SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

IBM CORPORATION
IBM POWER™ 595 WITH POWERVM™ *(SSDs)*

SPC-1 V1.11

Submitted for Review: October 7, 2009
Submission Identifier: A00083

First Edition – October 2009

Trademarks

Table of Contents

AUDIT CERTIFICATION

Bruce McNutt
IBM Corporation
650 Harry Road
San Jose, CA 95120

October5, 2009

The SPC Benchmark 1™ results listed below for the IBM Power™ 595 with PowerVM *(SSDs)* were produced in compliance with the SPC Benchmark 1™ 1.11 Onsite Audit requirements.

SPC Benchmark 1™ 1.11 Results	
Tested Storage Configuration (TSC) Name: IBM Power™ 595 with PowerVM *(SSDs)*	
Metric	**Reported Result**
SPC-1 IOPS™	300,993.85
SPC-1 Price-Performance	$10.77/SPC-1 IOPS™
Total ASU Capacity	2,874.944 GB
Data Protection Level	Protected *(Mirroring)*
Total TSC Price (including three-year maintenance)	$3,243,117

The following SPC Benchmark 1™ Onsite Audit requirements were reviewed and found compliant with 1.11 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items, based on information supplied by 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, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.

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

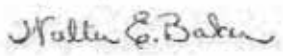
AUDIT CERTIFICATION *(CONT.)*

- The following Host System requirements, based on information supplied by IBM Corporation:
  - ✓ The type of Host System including the number of processors and main memory.
  - ✓ The presence and version number of the SPC-1 Workload Generator on each Host System.
  - ✓ The TSC boundary within each Host System.
- The Test Results Files and resultant Summary Results Files received from IBM Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- The differences between the Tested Storage Configuration (TSC) used for the benchmark and Priced Storage Configuration were documented and, if applied to the Priced Storage Configuration, would not have an impact on the reported SPC-1 performance.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

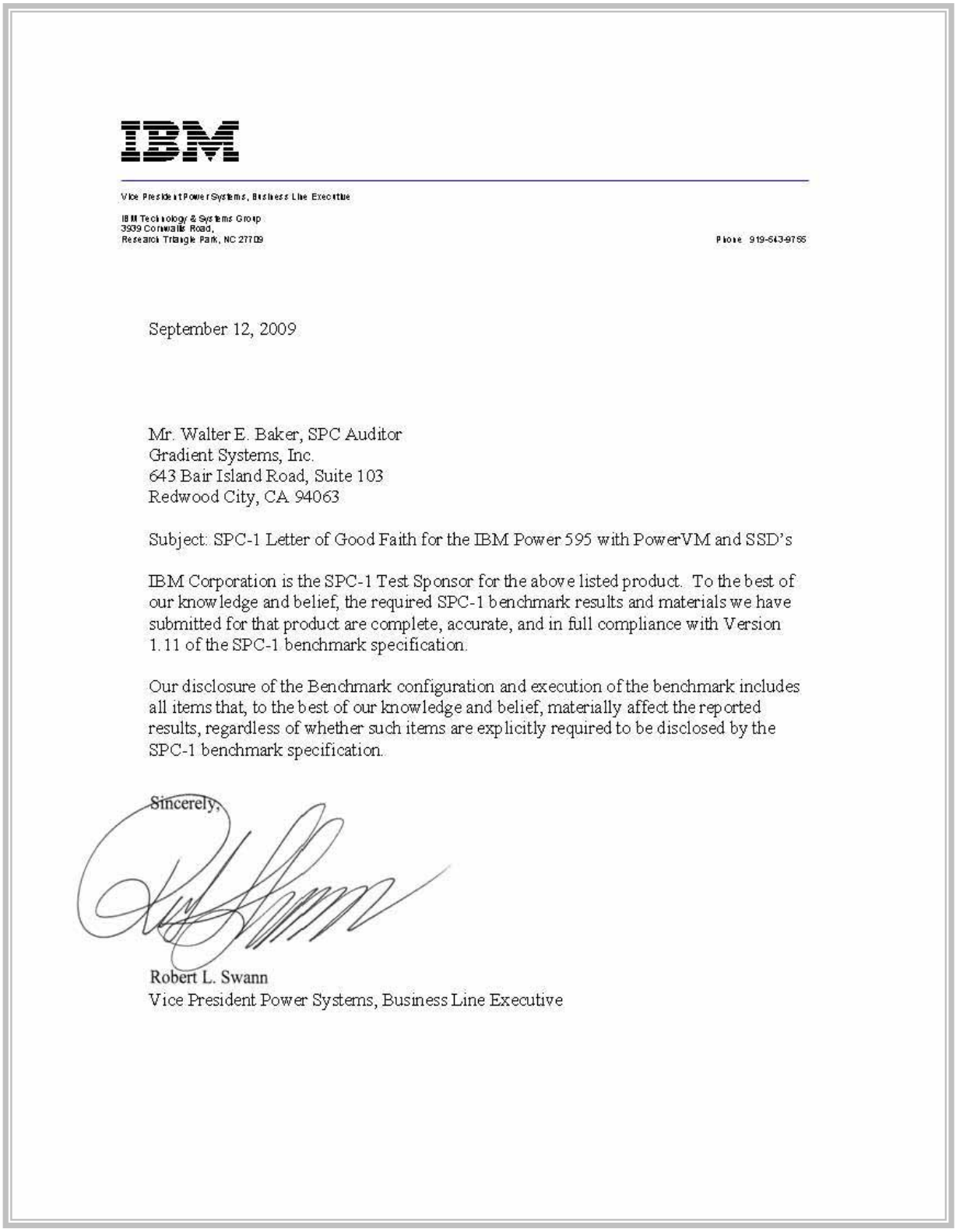
Respectfully,



Walter E. Baker
SPC Auditor

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

LETTER OF GOOD FAITH



IBM

Vice President Power Systems, Business Line Executive

IBM Technology & Systems Group
3939 Cornwallis Road,
Research Triangle Park, NC 27709

Phone: 919-543-9755

September 12, 2009

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

Subject: SPC-1 Letter of Good Faith for the IBM Power 595 with PowerVM and SSD's

IBM 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 Version 1.11 of the SPC-1 benchmark specification.

Our disclosure of the Benchmark configuration and execution of the benchmark includes all items that, to the best of our knowledge and belief, materially affect the reported results, regardless of whether such items are explicitly required to be disclosed by the SPC-1 benchmark specification.

Sincerely,

Robert L. Swann
Vice President Power Systems, Business Line Executive

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	IBM Corporation – http://www.ibm.com Bruce McNutt – bmcnutt@us.ibm.com 650 Harry Road San Jose, CA 95120 Phone: (408) 927-2717
Test Sponsor Alternate Contact	IBM Corporation – http://www.ibm.com David Whitworth – davidw@us.ibm.com 11501 Burnet Rd. Austin, TX 78758 Phone: (512) 286-9218
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	V1.11
SPC-1 Workload Generator revision number	V2.1.0
Date Results were first used publicly	October 7, 2009
Date the FDR was submitted to the SPC	October 7, 2009
Date the priced storage configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	October 5, 2009

Tested Storage Product (TSP) Description

This submission features the IBM Power 595 host processor as a virtualization platform, which is included in the Priced Storage Configuration. The Power 595, as configured for this submission, includes the IBM PowerVM Enterprise Edition with Power Hypervisor, which allows multiple AIX Logical Partitions *(LPARs)* to run with high levels of I/O and processor performance. Each LPAR functions as an independent logical host system. I/O virtualization is provided with the Virtual I/O Server (VIOS), a feature of IBM PowerVM.

The Power 595 processing platform capability for I/O virtualization, with high levels of I/O performance, has the ability to support a wide variety of storage technologies. The present submission showcases the performance potential of this platform with the use of the EXP12S enclosure as a base for housing a total of 84 solid state drives.

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: IBM Power™ 595 with PowerVM™ *(SSDs)*	
Metric	**Reported Result**
SPC-1 IOPS™	300,993.85
SPC-1 Price-Performance	$10.77/SPC-1 IOPS™
Total ASU Capacity	2,874.944 GB
Data Protection Level	Protected *(Mirroring)*
Total TSC Price (including three-year maintenance)	$3,243,117

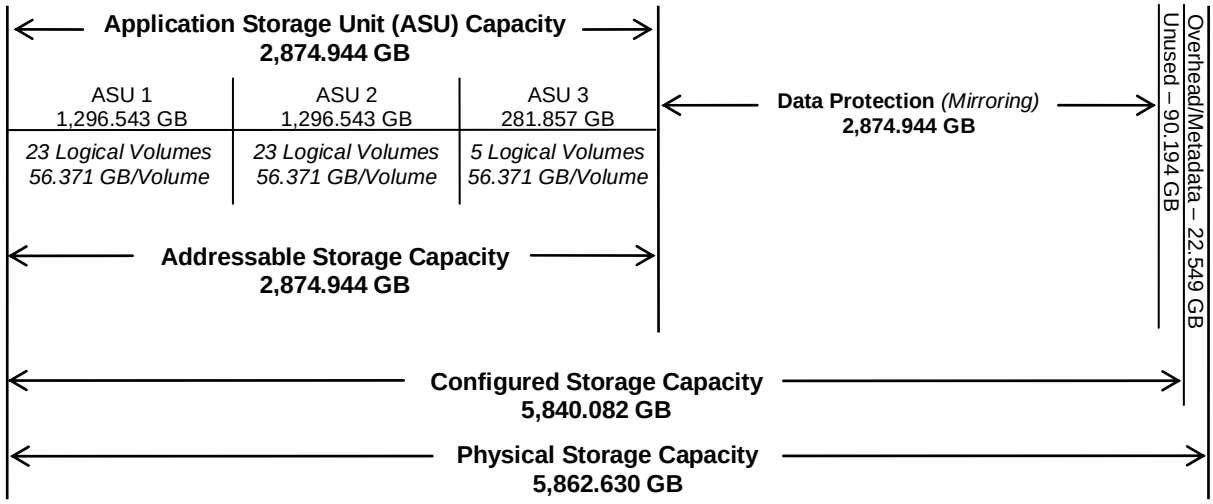
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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

A **Data Protection Level** of **Protected** using ***Mirroring*** configures two or more identical copies of user data. The data protection consisted of a logical volume group with two copy pools, managed by the AIX Logical Volume Manager (LVM).

Storage Capacities, Relationships, and Utilization

The following diagram and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.



SPC-1 Storage Capacity Utilization	
Application Utilization	49.04%
Protected Application Utilization	98.08%
Unused Storage Ratio	1.54%

Application Utilization: Total ASU Capacity *(2,874.944 GB)* divided by Physical Storage Capacity *(5,862.630 GB)*

Protected Application Utilization: (Total ASU Capacity *(2,874.944 GB)* plus total Data Protection Capacity *(2,874.944 GB)* minus unused Data Protection Capacity *(0.000 GB)*) divided by Physical Storage Capacity *(5,862.630 GB)*

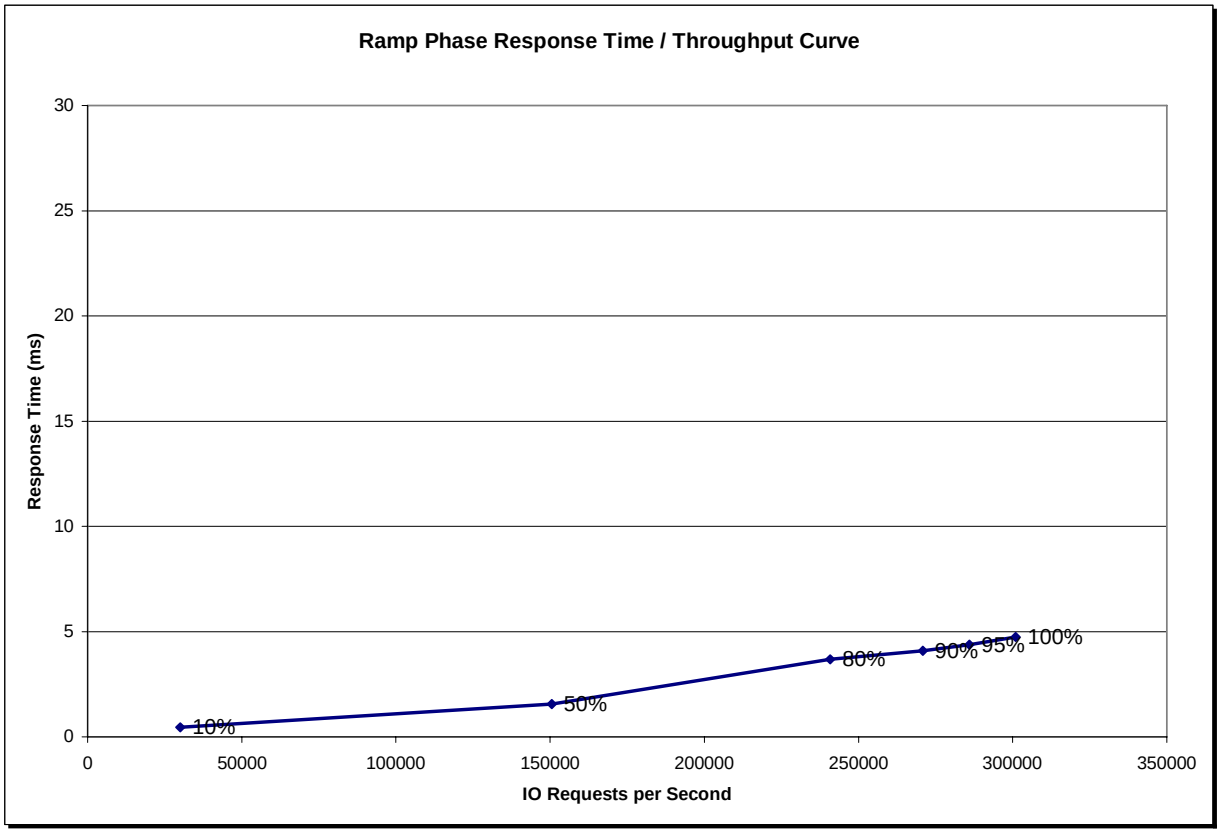
Unused Storage Ratio: Total Unused Capacity *(90.194 GB)* divided by Physical Storage Capacity *(5,862.630 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 19-20 in the Full Disclosure Report.

Response Time – Throughput Curve

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

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



Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	30,097.66	150,494.88	240,804.68	270,883.02	285,989.55	300,993.85
Average Response Time (ms):						
All ASUs	0.46	1.55	3.68	4.08	4.37	4.75
ASU-1	0.53	1.82	4.05	4.53	4.85	5.25
ASU-2	0.54	1.85	4.06	4.51	4.81	5.17
ASU-3	0.26	0.85	2.71	2.94	3.17	3.51
Reads	0.80	2.67	5.20	5.87	6.27	6.73
Writes	0.23	0.82	2.69	2.92	3.14	3.47

Priced Storage Configuration Pricing

Product	Description	Qty	Unit Price	Ext Price	Unit Maint per month	Unit Maint OTC	Maint Price
	Server						
9119-595	Power 595 host processor	1	91,000	91,000	2625		63,000
0553	19 inch, 2.0 meter high rack	1	4,745	4,745			
1816	GX Bus I/O Hub, 2-Port, IBT-copper, (Ranger-C) (InfiniBand)	4	4,000	16,000			
1831	2.5M Enhanced 12X Cable (to connect to a gx card in node)	8	650	5,200			
1834	8.0 Meter 12X Cable	4	960	3,840			
3279	146.8 GB 15K RPM Ultra320 Disk Drive	16	1,299	20,784			
4705	0/8 - core, 64GB-enabled POWER6 5.0GHz CoD, 0-core Active	6	67,700	406,200	520		74,880
4755	Single Processor Activation for FC 4695 (5.0 GHz)	48	30,300	1,454,400	280		322,560
5681	256GB Bundle DDR2 Activations	1	387,840	387,840			
5701	IBM 2-Port 10/100/1000 Base-TX Ethernet PCI-X Adapter	5	699	3,495			
5720	DVD/Tape SAS External Storage Unit	1	3,599	3,599			
5756	IDE Slimeline DVD-ROM Drive	1	275	275			
5797	12x I/O Drawer PCI-X, with repeater	2	32,000	64,000	170		8,160
5912	PCI-X DDR Dual - x4 SAS Adapter	1	1,092	1,092			
5951	Quiet Touch Keyboard - USB, Business Black,	1	104	104			
6333	Bulk Power Regulator	6	4,200	25,200			
6334	Bulk Power Distribution Assembly	2	2,500	5,000			
6654	14-Ft 1PH/24-30A Pwr Cord	3	240	720			
6865	Acoustic Doors (F&F), H CEC Rack	1	12,000	12,000			
6869	Acoustic Doors (F&F), H I/O Expansion Rack	1	14,500	14,500			
6941	UPIC Cable Group, BPD1 to I/O Drawer at A01	2	500	1,000			
6942	UPIC Cable Group, BPD1 to I/O Drawer at A05	1	500	500			
6943	UPIC Cable Group, BPD1 to I/O Drawer at A09	1	500	500			
6952	UPIC Y-Cable Group (BPC to Fans)	1	5,000	5,000			
6961	UPIC Y-Cable Group BPD1 to Processor Nodes	4	650	2,600			
7188	Power Distribution Unit	3	3,000	9,000			
7802	Ethernet Cable, 15M, Hardware Management	2	34	68			
8201	0/256GB 667MHz DDR2 Memory Package (32x#5694)	1	97,120	97,120			
8696	Line Cord, 6AWG/Type W, 14ft, IEC309 60A Plug	4	2,500	10,000			
8841	Mouse - Business Black with Keyboard Attachment	1	78	78			
7042-C06	HMC 1:7042-C06 Desktop Hardw.Mgmt.Console	1	1,830	1,830	48	192	1,344
5692-A6P	AIX V6 (media only)	1	50	50			
5765-G62	AIX Software per Processor	48	2,495	119,760			
5765-AME	AIX IBM Management Edition for AIX	48	490	23,520			
5764-PVE	PowerVM Enterprise Edition	48	1,999	95,952			
5773-SM3-474	AIX Software Maintenance (3Y)	48	2,836	136,128			
5773-SM3-476	AIX Software Maintenance 24x7 Upgrade (3Y)	48	732	35,136			
5773-PVE-1007	PowerVM Enterprise Edition SW Maintenance (3Y)	48	594	28,512			
5773-AME-989	AIX IBM Mgmt Edition of AIX Software Maintenance (3Y)	48	196	9,408			
5773-0570	HMC Software SUB (3Y)	1	236	236			
5773-0569	HMC Software Support (3Y)	1	675	675			
				3,097,067			**469,944**
	Storage						
3586	69GB 3.5 SAS Solid State Drive	84	13,235	1,111,740			
3692	SAS Cable (YO) Adapter to SAS Enclosure	14	146	2,044			
5886	EXP12S Expansion Drawer	14	5,956	83,384	200		67,200
5904	PCI-X DDR 1.5GB cache SAS RAID Adapter (BSC)	14	11,250	157,500			
6671	Power Cord (9-foot), Drawer to IBM PDU, 250V/10A	28	19	532			
				1,355,200			**67,200**
	Subtotal			**4,452,267**			**537,144**
	Discount (Server 35%)			(1,083,973)			(164,480)
	Discount (Storage 35%)			(474,320)			(23,520)
				2,893,974			349,144
	Total						**3,243,117**

