SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

IBM CORPORATION
IBM TOTALSTORAGE® DS4300 WITH TURBO OPTION
(MIRRORED WRITE CACHE)

SPC-1 V1.7

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Notes

The following terms, used in this document, are defined as:

- Kilobyte (KB) is equal to 1,000 (10^3) bytes.
- Megabyte (MB) is equal to 1,000,000 (10^6) bytes.
- Gigabyte (GB) is equal to 1,000,000,000 (10^9) bytes.
- Terabyte (TB) is equal to 1,000,000,000,000 (10^{12}) bytes.

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AUDIT CERTIFICATION

IBM Corporation
Bruce McNutt
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9000 S. Rita Road
Tucson, AZ 85744

August 26, 2003

The SPC Benchmark 1™ results listed below for the IBM TotalStorage® FAStT600 with Turbo Option *(mirrored write cache)* were produced in compliance with the SPC Benchmark 1™ V1.7 Remote Audit requirements.

SPC Benchmark 1™ V1.7 Results	
Tested Storage Configuration (TSC) Name: IBM TotalStorage® FAStT600 with Turbo Option *(mirrored write cache)*	
Metric	**Reported Result**
SPC-1 IOPS™	9,099.86
SPC-1 Price-Performance	$11.86/SPC-1 IOPS™
Total ASU Capacity	478.43 GB
Data Protection Level	Mirroring
SPC-1 LRT™	2.30 ms
Total TSC Price (including three-year maintenance)	$107,900

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with V1.7 of the SPC Benchmark 1™ specification:

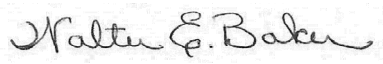
- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified using information supplied by IBM Corporation:
  - ✓ Physical Storage Capacity and requirements.
  - ✓ Configured Storage Capacity and requirements.
  - ✓ Addressable Storage Capacity and requirements.
  - ✓ Capacity of each Logical Volume and requirements.
  - ✓ Capacity of each Application Storage Unit (ASU) and requirements.

- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, included customer tunable parameters.
- Commands and parameters used to configure the SPC-1 Workload Generator.
- The following Host System requirements were reviewed using documentation supplied by IBM Corporation:
  - ✓ The type of Host System including the number of processors and main memory.
  - ✓ The presence and version number of the Workload Generator on the Host System.
  - ✓ The TSC boundary within the Host System.
- The Test Results Files and resultant Summary Results Files received for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- The differences between the Tested Storage Configuration (TSC) used for the benchmark and Priced Storage Configuration are documented in the Executive Summary. The differences, if applied to the TSC, would not have a negative impact on the reported SPC-1 performance.
- The final version of the pricing spreadsheet 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.

Audit Notes:

There were no additional audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

LETTER OF GOOD FAITH

P.O. Box 12195
Research Triangle Park, NC 27709

Date: *26 Aug 2003*

From: *IBM Corporation, Test Sponsor*

Submitted by:
J.R. Hagan, Jr.
VP, Storage Systems
3039 Cornwallis
RTP, NC 27709

Contact Information:
John Ponder / Bruce McNutt
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To: *Walter E. Baker, SPC Auditor*
Gradient Systems, Inc.
643 Bair Island Road, Suite 103
Redwood City, CA 94063-2775

Subject: Letter of good faith for the SPC Benchmark-1™ results on the IBM TotalStorage® FAStT600 with Turbo Option (with cache mirroring enabled).

IBM sponsored testing of the above listed product in compliance with the SPC-Benchmark-1 Specification. To the best of our knowledge and belief, the associated test results, including the SPC-1 Full Disclosure Report documenting the SPC Benchmark-1 results (per Clause 10 of the SPC Benchmark-1 Specification), are accurate.

Signed:

Roland Hagan

J.R. Hagan, Jr.
Vice President, Storage Systems
26 Aug 2003

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
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Auditor	Storage Performance Council www.storageperformance.org Walter E. Baker AuditService@storageperformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063-2755 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-1 Specification revision number	V1.7
SPC-1 Workload Generator revision number	V2.00.03
Date Results were first used publicly	August 26, 2003
Date FDR was submitted to the SPC	August 26, 2003
Date revised FDR was submitted to the SPC Product name change from FASt600 to DS4300 Pricing was revised to include the price of the Turbo option.	 September 5, 2005 April 15, 2004
Date the TSC is/was available for shipment to customers	September 12, 2003
Date the TSC completed audit certification	August 26, 2003

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: IBM TotalStorage® DS4300 with Turbo Option *(mirrored write cache)*	
Metric	**Reported Result**
SPC-1 IOPS™	9,099.86
SPC-1 Price-Performance	$14.23/SPC-1 IOPS™
Total ASU Capacity	478.437GB
Data Protection Level	Mirroring
SPC-1 LRT™	2.30ms
Total TSC Price (including three-year maintenance)	$129,470

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

Total ASU (Application Storage Unit) **Capacity** represents the total storage capacity read and written in the course of executing the SPC-1 benchmark. The Addressable Storage Capacity, which contains the Total ASU Capacity, was 478.437 GB. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity. The actual Configured Storage Capacity was 956.874 GB, which included the multiple copies of user data required by a Data Protection Level of Mirroring. The Configured Storage Capacity utilized 52.54% of the priced Physical Storage Capacity of 1,821.003 GB.

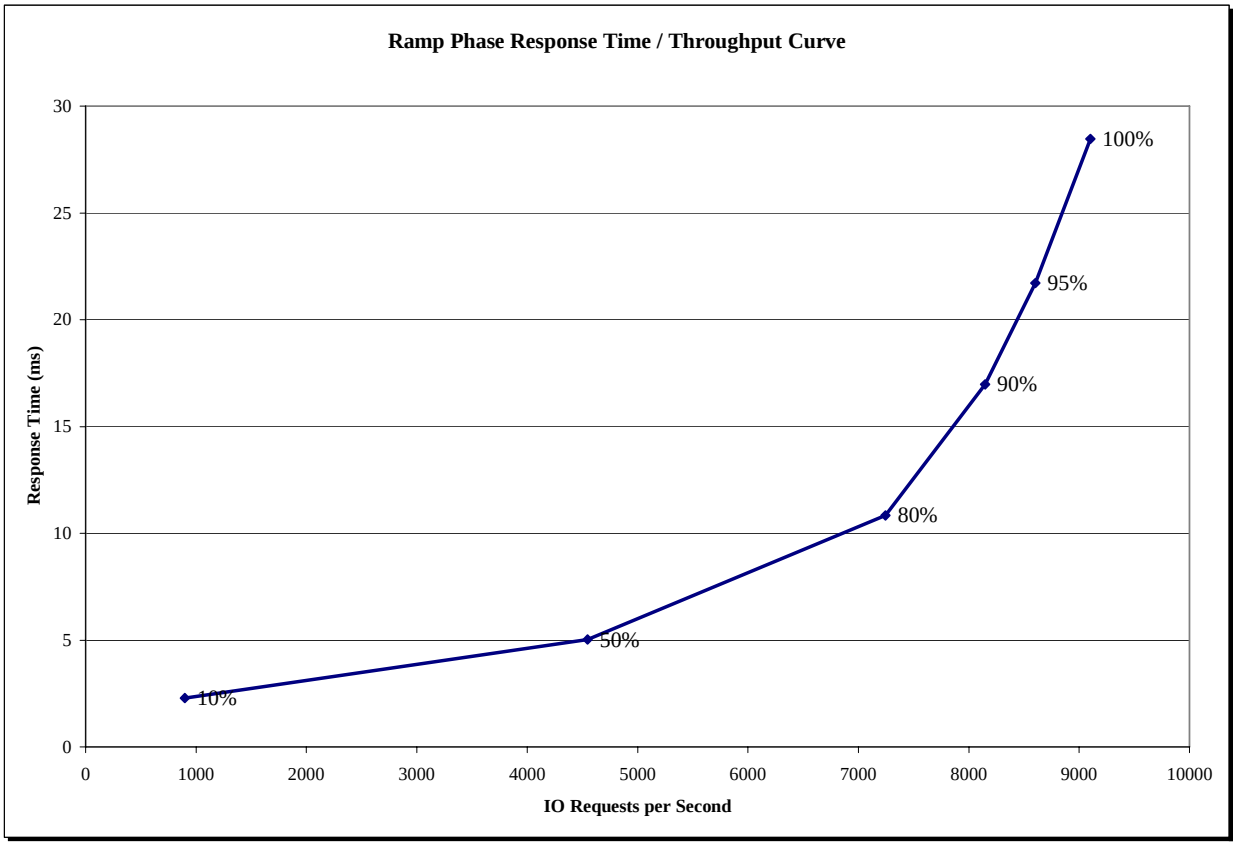
A **Data Protection Level** of Mirroring configures two or more identical copies of user data, maintained on separate disks.

The **SPC-1 LRT™** metric is the Average Response Time measured at the 10% load point, as illustrated on the next page. SPC-1 LRT™ represents the Average Response Time measured on a lightly loaded Tested Storage Configuration (TSC).

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 the 100% load point cannot exceed 30 milliseconds or the benchmark measurement is invalid.



Response Time – Throughput Data

Response Time - Throughput

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	899.57	4548.09	7244.26	8147.33	8601.28	9099.86
Average Response Time (ms):						
All ASUs	2.30	5.03	10.84	16.97	21.72	28.46
ASU-1	2.91	5.83	12.05	17.50	21.56	26.85
ASU-2	2.30	5.21	9.42	14.79	19.14	25.99
ASU-3	1.01	3.27	8.88	16.81	23.20	32.97
Reads	4.38	8.10	13.34	17.22	19.97	23.60
Writes	0.95	3.03	9.21	16.81	22.86	31.63

Tested Storage Configuration Pricing *(Priced Storage Configuration)*

M/T/M	fc#	description	Qty	US List Prices Unit Price	Aggregate Price	Total
1722-60U		IBM TotalStorage FAStT600 Storage Server	1	14,999	14,999	
	2000	FAStT600 Turbo feature	1	21,570	21,570	
	2104	FAStT FC-2/133 host bus adapter	4	1,485	5,940	
	2210	Shortwave SFP	6	499	2,994	
	5625	25 meter fiber optic cable	4	189	756	
	7109	FAStT Storage Manager v8.4 upgrade	1	2,999	2,999	
1740-1RU		IBM TotalStorage FAStT EXP700 Storage Expansion Unit	3	6,000	18,000	
	2210	Shortwave SFP	12	499	5,988	
	5211	FAStT 36.4GB/15K rpm 2Gb FC Disk Drive Module	50	1,115	55,750	
	5601	1 meter fiber optic cable	6	79	474	
	9006	Attach to FAStT600	8	0	0	
						$ 129,470

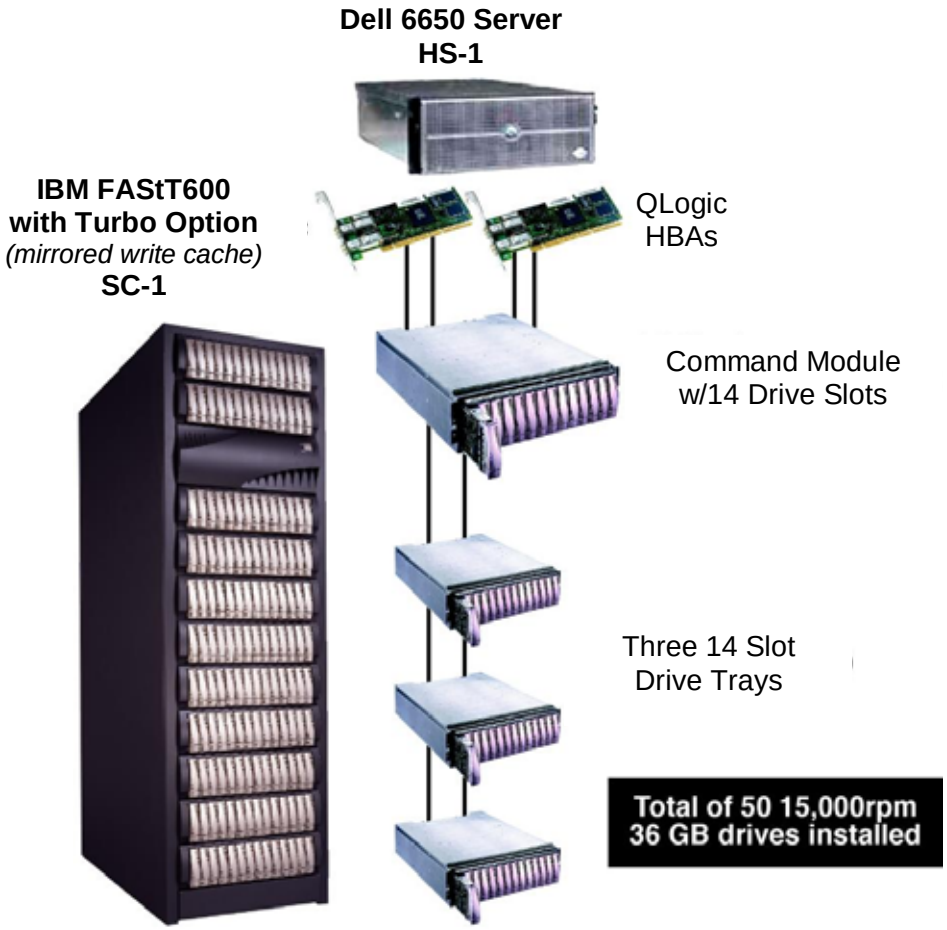
Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration

The following are the differences between the TSC and Priced Storage Configuration:

- Four FAStT FC-2/133 HBAs (single port) were priced rather than the two QLogic 2342 dual channel HBAs used in the TSC.
- The priced disk drives have been configured to self-identify as a FAStT brand.
- The mounting of each drive is in an IBM drive carrier.
- The 'data scrubbing' option has a default setting of "off" in the TSC, but would need to be explicitly set to "off" in the Priced Storage Configuration.
- Twenty-five meter fiber optic cables were priced rather than the 30 meter cables used in the TSC.

The differences listed above, if applied to the TSC, would not have a negative performance impact on the reported SPC-1 performance.

Benchmark Configuration/Tested Storage Configuration Diagram



Host System:	Tested Storage Configuration (TSC):
UID=HS-	UID=SC-1
1Dell 6650	Command Module
4 – Pentium 4 Xeon 2GHz with Hyperthreading Enabled	2 Qlogic 2342 dual-port fibre channel host bus adapters
3GB Main Memory	2 – Disk Array Controllers, 1GB RAM Each
Windows 2003, Service Pack 3	4 – 2gb Fibre Channel host connections
WG	2 – 2gb Fibre Channel drive connections
	3 – Drive Modules
	50 x 36GB 15K RPM Disk Drives

CONFIGURATION INFORMATION

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

Clause 9.2.4.4.1

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

A diagram of the benchmark configuration and tested storage configuration is included on the preceding page. The configuration consisted of a single host system, with two Qlogic 2342 PCI to dual-channel 2gb fibre channel host adapters. The four host system, fibre channel connections are directly connected to the command module. The host system is running Windows 2000, with Service Pack 3 applied.

Storage Network Configuration

Clause 9.2.4.4.2

If a storage network is employed in the BC/TSC, the FDR shall contain a topology diagram… . This diagram should include, but is not limited to the following components:

1. *Storage Controller and Domain Controllers (see Clause 9.2.4.4.1)*
2. *Host Systems (see Clause 9.2.4.4.1)*
3. *Routers and Bridges*
4. *Hubs and Switches*
5. *HBAs to Host Systems and Front End Port to Storage Controllers*

Additionally the diagram shall:

- *Illustrate the physical connection between components.*
- *Describe the type of each physical connection.*
- *Describe the network protocol used over each physical connection.*
- *The maximum theoretical transfer rate of each class of interconnect used in the configuration.*
- *Correlate with the BC Configuration Diagram in Clause 9.2.4.4.1.*

The Test Sponsor shall additionally supply (referenced in an appendix) a wiring diagram of the physical connections and physical port assignments used in the storage network. The diagram should allow anyone to exactly replicate the physical configuration of the storage network.

