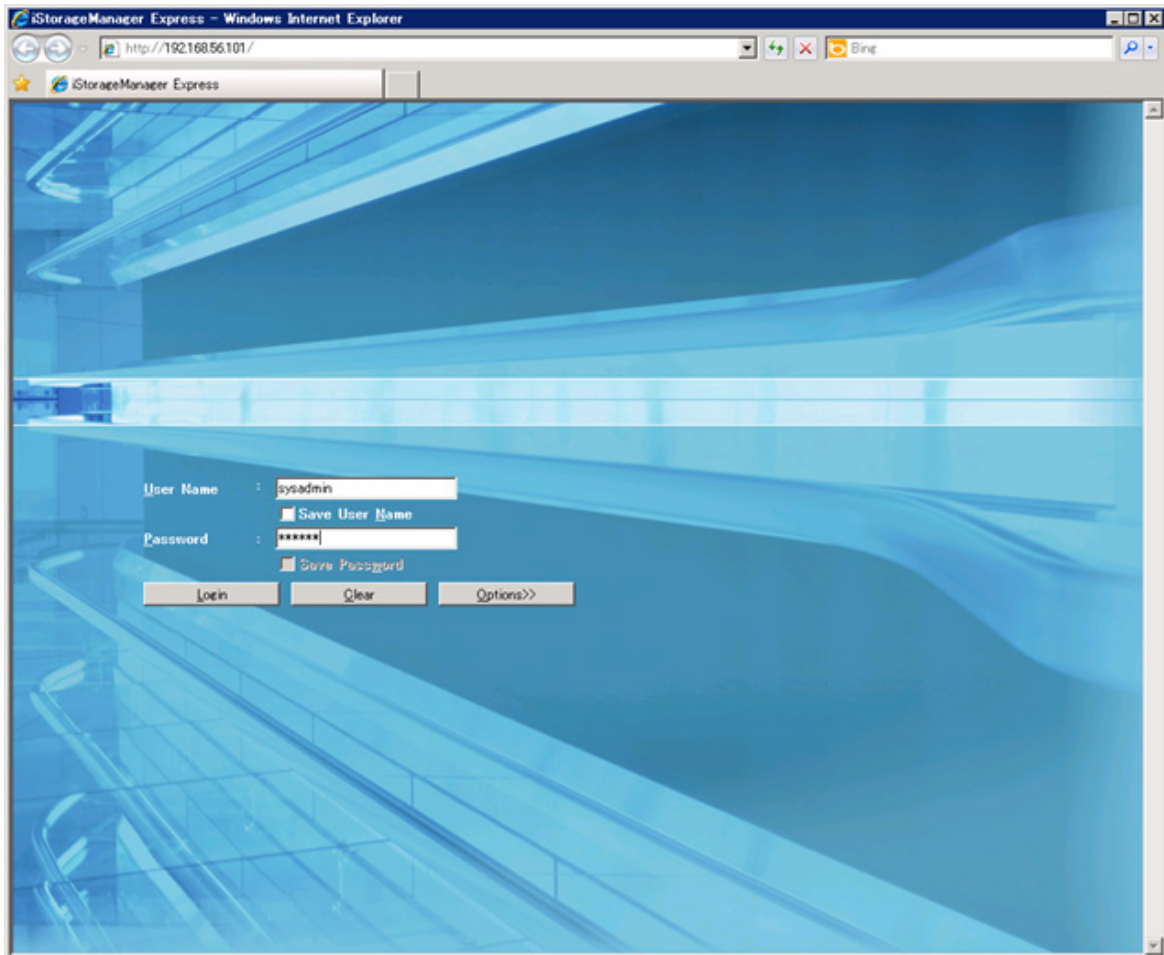
Create Volume Groups *(Pool Bind)*

Click **Configuration** and **Pool** on the main menu to open the appropriate submenu.
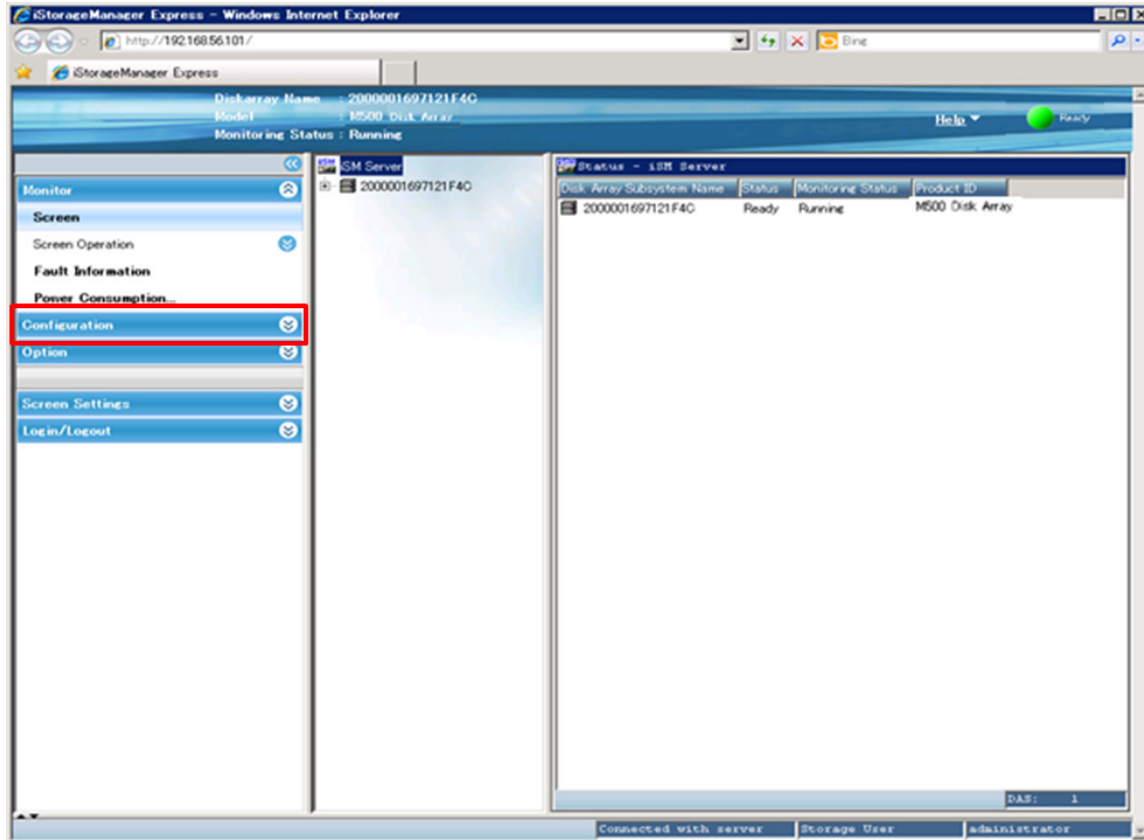

Then click **Pool Bind** on that submenu.
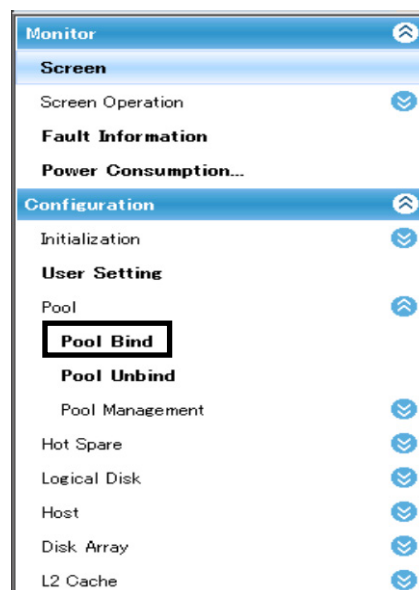
There were 22 volume groups created, each of which contained a single RAID1/10 *(mirrored)* volume.