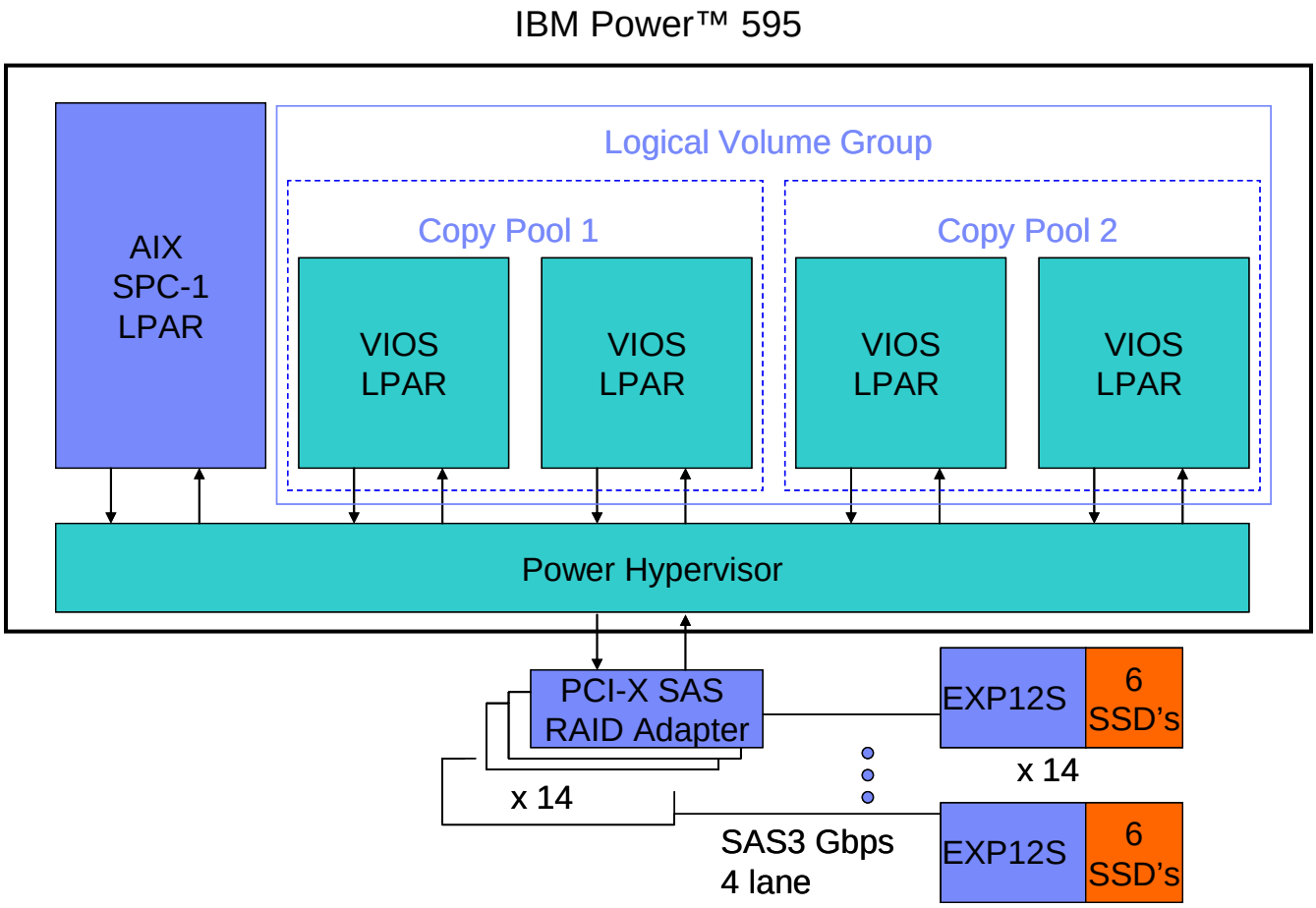
Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration

The IBM Power™ 595 in the TSC contained 64 Power6 cores on 32 chips. The TSC only utilized 48 of the cores on 24 chips as illustrated below and listed on page 16. The remaining 16 cores on 8 chips were unused during the benchmark measurements and not included in the Priced Storage Configuration.

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

The IBM Power™ 595 in the BC/ TSC contained 64 Power6 cores on 32 chips. The TSC only utilized 48 of the cores on 24 chips. The remaining 16 cores on 8 chips were unused during the benchmark measurements and not included in the Priced Storage Configuration.

Both the BC/TSC and the Priced Storage Configuration included 16 Ultra320 system disk drives that were not part of the SPC-1 data repository.



Benchmark Configuration/Tested Storage Configuration Priced Storage Configuration Components

Tested Storage Configuration (TSC) / Priced Storage Configuration:
IBM Power™ 595: 48 – 5.0 GHz Power6 cores on 24 chips (2 cores per chip) 4 MB L2 cache per core 32 MB L3 cache per chip LPAR 1 – Host System *(WG)*: 32 cores LPAR 2 – Virtual I/O Server 1: 4 cores LPAR 3 – Virtual I/O Server 2: 4 cores LPAR 4 – Virtual I/O Server 3: 6 cores LPAR 5 – Virtual I/O Server 4: 2 cores *(The BC/TSC contained 16 additional Power6 cores that were unused in the benchmark measurements and not included in the Priced Storage Configuration)*
256 GB main memory: LPAR 1 – Host System *(WG)*: 200 GB LPAR 2 – Virtual I/O Server 1: 8 GB LPAR 3 – Virtual I/O Server 2: 8 GB LPAR 4 – Virtual I/O Server 3: 8 GB LPAR 5 – Virtual I/O Server 4: 8 GB
14 – PCI-X DDR 1.5 GB cache SAS RAID Adapters
14 – EXP12S expansion drawers
84 – 69.793 GB 3.5” SAS Solid State Devices *(SSDs)* *6 SSDs per EXP12S*
AIX 6.1
IBM PowerVM, Enterprise Edition including Virtual I/O Server *(VIOS)*
AIX Logical Volume Manager (LVM)
PCI-X

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 15 *(Benchmark Configuration/Tested Storage Configuration/Priced 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 TSC did not utilize network storage.

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

Clause 9.4.3.4.3

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

The Host System and TSC table of components may be found on page 16 *(Benchmark Configuration/Tested Storage Configuration / Priced Storage Configuration Components).*

Customer Tunable Parameters and Options

Clause 9.4.3.5.1

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

option. If the parameter name is not self-explanatory to a knowledgeable practitioner, a brief description of the parameter's use must also be included in the FDR entry.

"Appendix B: Customer Tunable Parameters and Options" on page 62 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

Tested Storage Configuration (TSC) Description

Clause 9.4.3.5.2

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

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

"Appendix C: Tested Storage Configuration (TSC) Creation" on page 63 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 66.

SPC-1 DATA REPOSITORY

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

Storage Capacities and Relationships

Clause 9.4.3.6.1

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

SPC-1 Storage Capacities

SPC-1 Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	2,874.944
Addressable Storage Capacity	Gigabytes (GB)	2,874.944
Configured Storage Capacity	Gigabytes (GB)	5,840.082
Physical Storage Capacity	Gigabytes (GB)	5,862.630
Data Protection *(Mirroring)*	Gigabytes (GB)	2,874.944
Required Storage *(overhead/metadata)*	Gigabytes (GB)	22.549
Global Storage Overhead	Gigabytes (GB)	0.000
Total Unused Storage	Gigabytes (GB)	90.194

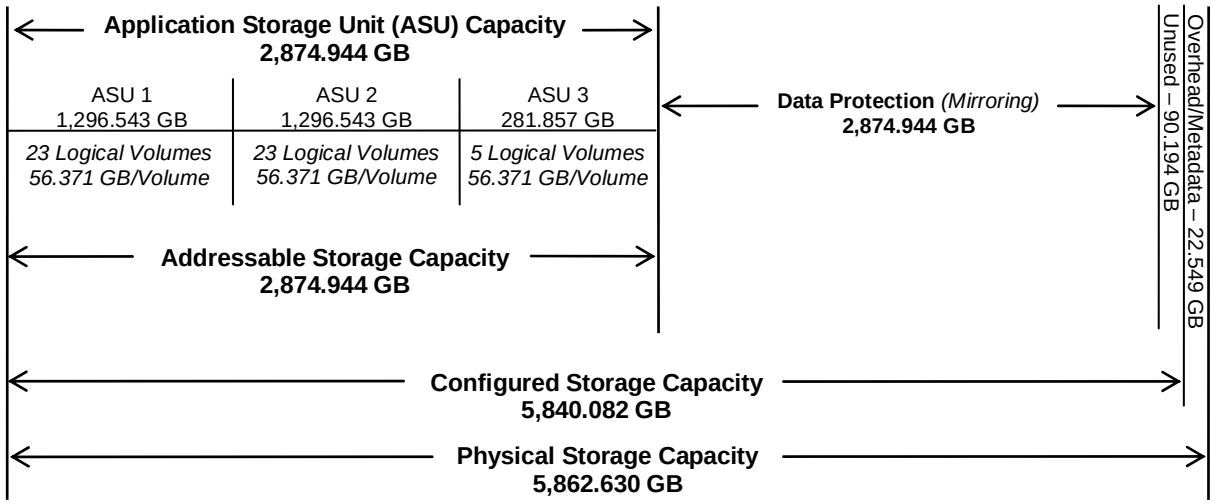
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	**Configured Storage Capacity**	**Physical Storage Capacity**
Total ASU Capacity	100.00%	49.23%	49.04%
Required for Data Protection *(Mirrored)*		49.23%	49.04%
Addressable Storage Capacity		49.23%	49.04%
Required Storage *(overhead/metadata)*		0.39%	0.38%
Configured Storage Capacity			99.62%
Global Storage Overhead			0.00%
Unused Storage:			
Addressable	0.00%		
Configured		1.54%	
Physical			0.00%

The Physical Storage Capacity consisted of 5,862.630 GB distributed over 84 Solid State Devices *(SSDs)* each with a formatted capacity of 69.793 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0.000 GB (0.00%) of Physical Storage Capacity. There was 90.194 GB (1.54%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.000 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(mirroring)* capacity was 2,874.944 GB of which 2,874.944 GB was utilized. The total Unused Storage was 90.194 GB.

SPC-1 Storage Capacities and Relationships Illustration

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



Logical Volume Capacity and ASU Mapping

Clause 9.4.3.6.3

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

Logical Volume Capacity and Mapping		
ASU-1 (1,296.543 GB)	**ASU-2 (1,296.543 GB)**	**ASU-3 (281.857 GB)**
23 Logical Volumes 56.371 GB per Logical Volume (56.371 GB used per Logical Volume)	23 Logical Volumes 56.371 GB per Logical Volume (56.371 GB used per Logical Volume)	5 Logical Volumes 56.371 GB per Logical Volume (56.371 GB used per Logical Volume)

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

Storage Capacity Utilization

Clause 9.4.3.6.2

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

Clause 2,8.1

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

Clause 2,8.2

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

Clause 2,8.3

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

SPC-1 Storage Capacity Utilization	
Application Utilization	49.04%
Protected Application Utilization	98.08%
Unused Storage Ratio	1.54%

SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. "SPC-1 Test Execution Definitions" on page 59 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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

SPC-1 Tests, Test Phases, and Test Runs

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

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

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

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

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

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

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.4.3.7.1

For the Sustainability Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 67.

Sustainability Test Results File

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

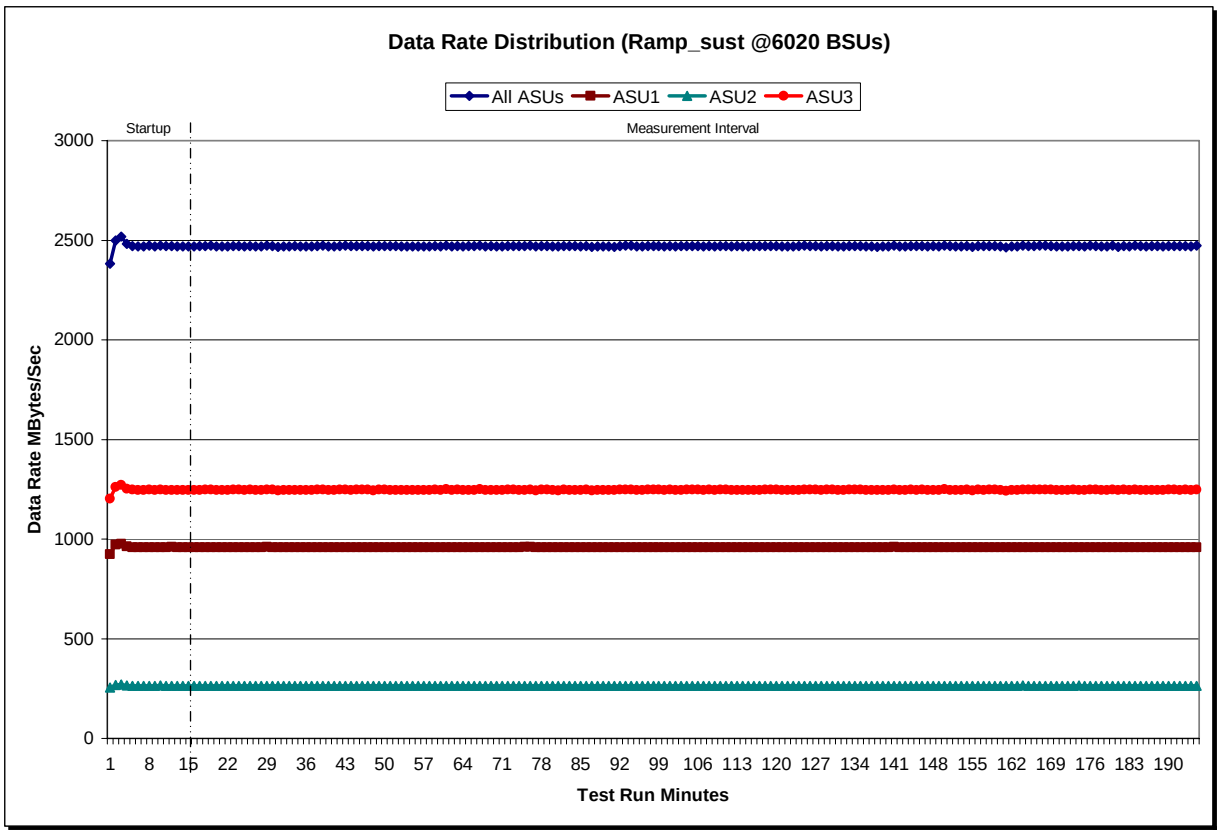
Sustainability Test Results File

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

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	20:04:19	20:19:19	0-14	0:15:00
Measurement Interval	20:19:19	23:19:21	15-194	3:00:02