A storage area network was not used for this test.

Host System Configuration

Clause 9.2.4.4.3

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

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

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

Customer Tuning Parameters and Options

Clause 9.2.4.5.1

All Benchmark Configuration (BC) components with customer tunable parameter and options that have been altered from their default values must be listed in the FDR. The FDR entry for each of those components must include both the name of the component and the altered value of the parameter or option.

Windows 2000 Registry Changes

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\ql2300\Device\MaximumSGList=0xff

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\ql2300\Device\NumberOfRequests=0xe0

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Disk\TimeOutValue=0x78

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\ql2300\Device\DriverParameters=UseSameNN=1;BusChange=0;

Array Controller Options

All array controller configuration options were set by the configuration script list in “Appendix A: TSC Configuration Script” on page 65.

Host Bus Adapter Options

The table below lists the Host Bus Adapter options that were changed from their default values.

Host Bus Adapter Settings		
Item	**Default**	**New Value**
Host Adapter Settings		
Loop Reset Delay	5	8
Adapter Hard Loop ID	Disabled	Enabled
Hard Loop ID (unique for each)	0	Eg. 22
Advanced Adapter Settings		
Execution Throttle	16	255
Fast Command Posting	Disabled	Enabled
LUNs per Target	8	0
Enable Target Reset	No	Yes
Login Retry Count	8	30
Port Down Retry Count	8	70
Extended Firmware Settings		
Data Rate	0	2

Tested Storage Configuration (TSC) Description

Clause 9.2.4.5.2

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

- *All physical components that comprise the TSC. Those components are also illustrated in the Benchmark Configuration (BC) diagram in Clause 9.2.4.4.1 and, if applicable, 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.*

In addition the FDR may include listings of scripts and/or commands used to configure the physical components that comprise the TSC.

The TSC was configured as detailed in the "Benchmark Configuration/Tested Storage Configuration Diagram" on page 13 of this document. Each one of the host adapters was directly connected to a host port on the storage array command module. The disk drives were equally divided among the drive-side fibre channel connections of the storage array command module.

The configuration of the TSC was performed using a script, which is located in "Appendix A: TSC Configuration Script" on page 65. The LUNs created by the script comprise the reported Configured Storage Capacity, which contains both the Addressable Storage Capacity and a mirror of the Addressable Storage Capacity.

SPC-1 Workload Generator Storage Configuration

Clause 9.2.4.5.3

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

The following SPC-1 Workload Generator storage configuration commands and parameters were used:

```
javaparms="-Xmx64m -Xms64m"
sd=asu1_1,lun=\\.\PhysicalDrive1,size=215296770048
sd=asu2_1,lun=\\.\PhysicalDrive2,size=215296770048
sd=asu3_1,lun=\\.\PhysicalDrive3,size=47843726677
```

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).

User Data Copy: An identical copy of user data maintained on separate disks.

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.

Storage Capacities and Relationships

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

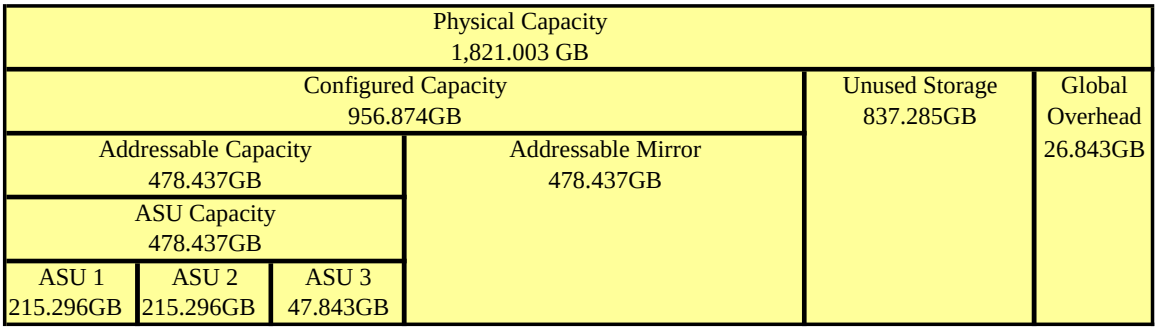
SPC-1 Storage Capacities

SPC-1 Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	478.437
Addressable Storage Capacity	Gigabytes (GB)	478.437
Configured Storage Capacity	Gigabytes (GB)	956.874
Physical Storage Capacity	Gigabytes (GB)	1,821.003
User Data Copy (Mirroring)	Gigabytes (GB)	478.437
Required Storage (metadata) & Hot Spares	Gigabytes (GB)	0.00
Global Storage Overhead	Gigabytes (GB)	26.843
Total Unused Storage	Gigabytes (GB)	837.285

The Physical Storage Capacity consisted of 50 disk drives with a formatted capacity of 36.420GB each. Each disk drive had 0.536GB reserved by the disk array management firmware, for a total of 26.843GB of Global Storage Overhead. The Total Unused Storage capacity was 837.285GB.

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

SPC-1 Storage Hierarchy Ratios			
	Addressable Storage Capacity	**Configured Storage Capacity**	**Physical Storage Capacity**
Total ASU Capacity	100.00%	50.00%	26.27%
User Data Copy (Mirror)		50.00%	26.27%
Addressable Storage Capacity		50.00%	26.27%
Required Storage (metadata) & Hot Spares		0%	0%
Configured Storage Capacity			52.54%
Global Storage Overhead			1.47%
Unused Storage	0.00%	0.00%	45.97%

The Addressable Storage Capacity and Configured Storage Capacity contained no Unused Storage. The Physical Storage Capacity contained 45.97% (837.285 GB) of Unused Storage.

Logical Volume Capacity and ASU Mapping

Clause 9.2.4.6.2

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

Logical Volume Capacity and Mapping		
ASU-1 (215.296 GB)	**ASU-2 (215.296 GB)**	**ASU-3 (47.843 GB)**
1 Logical Volumes 215.296 GB per Logical Volume (215.296 GB used/Logical Volume)	1 Logical Volumes 215.296 GB per Logical Volume (215.296 GB used/Logical Volume)	1 Logical Volumes 47.843 GB per Logical Volume (47.843 GB used/Logical Volume)

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

SPC-1 BENCHMARK EXECUTION RESULTS

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.*

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.*

Measurement Interval: *The finite and contiguous time period, after the Tested Storage Configuration (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.*

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. Comment: Steady Stated is achieved only after caches in the TSC have filled and as a result the I/O Request throughput of the TSC has stabilized.*

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

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.*

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 Figure 5-1 below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.*

Sustainability Test Phase

Clause 5.4.2.1

The Sustainability Test Phase consists of one Test Run at the 100% load point with a Measurement Interval of three (3) hours. The intent is to demonstrate a sustained maximum I/O Request Throughput as well as insuring the Tested Storage Configuration (TSC) has reached steady state prior to measuring the maximum I/O Request Throughput (SPC-1™ IOPS).

The reported I/O Request Throughput of the Sustainability Test Run must be within 5% of the reported SPC-1™ IOPS primary metric. The Average Response Time measured in Sustainability Test Run cannot exceed thirty (30) milliseconds.

Clause 9.2.4.7.1

For the Sustainability Test Phase the FDR shall contain:

1. *A Data Rate Distribution (data table and graph).*
2. *I/O Request Throughput Distribution (data table and graph).*
3. *The human readable Test Run Results File produced by the Workload Generator.*
4. *A listing or screen image of all input parameters supplied to the Workload Generator.*
5. *The Measured Intensity Multiplier for each I/O stream.*
6. *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, and Response Time Ramp Test Runs are listed below.

```
java -Xmx64m -Xms64m metrics -b 182 -s 1200
```

Sustainability Test Results File

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

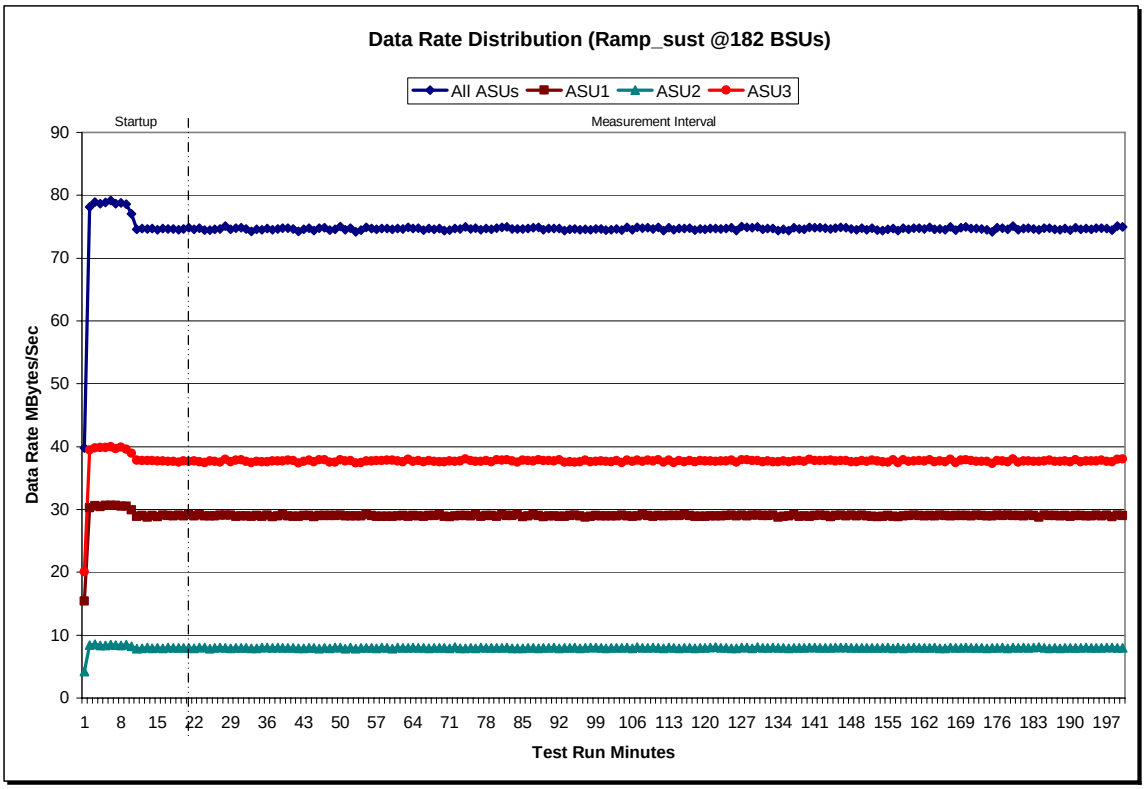
Sustainability Test Results File

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

Ramp-Up/Start-Up	17:34:48	17:54:48	0-19	0:20:00
Measurement Interval	17:54:48	20:54:48	20-199	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	39.8	15.45	4.24	20.07	67	74.60	29.00	7.95	37.65	134	74.56	28.89	7.96	37.71
1	78.2	30.28	8.42	39.47	68	74.71	29.19	7.94	37.58	135	74.41	28.96	7.88	37.57
2	78.9	30.59	8.54	39.76	69	74.41	28.89	7.94	37.58	136	74.82	29.15	7.94	37.73
3	78.7	30.46	8.38	39.83	70	74.47	28.86	7.91	37.71	137	74.63	28.91	7.96	37.76
4	78.9	30.67	8.37	39.83	71	74.71	28.94	8.09	37.68	138	74.55	28.93	7.97	37.65
5	79.2	30.68	8.52	39.99	72	74.62	29.03	7.90	37.69	139	74.91	28.93	8.02	37.96
6	78.7	30.62	8.42	39.64	73	74.98	29.03	7.93	38.01	140	74.82	29.01	8.03	37.79
7	78.8	30.50	8.37	39.89	74	74.67	28.97	7.94	37.75	141	74.85	29.09	7.97	37.78
8	78.6	30.50	8.48	39.61	75	74.75	29.17	7.92	37.66	142	74.79	29.00	7.99	37.80
9	77.0	29.91	8.22	38.92	76	74.55	28.91	8.02	37.62	143	74.63	28.85	7.97	37.81
10	74.6	28.88	7.85	37.85	77	74.73	29.03	7.94	37.77	144	74.76	29.01	8.04	37.71
11	74.7	29.02	7.93	37.77	78	74.56	29.00	7.97	37.59	145	74.92	29.07	8.06	37.79
12	74.6	28.80	8.04	37.78	79	74.77	28.90	8.00	37.88	146	74.82	29.00	8.03	37.79
13	74.7	29.04	7.91	37.77	80	74.92	29.17	7.94	37.81	147	74.65	29.06	7.99	37.60
14	74.5	28.85	7.94	37.73	81	74.97	29.05	8.02	37.90	148	74.48	28.93	7.97	37.58
15	74.7	29.08	7.91	37.70	82	74.68	29.03	7.92	37.73	149	74.78	29.07	7.96	37.74
16	74.7	29.01	8.01	37.63	83	74.62	29.22	7.89	37.51	150	74.52	28.94	7.94	37.63
17	74.6	28.99	7.96	37.67	84	74.62	28.85	7.91	37.85	151	74.77	28.92	7.99	37.86
18	74.5	29.07	7.96	37.49	85	74.74	28.99	7.94	37.81	152	74.46	28.82	7.95	37.69
19	74.6	28.93	8.00	37.69	86	74.82	29.14	7.94	37.74	153	74.41	28.88	7.97	37.56
20	74.8	29.16	7.99	37.66	87	74.89	29.05	7.93	37.91	154	74.55	29.02	8.04	37.49
21	74.6	28.97	7.91	37.71	88	74.54	28.82	7.95	37.77	155	74.69	28.89	7.93	37.88
22	74.8	29.13	8.05	37.58	89	74.69	28.94	7.97	37.79	156	74.37	28.86	8.06	37.45
23	74.5	28.98	8.04	37.45	90	74.70	28.96	8.01	37.73	157	74.80	28.98	7.93	37.89
24	74.5	28.96	7.81	37.68	91	74.71	28.92	7.88	37.91	158	74.60	29.00	7.95	37.65
25	74.6	28.96	7.96	37.67	92	74.37	28.89	7.96	37.52	159	74.79	29.07	8.03	37.69
26	74.6	29.11	8.02	37.50	93	74.61	29.02	7.98	37.61	160	74.79	29.02	7.98	37.79
27	75.1	29.11	8.00	37.96	94	74.63	29.09	8.01	37.52	161	74.67	28.96	7.97	37.74
28	74.6	29.08	7.91	37.58	95	74.48	28.96	7.93	37.58	162	74.90	29.01	7.96	37.94
29	74.8	28.93	7.97	37.86	96	74.59	28.78	7.97	37.84	163	74.58	28.96	8.01	37.60
30	74.8	28.96	7.99	37.88	97	74.53	28.90	8.02	37.61	164	74.67	29.07	7.88	37.71
31	74.6	28.97	7.98	37.67	98	74.67	29.02	8.01	37.63	165	74.51	29.05	7.90	37.56
32	74.2	28.87	7.92	37.43	99	74.63	28.95	7.97	37.72	166	74.94	28.97	8.02	37.95
33	74.6	29.01	7.92	37.63	100	74.47	28.95	7.89	37.64	167	74.44	29.03	7.98	37.42
34	74.5	28.91	8.03	37.58	101	74.53	28.98	7.99	37.57	168	74.85	29.00	7.99	37.87
35	74.7	29.10	8.05	37.58	102	74.66	28.96	7.94	37.75	169	74.95	29.03	8.01	37.91
36	74.5	28.86	7.95	37.73	103	74.47	29.07	7.97	37.44	170	74.70	28.96	7.97	37.77
37	74.6	28.94	8.01	37.68	104	74.88	28.99	8.06	37.83	171	74.74	29.09	7.98	37.67
38	74.8	29.14	7.95	37.70	105	74.50	28.92	7.92	37.66	172	74.66	29.05	7.98	37.62
39	74.8	28.98	7.96	37.82	106	74.90	28.96	8.07	37.87	173	74.53	28.96	7.93	37.64
40	74.7	28.91	8.00	37.77	107	74.80	29.17	7.98	37.65	174	74.21	28.93	7.98	37.29
41	74.2	28.91	7.91	37.42	108	74.86	29.03	7.98	37.85	175	74.84	29.08	7.96	37.79
42	74.6	29.05	7.88	37.68	109	74.64	28.91	8.01	37.72	176	74.77	29.03	8.05	37.69
43	74.8	29.03	7.95	37.82	110	74.91	29.03	7.95	37.92	177	74.55	29.07	7.92	37.56
44	74.4	28.84	7.99	37.55	111	74.36	28.96	7.90	37.50	178	75.09	29.01	8.03	38.05
45	74.8	29.04	7.86	37.89	112	74.85	29.00	8.01	37.84	179	74.53	29.04	7.94	37.54
46	74.9	29.02	7.95	37.88	113	74.50	29.03	7.99	37.48	180	74.71	28.99	8.01	37.72
47	74.4	29.01	7.91	37.50	114	74.71	29.00	7.92	37.79	181	74.75	29.08	7.98	37.69
48	74.6	29.01	8.01	37.54	115	74.71	29.13	7.98	37.59	182	74.67	29.01	8.01	37.66
49	75.0	29.08	8.03	37.93	116	74.77	29.02	7.96	37.78	183	74.49	28.78	8.08	37.63
50	74.5	28.97	7.84	37.72	117	74.43	28.91	7.94	37.58	184	74.77	29.07	7.99	37.72
51	74.8	28.96	8.06	37.75	118	74.65	28.91	7.97	37.77	185	74.78	29.04	7.92	37.83
52	74.2	28.94	7.87	37.39	119	74.60	28.92	7.95	37.74	186	74.61	29.02	7.98	37.62
53	74.4	28.99	7.97	37.47	120	74.69	28.96	8.02	37.72	187	74.54	28.98	7.90	37.66
54	74.9	29.20	7.98	37.74	121	74.69	28.96	8.11	37.62	188	74.73	29.04	7.96	37.72
55	74.7	29.05	7.98	37.69	122	74.67	28.98	7.98	37.71	189	74.48	28.93	7.95	37.59
56	74.6	28.89	7.89	37.77	123	74.70	29.05	7.96	37.69	190	74.83	29.01	7.94	37.88
57	74.7	28.89	8.02	37.79	124	74.83	29.09	7.94	37.81	191	74.55	29.04	7.94	37.57
58	74.7	28.91	7.97	37.84	125	74.37	28.98	7.88	37.51	192	74.72	28.96	8.04	37.73
59	74.6	28.89	7.86	37.83	126	75.03	29.09	8.06	37.87	193	74.61	28.97	7.96	37.69
60	74.7	28.93	8.05	37.71	127	74.92	28.98	8.01	37.93	194	74.80	29.12	7.97	37.71
61	74.7	29.06	8.00	37.60	128	74.83	29.09	7.93	37.80	195	74.77	28.98	7.95	37.84
62	74.9	28.93	7.97	37.99	129	74.95	29.10	8.08	37.77	196	74.73	29.07	8.00	37.66
63	74.7	29.01	8.02	37.65	130	74.56	29.02	7.95	37.59	197	74.46	28.85	8.00	37.60
64	74.8	28.99	7.99	37.79	131	74.71	29.02	7.97	37.73	198	75.07	29.10	7.99	37.98
65	74.5	28.90	7.97	37.60	132	74.68	29.08	8.01	37.59	199	74.99	29.00	7.98	38.02
66	74.7	29.03	7.92	37.77	133	74.38	28.80	8.00	37.59					