Examples of the Pool Bind menus are listed below. The values displayed in menu were not the values used to configure the TSC. The specific parameter values for each of the 25 volume groups are listed in the Volume Group Parameters section.

Each volume group is created, starting with the first Pool Bind menu, by selecting the following specifications:

- **Physical disk type** of *SAS*

- **RAID type** of *RAID1/10*
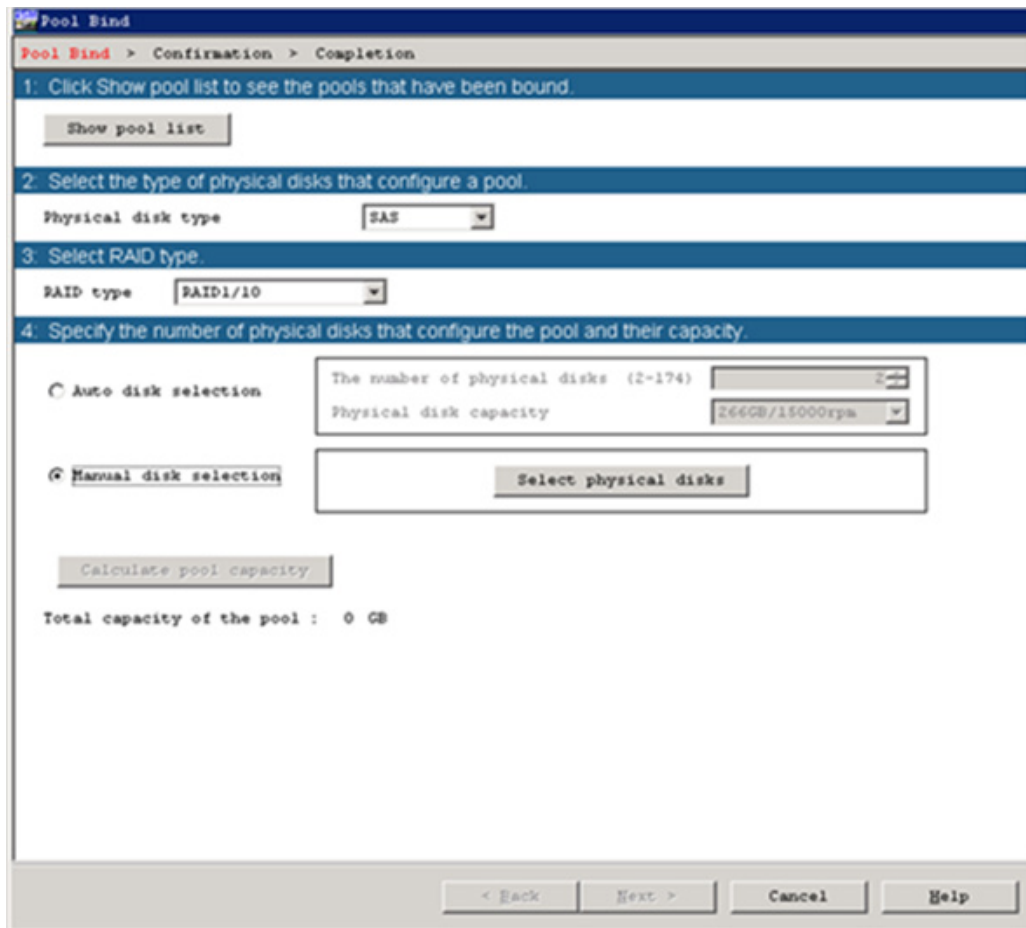
Specify 32 physical disks to be assigned to a pool by selecting the **Manual disk selection** option and clicking on **Select physical disks**, which will display the second Pool Bind menu.