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	2,382.48	924.85	254.78	1,202.85	65	2,469.84	959.27	263.53	1,247.04	130	2,469.58	959.45	264.47	1,245.66
1	2,499.87	971.58	267.10	1,261.19	66	2,473.24	959.81	263.91	1,249.52	131	2,469.64	958.92	263.66	1,247.06
2	2,518.30	977.22	269.03	1,272.05	67	2,468.89	958.67	263.93	1,246.29	132	2,470.22	959.12	263.62	1,247.48
3	2,481.78	963.87	264.80	1,253.11	68	2,469.98	959.31	263.96	1,246.71	133	2,471.49	959.73	263.79	1,247.96
4	2,471.14	959.57	263.10	1,248.47	69	2,468.32	958.72	263.61	1,245.98	134	2,470.97	959.12	263.99	1,247.86
5	2,468.45	959.42	263.66	1,245.37	70	2,469.23	958.50	263.62	1,247.10	135	2,469.53	958.79	264.03	1,246.71
6	2,467.88	958.10	263.37	1,246.41	71	2,471.74	959.04	263.73	1,248.97	136	2,469.46	958.81	263.89	1,246.75
7	2,472.46	959.93	263.96	1,248.57	72	2,471.79	959.88	264.42	1,247.50	137	2,467.23	958.82	263.15	1,245.26
8	2,469.10	959.67	263.89	1,245.54	73	2,470.35	958.88	264.41	1,247.06	138	2,469.65	959.19	263.67	1,246.79
9	2,472.92	958.84	264.71	1,249.37	74	2,470.98	960.10	263.80	1,247.08	139	2,469.02	959.35	263.90	1,245.76
10	2,470.14	959.29	263.56	1,247.29	75	2,473.30	960.38	263.99	1,248.93	140	2,473.36	960.30	264.01	1,249.05
11	2,470.36	960.07	263.78	1,246.51	76	2,468.48	959.77	263.75	1,244.96	141	2,468.99	958.90	263.36	1,246.73
12	2,467.94	958.97	263.43	1,245.53	77	2,471.17	958.75	264.03	1,248.39	142	2,468.63	959.51	263.69	1,245.44
13	2,467.93	958.98	263.17	1,245.79	78	2,470.91	959.74	263.70	1,247.47	143	2,470.79	959.50	263.73	1,247.55
14	2,468.63	958.07	264.08	1,246.48	79	2,468.05	958.63	263.26	1,246.16	144	2,470.58	959.09	264.26	1,247.24
15	2,469.23	959.13	263.86	1,246.25	80	2,467.68	959.21	263.88	1,244.59	145	2,470.11	958.97	263.78	1,247.36
16	2,470.01	959.61	263.83	1,246.57	81	2,471.46	959.54	263.56	1,248.36	146	2,469.27	959.02	263.61	1,246.65
17	2,470.99	959.40	264.13	1,247.45	82	2,470.57	959.66	263.88	1,247.03	147	2,470.17	959.16	263.77	1,247.24
18	2,472.14	959.84	264.46	1,247.84	83	2,470.19	959.89	263.32	1,246.98	148	2,469.38	959.18	263.54	1,246.66
19	2,468.77	958.05	263.66	1,247.05	84	2,468.00	958.62	263.79	1,245.59	149	2,472.21	959.26	263.25	1,249.71
20	2,468.79	958.63	263.52	1,246.65	85	2,471.20	959.15	264.25	1,247.79	150	2,469.87	959.72	263.80	1,246.36
21	2,468.45	959.18	263.78	1,245.49	86	2,466.94	959.05	263.71	1,244.19	151	2,469.68	959.43	263.79	1,246.46
22	2,471.17	959.93	263.76	1,247.48	87	2,468.67	958.82	263.46	1,246.39	152	2,468.67	958.50	263.88	1,246.29
23	2,470.18	958.86	263.86	1,247.46	88	2,468.36	958.44	263.13	1,246.78	153	2,470.44	959.07	263.36	1,248.01
24	2,468.93	958.81	263.82	1,246.30	89	2,469.73	958.88	263.61	1,247.23	154	2,467.30	958.93	263.41	1,244.96
25	2,469.93	958.57	263.90	1,247.46	90	2,467.51	958.47	263.13	1,245.92	155	2,470.99	959.25	264.02	1,247.72
26	2,467.61	958.52	263.69	1,245.40	91	2,470.69	959.81	263.30	1,247.58	156	2,470.12	959.46	263.54	1,247.11
27	2,469.24	958.83	263.68	1,246.73	92	2,472.49	959.96	263.55	1,248.98	157	2,470.61	959.30	263.64	1,247.68
28	2,472.45	960.18	264.13	1,248.14	93	2,472.49	959.26	264.55	1,248.69	158	2,470.04	958.97	263.59	1,247.48
29	2,471.37	959.51	264.23	1,247.62	94	2,468.53	958.62	263.83	1,246.07	159	2,468.54	958.78	263.78	1,245.99
30	2,467.27	958.72	263.41	1,245.14	95	2,467.71	958.77	263.78	1,245.17	160	2,464.54	958.95	263.36	1,242.23
31	2,468.00	958.66	263.79	1,245.55	96	2,470.71	959.34	264.00	1,247.37	161	2,468.49	959.17	263.77	1,245.54
32	2,469.42	958.59	263.75	1,247.08	97	2,469.99	958.45	264.23	1,247.31	162	2,468.47	959.27	263.36	1,245.84
33	2,471.20	960.00	263.99	1,247.21	98	2,471.72	959.93	263.45	1,248.34	163	2,473.94	959.96	264.59	1,249.39
34	2,469.09	958.64	264.52	1,245.92	99	2,469.35	958.88	264.26	1,246.21	164	2,471.02	959.18	263.65	1,248.20
35	2,469.31	958.72	263.95	1,246.63	100	2,471.47	959.43	264.07	1,247.97	165	2,471.52	959.15	264.02	1,248.35
36	2,467.79	958.45	264.04	1,245.30	101	2,469.08	959.46	263.60	1,246.03	166	2,472.33	959.86	264.38	1,248.09
37	2,470.23	958.56	264.33	1,247.34	102	2,470.15	958.99	263.95	1,247.21	167	2,472.25	959.84	264.23	1,248.18
38	2,473.09	959.82	264.45	1,248.81	103	2,470.95	958.62	264.01	1,248.33	168	2,471.31	959.38	264.29	1,247.64
39	2,468.83	959.64	263.27	1,245.92	104	2,471.27	958.85	264.07	1,248.35	169	2,469.07	959.61	264.28	1,245.18
40	2,469.37	958.87	263.70	1,246.80	105	2,471.29	959.93	263.97	1,247.39	170	2,468.54	958.89	263.75	1,245.90
41	2,470.32	958.40	264.01	1,247.92	106	2,467.94	958.19	263.78	1,245.97	171	2,469.22	959.14	263.53	1,246.56
42	2,472.89	959.84	263.69	1,249.36	107	2,470.46	959.15	263.67	1,247.65	172	2,470.71	959.31	263.40	1,248.00
43	2,470.69	959.87	264.25	1,246.58	108	2,469.19	959.14	263.06	1,246.99	173	2,470.48	959.06	264.59	1,246.83
44	2,470.88	959.23	263.81	1,247.84	109	2,471.14	959.40	264.07	1,247.68	174	2,469.60	959.24	263.69	1,246.67
45	2,470.82	958.99	263.49	1,248.34	110	2,471.87	959.44	263.85	1,248.57	175	2,473.42	959.95	264.43	1,249.04
46	2,471.68	959.00	264.42	1,248.25	111	2,468.59	958.60	264.20	1,245.79	176	2,471.45	959.83	263.99	1,247.63
47	2,468.11	959.50	264.38	1,244.23	112	2,470.75	959.61	264.17	1,246.97	177	2,469.01	959.07	263.63	1,246.31
48	2,469.81	959.01	263.30	1,247.51	113	2,468.68	959.44	263.57	1,245.67	178	2,468.39	958.97	263.29	1,246.13
49	2,470.89	959.19	263.98	1,247.72	114	2,469.26	958.80	263.55	1,246.92	179	2,472.13	959.53	263.79	1,248.82
50	2,470.29	959.73	264.14	1,246.42	115	2,470.33	959.39	263.81	1,247.12	180	2,467.02	958.44	263.18	1,245.40
51	2,470.33	959.29	264.07	1,246.97	116	2,471.13	959.81	264.32	1,247.00	181	2,471.46	959.12	263.91	1,248.44
52	2,468.26	959.26	263.18	1,245.82	117	2,470.85	959.61	263.59	1,247.65	182	2,468.75	958.61	264.29	1,245.84
53	2,468.06	959.05	263.50	1,245.51	118	2,470.03	959.12	263.47	1,247.44	183	2,472.56	959.53	263.80	1,249.24
54	2,467.93	958.62	263.79	1,245.52	119	2,470.31	959.34	263.66	1,247.31	184	2,470.24	959.58	264.26	1,246.39
55	2,469.23	958.90	264.05	1,246.28	120	2,468.52	958.31	263.38	1,246.83	185	2,468.49	959.05	263.61	1,245.83
56	2,468.52	959.44	263.61	1,245.48	121	2,469.73	959.33	263.45	1,246.95	186	2,469.83	958.65	264.12	1,247.05
57	2,467.97	958.59	264.15	1,245.23	122	2,467.68	958.45	263.60	1,245.63	187	2,470.08	959.77	263.54	1,246.76
58	2,471.27	959.65	264.16	1,247.45	123	2,469.93	959.66	264.09	1,246.17	188	2,469.31	958.94	263.48	1,246.89
59	2,469.32	959.25	263.90	1,246.17	124	2,472.49	959.50	264.16	1,248.82	189	2,471.49	959.52	264.16	1,247.81
60	2,473.23	960.00	263.62	1,249.62	125	2,471.63	959.15	264.12	1,248.36	190	2,470.09	958.73	263.92	1,247.43
61	2,468.81	958.00	263.76	1,247.04	126	2,471.71	959.37	263.82	1,248.53	191	2,469.96	959.45	263.82	1,246.69
62	2,470.60	959.18	264.06	1,247.36	127	2,469.23	959.43	263.89	1,245.91	192	2,471.27	959.04	264.20	1,248.03
63	2,468.68	958.44	263.59	1,246.65	128	2,469.78	958.66	263.81	1,247.31	193	2,468.64	958.98	263.49	1,246.18
64	2,470.05	959.12	264.31	1,246.61	129	2,471.16	959.37	263.96	1,247.82	194	2,472.81	959.75	264.17	1,248.89

Sustainability – Data Rate Distribution Graph

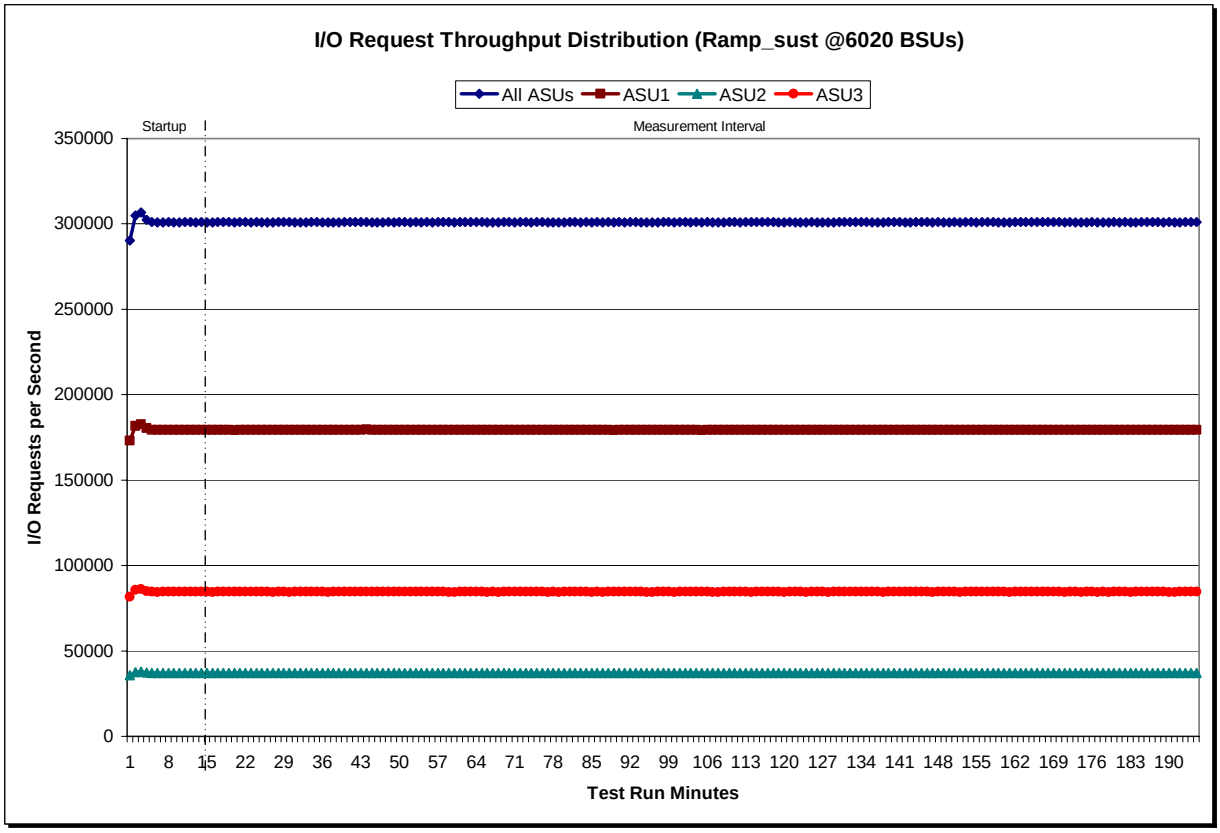


Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	20:04:19	20:19:19	0-14	0:15:00
Measurement Interval	20:19:19	23:19:21	15-194	3:00:02

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	290,346.47	173,031.48	35,716.57	81,598.42	65	300,816.98	179,324.53	37,002.98	84,489.47	130	301,098.82	179,454.22	37,085.07	84,559.53
1	304,892.63	181,706.12	37,507.65	85,678.87	66	300,989.70	179,399.58	37,024.48	84,565.63	131	301,029.42	179,371.10	37,034.17	84,624.15
2	306,677.82	182,763.43	37,683.47	86,230.92	67	300,878.07	179,341.65	37,020.50	84,515.92	132	301,066.10	179,393.52	37,044.80	84,627.78
3	302,497.22	180,297.38	37,183.72	85,016.12	68	301,087.58	179,434.38	37,040.43	84,612.77	133	301,118.35	179,465.97	37,020.12	84,632.27
4	301,003.20	179,464.55	36,973.20	84,565.45	69	300,997.42	179,420.37	37,002.27	84,574.78	134	301,136.37	179,519.02	37,006.02	84,611.33
5	300,897.62	179,415.40	36,986.63	84,495.58	70	300,933.02	179,316.70	37,036.18	84,580.13	135	300,970.63	179,408.40	37,021.37	84,540.87
6	300,950.08	179,310.32	37,022.95	84,616.82	71	301,032.12	179,375.92	37,061.90	84,594.30	136	300,886.05	179,315.50	36,999.97	84,570.58
7	301,049.10	179,435.45	37,012.43	84,601.22	72	301,005.38	179,367.40	37,070.42	84,567.57	137	300,955.15	179,444.67	37,000.03	84,510.45
8	300,957.88	179,377.62	37,025.50	84,554.77	73	300,941.72	179,301.62	37,049.02	84,591.08	138	301,049.57	179,422.73	37,003.43	84,623.40
9	300,969.68	179,312.45	37,044.97	84,612.27	74	301,032.88	179,451.03	37,021.03	84,560.82	139	301,008.25	179,424.57	37,035.95	84,547.73
10	301,034.57	179,380.20	37,002.87	84,651.50	75	301,115.70	179,486.58	37,058.12	84,571.00	140	301,058.35	179,419.17	36,990.30	84,648.88
11	301,054.35	179,499.97	37,009.30	84,545.08	76	300,953.87	179,464.90	37,005.03	84,483.93	141	300,942.98	179,363.80	37,014.87	84,564.32
12	300,916.42	179,323.53	37,012.75	84,580.13	77	300,987.17	179,378.70	36,985.28	84,623.18	142	300,967.93	179,412.33	37,000.02	84,555.58
13	300,996.77	179,368.62	37,002.45	84,625.70	78	300,918.53	179,400.30	37,001.33	84,516.90	143	301,006.13	179,434.68	36,996.30	84,575.15
14	300,829.80	179,295.40	36,978.92	84,555.48	79	300,917.33	179,388.82	36,974.90	84,553.62	144	301,037.07	179,407.27	37,052.50	84,577.30
15	300,935.20	179,405.27	37,005.18	84,524.75	80	301,049.23	179,432.52	37,066.53	84,550.18	145	301,006.00	179,363.53	37,031.43	84,611.03
16	301,038.73	179,417.78	37,028.57	84,592.38	81	301,115.32	179,496.53	37,014.33	84,604.45	146	300,899.50	179,378.17	36,986.77	84,534.57
17	301,017.02	179,401.42	37,019.60	84,596.00	82	300,957.13	179,376.68	37,031.18	84,549.27	147	301,049.25	179,443.43	37,022.43	84,583.38
18	301,192.75	179,490.78	37,061.37	84,640.60	83	301,047.33	179,461.33	37,018.37	84,567.63	148	300,946.60	179,383.40	37,006.65	84,556.55
19	300,814.65	179,242.48	36,981.03	84,591.13	84	300,912.58	179,410.33	36,986.05	84,516.20	149	300,971.83	179,371.50	36,969.83	84,630.50
20	301,098.30	179,442.27	37,036.57	84,619.47	85	301,038.30	179,443.90	37,043.90	84,550.50	150	301,051.05	179,411.47	37,053.32	84,586.27
21	301,022.60	179,441.38	37,030.40	84,550.82	86	300,948.47	179,420.40	37,063.92	84,464.15	151	300,971.97	179,455.23	36,989.57	84,527.17
22	300,987.65	179,406.47	37,015.32	84,565.87	87	300,994.43	179,404.83	36,991.95	84,597.65	152	301,133.53	179,449.82	37,041.80	84,641.92
23	301,089.38	179,487.40	37,003.43	84,598.55	88	300,836.88	179,279.47	36,984.53	84,572.88	153	301,017.38	179,412.32	37,012.27	84,592.80
24	300,912.47	179,296.67	37,021.98	84,593.82	89	301,050.52	179,375.47	37,046.50	84,628.55	154	300,966.95	179,418.73	37,008.32	84,539.90
25	300,965.73	179,349.98	37,031.57	84,584.18	90	300,925.23	179,330.82	37,017.68	84,576.73	155	301,089.17	179,443.32	37,066.35	84,579.50
26	300,936.00	179,352.73	37,044.62	84,538.65	91	301,003.22	179,415.15	37,015.85	84,572.22	156	301,096.33	179,498.80	37,016.02	84,581.52
27	301,012.43	179,403.15	37,001.70	84,607.58	92	301,071.07	179,455.20	36,994.47	84,621.40	157	301,017.95	179,364.88	37,018.68	84,634.38
28	301,102.10	179,450.33	37,029.75	84,622.02	93	300,940.40	179,302.77	37,019.15	84,618.48	158	300,956.48	179,358.95	37,009.38	84,588.15
29	301,011.92	179,406.95	37,069.47	84,535.50	94	300,915.72	179,347.07	37,034.75	84,533.90	159	300,893.95	179,342.38	36,990.57	84,561.00
30	300,964.90	179,407.73	37,012.85	84,544.32	95	300,924.58	179,398.10	37,014.65	84,511.83	160	300,906.70	179,388.52	37,003.02	84,515.17
31	300,925.27	179,357.60	37,020.57	84,547.10	96	300,975.18	179,333.92	37,045.85	84,595.42	161	301,063.62	179,453.83	37,035.53	84,574.25
32	300,961.35	179,362.00	36,991.47	84,607.88	97	301,051.85	179,322.83	37,092.33	84,636.68	162	301,056.08	179,461.78	36,987.23	84,607.07
33	301,151.95	179,499.90	37,069.48	84,582.57	98	301,034.92	179,432.23	37,012.23	84,590.45	163	301,090.72	179,467.77	37,032.92	84,590.03
34	300,997.85	179,371.63	37,060.20	84,566.02	99	300,953.60	179,383.48	37,060.73	84,509.38	164	301,098.65	179,405.55	37,034.62	84,658.48
35	300,962.50	179,362.07	37,026.62	84,573.82	100	301,064.62	179,410.35	36,990.48	84,663.78	165	301,039.23	179,440.75	37,035.73	84,562.75
36	300,893.15	179,341.00	37,023.57	84,528.58	101	301,004.50	179,431.58	36,986.73	84,586.18	166	301,036.75	179,428.03	37,035.67	84,573.05
37	300,936.07	179,301.83	37,040.60	84,593.63	102	300,955.05	179,373.15	37,026.62	84,555.28	167	301,015.67	179,421.33	37,032.05	84,562.28
38	300,977.33	179,379.98	37,049.35	84,548.00	103	301,024.08	179,379.75	37,027.47	84,616.87	168	301,015.97	179,426.62	37,047.32	84,542.03
39	301,181.22	179,516.63	36,970.75	84,693.83	104	300,856.25	179,282.57	37,031.30	84,542.38	169	301,030.72	179,429.50	37,050.80	84,550.42
40	301,059.65	179,402.00	37,058.75	84,598.90	105	301,022.82	179,412.07	37,010.88	84,599.87	170	300,921.18	179,369.13	37,019.63	84,532.42
41	300,997.28	179,342.15	37,027.60	84,627.53	106	300,982.48	179,407.90	37,054.48	84,520.10	171	301,037.47	179,450.92	37,009.15	84,577.40
42	301,019.75	179,418.93	37,023.05	84,577.77	107	300,901.42	179,355.87	37,022.13	84,523.42	172	300,976.82	179,347.93	37,011.83	84,617.05
43	301,168.87	179,539.30	37,057.43	84,572.13	108	300,915.18	179,388.68	36,980.98	84,545.52	173	300,969.15	179,360.18	37,089.15	84,519.82
44	300,951.73	179,374.25	37,013.67	84,563.82	109	301,007.33	179,422.77	37,026.85	84,557.72	174	300,975.13	179,428.13	37,006.43	84,540.57
45	300,943.33	179,360.60	37,008.40	84,574.33	110	301,079.38	179,437.87	37,006.93	84,634.58	175	300,994.23	179,387.45	37,029.38	84,577.40
46	300,982.05	179,377.25	37,031.47	84,573.33	111	300,958.77	179,353.65	37,044.58	84,560.53	176	300,927.12	179,381.92	37,026.45	84,518.75
47	301,089.75	179,477.40	37,064.47	84,547.88	112	301,067.43	179,420.23	37,051.62	84,595.58	177	300,959.12	179,416.20	36,993.80	84,549.12
48	300,902.42	179,301.50	36,997.57	84,603.35	113	301,027.02	179,448.78	37,043.70	84,534.53	178	300,929.88	179,368.32	37,038.12	84,523.45
49	301,033.88	179,436.57	37,024.75	84,572.57	114	301,025.73	179,380.00	37,022.23	84,623.50	179	301,148.03	179,488.15	37,025.40	84,634.48
50	301,064.82	179,440.83	37,071.80	84,552.18	115	301,030.97	179,411.62	37,027.05	84,592.30	180	300,917.93	179,381.12	36,986.18	84,550.63
51	300,962.28	179,341.02	37,044.30	84,576.97	116	301,000.72	179,428.27	37,031.73	84,540.72	181	301,087.72	179,402.45	37,035.68	84,649.58
52	301,024.08	179,400.82	37,044.43	84,578.83	117	301,088.13	179,461.88	37,003.68	84,622.57	182	300,983.93	179,361.27	37,086.58	84,536.08
53	300,949.78	179,389.58	36,981.90	84,578.30	118	300,977.55	179,409.43	36,991.00	84,577.12	183	300,957.40	179,348.58	37,021.43	84,587.38
54	301,044.73	179,434.15	37,050.32	84,560.27	119	300,855.90	179,336.65	36,995.52	84,523.73	184	301,115.82	179,429.53	37,071.12	84,615.17
55	300,939.42	179,366.80	37,007.22	84,565.40	120	301,009.98	179,401.87	37,036.77	84,571.35	185	301,017.17	179,416.23	37,021.05	84,579.88
56	300,992.87	179,398.90	37,029.35	84,564.62	121	300,981.68	179,399.35	36,998.75	84,583.58	186	301,060.30	179,379.02	37,049.00	84,632.28
57	301,044.25	179,347.73	37,055.95	84,640.57	122	300,910.67	179,345.17	37,014.63	84,550.87	187	301,012.75	179,413.57	37,007.00	84,592.18
58	301,021.62	179,469.85	37,040.97	84,510.80	123	300,888.07	179,397.68	37,007.97	84,482.42	188	300,969.95	179,371.20	37,032.48	84,566.27
59	300,936.05	179,386.25	37,030.87	84,518.93	124	301,034.87	179,362.85	37,029.95	84,642.07	189	301,070.82	179,442.57	37,094.35	84,533.90
60	301,063.93	179,446.17	37,010.33	84,607.43	125	300,914.42	179,355.22	36,997.10	84,562.10	190	300,862.37	179,297.03	37,054.50	84,510.83
61	301,000.53	179,359.67	37,028.38	84,612.48	126	300,965.08	179,386.30	37,021.95	84,556.83	191	300,912.05	179,304.05	37,007.08	84,600.92
62	301,051.33	179,438.15	37,017.85	84,595.33	127	300,844.83	179,362.00	36,980.27	84,502.57	192	301,085.83	179,423.67	37,058.45	84,603.72
63	301,078.55	179,424.80	37,053.90	84,599.85	128	300,914.08	179,340.22	37,001.27	84,572.60	193	301,006.73	179,408.22	37,000.03	84,598.48
64	301,071.08	179,382.13	37,051.88	84,637.07	129	301,101.47	179,490.40	37,011.28	84,599.78	194	301,030.03	179,430.28	37,011.57	84,588.18
										Average	***300,999.60***	***179,399.48***	***37,024.81***	***84,575.31***