Sustainability – Data Rate Distribution Graph

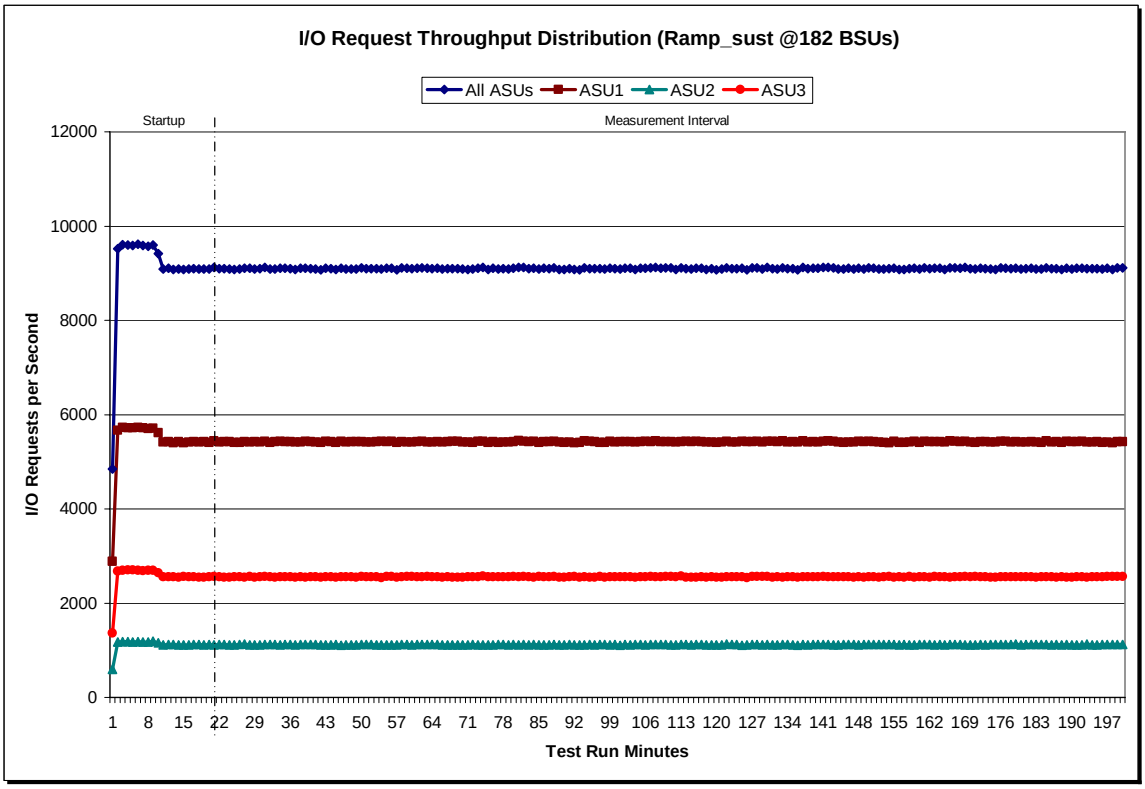


Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	17:34:48	17:54:48	0-19	0:20:00
Measurement Interval	17:54:48	20:54:48	20-199	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	4847.40	2889.17	592.98	1365.25	67	9100.23	5431.57	1116.63	2552.03	134	9100.98	5425.62	1115.02	2560.35
1	9521.73	5663.98	1177.35	2680.40	68	9099.05	5435.98	1113.87	2549.20	135	9075.47	5416.48	1109.35	2549.63
2	9604.08	5730.02	1180.93	2693.13	69	9085.88	5421.15	1116.98	2547.75	136	9124.47	5444.60	1120.45	2559.42
3	9599.13	5715.32	1181.13	2702.68	70	9083.82	5416.05	1112.78	2554.98	137	9097.37	5418.43	1118.60	2560.33
4	9592.93	5716.38	1173.50	2703.05	71	9089.57	5408.13	1124.22	2557.22	138	9102.10	5423.78	1120.50	2557.82
5	9616.45	5731.30	1186.60	2698.55	72	9103.20	5435.15	1113.22	2554.83	139	9103.28	5418.88	1123.60	2560.80
6	9587.67	5722.25	1174.42	2691.00	73	9122.28	5435.20	1114.43	2572.65	140	9122.75	5434.13	1123.65	2564.97
7	9570.88	5703.78	1175.00	2692.10	74	9083.68	5410.33	1117.60	2555.75	141	9120.70	5439.38	1120.67	2560.65
8	9597.67	5708.65	1191.58	2697.43	75	9102.82	5429.45	1113.17	2560.20	142	9111.22	5435.90	1116.72	2558.60
9	9416.50	5615.20	1160.95	2640.35	76	9088.93	5412.07	1121.17	2555.70	143	9088.38	5415.10	1116.80	2556.48
10	9088.40	5416.85	1112.27	2559.28	77	9095.27	5421.15	1119.32	2554.80	144	9089.33	5411.63	1121.38	2556.32
11	9104.60	5423.83	1120.07	2560.70	78	9085.30	5415.17	1113.57	2556.57	145	9103.37	5419.05	1123.58	2560.73
12	9081.12	5401.35	1120.90	2558.87	79	9109.77	5423.93	1119.08	2566.75	146	9090.38	5418.82	1120.13	2551.43
13	9090.93	5429.28	1114.08	2547.57	80	9123.60	5450.92	1115.37	2557.32	147	9104.28	5433.70	1116.07	2554.52
14	9082.20	5403.88	1116.07	2562.25	81	9124.78	5436.47	1123.08	2565.23	148	9088.68	5421.53	1122.18	2544.97
15	9087.58	5416.65	1115.65	2555.28	82	9098.72	5428.63	1113.40	2556.68	149	9115.98	5432.90	1124.17	2558.92
16	9095.45	5422.08	1120.32	2553.05	83	9104.68	5437.85	1121.28	2545.55	150	9105.38	5424.18	1121.90	2559.30
17	9088.00	5419.03	1119.68	2549.28	84	9089.63	5406.40	1113.98	2569.25	151	9092.27	5421.15	1119.58	2551.53
18	9088.10	5427.52	1112.98	2547.60	85	9101.88	5426.33	1115.17	2560.38	152	9087.35	5406.78	1120.63	2559.93
19	9089.15	5409.30	1120.77	2559.08	86	9100.35	5427.88	1114.03	2558.43	153	9093.77	5403.77	1126.83	2563.17
20	9125.57	5446.07	1117.55	2561.95	87	9115.78	5432.47	1121.65	2561.67	154	9102.28	5429.88	1122.57	2549.83
21	9099.32	5420.65	1120.92	2557.75	88	9078.53	5413.78	1113.10	2551.65	155	9084.02	5409.68	1114.98	2559.35
22	9093.87	5421.63	1124.45	2547.78	89	9076.35	5407.38	1117.10	2551.87	156	9081.12	5408.42	1125.20	2547.50
23	9087.70	5422.53	1114.80	2550.37	90	9095.12	5413.65	1124.02	2557.45	157	9093.90	5415.68	1115.88	2562.33
24	9080.13	5406.32	1112.52	2561.30	91	9082.07	5397.20	1115.10	2569.77	158	9101.67	5432.72	1118.32	2550.63
25	9091.25	5411.72	1118.83	2560.70	92	9070.47	5405.65	1118.70	2546.12	159	9086.92	5405.95	1125.62	2555.35
26	9109.28	5428.43	1128.75	2552.10	93	9113.30	5440.50	1116.33	2556.47	160	9116.97	5434.50	1121.98	2560.48
27	9103.43	5417.83	1116.45	2569.15	94	9098.23	5430.50	1123.25	2544.48	161	9099.25	5425.00	1123.33	2550.92
28	9088.58	5427.92	1115.13	2545.53	95	9099.28	5428.27	1118.57	2552.45	162	9105.88	5425.82	1114.85	2565.22
29	9097.75	5420.85	1118.27	2558.63	96	9098.25	5407.13	1125.93	2565.18	163	9107.95	5428.72	1123.65	2555.58
30	9121.88	5434.95	1123.18	2563.75	97	9085.40	5411.93	1124.45	2549.02	164	9084.03	5413.47	1112.20	2558.37
31	9090.98	5408.95	1122.38	2559.65	98	9106.57	5431.97	1115.50	2559.10	165	9117.68	5440.32	1124.67	2552.70
32	9091.83	5425.43	1121.17	2545.23	99	9093.77	5418.13	1119.75	2555.88	166	9114.12	5432.15	1122.20	2559.77
33	9103.75	5432.18	1115.40	2556.17	100	9089.23	5424.73	1109.67	2554.83	167	9108.13	5426.82	1123.18	2558.13
34	9108.50	5425.28	1124.85	2558.37	101	9106.33	5428.62	1121.98	2555.73	168	9124.32	5437.68	1118.68	2567.95
35	9101.23	5421.27	1121.33	2558.63	102	9102.95	5425.07	1117.00	2560.88	169	9097.90	5419.98	1116.90	2561.02
36	9082.57	5416.87	1115.35	2550.35	103	9081.23	5414.08	1120.85	2546.30	170	9087.88	5411.65	1114.62	2561.62
37	9104.72	5420.18	1123.67	2560.87	104	9109.52	5422.32	1126.63	2560.57	171	9110.03	5428.28	1124.50	2557.25
38	9109.33	5437.48	1121.23	2550.62	105	9106.95	5430.20	1118.25	2558.50	172	9101.25	5428.25	1118.15	2554.85
39	9099.80	5426.22	1119.40	2554.18	106	9117.95	5425.57	1124.22	2568.17	173	9086.03	5415.78	1124.32	2545.93
40	9090.83	5414.63	1121.15	2555.05	107	9126.70	5439.58	1126.18	2560.93	174	9081.37	5413.32	1121.60	2546.45
41	9071.78	5409.42	1117.17	2545.20	108	9107.13	5426.30	1124.35	2556.48	175	9115.72	5431.70	1124.50	2559.52
42	9106.20	5436.43	1112.25	2557.52	109	9112.78	5426.80	1122.07	2563.92	176	9106.32	5433.65	1119.67	2553.00
43	9098.52	5425.03	1112.65	2560.83	110	9111.15	5424.15	1118.42	2568.58	177	9096.32	5419.85	1121.38	2555.08
44	9079.92	5408.77	1120.93	2550.22	111	9084.00	5415.35	1111.83	2556.82	178	9106.42	5421.75	1127.48	2557.18
45	9103.27	5432.97	1109.15	2561.15	112	9116.48	5426.70	1119.02	2570.77	179	9085.17	5413.15	1118.10	2553.92
46	9089.63	5418.73	1116.37	2554.53	113	9098.92	5435.08	1119.42	2544.42	180	9098.12	5421.07	1120.22	2556.83
47	9092.12	5425.15	1113.27	2553.70	114	9089.22	5422.67	1117.62	2548.93	181	9107.35	5425.23	1121.20	2560.92
48	9090.32	5421.50	1118.43	2550.38	115	9103.43	5432.22	1119.18	2552.03	182	9087.08	5414.82	1120.72	2551.55
49	9114.73	5428.60	1121.23	2564.90	116	9108.87	5427.07	1122.48	2559.32	183	9086.50	5411.80	1120.53	2554.17
50	9093.32	5413.40	1120.02	2559.90	117	9082.63	5413.27	1117.52	2551.85	184	9113.75	5440.85	1118.93	2553.97
51	9096.60	5417.00	1119.55	2560.05	118	9093.25	5418.50	1114.97	2559.78	185	9097.60	5418.80	1118.22	2560.58
52	9096.43	5424.10	1117.05	2555.28	119	9074.60	5406.47	1115.37	2552.77	186	9098.75	5424.50	1123.92	2550.33
53	9085.37	5432.65	1115.80	2536.92	120	9085.43	5416.70	1117.83	2550.90	187	9082.22	5411.15	1114.28	2556.78
54	9102.65	5421.45	1113.98	2567.22	121	9113.67	5431.23	1128.38	2554.05	188	9105.58	5431.18	1122.10	2552.30
55	9108.15	5433.15	1113.27	2561.73	122	9098.28	5420.47	1120.88	2556.93	189	9092.80	5422.93	1117.20	2552.67
56	9073.42	5409.88	1115.02	2548.52	123	9094.32	5418.28	1121.02	2555.02	190	9103.50	5427.65	1115.73	2560.12
57	9110.17	5423.72	1125.45	2561.00	124	9104.00	5438.38	1108.52	2557.10	191	9104.33	5432.02	1117.12	2555.20
58	9107.37	5418.60	1123.93	2564.83	125	9075.13	5424.77	1111.68	2538.68	192	9093.58	5413.25	1130.47	2549.87
59	9099.13	5419.00	1114.88	2565.25	126	9115.90	5428.35	1123.53	2564.02	193	9095.00	5420.30	1116.33	2558.37
60	9106.60	5426.45	1123.08	2557.07	127	9114.03	5430.03	1118.85	2565.15	194	9093.17	5422.15	1115.78	2555.23
61	9112.48	5436.30	1120.17	2556.02	128	9091.87	5417.98	1110.87	2563.02	195	9085.32	5404.25	1125.27	2555.80
62	9104.50	5420.38	1120.43	2563.68	129	9126.90	5436.82	1125.48	2564.60	196	9101.98	5415.60	1121.07	2565.32
63	9099.70	5414.55	1127.10	2558.05	130	9093.03	5433.12	1115.38	2544.53	197	9080.63	5396.05	1122.47	2562.12
64	9107.72	5429.77	1122.95	2555.00	131	9092.63	5422.30	1115.58	2554.75	198	9112.98	5424.12	1122.12	2566.75
65	9085.90	5416.15	1118.08	2551.67	132	9114.18	5440.13	1124.93	2549.12	199	9112.05	5427.02	1121.72	2563.32
66	9095.65	5426.62	1110.65	2558.38	133	9093.58	5415.32	1119.28	2558.98					