Select the appropriate 32 physical disks and then click the **OK** button, which will return to
the first Pool Bind menu.
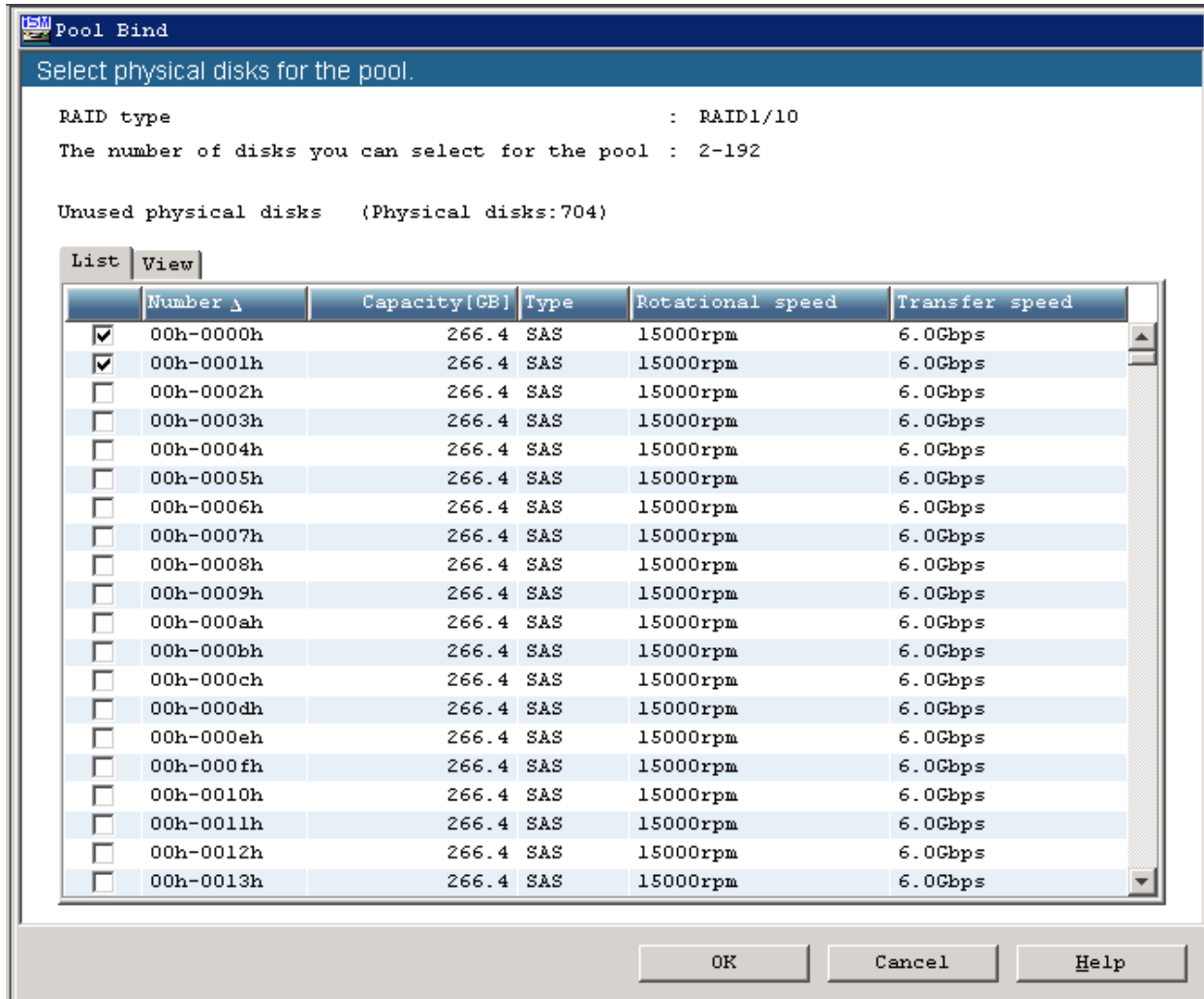
Click on the **Next** button, which will cause a confirmation menu to be displayed.
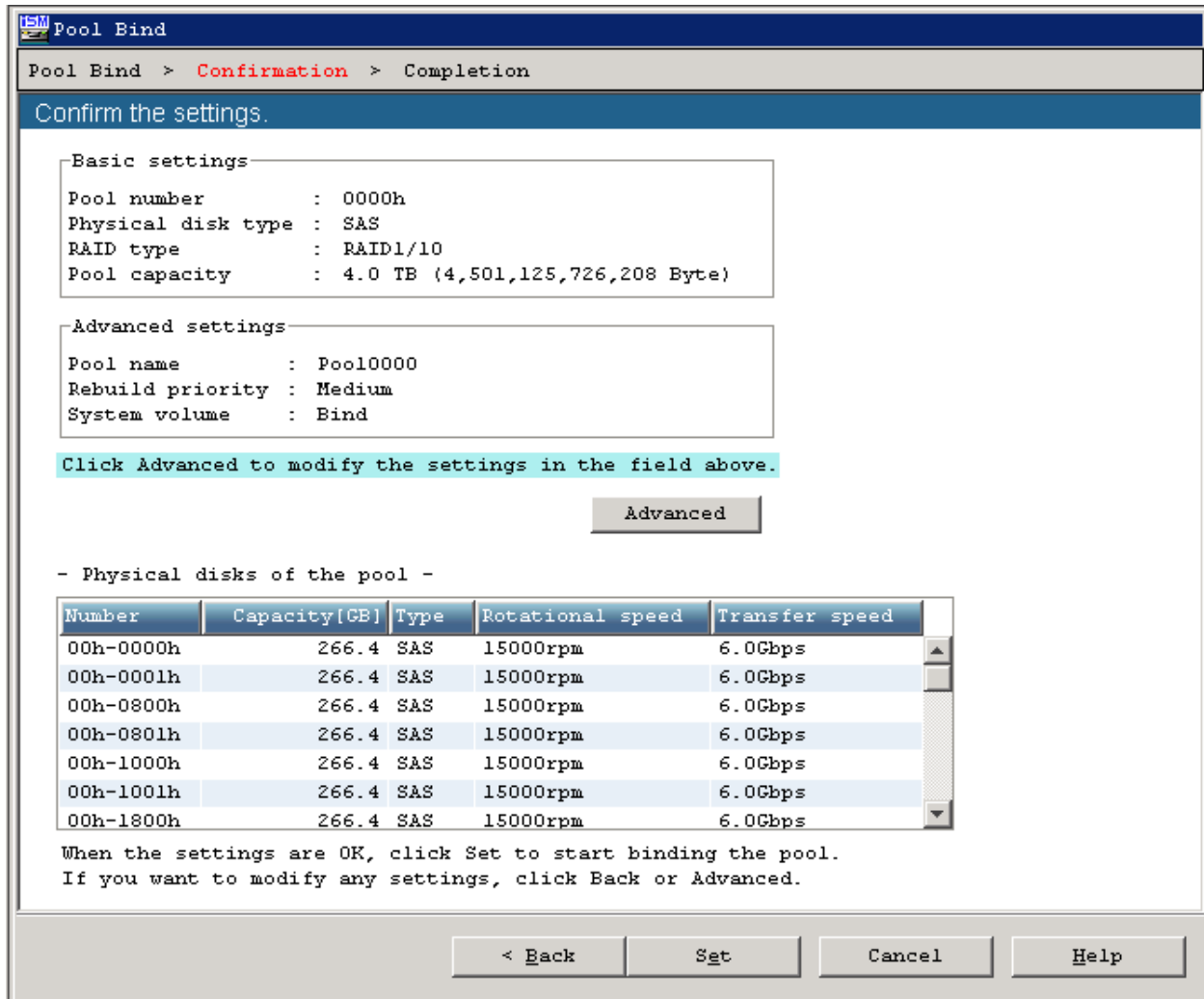
This menu will display the pool number, physical disk type, RAID type and physical disks selected to configure the pool. The pool number is automatically assigned.

If all of the displayed information is correct, click on the **Set** button to display the following confirmation message.