Sustainability – I/O Request Throughput Distribution Graph

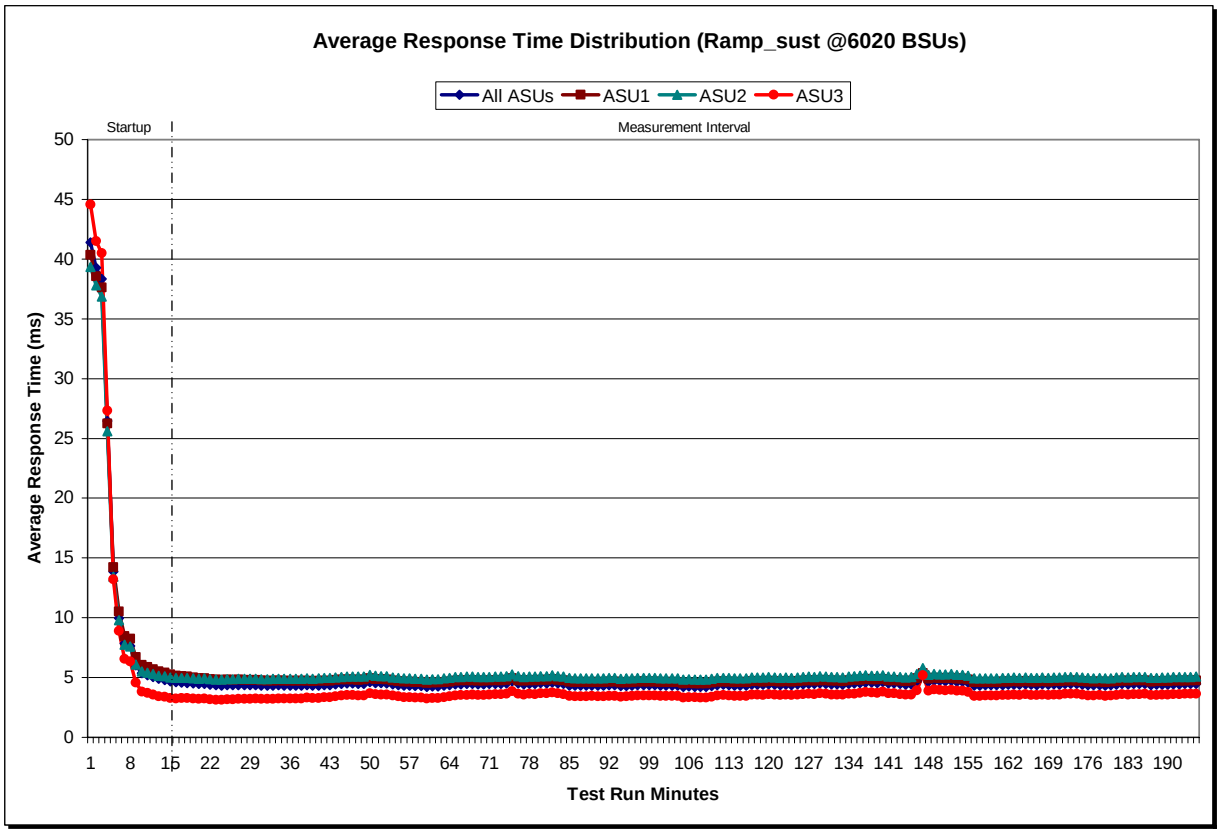


Sustainability – Average Response Time (ms) Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	20:04:19	20:19:19	0-14	0:15:00
Measurement Interval	20:19:19	23:19:21	15-194	3:00:02

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	41.41	40.35	39.34	44.56	65	4.43	4.74	5.05	3.51	130	4.43	4.70	5.03	3.58
1	39.29	38.55	37.79	41.51	66	4.46	4.76	5.07	3.54	131	4.42	4.70	5.03	3.57
2	38.34	37.63	36.86	40.51	67	4.45	4.75	5.07	3.55	132	4.40	4.68	5.01	3.55
3	26.47	26.24	25.61	27.31	68	4.42	4.72	5.03	3.52	133	4.48	4.75	5.07	3.63
4	13.84	14.23	13.44	13.20	69	4.42	4.72	5.03	3.53	134	4.50	4.78	5.10	3.65
5	9.97	10.51	9.79	8.89	70	4.45	4.74	5.05	3.57	135	4.53	4.80	5.13	3.69
6	7.84	8.48	7.73	6.53	71	4.47	4.76	5.07	3.59	136	4.59	4.85	5.18	3.77
7	7.64	8.26	7.60	6.35	72	4.46	4.75	5.08	3.59	137	4.57	4.83	5.15	3.75
8	6.03	6.70	6.09	4.58	73	4.51	4.79	5.12	3.65	138	4.55	4.82	5.15	3.73
9	5.35	6.04	5.50	3.83	74	4.68	4.94	5.26	3.87	139	4.60	4.86	5.19	3.81
10	5.19	5.85	5.39	3.70	75	4.49	4.77	5.10	3.65	140	4.49	4.76	5.09	3.66
11	5.04	5.69	5.28	3.55	76	4.42	4.70	5.02	3.56	141	4.49	4.75	5.08	3.65
12	4.89	5.52	5.16	3.43	77	4.47	4.74	5.08	3.63	142	4.45	4.72	5.04	3.61
13	4.80	5.41	5.11	3.38	78	4.46	4.74	5.07	3.61	143	4.40	4.68	5.00	3.55
14	4.67	5.25	5.02	3.29	79	4.52	4.79	5.12	3.68	144	4.43	4.70	5.03	3.58
15	4.59	5.15	4.97	3.25	80	4.52	4.78	5.12	3.68	145	4.70	4.95	5.28	3.93
16	4.57	5.11	4.96	3.26	81	4.58	4.85	5.18	3.75	146	5.37	5.38	5.79	5.18
17	4.54	5.06	4.95	3.27	82	4.51	4.79	5.12	3.66	147	4.65	4.89	5.22	3.87
18	4.50	5.00	4.93	3.25	83	4.46	4.74	5.06	3.60	148	4.73	4.97	5.30	3.99
19	4.45	4.94	4.90	3.21	84	4.34	4.63	4.96	3.44	149	4.70	4.94	5.27	3.95
20	4.46	4.94	4.92	3.25	85	4.32	4.61	4.94	3.42	150	4.68	4.92	5.25	3.93
21	4.40	4.87	4.86	3.18	86	4.31	4.60	4.92	3.42	151	4.70	4.94	5.28	3.96
22	4.35	4.83	4.84	3.14	87	4.32	4.61	4.93	3.43	152	4.66	4.90	5.23	3.89
23	4.34	4.80	4.83	3.14	88	4.32	4.61	4.94	3.44	153	4.65	4.90	5.23	3.88
24	4.36	4.82	4.87	3.17	89	4.32	4.61	4.94	3.44	154	4.56	4.81	5.14	3.77
25	4.35	4.80	4.87	3.16	90	4.31	4.60	4.93	3.43	155	4.32	4.60	4.92	3.47
26	4.37	4.81	4.90	3.21	91	4.35	4.64	4.96	3.47	156	4.32	4.60	4.92	3.47
27	4.36	4.80	4.90	3.21	92	4.34	4.63	4.95	3.46	157	4.34	4.62	4.94	3.50
28	4.36	4.79	4.91	3.21	93	4.29	4.58	4.91	3.39	158	4.34	4.62	4.94	3.49
29	4.36	4.78	4.91	3.23	94	4.30	4.59	4.92	3.42	159	4.35	4.62	4.94	3.50
30	4.32	4.74	4.87	3.20	95	4.32	4.60	4.94	3.44	160	4.37	4.64	4.96	3.53
31	4.31	4.73	4.87	3.19	96	4.37	4.65	4.98	3.50	161	4.38	4.65	4.98	3.55
32	4.33	4.73	4.89	3.22	97	4.36	4.64	4.98	3.50	162	4.40	4.67	5.00	3.57
33	4.34	4.74	4.90	3.25	98	4.35	4.64	4.96	3.48	163	4.38	4.65	4.98	3.54
34	4.31	4.71	4.88	3.23	99	4.37	4.64	4.98	3.50	164	4.43	4.69	5.01	3.61
35	4.33	4.73	4.91	3.25	100	4.33	4.61	4.95	3.45	165	4.38	4.65	4.98	3.54
36	4.32	4.70	4.90	3.25	101	4.33	4.61	4.94	3.46	166	4.37	4.65	4.97	3.53
37	4.33	4.71	4.91	3.25	102	4.32	4.60	4.93	3.44	167	4.41	4.68	5.00	3.58
38	4.35	4.73	4.94	3.30	103	4.33	4.61	4.94	3.46	168	4.38	4.65	4.97	3.54
39	4.32	4.69	4.91	3.27	104	4.20	4.49	4.82	3.30	169	4.41	4.68	5.01	3.58
40	4.33	4.70	4.93	3.28	105	4.24	4.53	4.85	3.35	170	4.40	4.67	4.99	3.56
41	4.37	4.73	4.96	3.34	106	4.22	4.51	4.84	3.34	171	4.47	4.73	5.05	3.65
42	4.36	4.73	4.95	3.33	107	4.21	4.51	4.83	3.31	172	4.46	4.73	5.05	3.64
43	4.42	4.78	5.01	3.40	108	4.21	4.51	4.83	3.32	173	4.46	4.72	5.04	3.63
44	4.47	4.82	5.06	3.48	109	4.28	4.57	4.90	3.39	174	4.41	4.68	4.99	3.57
45	4.50	4.84	5.09	3.53	110	4.36	4.65	4.98	3.48	175	4.36	4.65	4.97	3.50
46	4.49	4.83	5.09	3.52	111	4.38	4.66	4.99	3.51	176	4.34	4.63	4.94	3.48
47	4.46	4.79	5.06	3.50	112	4.36	4.64	4.97	3.49	177	4.37	4.65	4.97	3.51
48	4.47	4.81	5.07	3.51	113	4.32	4.61	4.93	3.46	178	4.33	4.61	4.92	3.47
49	4.62	4.93	5.21	3.69	114	4.32	4.60	4.92	3.45	179	4.35	4.63	4.94	3.48
50	4.55	4.87	5.14	3.61	115	4.33	4.61	4.93	3.46	180	4.39	4.68	4.99	3.53
51	4.53	4.85	5.12	3.58	116	4.39	4.67	5.00	3.55	181	4.45	4.73	5.04	3.59
52	4.51	4.83	5.11	3.58	117	4.41	4.68	5.01	3.57	182	4.42	4.70	5.01	3.56
53	4.42	4.74	5.02	3.48	118	4.39	4.66	4.99	3.54	183	4.46	4.74	5.05	3.60
54	4.36	4.68	4.96	3.40	119	4.43	4.70	5.03	3.60	184	4.46	4.74	5.05	3.61
55	4.31	4.63	4.92	3.35	120	4.39	4.67	4.99	3.55	185	4.47	4.74	5.05	3.63
56	4.31	4.63	4.92	3.36	121	4.36	4.64	4.97	3.51	186	4.37	4.65	4.97	3.51
57	4.27	4.60	4.89	3.32	122	4.40	4.67	5.00	3.57	187	4.39	4.67	4.98	3.53
58	4.28	4.60	4.90	3.32	123	4.37	4.65	4.98	3.52	188	4.41	4.69	5.00	3.56
59	4.21	4.54	4.83	3.23	124	4.41	4.69	5.02	3.57	189	4.41	4.68	5.00	3.56
60	4.25	4.58	4.87	3.29	125	4.43	4.70	5.03	3.60	190	4.45	4.72	5.03	3.61
61	4.25	4.57	4.87	3.29	126	4.47	4.74	5.07	3.65	191	4.43	4.71	5.03	3.59
62	4.30	4.62	4.92	3.35	127	4.45	4.72	5.05	3.61	192	4.45	4.73	5.04	3.62
63	4.34	4.65	4.96	3.41	128	4.50	4.77	5.10	3.66	193	4.47	4.74	5.05	3.64
64	4.42	4.73	5.03	3.49	129	4.46	4.73	5.06	3.62	194	4.47	4.74	5.06	3.64
										Average	***4.42***	***4.72***	***5.01***	***3.51***

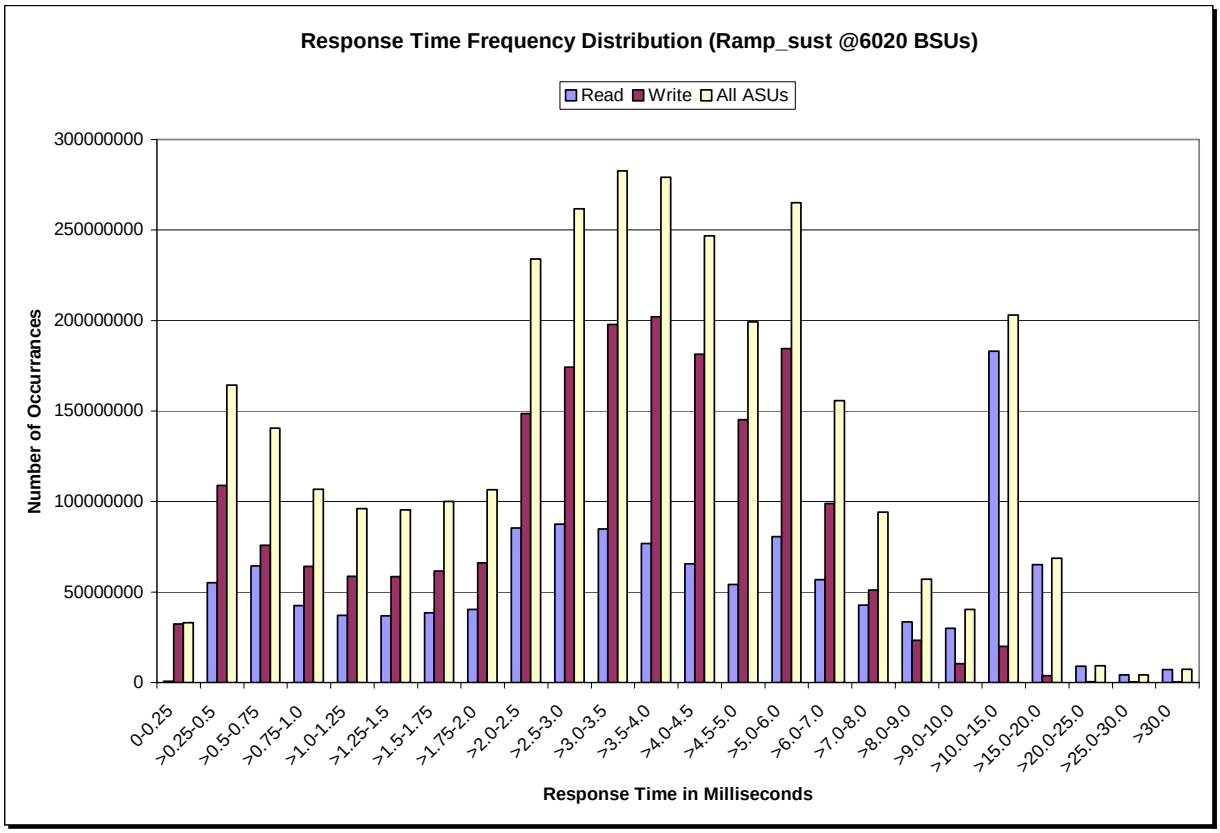
Sustainability – Average Response Time (ms) Distribution Graph



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	673,994	55,265,917	64,442,539	42,619,168	37,185,749	36,807,368	38,445,928	40,479,970
Write	32,377,938	108,993,463	75,931,982	64,194,384	58,767,000	58,563,239	61,619,539	66,136,377
All ASUs	33,051,932	164,259,380	140,374,521	106,813,552	95,952,749	95,370,607	100,065,467	106,616,347
ASU1	18,638,785	98,261,859	88,245,593	64,195,832	57,474,848	57,277,190	60,117,956	63,875,737
ASU2	4,304,151	19,179,423	16,752,577	12,421,560	11,182,193	11,202,023	11,842,670	12,686,681
ASU3	10,108,996	46,818,098	35,376,351	30,196,160	27,295,708	26,891,394	28,104,841	30,053,929
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	85,407,214	87,592,337	84,924,022	76,834,415	65,513,526	54,086,970	80,505,998	56,799,350
Write	148,467,561	174,155,457	197,801,017	202,151,567	181,323,770	145,196,725	184,584,646	98,849,104
All ASUs	233,874,775	261,747,794	282,725,039	278,985,982	246,837,296	199,283,695	265,090,644	155,648,454
ASU1	138,553,875	151,318,166	158,531,195	152,364,729	132,775,523	107,039,902	145,321,831	89,531,608
ASU2	27,919,062	31,026,215	32,898,958	31,718,272	27,485,639	21,862,789	28,983,248	17,649,455
ASU3	67,401,838	79,403,413	91,294,886	94,902,981	86,576,134	70,381,004	90,785,565	48,467,391
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	42,862,703	33,570,416	29,845,684	183,005,190	65,097,358	8,937,328	4,205,757	7,089,704
Write	51,158,088	23,412,436	10,523,789	19,897,857	3,693,226	431,986	160,484	204,399
All ASUs	94,020,791	56,982,852	40,369,473	202,903,047	68,790,584	9,369,314	4,366,241	7,294,103
ASU1	57,729,389	38,072,858	29,391,946	158,549,214	53,856,685	7,385,698	3,413,859	5,589,387
ASU2	11,515,599	7,781,803	6,181,529	36,941,579	13,947,712	1,855,748	896,544	1,632,380
ASU3	24,775,803	11,128,191	4,795,998	7,412,254	986,187	127,868	55,838	72,336

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

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

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

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

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

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

Clause 9.4.3.7.2

For the IOPS Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 67.