Sustainability – I/O Request Throughput Distribution Graph



Sustainability – 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	.0350	.2810	.0700	.2100	.0180	.0700	.0350	.2810
COV	.0074	.0024	.0053	.0027	.0099	.0050	.0072	.0021

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.*

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%.*

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

IOPS Test Phase

Clause 5.4.2.2

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

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

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

Clause 9.2.4.7.2

For the IOPS Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, and Response Time Ramp Test Runs are listed below.

```
java -Xmx64m -Xms64m metrics -b 182 -s 1200
```

IOPS Test Results File

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

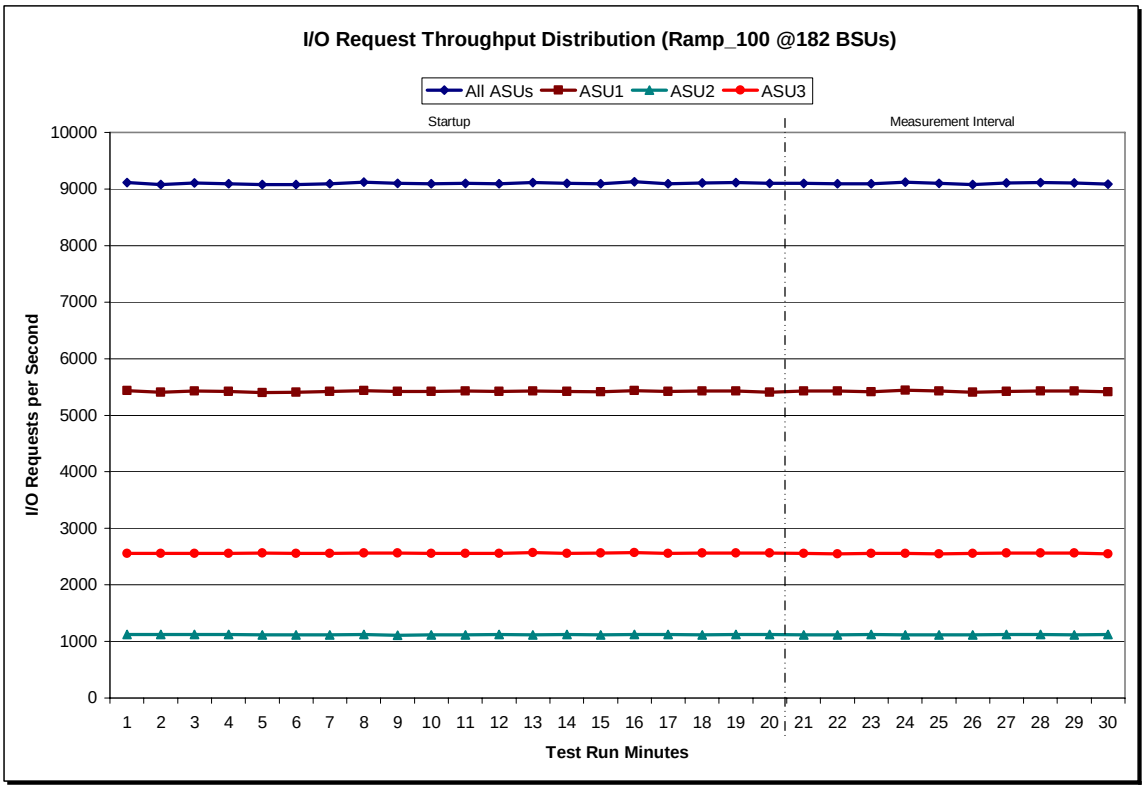
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

182 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:55:03	21:15:04	0-19	0:20:01
Measurement Interval	21:15:04	21:25:04	20-29	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9,117.85	5,436.18	1,123.00	2,558.67
1	9,079.92	5,407.12	1,120.05	2,552.75
2	9,103.92	5,426.23	1,122.23	2,555.45
3	9,096.43	5,421.65	1,120.13	2,554.65
4	9,077.18	5,402.68	1,114.92	2,559.58
5	9,081.13	5,410.20	1,118.38	2,552.55
6	9,092.50	5,422.70	1,114.45	2,555.35
7	9,122.60	5,433.48	1,124.98	2,564.13
8	9,097.35	5,424.13	1,111.95	2,561.27
9	9,090.92	5,418.63	1,117.37	2,554.92
10	9,102.13	5,430.02	1,113.08	2,559.03
11	9,095.07	5,417.65	1,122.80	2,554.62
12	9,114.30	5,428.75	1,117.62	2,567.93
13	9,103.33	5,422.82	1,121.43	2,559.08
14	9,090.67	5,411.83	1,118.63	2,560.20
15	9,125.33	5,433.92	1,121.53	2,569.88
16	9,095.57	5,419.95	1,122.15	2,553.47
17	9,104.77	5,427.98	1,117.20	2,559.58
18	9,113.83	5,430.42	1,121.78	2,561.63
19	9,097.38	5,408.45	1,125.50	2,563.43
20	9,099.75	5,427.70	1,114.47	2,557.58
21	9,096.18	5,425.08	1,119.23	2,551.87
22	9,089.55	5,414.52	1,122.33	2,552.70
23	9,119.63	5,443.40	1,118.58	2,557.65
24	9,100.17	5,430.57	1,119.43	2,550.17
25	9,079.47	5,404.98	1,115.97	2,558.52
26	9,106.03	5,424.67	1,120.42	2,560.95
27	9,116.47	5,428.72	1,123.00	2,564.75
28	9,104.27	5,425.82	1,116.42	2,562.03
29	9,087.07	5,413.75	1,121.33	2,551.98
Average	9,099.86	5,423.92	1,119.12	2,556.82

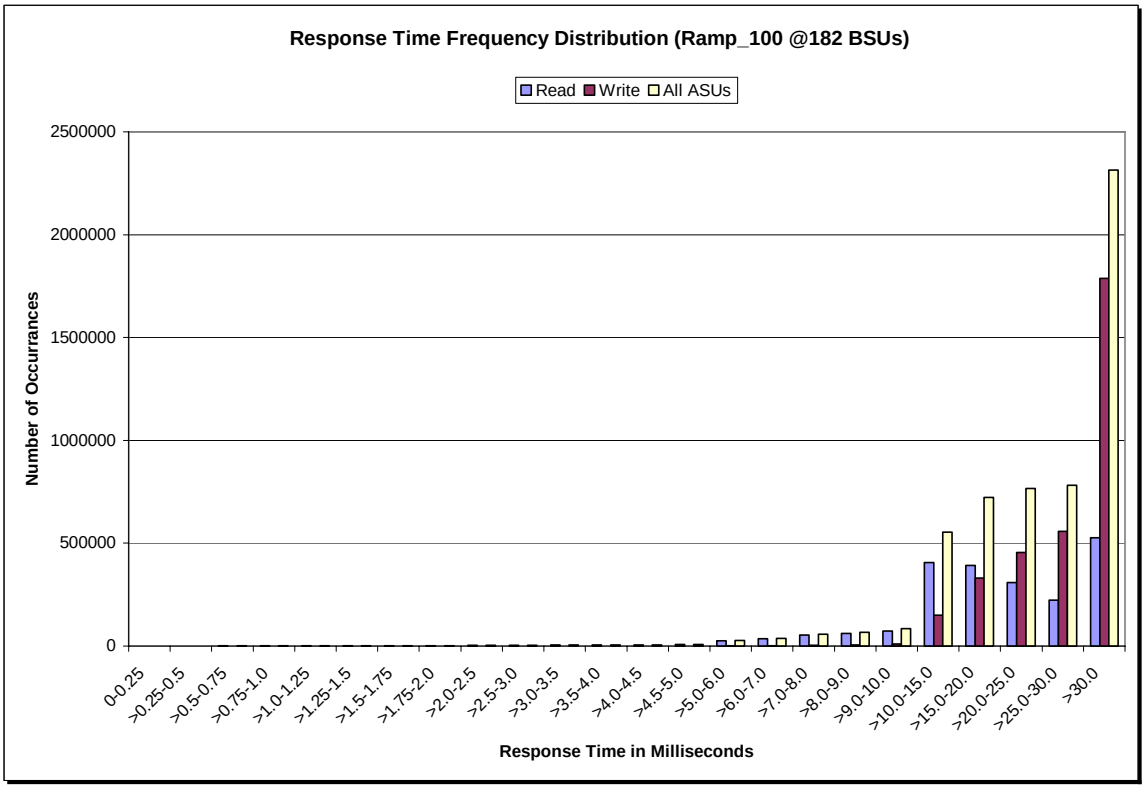
IOPS Test Run – I/O Request Throughput Distribution Graph



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	-	165	1,043	1,992	2,512	2,465	2,466	2,189
Write	-	-	-	-	-	1	1	2
All ASUs	-	165	1,043	1,992	2,512	2,466	2,467	2,191
ASU1	-	145	985	1,900	2,363	2,313	2,319	2,010
ASU2	-	20	58	92	149	153	148	180
ASU3	-	-	-	-	-	-	-	1
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	4,938	4,491	5,620	6,031	6,547	7,529	25,938	35,419
Write	7	38	82	121	221	217	1,253	2,006
All ASUs	4,945	4,529	5,702	6,152	6,768	7,746	27,191	37,425
ASU1	4,588	4,087	5,149	5,528	5,971	6,740	23,773	31,986
ASU2	353	430	544	620	775	981	3,306	5,246
ASU3	4	12	9	4	22	25	112	193
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	54,056	60,642	73,574	404,985	392,369	309,662	222,934	525,726
Write	3,991	6,642	10,843	149,651	329,808	456,053	558,226	1,787,232
All ASUs	58,047	67,284	84,417	554,636	722,177	765,715	781,160	2,312,958
ASU1	49,618	56,245	70,354	439,183	515,895	468,055	401,978	1,153,064
ASU2	8,028	10,103	12,478	84,653	105,444	104,730	97,609	235,339
ASU3	401	936	1,585	30,800	100,838	192,930	281,573	924,555

IOPS Test Run –Response Time Frequency Distribution Graph

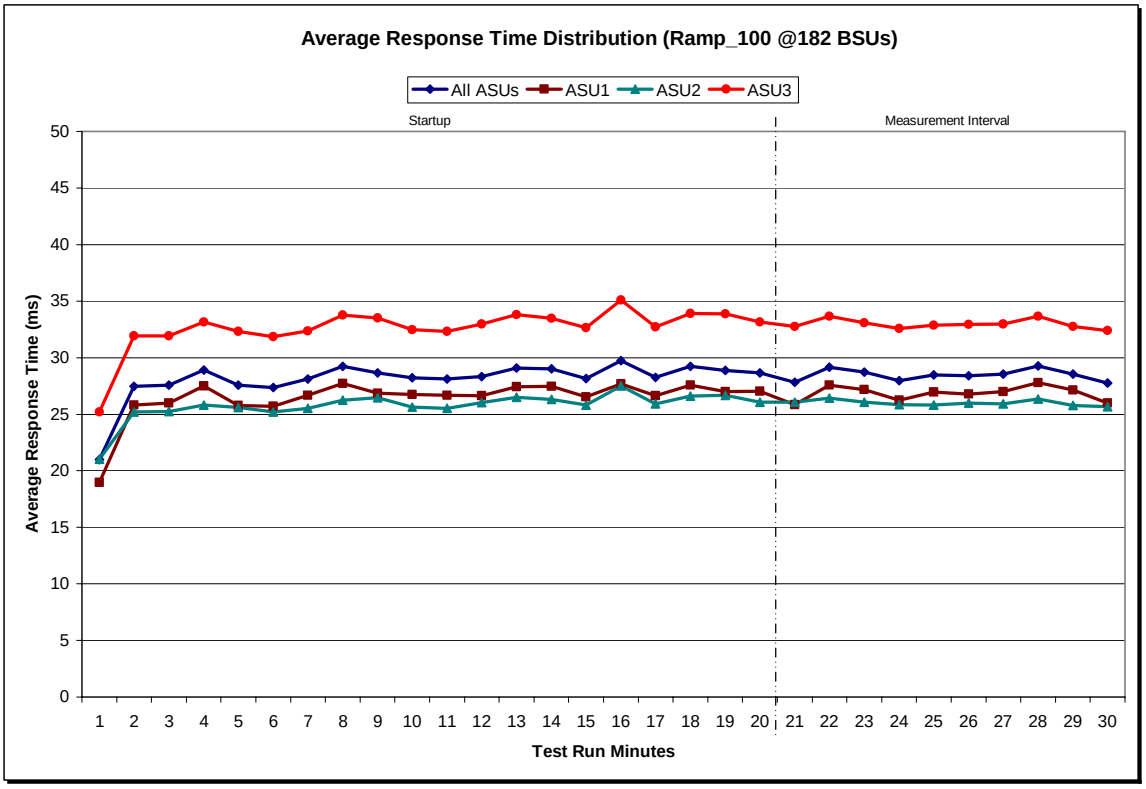


IOPS Test Run – Average Response Time (ms) Distribution Data

182 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:55:03	21:15:04	0-19	0:20:01
Measurement Interval	21:15:04	21:25:04	20-29	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	20.98	18.98	21.02	25.20
1	27.47	25.82	25.21	31.94
2	27.57	26.00	25.23	31.91
3	28.89	27.51	25.81	33.17
4	27.59	25.76	25.61	32.31
5	27.36	25.70	25.18	31.85
6	28.12	26.66	25.51	32.37
7	29.24	27.72	26.25	33.77
8	28.67	26.84	26.45	33.51
9	28.22	26.75	25.63	32.47
10	28.11	26.66	25.52	32.31
11	28.34	26.65	26.02	32.96
12	29.10	27.41	26.49	33.80
13	29.02	27.48	26.33	33.46
14	28.16	26.53	25.82	32.64
15	29.74	27.67	27.52	35.08
16	28.25	26.62	25.93	32.72
17	29.24	27.58	26.59	33.93
18	28.88	26.98	26.66	33.88
19	28.64	27.03	26.08	33.17
20	27.81	25.84	26.08	32.76
21	29.14	27.58	26.43	33.66
22	28.71	27.19	26.07	33.09
23	27.98	26.26	25.83	32.59
24	28.48	26.97	25.81	32.87
25	28.41	26.77	25.98	32.93
26	28.56	27.01	25.92	32.98
27	29.26	27.77	26.36	33.67
28	28.55	27.14	25.78	32.75
29	27.75	26.00	25.68	32.38
Average	28.46	26.85	25.99	32.97

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



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
5,459,688	3,146,730	2,312,958

IOPS Test Run – 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	.0350	.2810	.0700	.2100	.0180	.0698	.0351	.2810
COV	.0037	.0020	.0060	.0019	.0116	.0037	.0042	.0017

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.*

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%.*

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

Response Time Ramp Test Phase

Clause 5.4.2.3

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

The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 12.