Click on the **Yes** button to complete the pool bind and creation of the volume group. When the pool binding is successfully completed the following window is displayed.
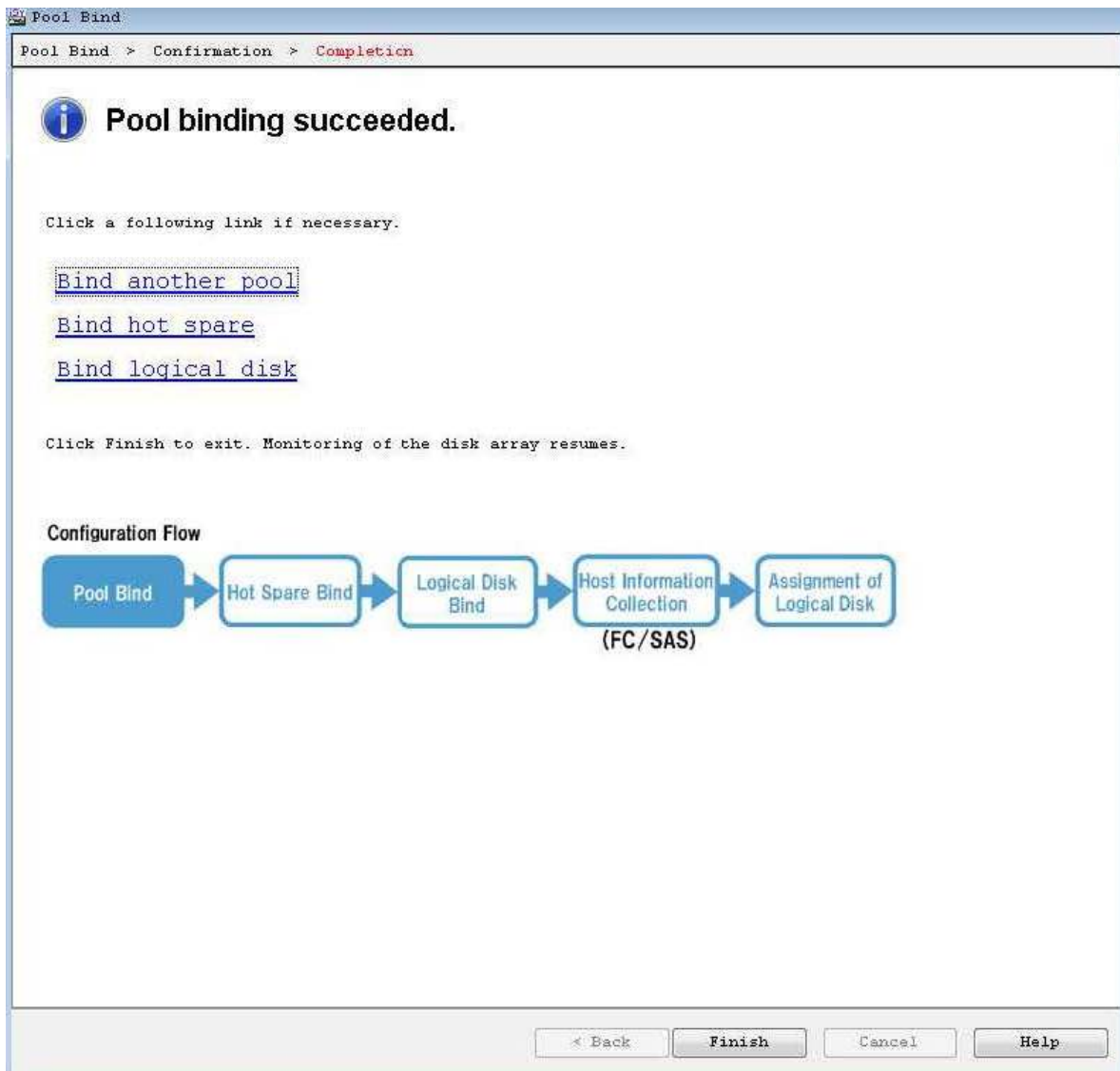
Click on **Bind another pool** to create another volume group or **Bind logical disk** to create the logical disks described in the next step.

Create Logical Disks *(Logical Disk Bind)*

The logical disks can be created by clicking the **Bind logical disk** option in the Pool Disk completion menu or by clicking **Configuration** then **Logical Disk Bind** in the main menu.

One logical disk was created from each of the 22 RAID1/10 volumes.

Examples of the Logical Disk Bind menus are listed below. The values displayed in example menus were not the values used to configure the TSC. The specific parameter values for each of the 22 logical disks are listed in the Logical Disk Parameters section.

Each logical disk was created, starting from the first Logical Disk Bind menu, with the following specifications:

- **Pool list:** Select the pool in which the logical disk will be bound.

- **Number of logical disks:** Select **1** as the number of logical disks.

- **Logical disk capacity:** Enter the capacity in GiB.

- The **logical disk name** is assigned automatically.
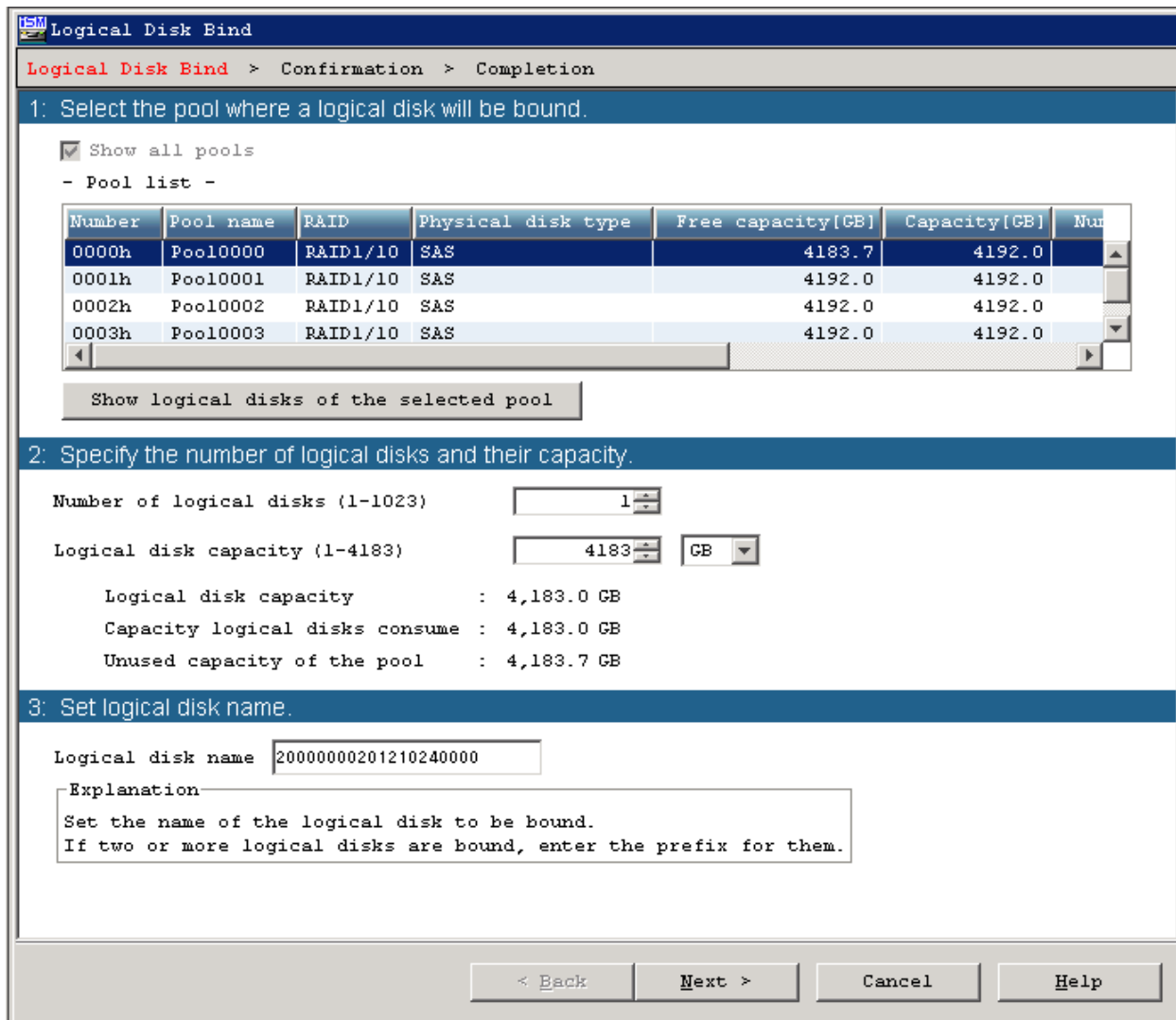
After entering the appropriate parameter values, click on the **Next** button, which will display.the following confirmation menu.