IOPS Test Results File

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

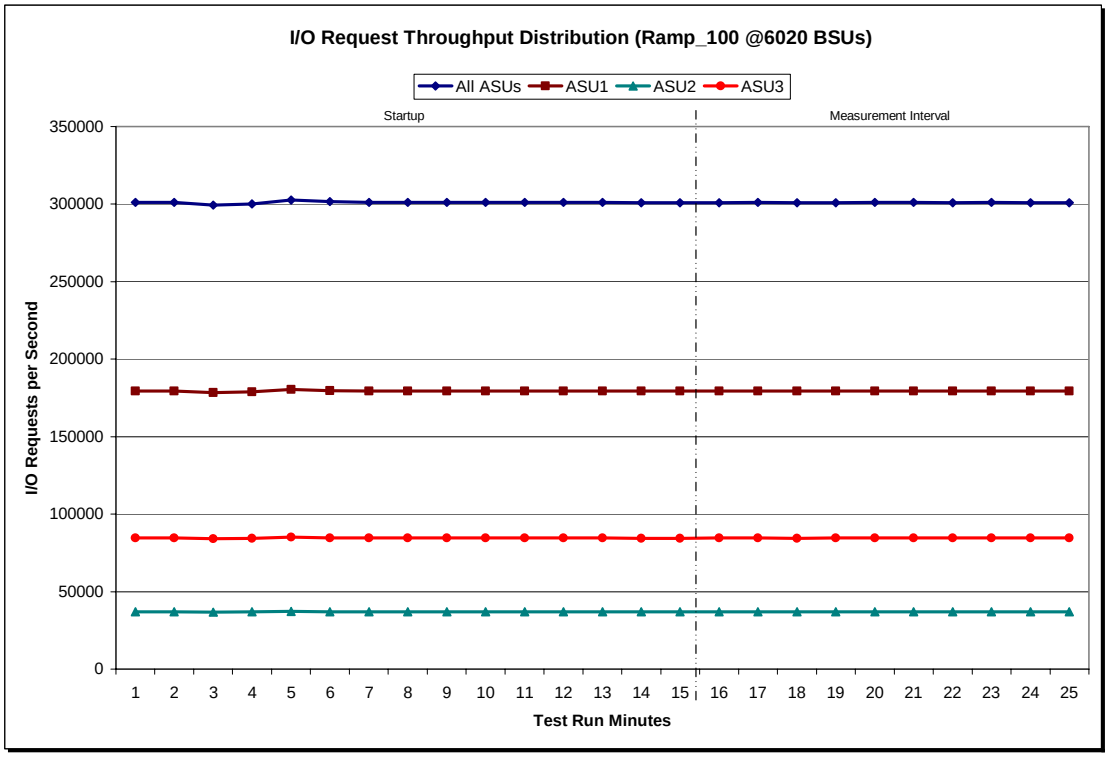
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

6020 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:21:16	23:36:17	0-14	0:15:01
Measurement Interval	23:36:17	23:46:18	15-24	0:10:01

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	301,161.60	179,464.57	37,027.52	84,669.52
1	301,068.82	179,388.12	37,053.60	84,627.10
2	299,456.38	178,486.45	36,794.60	84,175.33
3	300,009.30	178,793.25	36,924.13	84,291.92
4	302,746.35	180,439.13	37,227.30	85,079.92
5	301,650.83	179,774.62	37,087.82	84,788.40
6	301,021.83	179,434.10	37,035.45	84,552.28
7	301,037.63	179,444.88	37,017.85	84,574.90
8	301,066.32	179,468.53	37,042.93	84,554.85
9	301,052.45	179,469.02	37,025.88	84,557.55
10	301,008.93	179,404.83	37,037.15	84,566.95
11	301,090.38	179,450.07	37,024.70	84,615.62
12	301,043.95	179,455.32	36,978.82	84,609.82
13	300,932.93	179,384.75	37,063.43	84,484.75
14	300,947.18	179,366.58	37,051.82	84,528.78
15	300,969.95	179,415.08	37,003.38	84,551.48
16	301,084.77	179,375.97	37,038.15	84,670.65
17	300,941.00	179,441.02	36,993.58	84,506.40
18	300,952.42	179,411.90	36,987.90	84,552.62
19	301,047.73	179,422.12	37,002.47	84,623.15
20	301,098.20	179,417.22	37,033.27	84,647.72
21	300,974.90	179,371.37	37,041.67	84,561.87
22	301,025.03	179,387.93	37,070.53	84,566.57
23	300,924.90	179,399.05	36,974.72	84,551.13
24	300,919.62	179,378.47	36,983.13	84,558.02
Average	***300,993.85***	***179,402.01***	***37,012.88***	***84,578.96***

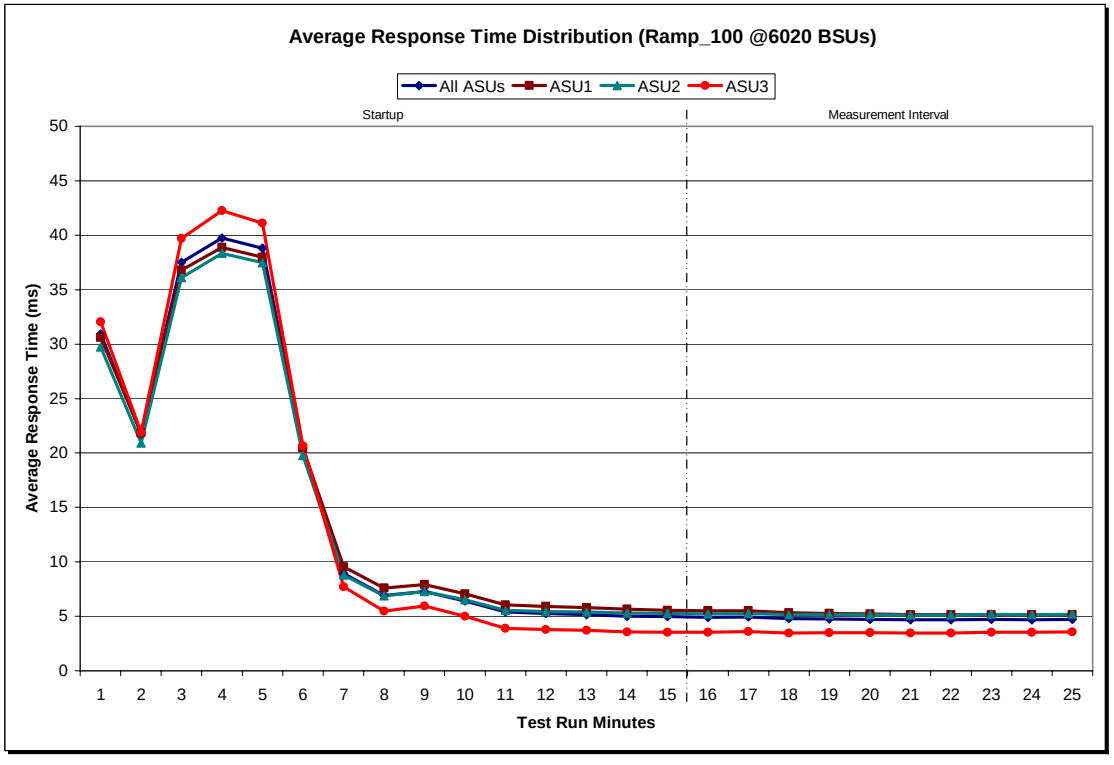
IOPS Test Run – I/O Request Throughput Distribution Graph



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

6020 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:21:16	23:36:17	0-14	0:15:01
Measurement Interval	23:36:17	23:46:18	15-24	0:10:01
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	30.91	30.61	29.73	32.05
1	21.74	21.84	20.93	21.88
2	37.52	36.79	36.11	39.70
3	39.76	38.87	38.35	42.27
4	38.80	37.99	37.47	41.10
5	20.43	20.45	19.78	20.66
6	8.93	9.54	8.77	7.71
7	6.90	7.59	6.86	5.47
8	7.28	7.90	7.29	5.95
9	6.42	7.07	6.51	5.01
10	5.38	6.06	5.54	3.88
11	5.25	5.91	5.45	3.77
12	5.15	5.79	5.39	3.70
13	5.01	5.64	5.29	3.57
14	4.95	5.55	5.25	3.54
15	4.91	5.49	5.23	3.53
16	4.93	5.49	5.27	3.58
17	4.79	5.33	5.16	3.47
18	4.75	5.26	5.15	3.48
19	4.71	5.21	5.14	3.48
20	4.67	5.16	5.12	3.45
21	4.66	5.13	5.12	3.47
22	4.71	5.16	5.17	3.54
23	4.69	5.14	5.16	3.52
24	4.70	5.14	5.19	3.56
Average	***4.75***	***5.25***	***5.17***	***3.51***

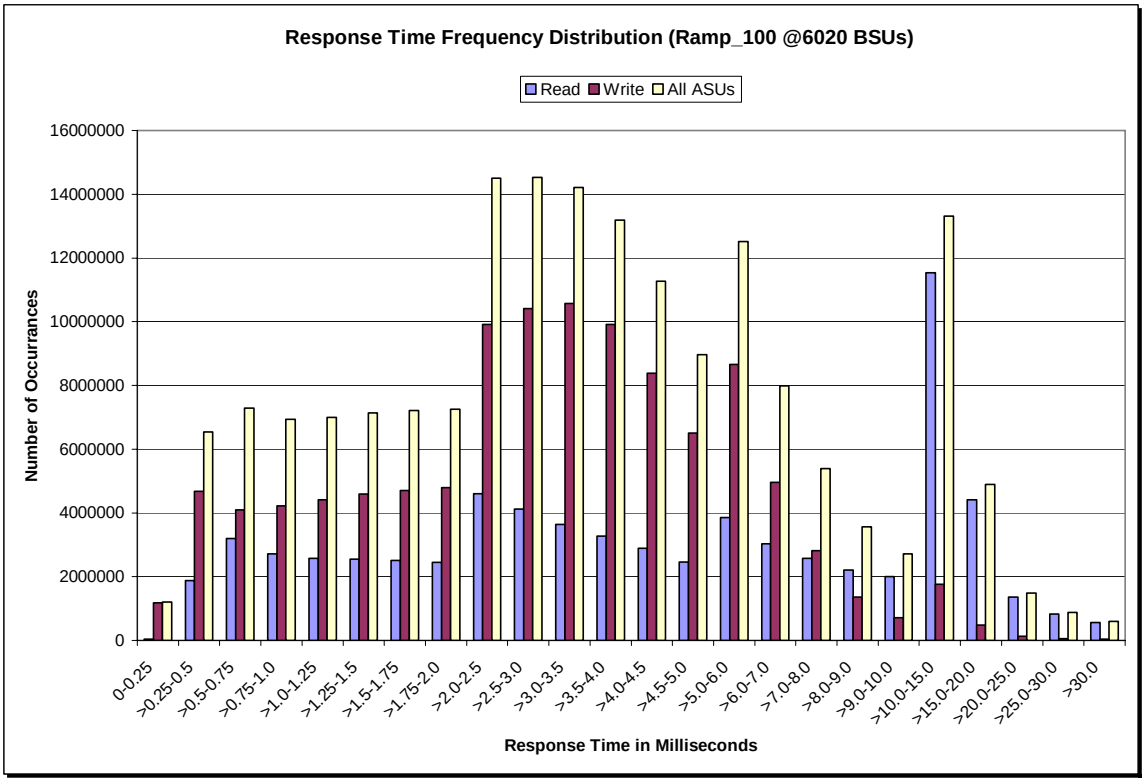
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	35986	1,872,899	3,198,649	2,714,324	2,578,994	2,548,458	2,513,774	2,450,748
Write	1174488	4,673,891	4,093,594	4,217,323	4,416,984	4,593,737	4,706,447	4,795,814
All ASUs	1210474	6,546,790	7,292,243	6,931,647	6,995,978	7,142,195	7,220,221	7,246,562
ASU1	691078	3,796,173	4,541,776	4,169,004	4,137,517	4,180,403	4,193,305	4,171,838
ASU2	157735	791,674	921,724	856,310	856,178	871,641	878,989	882,588
ASU3	361661	1,958,943	1,828,743	1,906,333	2,002,283	2,090,151	2,147,927	2,192,136
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	4,599,602	4,115,677	3,643,639	3,270,507	2,890,065	2,462,635	3,858,981	3,029,193
Write	9,909,966	10,414,857	10,575,010	9,919,084	8,378,752	6,506,435	8,655,436	4,955,188
All ASUs	14,509,568	14,530,534	14,218,649	13,189,591	11,268,817	8,969,070	12,514,417	7,984,381
ASU1	8,211,219	7,997,119	7,635,493	6,992,017	5,973,966	4,806,865	6,899,546	4,665,832
ASU2	1,754,507	1,724,561	1,645,500	1,492,814	1,249,391	980,679	1,364,495	894,821
ASU3	4,543,842	4,808,854	4,937,656	4,704,760	4,045,460	3,181,526	4,250,376	2,423,728
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	2,579,507	2,200,423	2,008,003	11,542,498	4,411,467	1,354,913	821,417	557,920
Write	2,812,611	1,360,839	706,950	1,768,567	483,709	123,280	49,596	42,128
All ASUs	5,392,118	3,561,262	2,714,953	13,311,065	4,895,176	1,478,193	871,013	600,048
ASU1	3,386,466	2,455,271	2,009,658	10,420,461	3,889,788	1,224,909	728,290	462,332
ASU2	640,865	460,096	381,361	2,144,247	810,867	204,452	123,175	118,866
ASU3	1,364,787	645,895	323,934	746,357	194,521	48,832	19,548	18,850

IOPS Test Run –Response Time Frequency Distribution Graph



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
180,594,965	179,994,917	600,048

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

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

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.4.3

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

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

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

Clause 9.4.3.7.3

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 67.