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

Clause 9.2.4.7.3

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, and Response Time Ramp Test Runs are listed below.

```
java -Xmx64m -Xms64m metrics -b 182 -s 1200
```

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 - 182 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:55:03	21:15:04	0-19	0:20:01
Measurement Interval	21:15:04	21:25:04	20-29	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	9,117.85	5,436.18	1,123.00	2,558.67
1	9,079.92	5,407.12	1,120.05	2,552.75
2	9,103.92	5,426.23	1,122.23	2,555.45
3	9,096.43	5,421.65	1,120.13	2,554.65
4	9,077.18	5,402.68	1,114.92	2,559.58
5	9,081.13	5,410.20	1,118.38	2,552.55
6	9,092.50	5,422.70	1,114.45	2,555.35
7	9,122.60	5,433.48	1,124.98	2,564.13
8	9,097.35	5,424.13	1,111.95	2,561.27
9	9,090.92	5,418.63	1,117.37	2,554.92
10	9,102.13	5,430.02	1,113.08	2,559.03
11	9,095.07	5,417.65	1,122.80	2,554.62
12	9,114.30	5,428.75	1,117.62	2,567.93
13	9,103.33	5,422.82	1,121.43	2,559.08
14	9,090.67	5,411.83	1,118.63	2,560.20
15	9,125.33	5,433.92	1,121.53	2,569.88
16	9,095.57	5,419.95	1,122.15	2,553.47
17	9,104.77	5,427.98	1,117.20	2,559.58
18	9,113.83	5,430.42	1,121.78	2,561.63
19	9,097.38	5,408.45	1,125.50	2,563.43
20	9,099.75	5,427.70	1,114.47	2,557.58
21	9,096.18	5,425.08	1,119.23	2,551.87
22	9,089.55	5,414.52	1,122.33	2,552.70
23	9,119.63	5,443.40	1,118.58	2,557.65
24	9,100.17	5,430.57	1,119.43	2,550.17
25	9,079.47	5,404.98	1,115.97	2,558.52
26	9,106.03	5,424.67	1,120.42	2,560.95
27	9,116.47	5,428.72	1,123.00	2,564.75
28	9,104.27	5,425.82	1,116.42	2,562.03
29	9,087.07	5,413.75	1,121.33	2,551.98
Average	9,099.86	5,423.92	1,119.12	2,556.82

95% Load Level - 172 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:25:07	21:45:08	0-19	0:20:01
Measurement Interval	21:45:08	21:55:08	20-29	0:10:00

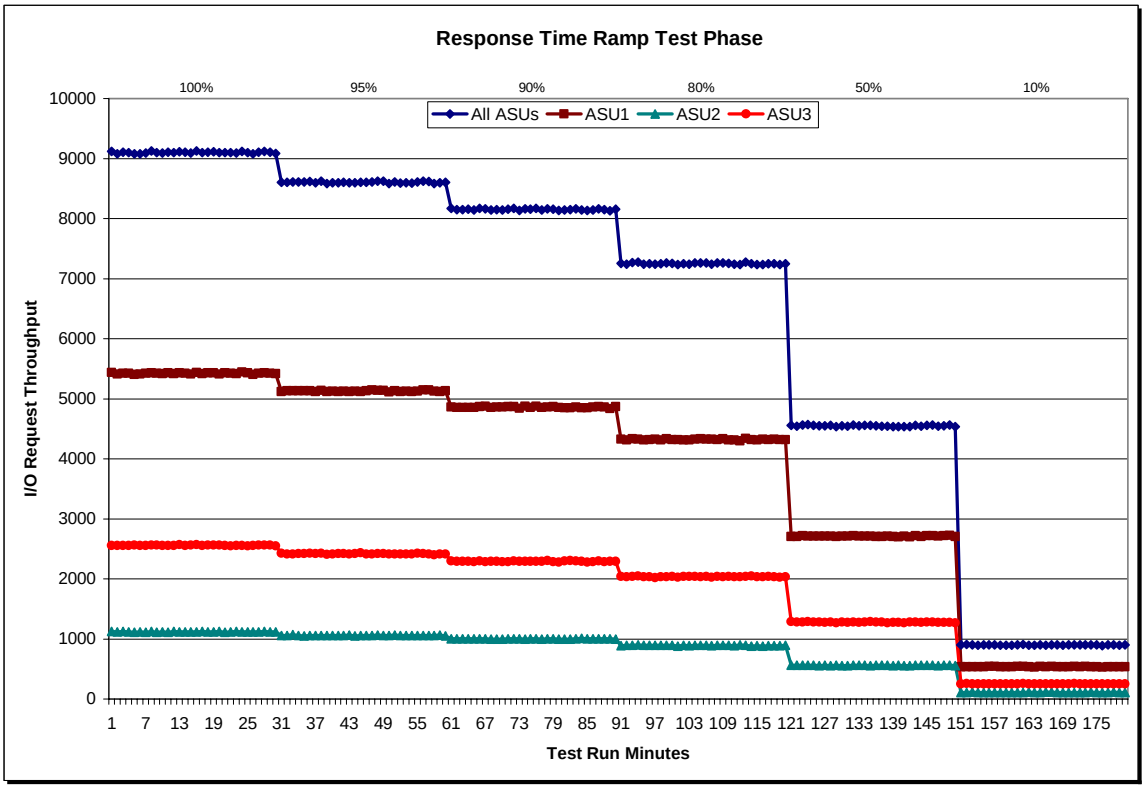
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	8,602.48	5,117.28	1,058.47	2,426.73
1	8,604.43	5,134.40	1,058.88	2,411.15
2	8,608.07	5,129.00	1,067.83	2,411.23
3	8,609.87	5,132.68	1,058.58	2,418.60
4	8,609.88	5,134.53	1,051.85	2,423.50
5	8,616.75	5,132.93	1,058.57	2,425.25
6	8,596.32	5,117.13	1,057.22	2,421.97
7	8,622.63	5,139.13	1,059.70	2,423.80
8	8,583.05	5,118.60	1,054.78	2,409.67
9	8,596.72	5,123.43	1,056.52	2,416.77
10	8,598.75	5,121.03	1,057.12	2,420.60
11	8,603.13	5,126.32	1,059.52	2,417.30
12	8,598.80	5,118.42	1,066.98	2,413.40
13	8,599.43	5,127.30	1,053.82	2,418.32
14	8,606.00	5,119.25	1,054.85	2,431.90
15	8,602.45	5,131.90	1,055.13	2,415.42
16	8,609.92	5,144.75	1,054.93	2,410.23
17	8,623.20	5,141.37	1,063.43	2,418.40
18	8,620.97	5,139.82	1,058.50	2,422.65
19	8,581.32	5,113.00	1,056.00	2,412.32
20	8,607.68	5,129.58	1,061.25	2,416.85
21	8,588.52	5,116.43	1,056.40	2,415.68
22	8,594.20	5,126.30	1,056.08	2,411.82
23	8,590.52	5,115.33	1,059.15	2,416.03
24	8,612.17	5,128.12	1,055.88	2,428.17
25	8,621.93	5,145.78	1,054.90	2,421.25
26	8,619.37	5,144.37	1,059.72	2,415.28
27	8,580.67	5,122.58	1,055.38	2,402.70
28	8,595.48	5,120.67	1,062.45	2,412.37
29	8,602.30	5,133.53	1,052.68	2,416.08
Average	8,601.28	5,128.27	1,057.39	2,415.62

Response Time Ramp Distribution (IOPS) Data (Continued)

90% Load Level - 163 BSUs	Start	Stop	Interval	Duration	80% Load Level - 145 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:55:11	22:15:12	0-19	0:20:01	Start-Up/Ramp-Up	22:25:15	22:45:16	0-19	0:20:01
Measurement Interval	22:15:12	22:25:12	20-29	0:10:00	Measurement Interval	22:45:16	22:55:16	20-29	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	8,166.17	4,862.95	1,004.13	2,299.08	0	7,254.37	4,323.58	888.97	2,041.82
1	8,147.73	4,851.45	1,003.82	2,292.47	1	7,241.22	4,313.10	896.68	2,031.43
2	8,147.12	4,851.33	1,003.67	2,292.12	2	7,269.62	4,331.63	894.10	2,043.88
3	8,155.40	4,857.38	1,003.37	2,294.65	3	7,272.23	4,323.97	899.55	2,048.72
4	8,143.13	4,857.15	1,002.70	2,283.28	4	7,242.53	4,314.55	891.75	2,036.23
5	8,168.62	4,867.42	1,002.30	2,298.90	5	7,249.40	4,321.78	896.08	2,031.53
6	8,161.15	4,877.05	1,000.68	2,283.42	6	7,241.40	4,328.53	895.03	2,017.83
7	8,140.43	4,853.80	997.02	2,289.62	7	7,245.45	4,314.30	894.28	2,036.87
8	8,148.08	4,858.35	997.47	2,292.27	8	7,261.35	4,335.30	891.63	2,034.42
9	8,143.95	4,861.77	999.37	2,282.82	9	7,251.48	4,318.25	892.70	2,040.53
10	8,158.52	4,868.28	1,002.83	2,287.40	10	7,230.58	4,317.53	883.32	2,029.73
11	8,168.88	4,869.43	1,002.38	2,297.07	11	7,249.97	4,314.87	893.58	2,041.52
12	8,134.82	4,837.37	1,003.50	2,293.95	12	7,243.45	4,314.80	888.63	2,040.02
13	8,165.52	4,874.52	998.33	2,292.67	13	7,259.33	4,322.98	896.73	2,039.62
14	8,153.60	4,855.87	1,003.07	2,294.67	14	7,262.10	4,334.75	893.48	2,033.87
15	8,168.10	4,872.10	1,006.25	2,289.75	15	7,259.25	4,324.18	892.40	2,042.67
16	8,141.12	4,853.40	994.52	2,293.20	16	7,243.50	4,326.58	887.42	2,029.50
17	8,164.55	4,861.58	1,001.07	2,301.90	17	7,258.08	4,317.32	898.15	2,042.62
18	8,156.67	4,867.37	1,006.25	2,283.05	18	7,261.90	4,331.77	896.50	2,033.63
19	8,133.82	4,856.65	996.20	2,280.97	19	7,252.40	4,314.20	895.57	2,042.63
20	8,141.67	4,845.40	998.60	2,297.67	20	7,238.67	4,312.82	888.68	2,037.17
21	8,150.27	4,850.20	997.72	2,302.35	21	7,233.38	4,301.60	901.12	2,030.67
22	8,159.83	4,859.62	1,002.82	2,297.40	22	7,272.80	4,335.90	897.20	2,039.70
23	8,143.32	4,844.78	1,007.12	2,291.42	23	7,245.28	4,318.63	880.47	2,046.18
24	8,134.27	4,850.22	1,005.75	2,278.30	24	7,234.75	4,312.97	887.77	2,034.02
25	8,144.87	4,860.23	1,002.72	2,281.92	25	7,235.92	4,322.57	881.03	2,032.32
26	8,163.45	4,865.03	1,001.65	2,296.77	26	7,248.48	4,320.22	888.50	2,039.77
27	8,148.05	4,862.92	1,002.43	2,282.70	27	7,249.67	4,324.50	890.97	2,034.20
28	8,131.12	4,833.67	1,003.83	2,293.62	28	7,233.58	4,315.63	890.15	2,027.80
29	8,156.45	4,865.73	999.62	2,291.10	29	7,250.07	4,318.95	897.47	2,033.65
Average	8,147.33	4,853.78	1,002.23	2,291.32	Average	7,244.26	4,318.38	890.34	2,035.55

50% Load Level - 91 BSUs	Start	Stop	Interval	Duration	10% Load Level - 18 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:55:18	23:15:19	0-19	0:20:01	Start-Up/Ramp-Up	23:25:21	23:45:22	0-19	0:20:01
Measurement Interval	23:15:19	23:25:19	20-29	0:10:00	Measurement Interval	23:45:22	23:55:22	20-29	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	4,553.08	2,707.37	560.13	1,285.58	0	899.93	536.63	110.55	252.75
1	4,545.68	2,706.45	559.50	1,279.73	1	906.13	538.88	111.13	256.12
2	4,559.77	2,718.22	560.20	1,281.35	2	899.70	536.47	112.60	250.63
3	4,566.87	2,714.60	566.08	1,286.18	3	897.20	534.40	111.58	251.22
4	4,554.37	2,709.68	560.33	1,284.35	4	900.67	538.72	109.25	252.70
5	4,547.75	2,709.92	557.02	1,280.82	5	901.47	542.75	108.27	250.45
6	4,550.38	2,710.38	562.80	1,277.20	6	903.88	541.23	111.07	251.58
7	4,552.72	2,712.72	558.80	1,281.20	7	897.50	537.23	108.93	251.33
8	4,536.83	2,703.43	564.17	1,269.23	8	896.13	536.22	109.57	250.35
9	4,547.93	2,712.97	555.40	1,279.57	9	897.75	536.30	110.98	250.47
10	4,539.33	2,711.38	554.95	1,273.00	10	903.32	540.67	111.35	251.30
11	4,561.30	2,716.08	560.63	1,284.58	11	906.42	540.25	111.68	254.48
12	4,549.55	2,711.02	560.87	1,277.67	12	897.07	533.92	111.88	251.27
13	4,555.97	2,713.27	560.12	1,282.58	13	892.73	531.67	110.83	250.23
14	4,555.43	2,712.32	554.93	1,288.18	14	902.18	539.18	111.55	251.45
15	4,548.75	2,706.80	560.08	1,281.87	15	898.23	535.03	112.40	250.80
16	4,543.87	2,705.82	559.97	1,278.08	16	903.17	540.45	111.97	250.75
17	4,540.88	2,708.73	561.23	1,270.92	17	902.12	537.80	110.13	254.18
18	4,537.48	2,702.55	558.62	1,276.32	18	894.47	533.43	108.67	252.37
19	4,538.75	2,701.30	560.58	1,276.87	19	901.72	538.73	109.60	253.38
20	4,538.70	2,712.38	555.15	1,271.17	20	904.70	539.32	110.68	254.70
21	4,538.70	2,699.52	558.58	1,280.60	21	901.18	536.58	110.85	253.75
22	4,557.62	2,717.43	562.22	1,277.97	22	899.87	539.22	108.02	252.63
23	4,544.98	2,704.92	564.97	1,275.10	23	901.97	535.83	112.95	253.18
24	4,556.05	2,716.40	560.82	1,278.83	24	900.67	537.82	111.10	251.75
25	4,560.12	2,715.68	563.48	1,280.95	25	889.42	528.68	111.58	249.15
26	4,539.05	2,712.33	554.47	1,272.25	26	899.47	537.25	109.58	252.63
27	4,550.90	2,717.03	561.90	1,271.97	27	900.18	536.75	111.88	251.55
28	4,559.70	2,722.62	560.32	1,276.77	28	896.15	534.88	111.15	250.12
29	4,535.05	2,707.82	558.83	1,268.40	29	902.08	536.87	111.62	253.60
Average	4,548.09	2,712.61	560.07	1,275.40	Average	899.57	536.32	110.94	252.31