This menu will list the settings of the logical disk to be bound. If all of the displayed information is correct, click on the **Set** button, which will display the following final confirmation menu.
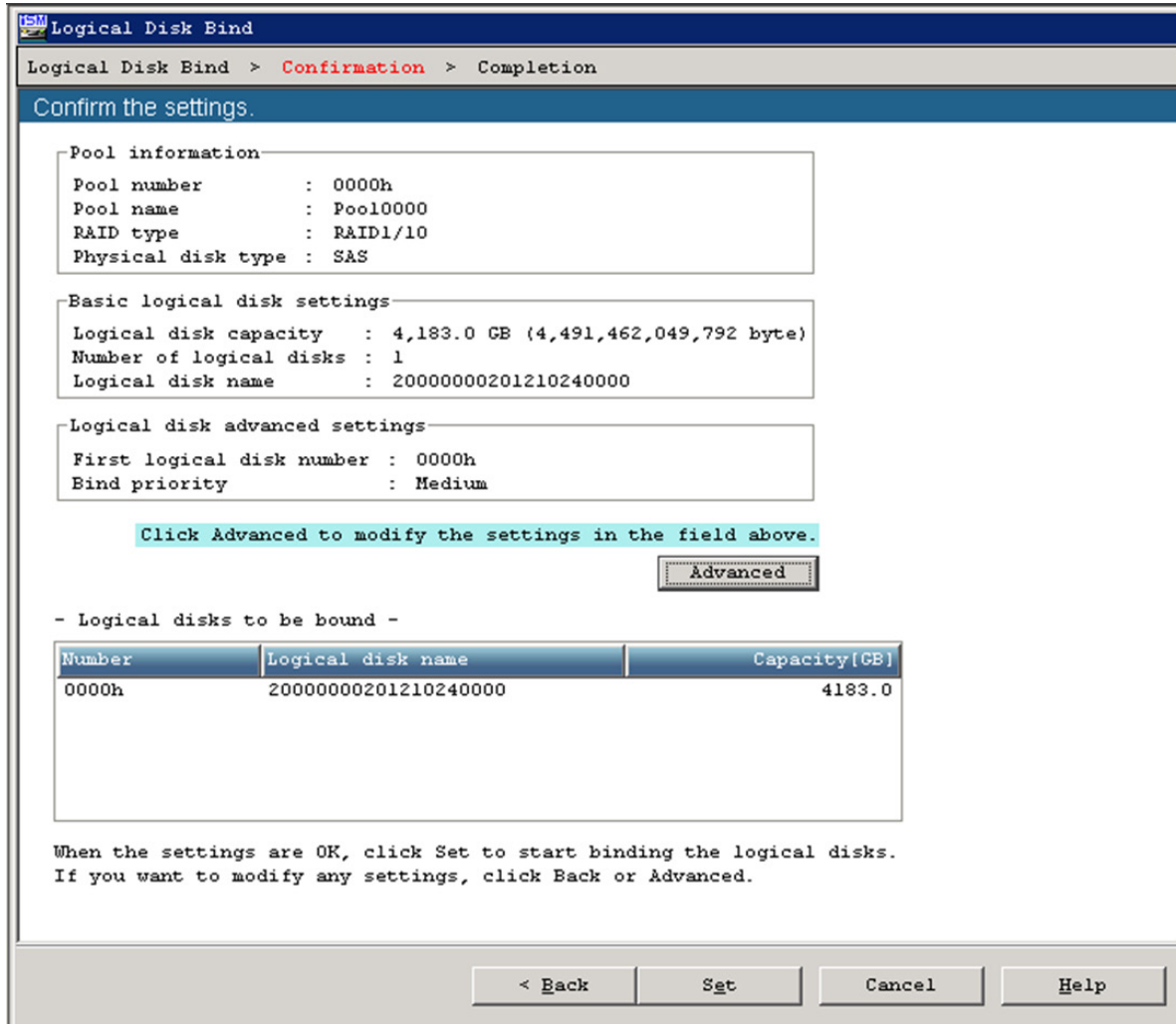
Click on the **Yes** button to create the logical disk.
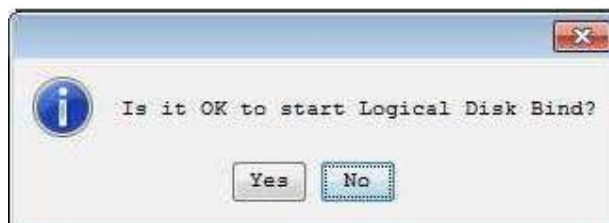
After that is completed, the following window is displayed.

Select **Bind another logical disk** to create another logical disk or click the **Finish** button after creating the last logical disk.

SPC-1 Logical Volume Creation

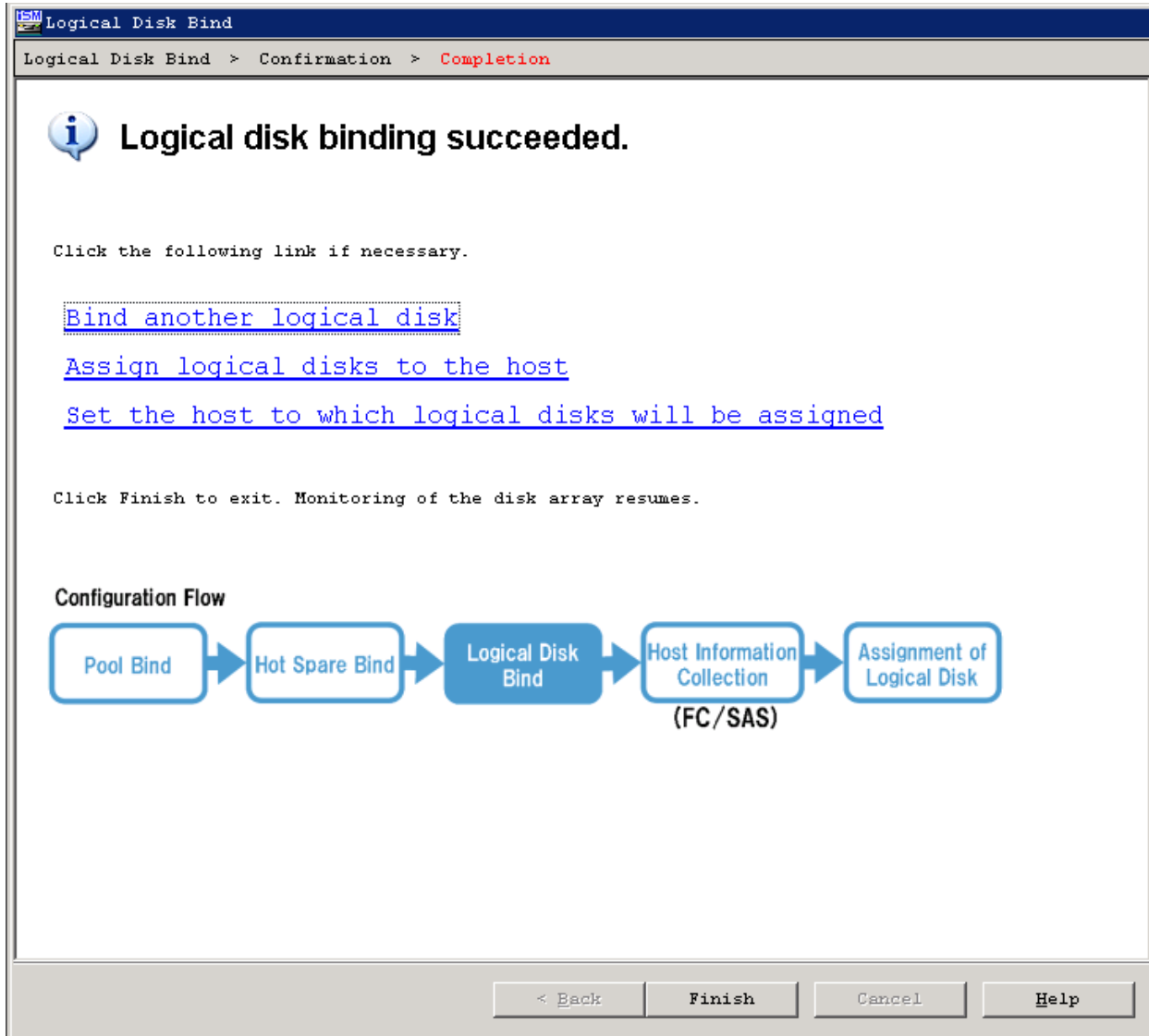The following steps are executed on a single Host System, using the Windows Disk Management utility, to create the SPC-1 Logical Volumes.