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 - 6020 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:21:16	23:36:17	0-14	0:15:01
Measurement Interval	23:36:17	23:46:18	15-24	0:10:01

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	301,161.60	179,464.57	37,027.52	84,669.52
1	301,068.82	179,388.12	37,053.60	84,627.10
2	299,456.38	178,486.45	36,794.60	84,175.33
3	300,009.30	178,793.25	36,924.13	84,291.92
4	302,746.35	180,439.13	37,227.30	85,079.92
5	301,650.83	179,774.62	37,087.82	84,788.40
6	301,021.83	179,434.10	37,035.45	84,552.28
7	301,037.63	179,444.88	37,017.85	84,574.90
8	301,066.32	179,468.53	37,042.93	84,554.85
9	301,052.45	179,469.02	37,025.88	84,557.55
10	301,008.93	179,404.83	37,037.15	84,566.95
11	301,090.38	179,450.07	37,024.70	84,615.62
12	301,043.95	179,455.32	36,978.82	84,609.82
13	300,932.93	179,384.75	37,063.43	84,484.75
14	300,947.18	179,366.58	37,051.82	84,528.78
15	300,969.95	179,415.08	37,003.38	84,551.48
16	301,084.77	179,375.97	37,038.15	84,670.65
17	300,941.00	179,441.02	36,993.58	84,506.40
18	300,952.42	179,411.90	36,987.90	84,552.62
19	301,047.73	179,422.12	37,002.47	84,623.15
20	301,098.20	179,417.22	37,033.27	84,647.72
21	300,974.90	179,371.37	37,041.67	84,561.87
22	301,025.03	179,387.93	37,070.53	84,566.57
23	300,924.90	179,399.05	36,974.72	84,551.13
24	300,919.62	179,378.47	36,983.13	84,558.02
Average	300,993.85	179,402.01	37,012.88	84,578.96

95% Load Level - 5719 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:47:36	0:02:37	0-14	0:15:01
Measurement Interval	0:02:37	0:12:38	15-24	0:10:01

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	286,262.13	170,632.87	35,178.28	80,450.98
1	286,052.87	170,499.50	35,152.75	80,400.62
2	285,891.48	170,390.50	35,174.78	80,326.20
3	286,015.80	170,467.03	35,194.22	80,354.55
4	285,872.82	170,331.50	35,196.30	80,345.02
5	286,008.50	170,436.83	35,222.07	80,349.60
6	286,062.23	170,485.30	35,173.18	80,403.75
7	285,924.80	170,388.53	35,137.62	80,398.65
8	286,008.25	170,498.52	35,200.60	80,309.13
9	285,880.87	170,370.87	35,165.35	80,344.65
10	285,929.50	170,463.93	35,172.53	80,293.03
11	286,056.15	170,437.63	35,216.75	80,401.77
12	286,079.68	170,453.45	35,232.62	80,393.62
13	285,965.22	170,463.30	35,141.78	80,360.13
14	286,089.33	170,533.97	35,179.10	80,376.27
15	286,069.47	170,510.10	35,176.28	80,383.08
16	285,982.93	170,472.90	35,153.80	80,356.23
17	285,854.82	170,414.00	35,129.03	80,311.78
18	286,120.13	170,545.82	35,179.73	80,394.58
19	285,881.72	170,426.40	35,136.37	80,318.95
20	286,073.58	170,468.00	35,203.82	80,401.77
21	286,047.92	170,502.13	35,187.50	80,358.28
22	285,840.27	170,392.17	35,145.47	80,302.63
23	286,047.08	170,568.73	35,152.53	80,325.82
24	285,977.60	170,443.15	35,200.72	80,333.73
Average	285,989.55	170,474.34	35,166.53	80,348.69

90% Load Level - 5418 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:13:53	0:28:54	0-14	0:15:01
Measurement Interval	0:28:54	0:38:55	15-24	0:10:01

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	271,111.32	161,583.62	33,354.70	76,173.00
1	270,907.13	161,437.40	33,345.27	76,124.47
2	270,863.73	161,448.32	33,315.67	76,099.75
3	270,826.60	161,427.20	33,321.43	76,077.97
4	270,947.28	161,539.65	33,351.97	76,055.67
5	270,882.22	161,456.62	33,307.95	76,117.65
6	270,770.20	161,403.15	33,278.95	76,088.10
7	270,994.03	161,507.25	33,334.15	76,152.63
8	270,974.87	161,491.43	33,347.30	76,136.13
9	270,857.20	161,385.87	33,336.25	76,135.08
10	270,960.45	161,488.78	33,355.85	76,115.82
11	270,848.65	161,397.25	33,332.48	76,118.92
12	270,966.38	161,459.97	33,346.62	76,159.80
13	270,980.90	161,504.22	33,308.32	76,168.37
14	270,827.05	161,430.12	33,295.20	76,101.73
15	270,922.42	161,461.82	33,313.72	76,146.88
16	270,893.08	161,426.52	33,294.67	76,171.90
17	270,953.85	161,432.65	33,355.42	76,165.78
18	270,782.43	161,413.70	33,298.92	76,069.82
19	270,796.55	161,355.47	33,308.17	76,132.92
20	270,843.80	161,353.85	33,331.37	76,158.58
21	270,908.02	161,383.17	33,358.80	76,166.05
22	270,931.40	161,441.72	33,334.37	76,155.32
23	270,934.87	161,448.88	33,324.53	76,161.45
24	270,863.82	161,388.43	33,340.03	76,135.35
Average	270,883.02	161,410.62	33,326.00	76,146.41

80% Load Level - 4816 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:40:03	0:55:04	0-14	0:15:01
Measurement Interval	0:55:04	1:05:05	10	0:10:01

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	240,820.08	143,541.75	29,626.73	67,651.60
1	240,742.83	143,542.20	29,594.95	67,605.68
2	240,893.27	143,569.97	29,634.93	67,688.37
3	240,768.93	143,507.67	29,577.18	67,684.08
4	240,800.47	143,459.78	29,661.78	67,678.90
5	240,818.88	143,498.58	29,634.62	67,685.68
6	240,847.52	143,510.78	29,651.32	67,685.42
7	240,777.00	143,481.37	29,630.33	67,665.30
8	240,731.53	143,526.55	29,589.00	67,615.98
9	240,687.65	143,494.12	29,559.98	67,633.55
10	240,673.32	143,472.92	29,585.28	67,615.12
11	240,863.05	143,564.02	29,609.80	67,689.23
12	240,810.52	143,518.50	29,621.88	67,670.13
13	240,790.28	143,567.13	29,632.98	67,590.17
14	240,688.40	143,415.75	29,618.80	67,653.85
15	240,835.77	143,535.92	29,624.23	67,675.62
16	240,756.22	143,524.32	29,604.40	67,627.50
17	240,701.53	143,432.02	29,621.22	67,648.30
18	240,737.00	143,497.80	29,602.85	67,636.35
19	240,820.27	143,511.07	29,600.82	67,708.38
20	240,836.43	143,511.95	29,625.42	67,699.07
21	240,843.12	143,549.07	29,598.30	67,695.75
22	240,892.38	143,566.03	29,610.43	67,715.92
23	240,813.78	143,519.53	29,620.07	67,674.18
24	240,810.27	143,528.32	29,629.02	67,652.93
Average	240,804.68	143,517.60	29,613.68	67,673.40

Response Time Ramp Distribution (IOPS) Data *(cont.)*

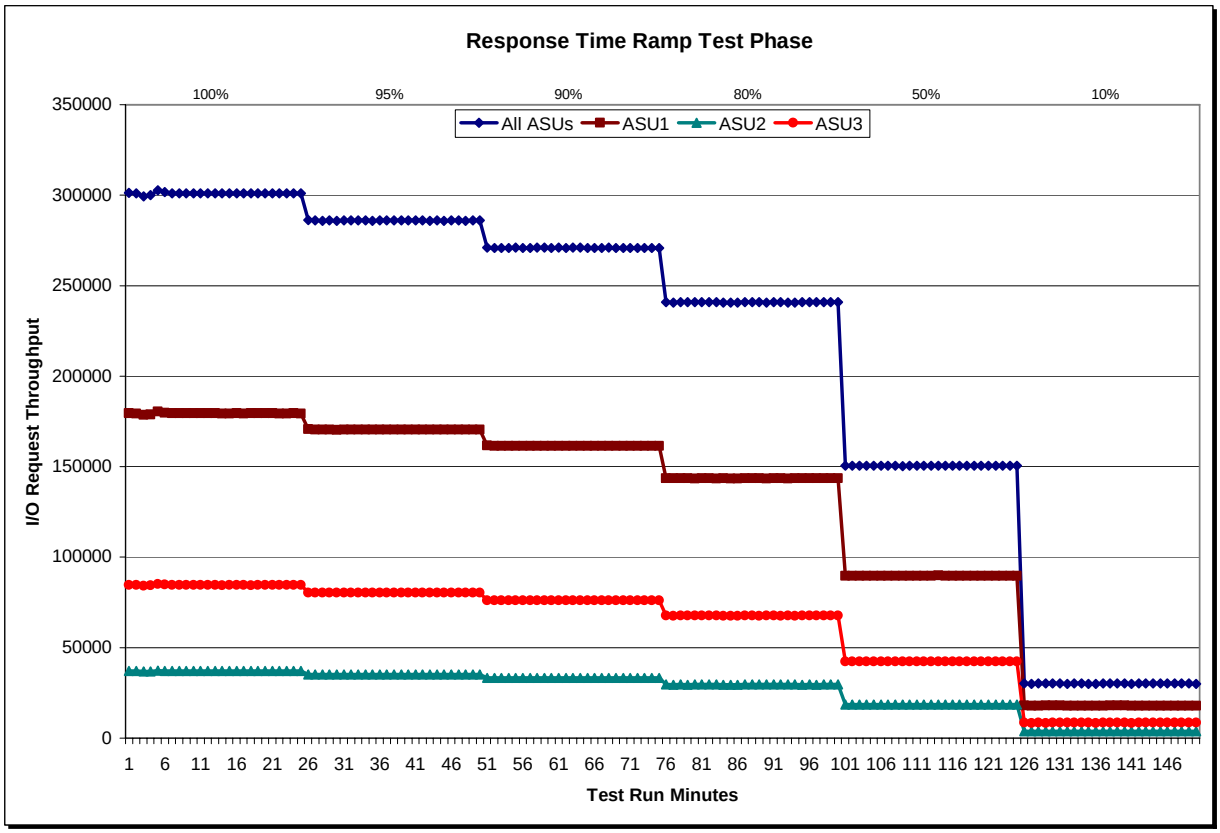
50% Load Level - 3010 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:05:53	1:20:54	0-14	0:15:01
Measurement Interval	1:20:54	1:30:54	15-24	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	150,546.50	89,698.00	18,532.90	42,315.60
1	150,495.75	89,655.88	18,561.82	42,278.05
2	150,460.43	89,701.75	18,499.70	42,258.98
3	150,457.90	89,670.43	18,509.72	42,277.75
4	150,470.52	89,660.97	18,508.73	42,300.82
5	150,565.83	89,752.43	18,487.03	42,326.37
6	150,464.37	89,693.47	18,500.12	42,270.78
7	150,451.70	89,690.25	18,478.22	42,283.23
8	150,389.22	89,610.47	18,511.47	42,267.28
9	150,458.77	89,659.17	18,503.30	42,296.30
10	150,459.77	89,655.05	18,542.63	42,262.08
11	150,465.13	89,698.42	18,496.82	42,269.90
12	150,565.35	89,738.58	18,507.02	42,319.75
13	150,577.08	89,782.28	18,505.02	42,289.78
14	150,555.47	89,731.08	18,502.33	42,322.05
15	150,476.07	89,682.63	18,500.37	42,293.07
16	150,457.43	89,667.63	18,497.47	42,292.33
17	150,508.55	89,666.67	18,540.55	42,301.33
18	150,525.10	89,727.10	18,504.02	42,293.98
19	150,544.30	89,732.42	18,524.38	42,287.50
20	150,418.17	89,660.22	18,512.35	42,245.60
21	150,527.32	89,728.55	18,509.88	42,288.88
22	150,527.33	89,709.98	18,486.37	42,330.98
23	150,456.10	89,638.93	18,488.02	42,329.15
24	150,508.45	89,743.25	18,492.68	42,272.52
Average	150,494.88	89,695.74	18,505.61	42,293.54

10% Load Level - 602 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:31:17	1:46:18	0-14	0:15:01
Measurement Interval	1:46:18	1:56:18	15-24	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	30,158.40	17,979.55	3,707.30	8,471.55
1	30,065.57	17,932.53	3,697.48	8,435.55
2	30,109.43	17,945.42	3,708.98	8,455.03
3	30,098.10	17,958.17	3,703.60	8,436.33
4	30,117.07	17,959.07	3,706.38	8,451.62
5	30,132.12	17,952.32	3,703.67	8,476.13
6	30,068.75	17,912.03	3,705.70	8,451.02
7	30,106.40	17,936.20	3,720.57	8,449.63
8	30,094.05	17,915.75	3,717.80	8,460.50
9	30,067.27	17,925.53	3,692.83	8,448.90
10	30,058.87	17,927.73	3,695.25	8,435.88
11	30,085.55	17,922.07	3,711.72	8,451.77
12	30,117.38	17,953.02	3,698.55	8,465.82
13	30,143.80	17,982.87	3,699.27	8,461.67
14	30,131.27	17,955.05	3,715.80	8,460.42
15	30,067.42	17,945.03	3,689.62	8,432.77
16	30,097.05	17,907.68	3,716.13	8,473.23
17	30,110.42	17,950.60	3,701.63	8,458.18
18	30,111.57	17,949.73	3,714.03	8,447.80
19	30,102.50	17,936.60	3,707.82	8,458.08
20	30,107.05	17,941.90	3,695.75	8,469.40
21	30,088.37	17,940.30	3,706.85	8,441.22
22	30,087.25	17,928.65	3,711.17	8,447.43
23	30,129.38	17,936.73	3,712.05	8,480.60
24	30,075.57	17,938.47	3,694.10	8,443.00
Average	30,097.66	17,937.57	3,704.92	8,455.17

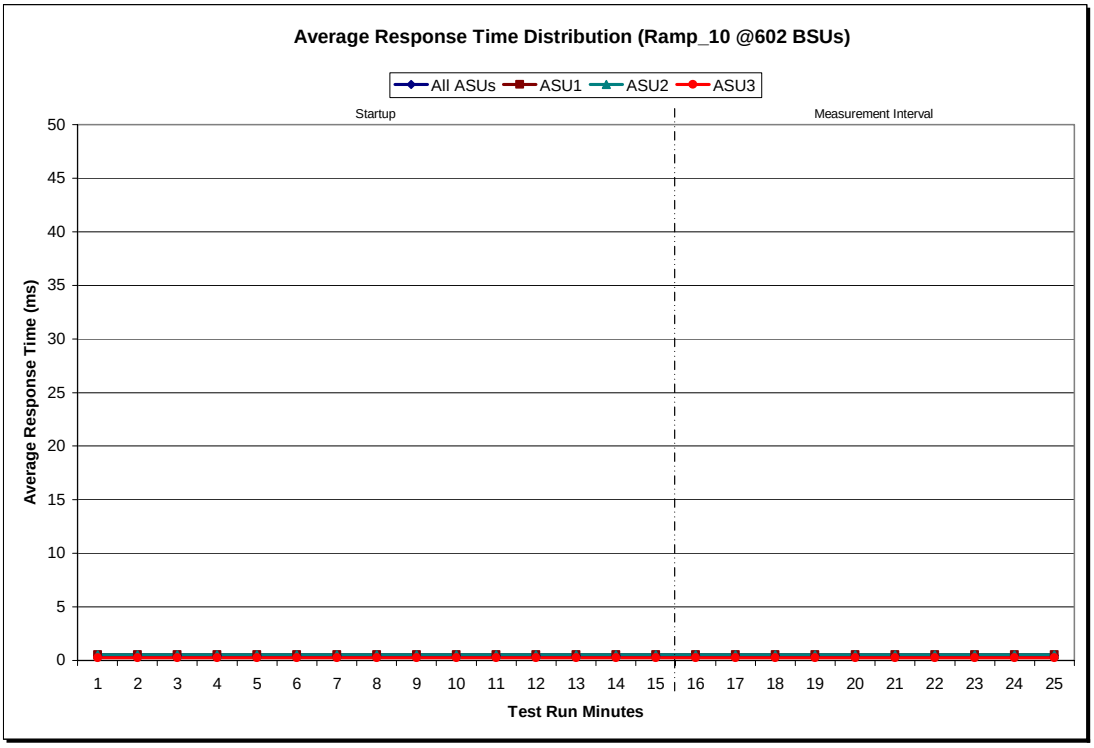
Response Time Ramp Distribution (IOPS) Graph



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

602 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:31:17	1:46:18	0-14	0:15:01
Measurement Interval	1:46:18	1:56:18	15-24	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.46	0.55	0.53	0.25
1	0.46	0.54	0.54	0.25
2	0.46	0.54	0.54	0.25
3	0.46	0.54	0.54	0.25
4	0.46	0.54	0.54	0.25
5	0.46	0.54	0.54	0.25
6	0.46	0.54	0.54	0.25
7	0.46	0.53	0.54	0.25
8	0.46	0.54	0.55	0.25
9	0.46	0.54	0.55	0.25
10	0.46	0.54	0.55	0.26
11	0.46	0.54	0.54	0.26
12	0.46	0.54	0.54	0.25
13	0.46	0.54	0.54	0.26
14	0.46	0.54	0.55	0.26
15	0.46	0.54	0.54	0.26
16	0.46	0.54	0.55	0.26
17	0.46	0.53	0.54	0.26
18	0.46	0.53	0.54	0.26
19	0.46	0.53	0.55	0.26
20	0.46	0.53	0.55	0.26
21	0.45	0.53	0.55	0.25
22	0.46	0.53	0.54	0.26
23	0.46	0.53	0.55	0.26
24	0.46	0.53	0.55	0.26
Average	***0.46***	***0.53***	***0.54***	***0.26***

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2809	0.0701	0.2099	0.0180	0.0700	0.0351	0.2809
COV	0.004	0.002	0.003	0.002	0.004	0.004	0.004	0.001

Repeatability Test

Clause 5.4.5

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

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

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

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

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

Clause 9.4.3.7.4

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 67.

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	***300,993.85***
Repeatability Test Phase 1	300,982.56
Repeatability Test Phase 2	300,986.70

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

	SPC-1 LRT™
Primary Metrics	***0.46 ms***
Repeatability Test Phase 1	0.45 ms
Repeatability Test Phase 2	0.45 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.