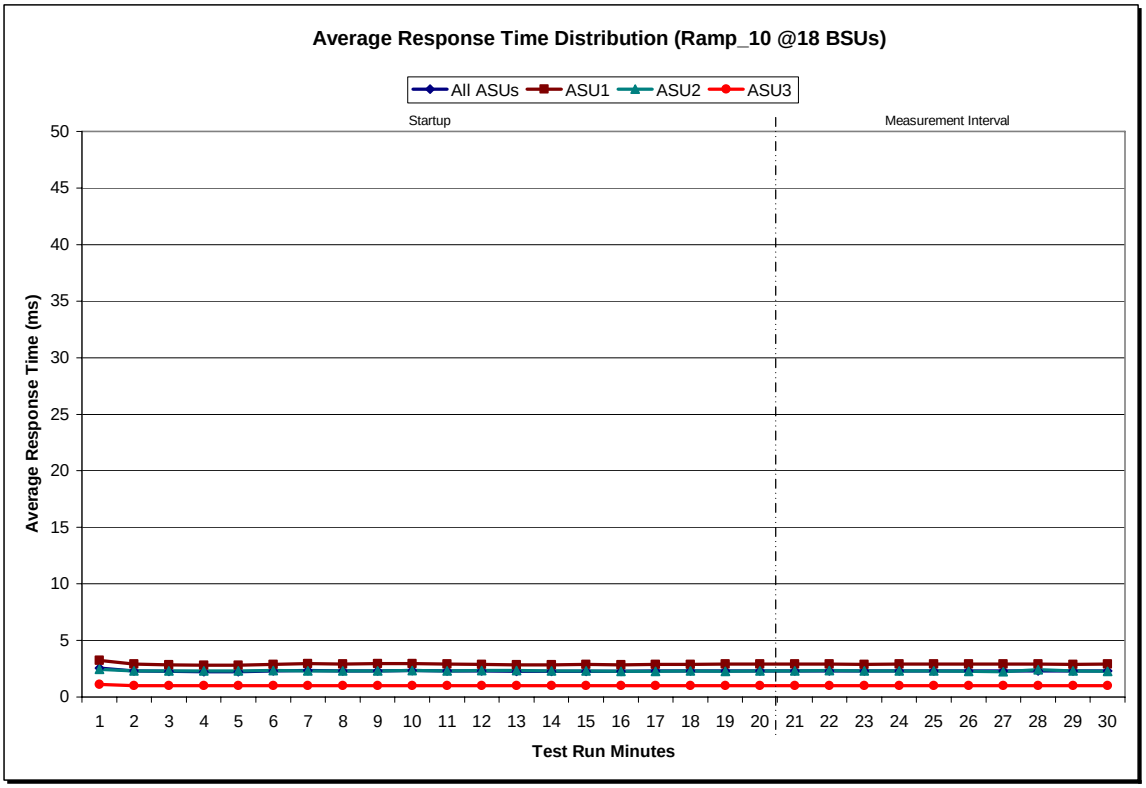
Response Time Ramp Distribution (IOPS) Graph



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

18 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:25:21	23:45:22	0-19	0:20:01
Measurement Interval	23:45:22	23:55:22	20-29	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.55	3.25	2.46	1.12
1	2.30	2.91	2.31	1.01
2	2.27	2.85	2.31	1.01
3	2.24	2.80	2.30	1.00
4	2.24	2.81	2.32	1.01
5	2.30	2.89	2.33	1.01
6	2.33	2.95	2.30	1.02
7	2.30	2.90	2.30	1.01
8	2.32	2.94	2.30	1.01
9	2.33	2.95	2.35	1.01
10	2.31	2.92	2.32	1.01
11	2.29	2.87	2.34	1.02
12	2.27	2.85	2.35	1.01
13	2.27	2.85	2.31	1.01
14	2.28	2.87	2.30	1.01
15	2.26	2.85	2.25	1.02
16	2.29	2.88	2.28	1.01
17	2.29	2.89	2.29	1.02
18	2.31	2.92	2.28	1.02
19	2.30	2.91	2.30	1.01
20	2.30	2.91	2.30	1.01
21	2.31	2.92	2.32	1.01
22	2.29	2.88	2.30	1.02
23	2.30	2.91	2.30	1.00
24	2.31	2.92	2.31	1.01
25	2.30	2.91	2.27	1.01
26	2.29	2.91	2.23	1.01
27	2.31	2.91	2.41	1.00
28	2.30	2.89	2.32	1.01
29	2.29	2.91	2.28	1.01
Average	2.30	2.91	2.30	1.01

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



SPC-1 LRT™ (10%) – 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	.0350	.2811	.0698	.2102	.0181	.0702	.0351	.2805
COV	.0185	.0068	.0067	.0054	.0277	.0207	.0224	.0031

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.*

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%.*

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

Repeatability Test

Clause 5.4.3

The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPS™ and SPC-1 LRT™ primary metrics 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™ primary metric. Each Average Response Time value must be less than the SPC-1 LRT™ primary metric plus 5%.

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

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

Clause 9.2.4.7.3

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 two Repeatability Test Phases. The content, appearance, and format of the table are specified in Table 9-11.*
2. *An I/O Request Throughput Distribution (data and graph).*
3. *An Average Response Time Distribution (data and graph).*
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 Repeatability Test Runs are listed below.

```
java -Xmx64m -Xms64m repeat1 -b 182 -s 1200
java -Xmx64m -Xms64m repeat2 -b 182 -s 1200
```

Repeatability Test Results File

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

	SPC-1 IOPS™	SPC-1 LRT™
Primary Metrics	*9099.86*	*2.30*
Repeatability Test Phase 1	9,097.56	2.32
Repeatability Test Phase 2	9,096.95	2.30

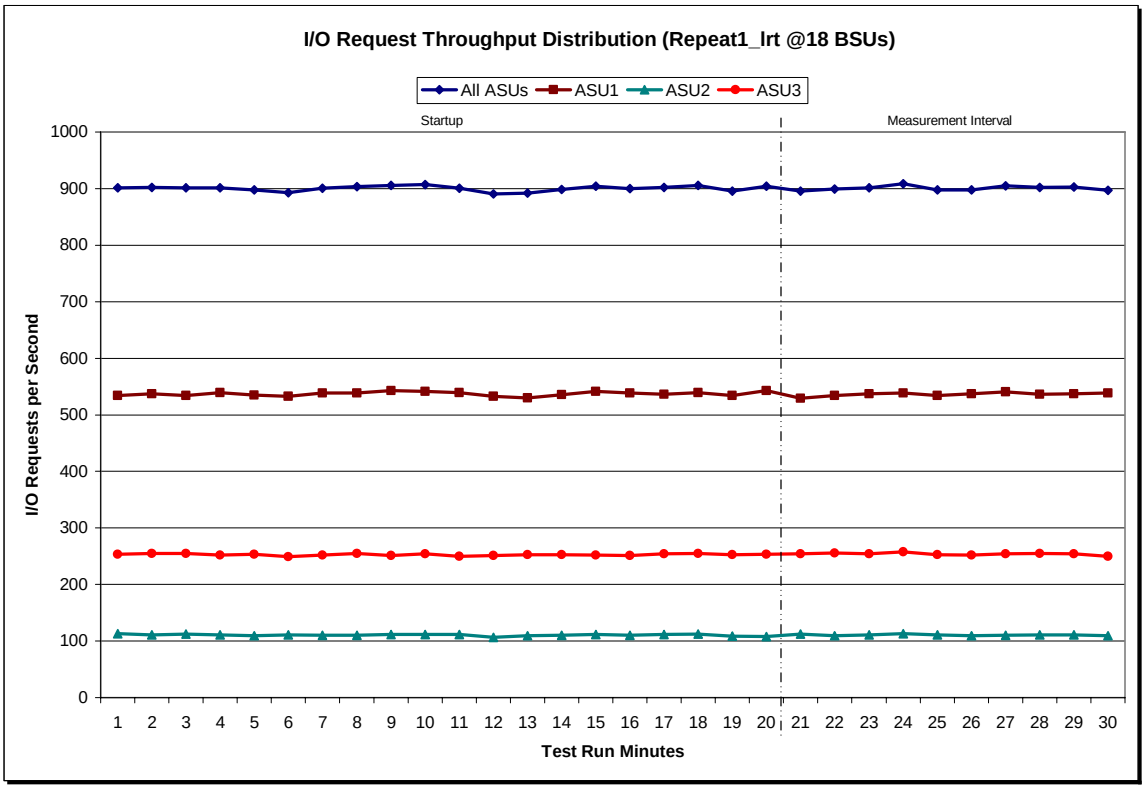
A link to the test result file generated from each Repeatability Test Run list is listed below.

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

Repeatability 1 LRT – I/O Request Throughput Distribution Data

18 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:34:27	15:54:27	0-19	0:20:00
Measurement Interval	15:54:27	16:04:27	20-29	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	901.35	534.45	113.25	253.65
1	902.37	536.73	110.65	254.98
2	901.13	534.15	112.42	254.57
3	901.68	539.18	110.70	251.80
4	897.70	534.57	109.77	253.37
5	892.65	532.73	110.63	249.28
6	900.62	538.37	109.92	252.33
7	903.45	538.28	110.18	254.98
8	905.72	542.58	111.58	251.55
9	907.07	541.35	111.32	254.40
10	900.70	538.90	111.63	250.17
11	890.27	532.78	106.50	250.98
12	892.17	529.63	109.78	252.75
13	898.80	535.88	110.33	252.58
14	904.55	541.25	111.27	252.03
15	899.70	538.22	109.92	251.57
16	902.22	536.38	111.83	254.00
17	905.70	538.90	112.22	254.58
18	895.62	534.13	108.92	252.57
19	904.27	543.02	107.63	253.62
20	895.67	529.32	112.53	253.82
21	899.12	534.22	109.60	255.30
22	901.58	536.85	110.75	253.98
23	908.90	538.27	112.70	257.93
24	897.48	534.12	110.55	252.82
25	898.07	537.08	109.27	251.72
26	905.12	540.73	110.35	254.03
27	902.10	536.35	110.57	255.18
28	902.48	537.12	110.90	254.47
29	897.10	538.23	109.30	249.57
Average	900.76	536.23	110.65	253.88

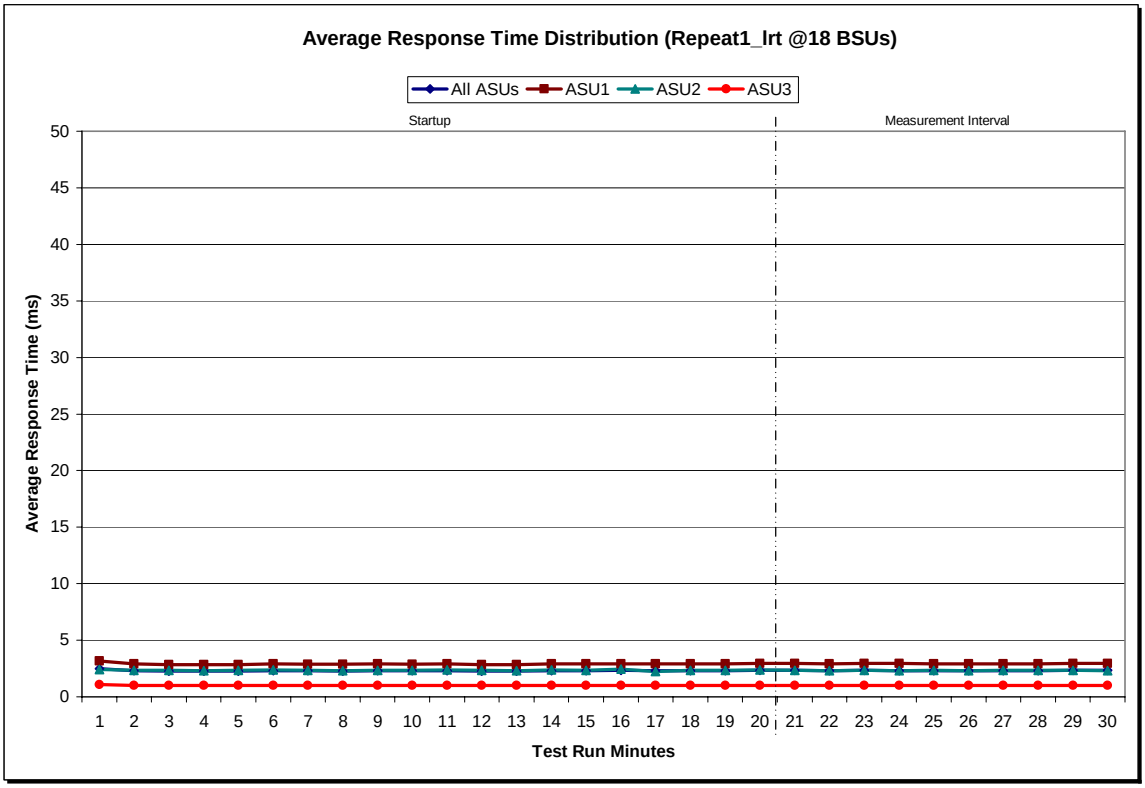
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

18 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:34:27	15:54:27	0-19	0:20:00
Measurement Interval	15:54:27	16:04:27	20-29	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.50	3.19	2.40	1.10
1	2.31	2.92	2.34	0.99
2	2.27	2.86	2.35	1.01
3	2.27	2.86	2.31	1.00
4	2.27	2.86	2.33	1.00
5	2.30	2.90	2.36	1.00
6	2.29	2.89	2.33	1.00
7	2.28	2.89	2.30	1.01
8	2.30	2.90	2.33	1.00
9	2.29	2.87	2.36	1.01
10	2.32	2.92	2.37	1.01
11	2.27	2.86	2.32	1.01
12	2.26	2.85	2.31	1.00
13	2.31	2.91	2.36	1.00
14	2.31	2.90	2.35	1.01
15	2.32	2.92	2.44	1.01
16	2.29	2.91	2.24	1.01
17	2.30	2.90	2.32	1.01
18	2.31	2.93	2.33	1.01
19	2.34	2.95	2.39	1.01
20	2.33	2.95	2.35	1.01
21	2.30	2.92	2.30	1.01
22	2.33	2.96	2.35	1.01
23	2.32	2.95	2.29	1.02
24	2.30	2.90	2.33	1.02
25	2.30	2.91	2.31	1.00
26	2.31	2.93	2.33	1.01
27	2.31	2.92	2.35	1.02
28	2.33	2.94	2.35	1.02
29	2.33	2.94	2.30	1.02
Average	2.32	2.93	2.33	1.01