1. Start the Windows Disk Management utility and confirm that the 25 logical disks, created above, are present as 22 Windows "Disks".

2. Convert all 22 Windows "Disks" to GPT Disks.

3. Convert all 22 Windows "Disks" to Dynamic Disks.

4. Create a Windows striped (RAID-0) volume for ASU-1 as follows:
   a. Select all 22 Windows "Disks".
   b. Set the capacity of each stripe to 1,349,235 MB *(MiB)*
   c. Assign drive letter "E" to the volume.
   d. Do not format the volume.

5. Create a Windows striped (RAID-0) volume for ASU-2 as follows:
   a. Select all 22 Windows "Disks".
   b. Set the capacity of each stripe to 1,349,235 MB *(MiB)*
   c. Assign drive letter "F" to the volume.
   d. Do not format the volume.

6. Create a Windows striped (RAID-0) volume for ASU-3 as follows:
   a. Select all 22 Windows "Disks".
   b. Set the capacity of each stripe to 299,830 MB *(MiB)*
   c. Assign drive letter "G" to the volume.
   d. Do not format the volume.

7. Reboot the Host Systems.

8. After the reboot completes, start the Windows Disk Management utility on each of the Host Systems.

9. On each Host System, select either the import foreign disk or reactivate Windows stripe sets option, as necessary, then assign drive letters to the stripe sets as were defined in steps 4-6 above.

Referenced Parameter Details

Volume Group Parameters

Pool Number	Physical Disk	RAID type	Select physical disks
0000	SAS	RAID1/10	00-0000,00-0001,00-0800,00-0801,00-1000, 00-1001,00-1800,00-1801,00-2000,00-2001, 00-2800,00-2801,00-3000,00-3001,00-3800, 00-3801,00-4000,00-4001,00-4800,00-4801, 00-5000,00-5001,00-5800,00-5801,00-6000, 00-6001,00-6800,00-6801,00-7000,00-7001, 00-7800,00-7801
0001	SAS	RAID1/10	00-0002,00-0003,00-0802,00-0803,00-1002, 00-1003,00-1802,00-1803,00-2002,00-2003, 00-2802,00-2803,00-3002,00-3003,00-3802, 00-3803,00-4002,00-4003,00-4802,00-4803, 00-5002,00-5003,00-5802,00-5803,00-6002, 00-6003,00-6802,00-6803,00-7002,00-7003, 00-7802,00-7803
0002	SAS	RAID1/10	00-0004,00-0005,00-0804,00-0805,00-1004, 00-1005,00-1804,00-1805,00-2004,00-2005, 00-2804,00-2805,00-3004,00-3005,00-3804, 00-3805,00-4004,00-4005,00-4804,00-4805, 00-5004,00-5005,00-5804,00-5805,00-6004, 00-6005,00-6804,00-6805,00-7004,00-7005, 00-7804,00-7805
0007	SAS	RAID1/10	00-000e,00-000f,00-080e,00-080f,00-100e, 00-100f,00-180e,00-180f,00-200e,00-200f, 00-280e,00-280f,00-300e,00-300f,00-380e, 00-380f,00-400e,00-400f,00-480e,00-480f, 00-500e,00-500f,00-580e,00-580f,00-600e, 00-600f,00-680e,00-680f,00-700e,00-700f, 00-780e,00-780f
0008	SAS	RAID1/10	00-0010,00-0011,00-0810,00-0811,00-1010, 00-1011,00-1810,00-1811,00-2010,00-2011, 00-2810,00-2811,00-3010,00-3011,00-3810, 00-3811,00-4010,00-4011,00-4810,00-4811, 00-5010,00-5011,00-5810,00-5811,00-6010, 00-6011,00-6810,00-6811,00-7010,00-7011, 00-7810,00-7811
0009	SAS	RAID1/10	00-0012,00-0013,00-0812,00-0813,00-1012, 00-1013,00-1812,00-1813,00-2012,00-2013, 00-2812,00-2813,00-3012,00-3013,00-3812, 00-3813,00-4012,00-4013,00-4812,00-4813, 00-5012,00-5013,00-5812,00-5813,00-6012, 00-6013,00-6812,00-6813,00-7012,00-7013, 00-7812,00-7813