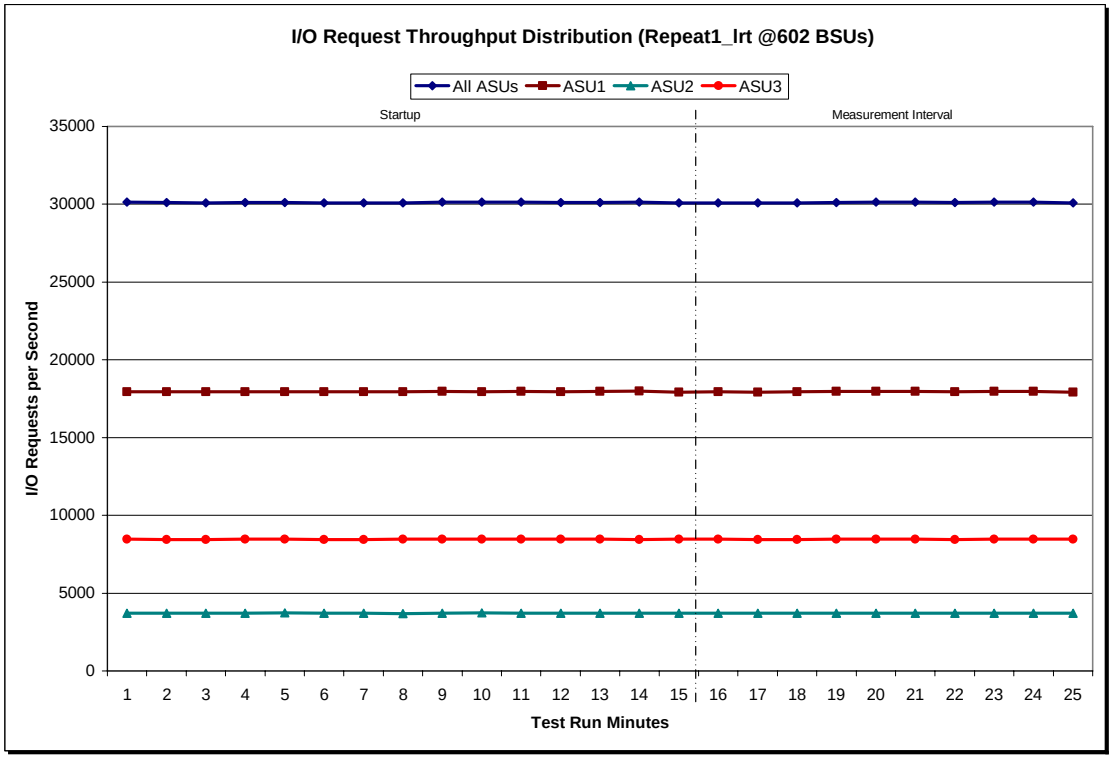
Repeatability Test Phase 1, Test Run 1 (LRT)
Repeatability Test Phase 1, Test Run 2 (IOPS)
Repeatability Test Phase 2, Test Run 1 (LRT)
Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

602 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:57:36	2:12:36	0-14	0:15:00
Measurement Interval	2:12:36	2:22:36	15-24	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	30,130.95	17,952.93	3,707.42	8,470.60
1	30,101.80	17,948.00	3,702.07	8,451.73
2	30,084.63	17,932.43	3,699.78	8,452.42
3	30,105.02	17,953.48	3,697.40	8,454.13
4	30,123.58	17,947.47	3,717.43	8,458.68
5	30,074.72	17,933.90	3,693.28	8,447.53
6	30,081.98	17,936.70	3,702.72	8,442.57
7	30,087.20	17,940.48	3,689.80	8,456.92
8	30,140.77	17,969.50	3,702.70	8,468.57
9	30,138.65	17,937.33	3,722.97	8,478.35
10	30,131.03	17,962.48	3,708.27	8,460.28
11	30,115.12	17,944.87	3,702.23	8,468.02
12	30,110.10	17,958.37	3,695.07	8,456.67
13	30,133.22	17,978.92	3,703.88	8,450.42
14	30,078.95	17,911.40	3,704.32	8,463.23
15	30,085.12	17,931.65	3,694.83	8,458.63
16	30,077.68	17,928.03	3,698.20	8,451.45
17	30,097.90	17,932.47	3,711.95	8,453.48
18	30,120.25	17,954.90	3,710.02	8,455.33
19	30,131.05	17,956.37	3,701.10	8,473.58
20	30,128.17	17,954.97	3,705.18	8,468.02
21	30,102.47	17,948.75	3,710.73	8,442.98
22	30,146.22	17,963.23	3,705.40	8,477.58
23	30,127.50	17,958.68	3,696.27	8,472.55
24	30,095.82	17,926.52	3,700.23	8,469.07
Average	***30,111.22***	***17,945.56***	***3,703.39***	***8,462.27***

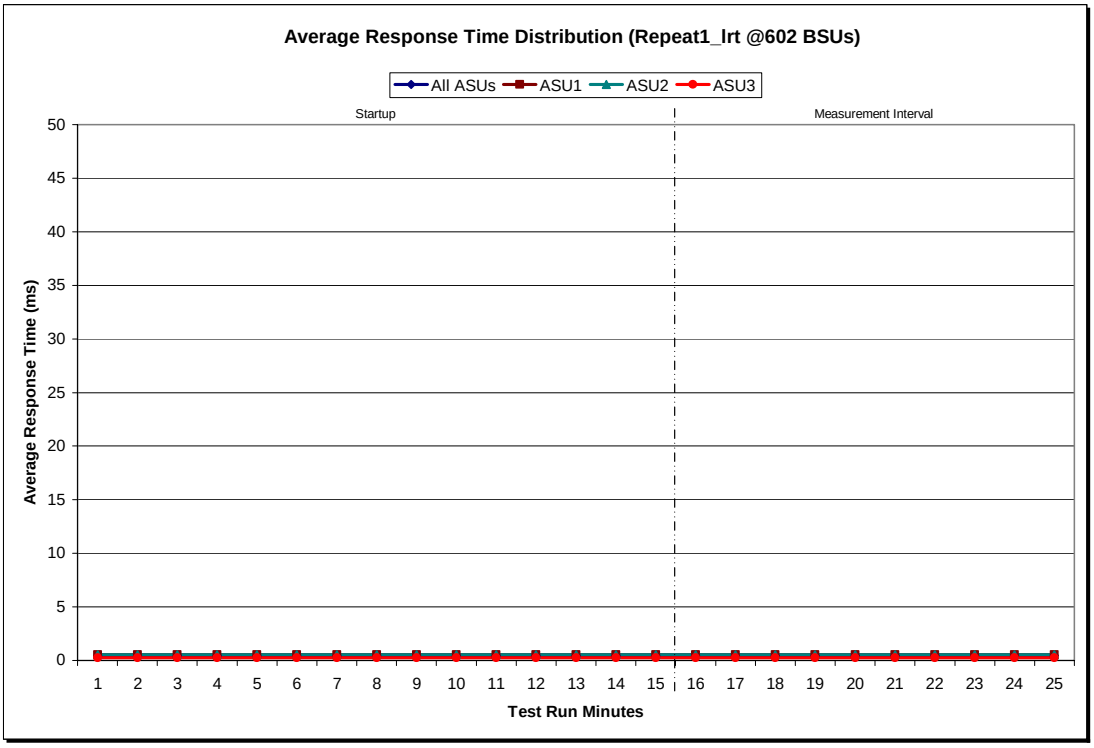
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

602 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:57:36	2:12:36	0-14	0:15:00
Measurement Interval	2:12:36	2:22:36	15-24	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.46	0.55	0.54	0.26
1	0.46	0.54	0.54	0.26
2	0.46	0.54	0.54	0.26
3	0.46	0.54	0.53	0.26
4	0.46	0.54	0.54	0.25
5	0.46	0.54	0.54	0.26
6	0.46	0.53	0.54	0.26
7	0.46	0.54	0.55	0.26
8	0.46	0.54	0.54	0.25
9	0.46	0.54	0.54	0.25
10	0.46	0.54	0.53	0.26
11	0.46	0.54	0.54	0.26
12	0.47	0.54	0.55	0.27
13	0.46	0.54	0.54	0.26
14	0.46	0.53	0.54	0.26
15	0.45	0.53	0.54	0.26
16	0.45	0.53	0.54	0.26
17	0.46	0.53	0.54	0.26
18	0.46	0.53	0.54	0.26
19	0.45	0.53	0.54	0.26
20	0.45	0.53	0.54	0.25
21	0.45	0.53	0.54	0.26
22	0.45	0.53	0.54	0.25
23	0.45	0.53	0.54	0.26
24	0.46	0.53	0.54	0.26
Average	***0.45***	***0.53***	***0.54***	***0.26***

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

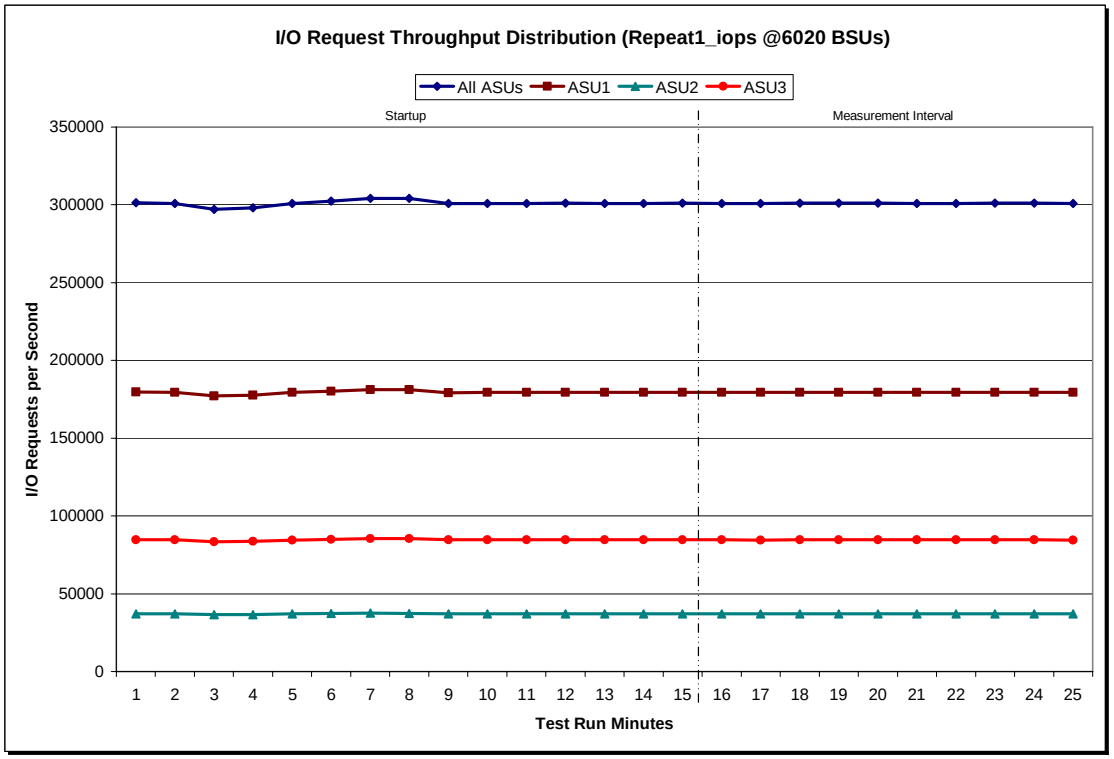


Repeatability 1 IOPS – I/O Request Throughput Distribution Data

6020 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:24:00	2:39:01	0-14	0:15:01
Measurement Interval	2:39:01	2:49:02	15-24	0:10:01

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	301,271.53	179,537.83	37,030.33	84,703.37
1	300,983.57	179,375.10	37,006.37	84,602.10
2	297,006.12	177,025.75	36,497.70	83,482.67
3	298,024.82	177,637.93	36,644.97	83,741.92
4	300,850.03	179,319.88	36,992.47	84,537.68
5	302,250.60	180,133.88	37,173.63	84,943.08
6	304,040.47	181,158.02	37,424.32	85,458.13
7	304,023.33	181,226.42	37,406.33	85,390.58
8	300,793.20	179,246.63	36,992.48	84,554.08
9	300,941.98	179,355.55	36,986.97	84,599.47
10	300,897.48	179,340.22	36,966.72	84,590.55
11	301,005.97	179,395.00	37,057.43	84,553.53
12	300,946.82	179,359.10	37,010.50	84,577.22
13	300,881.92	179,338.20	36,996.37	84,547.35
14	301,119.32	179,443.52	37,048.05	84,627.75
15	300,983.13	179,390.48	36,992.93	84,599.72
16	300,824.05	179,292.78	37,009.67	84,521.60
17	301,121.70	179,469.13	37,060.52	84,592.05
18	301,013.05	179,364.62	37,051.73	84,596.70
19	301,054.63	179,404.32	37,064.57	84,585.75
20	300,895.53	179,323.17	37,004.17	84,568.20
21	300,931.53	179,361.87	37,016.85	84,552.82
22	301,061.07	179,399.28	37,069.15	84,592.63
23	301,082.60	179,442.65	37,055.10	84,584.85
24	300,858.33	179,315.22	37,018.87	84,524.25
Average	***300,982.56***	***179,376.35***	***37,034.36***	***84,571.86***

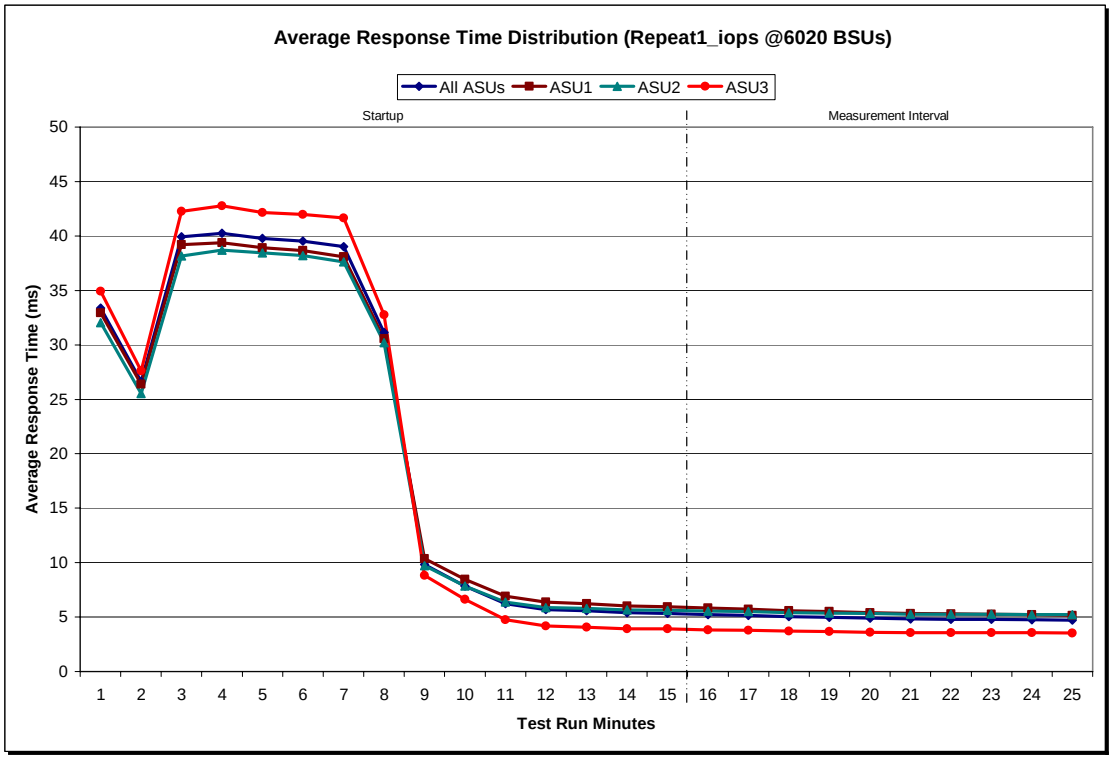
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

6020 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:24:00	2:39:01	0-14	0:15:01
Measurement Interval	2:39:01	2:49:02	15-24	0:10:01
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	33.39	32.94	32.04	34.91
1	26.62	26.39	25.53	27.59
2	39.92	39.18	38.15	42.26
3	40.24	39.37	38.71	42.75
4	39.77	38.92	38.45	42.17
5	39.53	38.65	38.20	41.98
6	39.03	38.07	37.63	41.66
7	31.13	30.56	30.20	32.76
8	9.84	10.35	9.73	8.81
9	7.86	8.45	7.86	6.62
10	6.24	6.91	6.36	4.77
11	5.68	6.36	5.86	4.18
12	5.58	6.24	5.80	4.08
13	5.39	6.03	5.66	3.92
14	5.33	5.94	5.63	3.92
15	5.22	5.82	5.55	3.82
16	5.14	5.71	5.50	3.76
17	5.04	5.59	5.41	3.69
18	4.97	5.50	5.37	3.66
19	4.88	5.40	5.32	3.60
20	4.81	5.31	5.26	3.55
21	4.79	5.28	5.24	3.55
22	4.77	5.24	5.24	3.57
23	4.74	5.20	5.22	3.56
24	4.71	5.17	5.21	3.54
Average	***4.91***	***5.42***	***5.33***	***3.63***

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

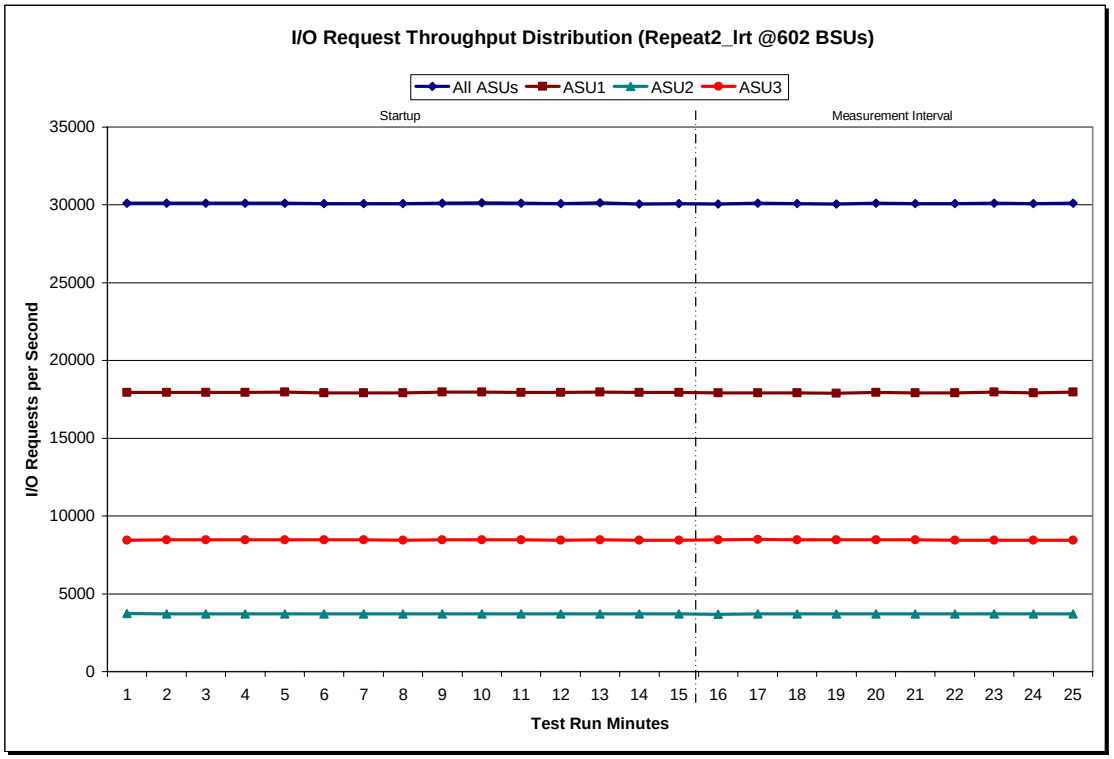


Repeatability 2 LRT – I/O Request Throughput Distribution Data

602 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:50:18	3:05:18	0-14	0:15:00
Measurement Interval	3:05:18	3:15:18	15-24	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	30,118.05	17,946.38	3,724.20	8,447.47
1	30,101.72	17,930.97	3,704.22	8,466.53
2	30,111.78	17,953.38	3,693.57	8,464.83
3	30,100.28	17,944.57	3,697.90	8,457.82
4	30,118.37	17,957.28	3,701.98	8,459.10
5	30,091.00	17,927.02	3,706.60	8,457.38
6	30,088.28	17,921.78	3,703.25	8,463.25
7	30,077.47	17,926.75	3,711.63	8,439.08
8	30,123.15	17,968.37	3,694.07	8,460.72
9	30,148.07	17,974.87	3,705.28	8,467.92
10	30,104.03	17,939.45	3,708.37	8,456.22
11	30,092.23	17,939.02	3,700.30	8,452.92
12	30,137.07	17,975.57	3,706.08	8,455.42
13	30,070.32	17,933.12	3,694.40	8,442.80
14	30,096.87	17,949.88	3,711.52	8,435.47
15	30,066.42	17,922.53	3,686.32	8,457.57
16	30,118.05	17,927.88	3,706.05	8,484.12
17	30,083.50	17,907.15	3,715.97	8,460.38
18	30,053.73	17,896.40	3,701.20	8,456.13
19	30,111.50	17,940.98	3,711.17	8,459.35
20	30,087.52	17,928.05	3,700.12	8,459.35
21	30,075.57	17,922.57	3,705.87	8,447.13
22	30,112.32	17,957.02	3,703.60	8,451.70
23	30,082.05	17,925.90	3,705.83	8,450.32
24	30,117.02	17,957.27	3,706.90	8,452.85
Average	***30,090.77***	***17,928.58***	***3,704.30***	***8,457.89***