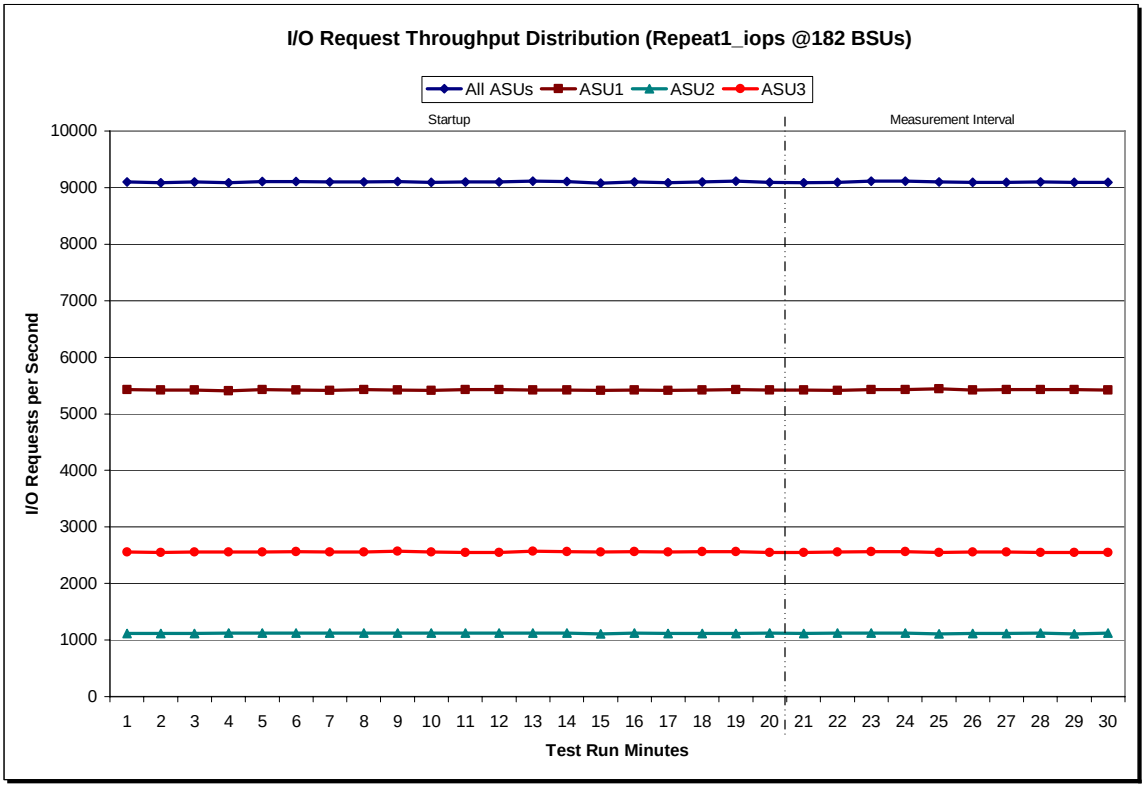
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

182 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:04:30	16:24:31	0-19	0:20:01
Measurement Interval	16:24:31	16:34:31	20-29	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	9,098.00	5,426.13	1,118.17	2,553.70
1	9,089.18	5,423.90	1,114.97	2,550.32
2	9,096.93	5,423.25	1,116.73	2,556.95
3	9,085.93	5,407.92	1,123.63	2,554.38
4	9,110.03	5,426.55	1,126.25	2,557.23
5	9,110.20	5,424.18	1,124.48	2,561.53
6	9,096.58	5,416.42	1,123.45	2,556.72
7	9,101.20	5,428.28	1,119.68	2,553.23
8	9,108.07	5,418.83	1,119.53	2,569.70
9	9,096.28	5,417.37	1,119.82	2,559.10
10	9,102.35	5,428.90	1,122.77	2,550.68
11	9,098.52	5,424.88	1,124.07	2,549.57
12	9,113.45	5,422.87	1,123.13	2,567.45
13	9,104.73	5,418.68	1,125.10	2,560.95
14	9,081.98	5,414.30	1,111.60	2,556.08
15	9,100.95	5,418.35	1,122.25	2,560.35
16	9,085.02	5,414.32	1,112.93	2,557.77
17	9,097.45	5,418.05	1,118.07	2,561.33
18	9,114.07	5,431.37	1,116.90	2,565.80
19	9,092.82	5,420.83	1,121.82	2,550.17
20	9,084.57	5,421.92	1,112.87	2,549.78
21	9,095.05	5,416.57	1,123.50	2,554.98
22	9,117.88	5,429.53	1,122.33	2,566.02
23	9,111.50	5,429.65	1,122.10	2,559.75
24	9,099.47	5,439.35	1,110.88	2,549.23
25	9,090.87	5,417.88	1,116.03	2,556.95
26	9,094.93	5,425.02	1,112.92	2,557.00
27	9,097.43	5,427.10	1,120.40	2,549.93
28	9,091.47	5,429.62	1,110.90	2,550.95
29	9,092.47	5,419.68	1,121.70	2,551.08
Average	9,097.56	5,425.63	1,117.36	2,554.57

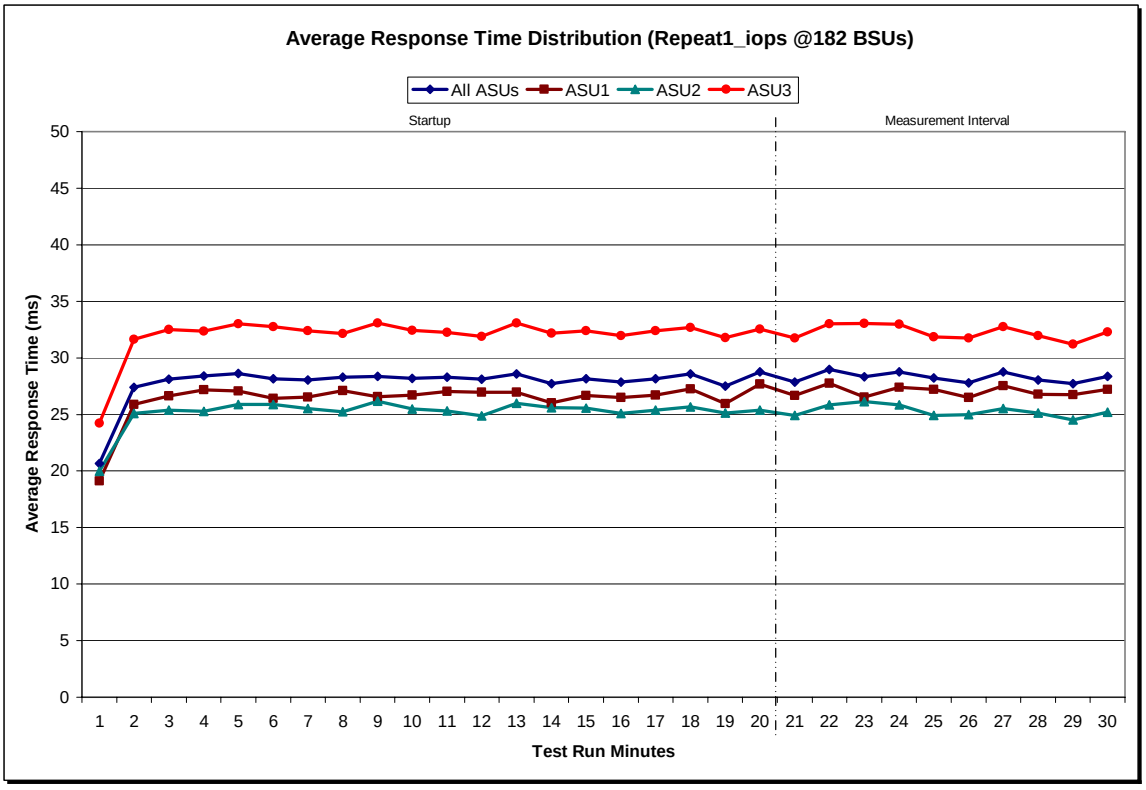
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

182 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:04:30	16:24:31	0-19	0:20:01
Measurement Interval	16:24:31	16:34:31	20-29	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	20.66	19.13	20.00	24.21
1	27.40	25.89	25.07	31.65
2	28.13	26.63	25.39	32.51
3	28.39	27.17	25.28	32.35
4	28.60	27.08	25.89	33.02
5	28.14	26.43	25.87	32.75
6	28.05	26.52	25.53	32.41
7	28.30	27.12	25.23	32.15
8	28.36	26.56	26.17	33.09
9	28.17	26.72	25.48	32.43
10	28.29	27.04	25.32	32.25
11	28.10	26.97	24.89	31.90
12	28.57	26.97	26.01	33.09
13	27.71	26.03	25.59	32.19
14	28.14	26.66	25.57	32.40
15	27.86	26.49	25.10	31.98
16	28.14	26.70	25.39	32.40
17	28.59	27.26	25.67	32.69
18	27.50	25.96	25.12	31.79
19	28.77	27.69	25.37	32.56
20	27.87	26.66	24.90	31.75
21	28.99	27.75	25.83	33.02
22	28.33	26.54	26.15	33.06
23	28.77	27.39	25.84	32.96
24	28.22	27.20	24.89	31.85
25	27.79	26.49	24.98	31.75
26	28.76	27.54	25.53	32.76
27	28.03	26.77	25.14	31.98
28	27.72	26.75	24.50	31.20
29	28.38	27.20	25.21	32.27
Average	28.29	27.03	25.30	32.26

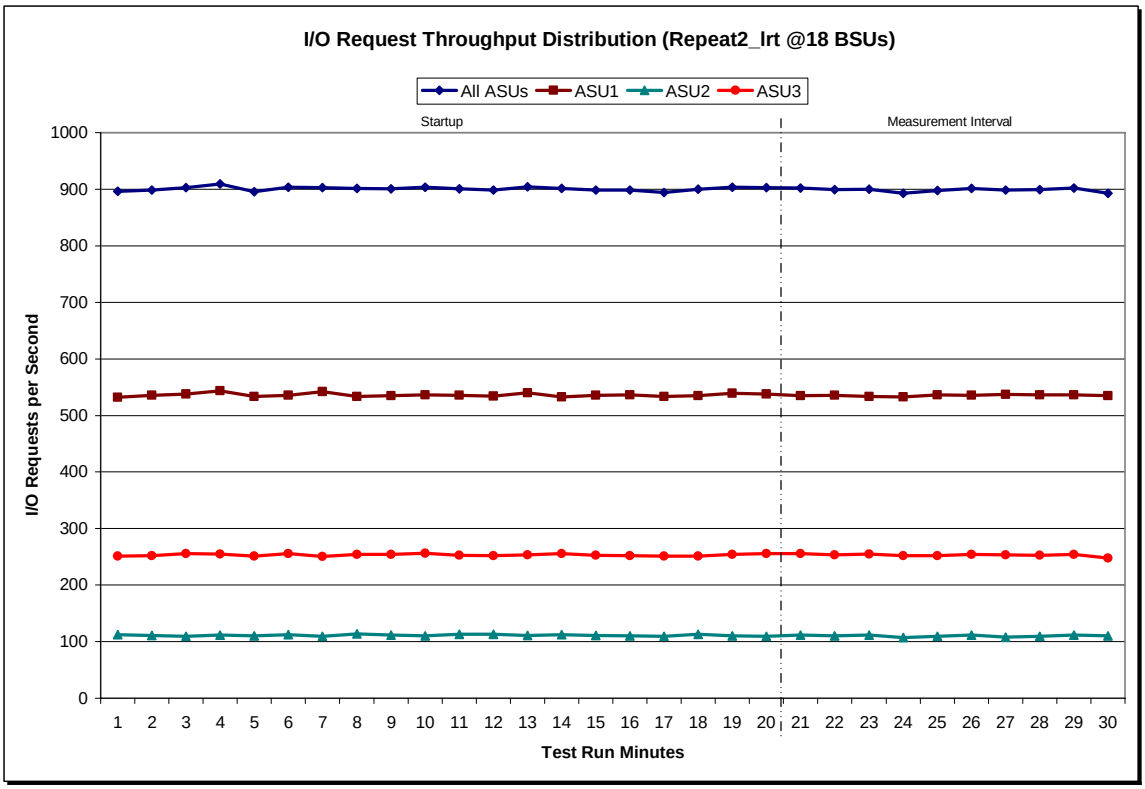
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

18 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:34:37	16:54:37	0-19	0:20:00
Measurement Interval	16:54:37	17:04:37	20-29	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	896.25	532.37	112.45	251.43
1	898.20	535.68	110.55	251.97
2	902.97	537.97	109.67	255.33
3	909.50	543.57	111.28	254.65
4	895.25	533.63	110.10	251.52
5	903.52	535.93	112.10	255.48
6	902.72	542.42	109.62	250.68
7	901.42	533.52	114.00	253.90
8	900.32	534.62	111.72	253.98
9	903.23	536.68	109.97	256.58
10	900.78	535.42	112.75	252.62
11	898.63	534.27	112.70	251.67
12	903.93	539.92	110.82	253.20
13	901.50	532.95	112.65	255.90
14	898.55	535.50	110.57	252.48
15	898.48	536.25	110.23	252.00
16	894.05	533.45	109.63	250.97
17	899.80	535.23	112.95	251.62
18	903.82	539.15	110.23	254.43
19	902.88	537.98	109.43	255.47
20	902.37	534.93	111.67	255.77
21	898.85	535.58	109.85	253.42
22	899.87	533.40	111.48	254.98
23	892.48	532.95	107.48	252.05
24	897.82	536.10	109.42	252.30
25	901.32	535.32	111.70	254.30
26	898.57	536.95	107.92	253.70
27	898.95	536.70	109.35	252.90
28	901.80	536.10	111.40	254.30
29	892.90	534.78	110.43	247.68
Average	898.49	535.28	110.07	253.14

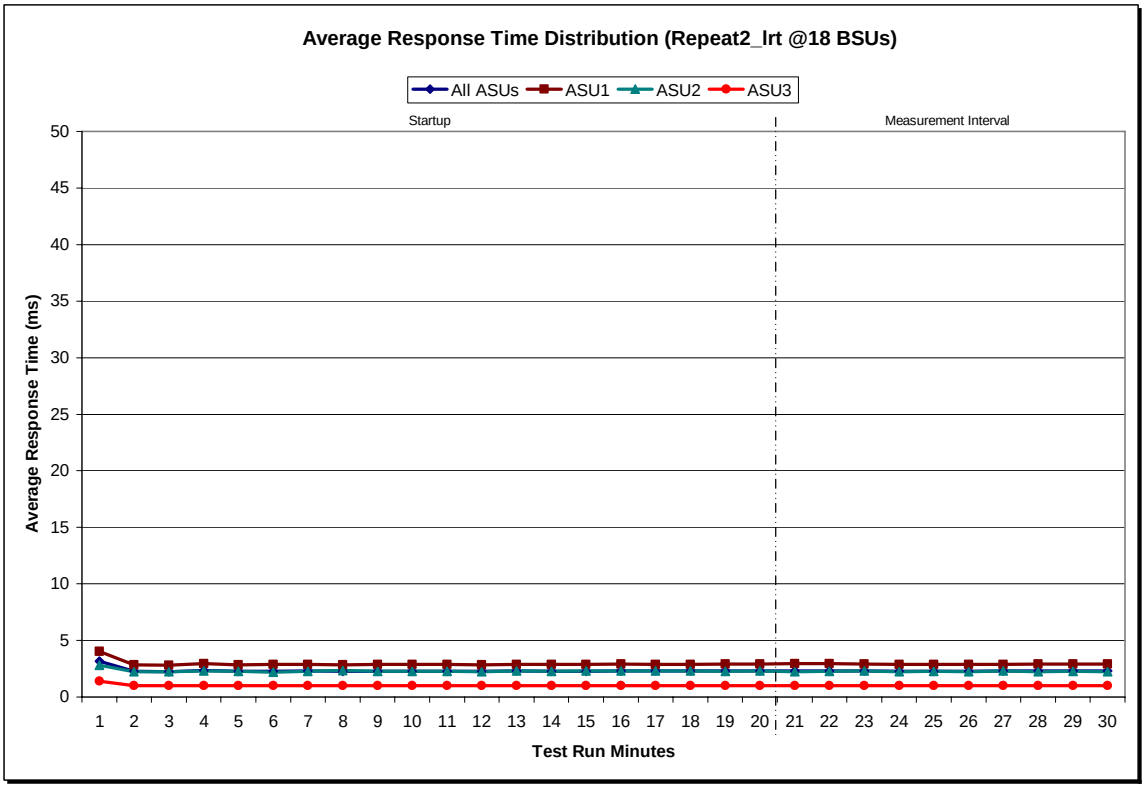
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