Pool Number	Physical Disk	RAID type	Select physical disks
000a	SAS	RAID1/10	00-0014,00-0015,00-0814,00-0815,00-1014, 00-1015,00-1814,00-1815,00-2014,00-2015, 00-2814,00-2815,00-3014,00-3015,00-3814, 00-3815,00-4014,00-4015,00-4814,00-4815, 00-5014,00-5015,00-5814,00-5815,00-6014, 00-6015,00-6814,00-6815,00-7014,00-7015, 00-7814,00-7815
000b	SAS	RAID1/10	00-0016,00-0017,00-0816,00-0817,00-1016, 00-1017,00-1816,00-1817,00-2016,00-2017, 00-2816,00-2817,00-3016,00-3017,00-3816, 00-3817,00-4016,00-4017,00-4816,00-4817, 00-5016,00-5017,00-5816,00-5817,00-6016, 00-6017,00-6816,00-6817,00-7016,00-7017, 00-7816,00-7817
000c	SAS	RAID1/10	00-0100,00-0101,00-0900,00-0901,00-1100, 00-1101,00-1900,00-1901,00-2100,00-2101, 00-2900,00-2901,00-3100,00-3101,00-3900, 00-3901,00-4100,00-4101,00-4900,00-4901, 00-5100,00-5101,00-5900,00-5901,00-6100, 00-6101,00-6900,00-6901,00-7100,00-7101, 00-7900,00-7901
000d	SAS	RAID1/10	00-0102,00-0103,00-0902,00-0903,00-1102, 00-1103,00-1902,00-1903,00-2102,00-2103, 00-2902,00-2903,00-3102,00-3103,00-3902, 00-3903,00-4102,00-4103,00-4902,00-4903, 00-5102,00-5103,00-5902,00-5903,00-6102, 00-6103,00-6902,00-6903,00-7102,00-7103, 00-7902,00-7903
0003	SAS	RAID1/10	00-0006,00-0007,00-0806,00-0807,00-1006, 00-1007,00-1806,00-1807,00-2006,00-2007, 00-2806,00-2807,00-3006,00-3007,00-3806, 00-3807,00-4006,00-4007,00-4806,00-4807, 00-5006,00-5007,00-5806,00-5807,00-6006, 00-6007,00-6806,00-6807,00-7006,00-7007, 00-7806,00-7807
0004	SAS	RAID1/10	00-0008,00-0009,00-0808,00-0809,00-1008, 00-1009,00-1808,00-1809,00-2008,00-2009, 00-2808,00-2809,00-3008,00-3009,00-3808, 00-3809,00-4008,00-4009,00-4808,00-4809, 00-5008,00-5009,00-5808,00-5809,00-6008, 00-6009,00-6808,00-6809,00-7008,00-7009, 00-7808,00-7809
0005	SAS	RAID1/10	00-000a,00-000b,00-080a,00-080b,00-100a, 00-100b,00-180a,00-180b,00-200a,00-200b, 00-280a,00-280b,00-300a,00-300b,00-380a, 00-380b,00-400a,00-400b,00-480a,00-480b, 00-500a,00-500b,00-580a,00-580b,00-600a, 00-600b,00-680a,00-680b,00-700a,00-700b, 00-780a,00-780b

Pool Number	Physical Disk	RAID type	Select physical disks
0006	SAS	RAID1/10	00-000c,00-000d,00-080c,00-080d,00-100c, 00-100d,00-180c,00-180d,00-200c,00-200d, 00-280c,00-280d,00-300c,00-300d,00-380c, 00-380d,00-400c,00-400d,00-480c,00-480d, 00-500c,00-500d,00-580c,00-580d,00-600c, 00-600d,00-680c,00-680d,00-700c,00-700d, 00-780c,00-780d
000e	SAS	RAID1/10	00-0104,00-0105,00-0904,00-0905,00-1104, 00-1105,00-1904,00-1905,00-2104,00-2105, 00-2904,00-2905,00-3104,00-3105,00-3904, 00-3905,00-4104,00-4105,00-4904,00-4905, 00-5104,00-5105,00-5904,00-5905,00-6104, 00-6105,00-6904,00-6905,00-7104,00-7105, 00-7904,00-7905
000f	SAS	RAID1/10	00-0106,00-0107,00-0906,00-0907,00-1106, 00-1107,00-1906,00-1907,00-2106,00-2107, 00-2906,00-2907,00-3106,00-3107,00-3906, 00-3907,00-4106,00-4107,00-4906,00-4907, 00-5106,00-5107,00-5906,00-5907,00-6106, 00-6107,00-6906,00-6907,00-7106,00-7107, 00-7906,00-7907
0010	SAS	RAID1/10	00-0108,00-0109,00-0908,00-0909,00-1108, 00-1109,00-1908,00-1909,00-2108,00-2109, 00-2908,00-2909,00-3108,00-3109,00-3908, 00-3909,00-4108,00-4109,00-4908,00-4909, 00-5108,00-5109,00-5908,00-5909,00-6108, 00-6109,00-6908,00-6909,00-7108,00-7109, 00-7908,00-7909
0011	SAS	RAID1/10	00-010a,00-010b,00-090a,00-090b,00-110a, 00-110b,00-190a,00-190b,00-210a,00-210b, 00-290a,00-290b,00-310a,00-310b,00-390a, 00-390b,00-410a,00-410b,00-490a,00-490b, 00-510a,00-510b,00-590a,00-590b,00-610a, 00-610b,00-690a,00-690b,00-710a,00-710b, 00-790a,00-790b
0012	SAS	RAID1/10	00-0200,00-0201,00-0a00,00-0a01,00-1200, 00-1201,00-1a00,00-1a01,00-2200,00-2201, 00-2a00,00-2a01,00-3200,00-3201,00-3a00, 00-3a01,00-4200,00-4201,00-4a00,00-4a01, 00-5200,00-5201,00-5a00,00-5a01,00-6200, 00-6201,00-6a00,00-6a01,00-7200,00-7201, 00-7a00,00-7a01
0013	SAS	RAID1/10	00-0202,00-0203,00-0a02,00-0a03,00-1202, 00-1203,00-1a02,00-1a03,00-2202,00-2203, 00-2a02,00-2a03,00-3202,00-3203,00-3a02, 00-3a03,00-4202,00-4203,00-4a02,00-4a03, 00-5202,00-5203,00-5a02,00-5a03,00-6202, 00-6203,00-6a02,00-6a03,00-7202,00-7203, 00-7a02,00-7a03

Pool Number	Physical Disk	RAID type	Select physical disks
0014	SAS	RAID1/10	00-0204,00-0205,00-0a04,00-0a05,00-1204, 00-1205,00-1a04,00-1a05,00-2204,00-2205, 00-2a04,00-2a05,00-3204,00-3205,00-3a04, 00-3a05,00-4204,00-4205,00-4a04,00-4a05, 00-5204,00-5205,00-5a04,00-5a05,00-6204, 00-6205,00-6a04,00-6a05,00-7204,00-7205, 00-7a04,00-7a05
0015	SAS	RAID1/10	00-0206,00-0207,00-0a06,00-0a07,00-1206, 00-1207,00-1a06,00-1a07,00-2206,00-2207, 00-2a06,00-2a07,00-3206,00-3207,00-3a06, 00-3a07,00-4206,00-4207,00-4a06,00-4a07, 00-5206,00-5207,00-5a06,00-5a07,00-6206, 00-6207,00-6a06,00-6a07,00-7206,00-7207, 00-7a06,00-7a07