18 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:34:37	16:54:37	0-19	0:20:00
Measurement Interval	16:54:37	17:04:37	20-29	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	3.15	4.05	2.79	1.41
1	2.26	2.86	2.25	1.02
2	2.23	2.82	2.23	1.00
3	2.34	2.97	2.30	1.02
4	2.26	2.86	2.26	1.01
5	2.26	2.87	2.20	1.01
6	2.29	2.89	2.27	1.01
7	2.27	2.86	2.33	1.02
8	2.28	2.87	2.28	1.02
9	2.27	2.87	2.27	1.02
10	2.27	2.87	2.27	1.01
11	2.26	2.85	2.24	1.02
12	2.29	2.88	2.32	1.01
13	2.27	2.88	2.26	1.01
14	2.27	2.86	2.29	1.01
15	2.30	2.91	2.29	1.01
16	2.29	2.90	2.30	1.01
17	2.29	2.89	2.30	1.01
18	2.31	2.93	2.25	1.01
19	2.31	2.92	2.30	1.01
20	2.31	2.95	2.24	1.01
21	2.31	2.94	2.28	1.01
22	2.29	2.90	2.30	1.01
23	2.28	2.89	2.24	1.01
24	2.28	2.87	2.27	1.02
25	2.28	2.89	2.24	1.01
26	2.29	2.89	2.30	1.01
27	2.30	2.92	2.23	1.01
28	2.29	2.91	2.27	1.01
29	2.31	2.93	2.23	1.01
Average	2.30	2.91	2.26	1.01

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

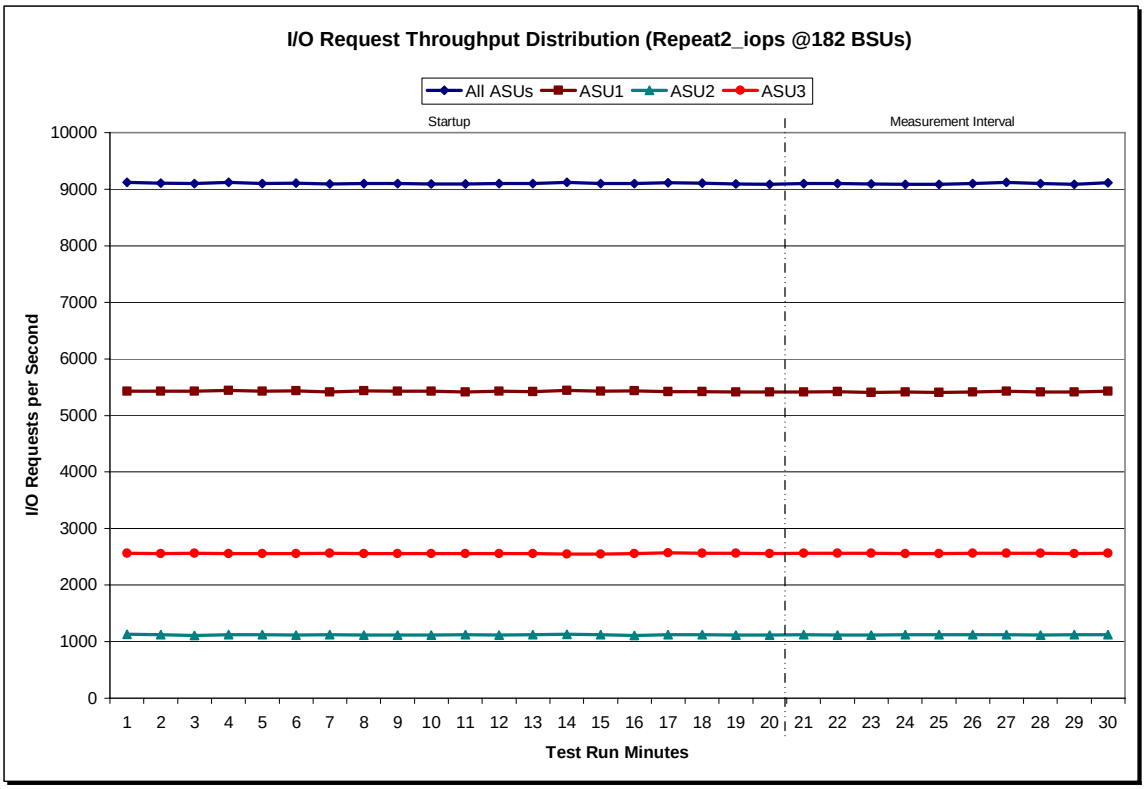


Repeatability 2 IOPS – I/O Request Throughput Distribution Data

182 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:04:40	17:24:41	0-19	0:20:01
Measurement Interval	17:24:41	17:34:41	20-29	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9,121.45	5,431.60	1,129.33	2,560.52
1	9,110.85	5,431.43	1,121.27	2,558.15
2	9,099.70	5,427.90	1,110.45	2,561.35
3	9,120.73	5,440.20	1,121.58	2,558.95
4	9,099.48	5,425.70	1,120.38	2,553.40
5	9,105.55	5,433.87	1,113.32	2,558.37
6	9,094.33	5,413.20	1,119.98	2,561.15
7	9,103.05	5,432.30	1,115.83	2,554.92
8	9,098.08	5,426.48	1,117.50	2,554.10
9	9,096.07	5,425.52	1,114.65	2,555.90
10	9,091.53	5,412.78	1,121.80	2,556.95
11	9,099.22	5,425.55	1,115.12	2,558.55
12	9,097.68	5,420.38	1,119.83	2,557.47
13	9,119.90	5,443.35	1,130.42	2,546.13
14	9,099.23	5,427.98	1,120.83	2,550.42
15	9,098.08	5,434.33	1,108.32	2,555.43
16	9,114.92	5,421.65	1,123.88	2,569.38
17	9,105.65	5,419.35	1,120.75	2,565.55
18	9,094.50	5,417.47	1,113.38	2,563.65
19	9,087.47	5,415.62	1,116.92	2,554.93
20	9,098.42	5,413.37	1,120.28	2,564.77
21	9,096.78	5,421.53	1,113.38	2,561.87
22	9,089.70	5,409.20	1,118.10	2,562.40
23	9,086.32	5,411.72	1,121.62	2,552.98
24	9,086.57	5,409.57	1,123.23	2,553.77
25	9,097.05	5,412.60	1,120.82	2,563.63
26	9,119.03	5,431.68	1,121.72	2,565.63
27	9,096.90	5,416.77	1,116.80	2,563.33
28	9,087.73	5,414.00	1,120.40	2,553.33
29	9,110.97	5,429.42	1,121.47	2,560.08
Average	9,096.95	5,416.99	1,119.78	2,560.18

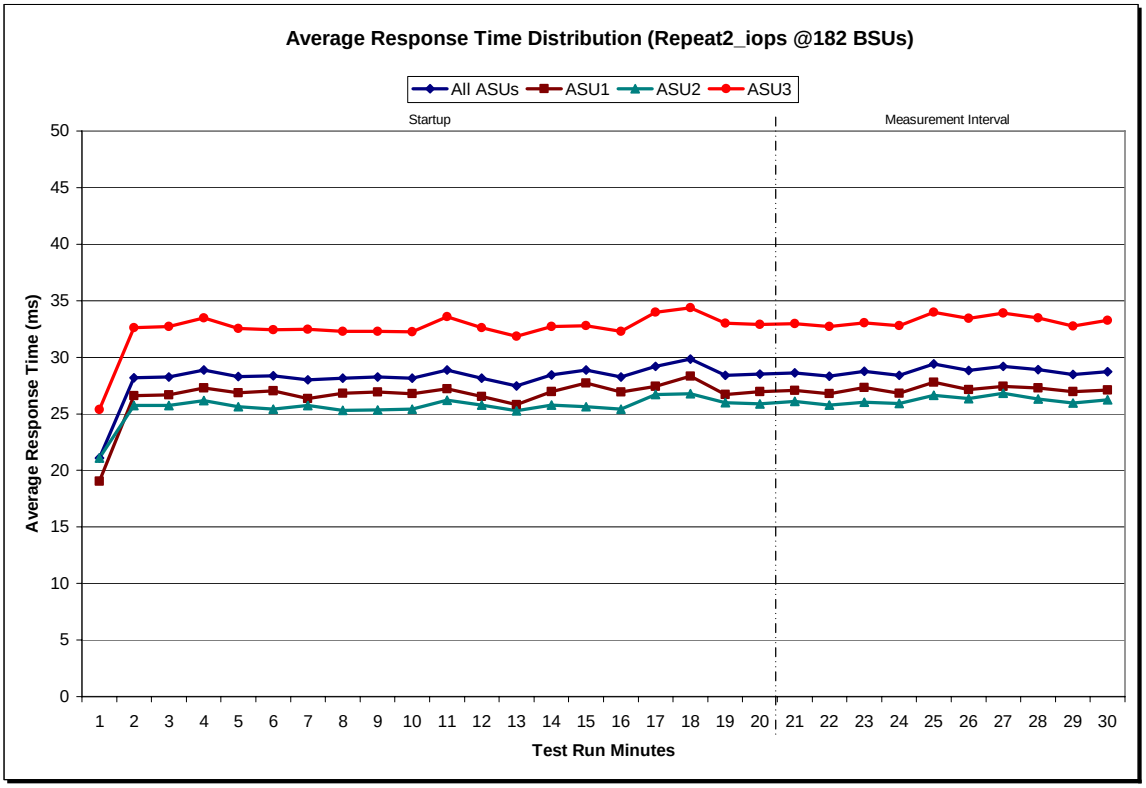
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

182 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:04:40	17:24:41	0-19	0:20:01
Measurement Interval	17:24:41	17:34:41	20-29	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	21.08	19.05	21.09	25.39
1	28.18	26.60	25.73	32.62
2	28.26	26.66	25.73	32.72
3	28.88	27.27	26.18	33.48
4	28.30	26.87	25.63	32.53
5	28.36	27.04	25.40	32.44
6	27.99	26.34	25.74	32.46
7	28.16	26.82	25.31	32.28
8	28.25	26.94	25.35	32.30
9	28.16	26.79	25.42	32.26
10	28.88	27.22	26.21	33.57
11	28.13	26.52	25.78	32.60
12	27.45	25.83	25.27	31.84
13	28.43	26.98	25.79	32.72
14	28.88	27.72	25.62	32.78
15	28.25	26.94	25.42	32.28
16	29.18	27.42	26.70	33.98
17	29.84	28.34	26.78	34.36
18	28.40	26.72	26.00	33.00
19	28.51	26.98	25.89	32.91
20	28.62	27.08	26.09	32.99
21	28.33	26.77	25.78	32.73
22	28.77	27.31	26.03	33.06
23	28.39	26.81	25.93	32.81
24	29.39	27.81	26.64	33.97
25	28.83	27.16	26.34	33.44
26	29.18	27.44	26.81	33.90
27	28.92	27.30	26.32	33.47
28	28.47	26.96	25.94	32.77
29	28.73	27.12	26.24	33.24
Average	28.76	27.18	26.21	33.24

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



Repeatability 1 (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	.0349	.2806	.0697	.2102	.0182	.0698	.0349	.2819
COV	.0278	.0058	.0127	.0072	.0251	.0170	.0320	.0063

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.*

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%.*

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

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	.0351	.2812	.0701	.2100	.0180	.0699	.0349	.2808
COV	.0061	.0019	.0048	.0028	.0113	.0044	.0074	.0015

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	.0350	.2813	.0695	.2099	.0177	.0698	.0349	.2817
COV	.0246	.0065	.0198	.0056	.0294	.0179	.0200	.0061

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	.0350	.2808	.0699	.2097	.0180	.0700	.0350	.2814
COV	.0078	.0015	.0067	.0016	.0153	.0059	.0094	.0015

Data Persistence Test

Clause 6

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

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

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

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

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

Clause 9.2.4.8

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Data Persistence Test are listed below.

java -Xmx256m -Xms256m persist1 -b 182
java -Xmx256m -Xms256m persist2

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	21,615,456
Total Number of Logical Blocks Verified	18,041,472
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.

TESTED STORAGE CONFIGURATION (TSC) AVAILABILITY DATE

Clause 9.2.4.9

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

The IBM TotalStorage® DS4300 with Turbo Option *(mirrored write cache).*, as documented in this Full Disclosure Report will become available for customer purchase and shipment on September 12, 2003.

PRICING INFORMATION

Clause 9.2.4.11

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

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

ANOMALIES OR IRREGULARITIES

Clause 9.2.4.10

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

There were no anomalies or irregularities observed during the course of the benchmark measurement of the IBM TotalStorage® DS4300 with Turbo Option *(mirrored write cache).*

APPENDIX A: TSC CONFIGURATION SCRIPT

```
/* SPC-1 configuration script    */
/* for the 2882 with 50 drives.  */

set controller[a] mode = active;
set controller[b] mode = active;

create volume drives[ 0,1  0,2  0,3  0,4  0,5  0,6  0,7  0,8  0,9  0,10 0,11 0,12 0,13 0,14
                      1,1  1,2  1,3  1,4  1,5  1,6  1,7  1,8  1,9  1,10 1,11 1,12 1,13 1,14 ]
RAIDLevel=1
segmentSize=128
userLabel="LUN 0"
capacity=215296770048
owner = A;

create volume drives[ 2,1  2,2  2,3  2,4  2,5  2,6  2,7  2,8  2,9  2,10 2,11 2,12 ]
RAIDLevel=1
segmentSize=512
userLabel="LUN 1"
capacity=215296770048
owner = b;

create volume drives[ 2,13  2,14  3,1  3,2  3,3  3,4   3,5  3,6  3,7  3,8 ]
RAIDLevel=1
segmentSize=64
userLabel="LUN 2"
capacity=47843726848
owner = b;

set volume["LUN 0"] mirrorEnabled = True writeCacheEnabled = True cacheWithoutBatteryEnabled = False readAheadMultiplier = 0;
set volume["LUN 1"] mirrorEnabled = True writeCacheEnabled = True cacheWithoutBatteryEnabled = False readAheadMultiplier = 0;
set volume["LUN 2"] mirrorEnabled = True writeCacheEnabled = True cacheWithoutBatteryEnabled = False readAheadMultiplier = 0;

set storageArray cacheFlushStop  = 70 cacheFlushStart = 70;


set storageArray defaultHostType = "Windows 2000/Server 2003 Non-Clustered";

set controller[a] HostNVSRAMByte[0x01, 0x17]=0x01;
set controller[b] HostNVSRAMByte[0x01, 0x17]=0x01;

/* Setup for RDAC failover environment */

set controller[a] HostNVSRAMByte[0x00, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x01, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x02, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x03, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x04, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x05, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x06, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x07, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x08, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x09, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0a, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0b, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0c, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0d, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0e, 0x24]=0x00;
set controller[a] HostNVSRAMByte[0x0f, 0x24]=0x00;
```

```
set controller[b] HostNVSRAMByte[0x00, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x01, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x02, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x03, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x04, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x05, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x06, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x07, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x08, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x09, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0a, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0b, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0c, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0d, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0e, 0x24]=0x00;
set controller[b] HostNVSRAMByte[0x0f, 0x24]=0x00;
```