Logical Disk Parameters

Pool list	Number of Logical Disks	Logical disk Capacity	Logical disk name
0000	1	4183	20000000201210240000
0001	1	4183	20000000201210240001
0002	1	4183	20000000201210240002
0003	1	4183	20000000201210240003
0004	1	4183	20000000201210240004
0005	1	4183	20000000201210240005
0006	1	4183	20000000201210240006
0007	1	4183	20000000201210240007
0008	1	4183	20000000201210240008
0009	1	4183	20000000201210240009
000a	1	4183	2000000020121024000A
000b	1	4183	2000000020121024000B
000c	1	4183	2000000020121024000C
000d	1	4183	2000000020121024000D
000e	1	4183	2000000020121024000E
000f	1	4183	2000000020121024000F
0010	1	4183	20000000201210240010
0011	1	4183	20000000201210240011
0012	1	4183	20000000201210240012
0013	1	4183	20000000201210240013
0014	1	4183	20000000201210240014
0015	1	4183	20000000201210240015

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

ASU Pre-Fill

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

```
compratio=1

sd=default,threads=4
sd=sd1,lun=\\.\e:,size=31125059665920
sd=sd2,lun=\\.\f:,size=31125059665920
sd=sd3,lun=\\.\g:,size=6916679925760

wd=default,rdpct=0,seek=-1,xfersize=1048576
wd=wd1,sd=sd1
wd=wd2,sd=sd2
wd=wd3,sd=sd3

rd=PREPSSD,wd=wd*,iorate=max,elapsed=999990,interval=10
```

Primary Metrics and Repeatability Tests

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

```
* spc1_metrics.cfg

host=master
slaves=(ns53_1,ns53_2,ns53_3,ns53_4,ns53_5,ns53_6,ns54_1,ns54_2,ns54_3,ns54_4,ns54_5
,ns54_6,ns54_7,ns56_1,ns56_2,ns56_3,ns56_4,ns56_5,ns56_6,ns57_1,ns57_2,ns57_3,ns57_4
,ns57_5,ns57_6,ns58_1,ns58_2,ns58_3,ns58_4,ns58_5,ns58_6)

sd=asu1_1,lun=\\.\e:,size=31125059665920
sd=asu2_1,lun=\\.\f:,size=31125059665920
sd=asu3_1,lun=\\.\g:,size=6916679925760
```

SPC-1 Persistence Test

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

```
* spc1_persist.cfg

sd=asu1_1,lun=\\.\e:,size=31125059665920
sd=asu2_1,lun=\\.\f:,size=31125059665920
sd=asu3_1,lun=\\.\g:,size=6916679925760
```

Slave JVMs

The Slave JVM command and parameter files are documented on page of *Appendix E: SPC-1 Workload Generator Input Parameters*.

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

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

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

The script also included the appropriate commands to capture the detailed TSC profile listings required for a Remote Audit.

```
call profile.bat
call prepssd.bat

copy /y spc1_metrics.cfg spc1.cfg

java -Xmx1536m -Xms1536m metrics -b 3050 -t 28800
java -Xmx1536m -Xms1536m repeat1 -b 3050
java -Xmx1536m -Xms1536m repeat2 -b 3050


copy /y spc1_persist.cfg spc1.cfg

java -Xmx1024m -Xms1024m -Xss256k persist1 -b 3050

call shutdown.bat
```

Detailed TSC System Profile

The following script and command file were used to capture the detailed TSC profile listings required for a Remote Audit.

profile.bat

```
c:\ns54\teraterm\ttermpro.exe /M=c:\ns54\teraterm\M700_profile.ttl
```

M700_profile.ttl

```
;; connection user/password
HOSTADDR = '192.168.10.100'
USERNAME = 'sysadmin'
PASSWORD = 'sys123'
;=================================================
;; config
COMMAND = HOSTADDR
strconcat COMMAND ':23 /nossh /T=1'

;; connect
connect COMMAND

;; login
wait 'login: '
sendln USERNAME
wait 'Password: '
sendln PASSWORD
```

```
;; command1
wait 'sysadmin@2000000020121024-0# '
sendln 'iSMenv gettime'

;; command2
wait 'sysadmin@2000000020121024-0# '
sendln 'iSMview -all'

;; command3
wait 'sysadmin@2000000020121024-0# '
sendln 'iSMenv gettime'

;; command4
wait 'sysadmin@2000000020121024-0# '
sendln 'exit'

;; finish
end
```

ASU Pre-Fill

The following script was invoked to execute the required ASU pre-fill using the command and parameter file documented in *Appendix D: SPC-1 Workload Generator Storage Commands and Parameters* on page 81.

prepssd.bat

```
c:\ns54\vdbench503rc11\vdbench -f c:\ns54\prepssd.txt -o c:\ns54\ssdprep
```

Slave JVMs

There were 31 Slave JVMs used in the Primary Metrics and Repeatability Tests. The first file, listed below, illustrates the commands to start the six Slave JVMs (**ns53_s1 – ns53_s6**) that executed on the first Host System. A similar file was used on each of the remaining four Host Systems to start the remaining 25 Slave JVMs (**ns54_s1 – ns54_s7**, **ns56_s1 – ns56_s6**, **ns57_s1 – ns57_s6** and **ns58_s1 – ns58_s6**.

The second file, listed below, is the command and parameter file for the first Slave JVM (**ns53_s1**). A similar file was used for the remaining 30 Slave JVMs.

ns53_s1.bat

```
start java -Xmx1024m -Xms1024m spc1 -fns53_s1.parm -ons53_s1
start java -Xmx1024m -Xms1024m spc1 -fns53_s2.parm -ons53_s2
start java -Xmx1024m -Xms1024m spc1 -fns53_s3.parm -ons53_s3
start java -Xmx1024m -Xms1024m spc1 -fns53_s4.parm -ons53_s4
start java -Xmx1024m -Xms1024m spc1 -fns53_s5.parm -ons53_s5
start java -Xmx1024m -Xms1024m spc1 -fns53_s6.parm -ons53_s6
```

ns53_s1.parm

```
host=ns53_1
master=ns54

sd=asu1,lun=\\.\e:
sd=asu2,lun=\\.\f:
sd=asu3,lun=\\.\g:
```

TSC Power Off

The following script and command file were used to execute the required TSC power off after completion of SPC-1 Persistence Test Run 1.

shutdown.bat

```
c:\ns54\teraterm\ttermpro.exe /M=c:\ns54\teraterm\M700_shutdown.ttl
```

M700_shutdown.bat

```
;; connection user/password
HOSTADDR = '192.168.10.100'
USERNAME = 'sysadmin'
PASSWORD = 'sys123'
;===================================================
;; config
COMMAND = HOSTADDR
strconcat COMMAND ':23 /nossh /T=1'

;; connect
connect COMMAND

;; login
wait 'login: '
sendln USERNAME
wait 'Password: '
sendln PASSWORD

;; command1
wait 'sysadmin@2000000020121024-0# '
sendln 'iSMenv gettime'

;; command2
wait 'sysadmin@2000000020121024-0# '
sendln 'iSMview -all'

;; command3
wait 'sysadmin@2000000020121024-0# '
sendln 'iSMcfg shutdown -time 5'

;; finish
end
```

Persistence Test Run 2

The following script was used to execute Persistence Test Run 2 *(read phase)* after the required TSC power shutdown and restart.

```
java -Xmx1024m -Xms1024m -Xss256k persist2

call profile.bat
```