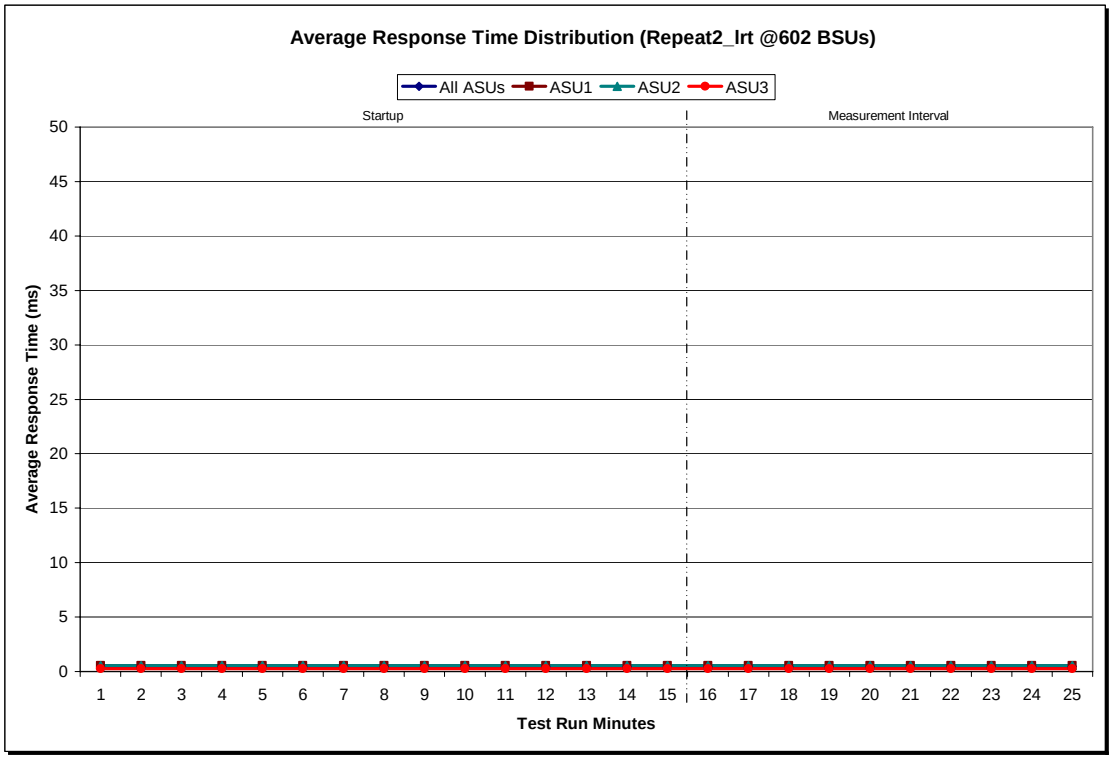
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

602 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:50:18	3:05:18	0-14	0:15:00
Measurement Interval	3:05:18	3:15:18	15-24	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.46	0.55	0.54	0.26
1	0.46	0.55	0.55	0.26
2	0.46	0.54	0.54	0.25
3	0.46	0.54	0.54	0.25
4	0.46	0.54	0.54	0.25
5	0.46	0.54	0.54	0.26
6	0.46	0.54	0.54	0.25
7	0.46	0.54	0.55	0.26
8	0.46	0.53	0.54	0.25
9	0.46	0.54	0.54	0.26
10	0.46	0.53	0.54	0.26
11	0.46	0.54	0.54	0.26
12	0.46	0.54	0.54	0.26
13	0.46	0.53	0.54	0.25
14	0.45	0.53	0.54	0.25
15	0.45	0.53	0.54	0.26
16	0.45	0.53	0.54	0.26
17	0.45	0.53	0.54	0.25
18	0.45	0.53	0.54	0.25
19	0.45	0.53	0.54	0.25
20	0.45	0.53	0.54	0.26
21	0.45	0.53	0.54	0.26
22	0.45	0.53	0.54	0.25
23	0.45	0.53	0.54	0.25
24	0.45	0.53	0.54	0.26
Average	***0.45***	***0.53***	***0.54***	***0.26***

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

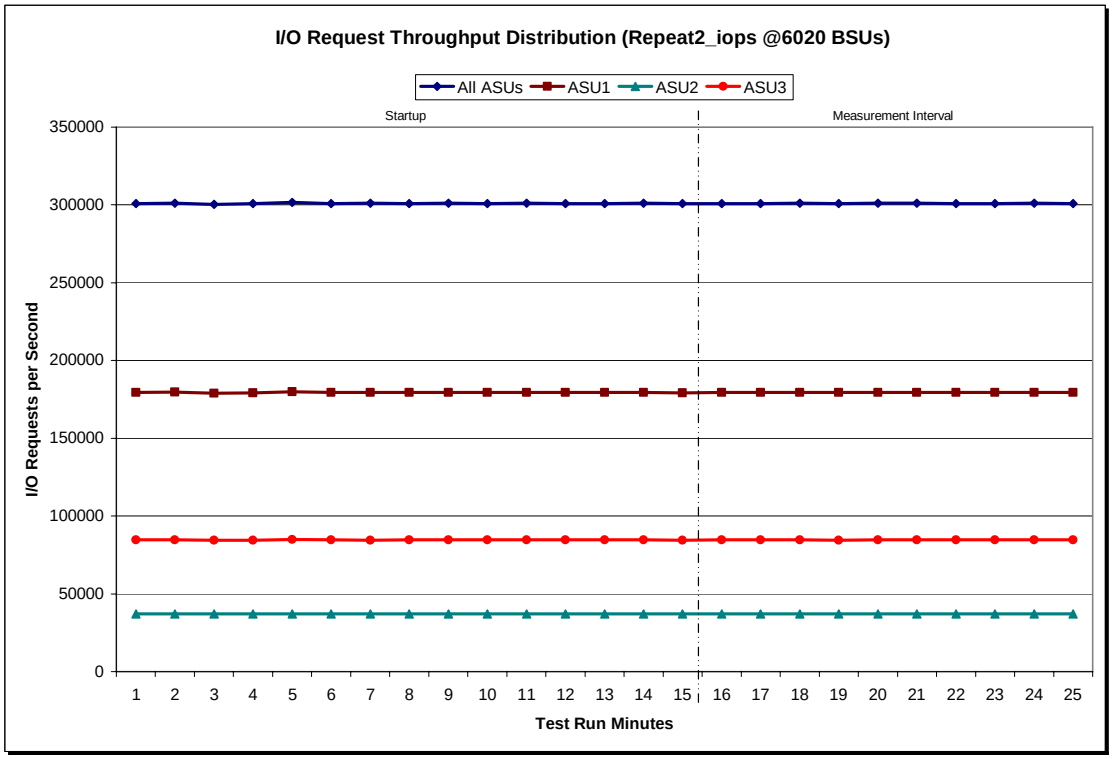


Repeatability 2 IOPS – I/O Request Throughput Distribution Data

6020 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:16:42	3:31:43	0-14	0:15:01
Measurement Interval	3:31:43	3:41:44	15-24	0:10:01

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	300,936.20	179,328.27	37,010.87	84,597.07
1	301,239.73	179,544.40	37,040.78	84,654.55
2	300,356.60	178,993.95	36,955.03	84,407.62
3	300,764.52	179,262.78	36,998.68	84,503.05
4	301,744.80	179,824.97	37,123.25	84,796.58
5	300,908.40	179,296.97	37,022.28	84,589.15
6	301,009.58	179,406.97	37,067.82	84,534.80
7	300,936.27	179,384.97	37,008.40	84,542.90
8	301,082.25	179,400.90	37,053.87	84,627.48
9	300,975.92	179,350.70	37,041.65	84,583.57
10	301,063.67	179,338.73	37,046.37	84,678.57
11	300,922.98	179,368.43	36,995.60	84,558.95
12	300,969.20	179,375.62	37,047.97	84,545.62
13	301,002.47	179,362.50	37,000.53	84,639.43
14	300,841.33	179,278.95	37,027.18	84,535.20
15	300,938.18	179,321.67	37,021.70	84,594.82
16	300,962.32	179,340.25	37,013.25	84,608.82
17	300,998.85	179,400.30	37,022.42	84,576.13
18	300,940.50	179,393.53	37,017.77	84,529.20
19	301,035.35	179,437.52	36,995.52	84,602.32
20	301,021.47	179,379.07	37,004.10	84,638.30
21	300,962.17	179,410.28	37,003.55	84,548.33
22	300,987.12	179,369.52	37,002.38	84,615.22
23	301,065.62	179,438.15	37,057.87	84,569.60
24	300,955.43	179,317.05	36,998.55	84,639.83
Average	***300,986.70***	***179,380.73***	***37,013.71***	***84,592.26***

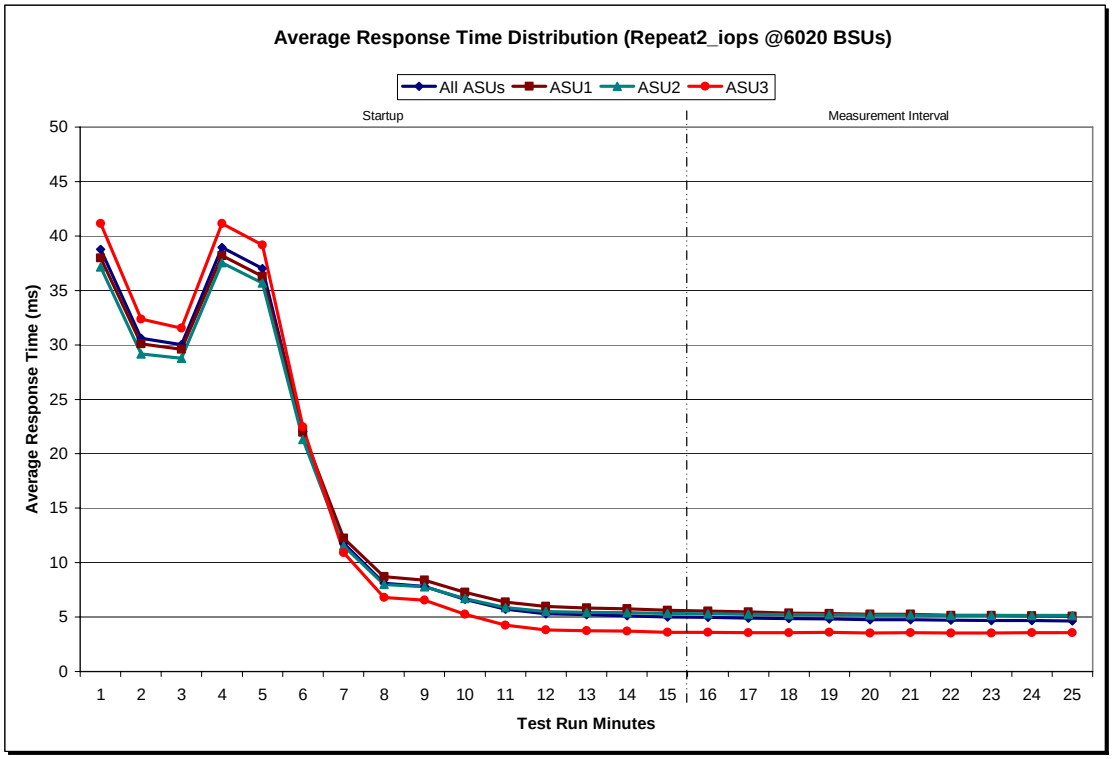
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

6020 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:16:42	3:31:43	0-14	0:15:01
Measurement Interval	3:31:43	3:41:44	15-24	0:10:01
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	38.77	37.98	37.14	41.15
1	30.62	30.09	29.14	32.37
2	30.03	29.60	28.75	31.52
3	38.96	38.20	37.56	41.16
4	37.02	36.29	35.69	39.16
5	22.02	21.96	21.30	22.48
6	11.76	12.22	11.53	10.89
7	8.09	8.73	8.00	6.79
8	7.79	8.39	7.79	6.53
9	6.62	7.26	6.68	5.25
10	5.72	6.39	5.87	4.25
11	5.31	5.97	5.51	3.82
12	5.21	5.85	5.44	3.75
13	5.12	5.74	5.39	3.70
14	5.01	5.60	5.31	3.60
15	4.97	5.55	5.29	3.61
16	4.91	5.46	5.26	3.58
17	4.84	5.37	5.21	3.56
18	4.83	5.33	5.22	3.58
19	4.75	5.24	5.17	3.53
20	4.77	5.24	5.19	3.58
21	4.70	5.16	5.15	3.54
22	4.69	5.14	5.15	3.55
23	4.68	5.12	5.15	3.56
24	4.66	5.09	5.14	3.55
Average	***4.78***	***5.27***	***5.19***	***3.56***

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2812	0.0700	0.02098	0.0180	0.0700	0.0350	0.2810
COV	0.005	0.001	0.003	0.001	0.005	0.002	0.002	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.002	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	0.0350	0.2809	0.0700	0.2099	0.0180	0.0701	0.0350	0.2811
COV	0.004	0.001	0.003	0.001	0.006	0.003	0.004	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	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.000	0.001	0.001	0.002	0.001	0.001	0.000

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.*

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 67.

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	129,279,008
Total Number of Logical Blocks Verified	99,422,176
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in Bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 9.2.4.9

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

The IBM Power™ 595 with PowerVM™ *(SSDs)* 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 found in the Priced Storage Configuration Pricing section on page 14.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.7

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

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

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Onsite Audit of the IBM Power™ 595 with PowerVM™ *(SSDs)*.

APPENDIX A: SPC-1 GLOSSARY

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

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

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

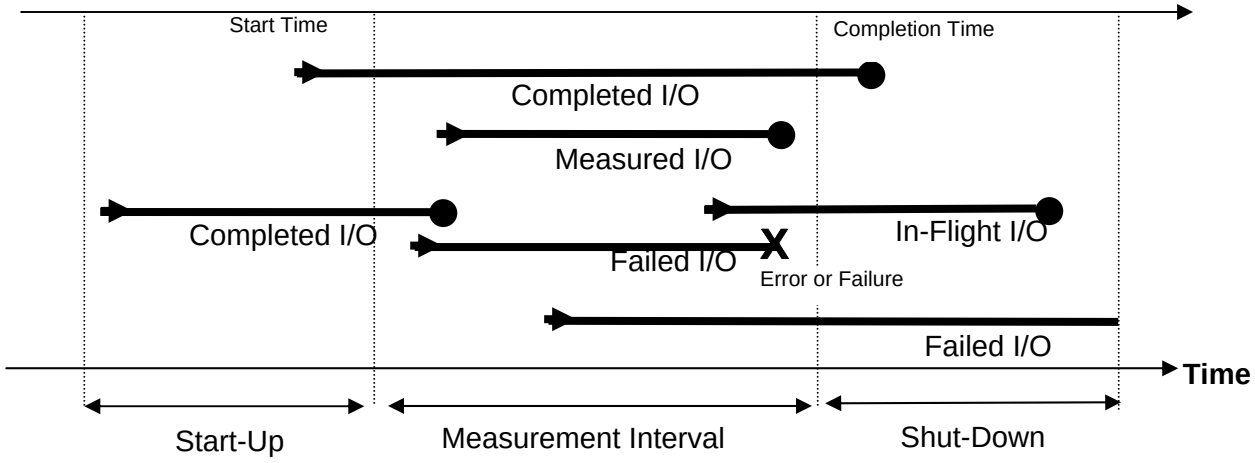
Test: A collection of Test Phases and or Test Runs sharing a common objective.

Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up

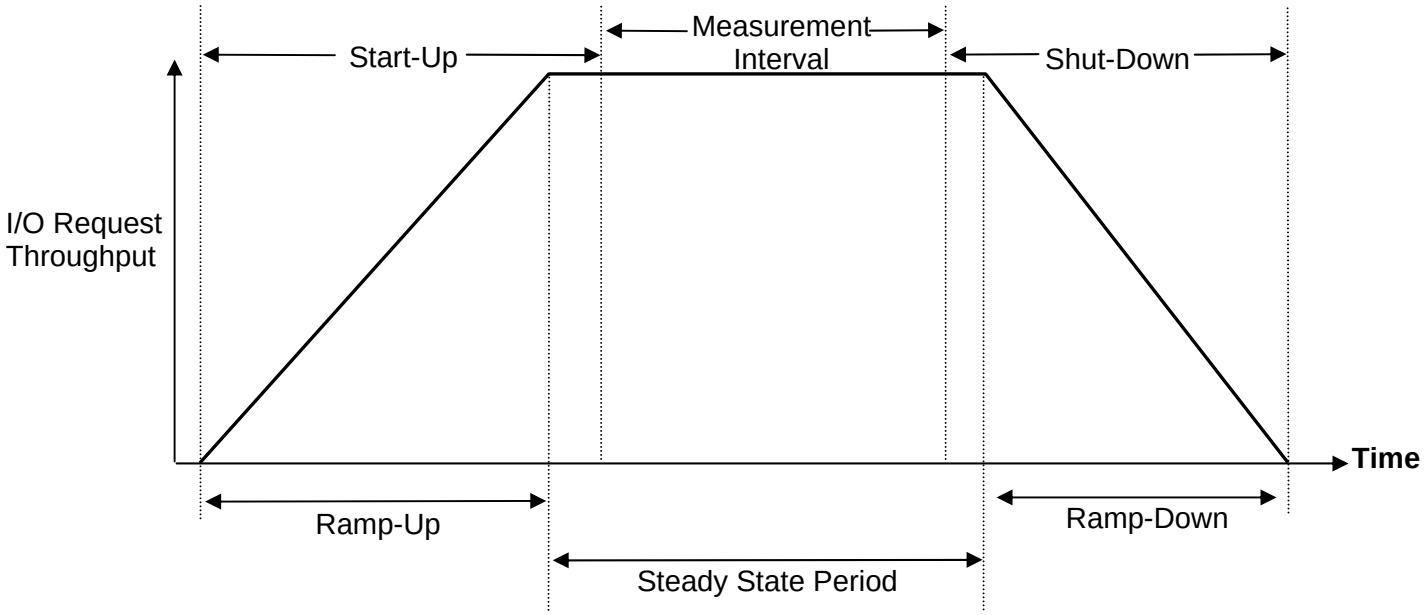
period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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

I/O Completion Types



SPC-1 Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

The write cache function of the PCI-X SAS RAID Adapter was disabled as described in Appendix B: Customer Tunable Parameters and Options on page 63.

The queue depth of each physical SSD was set to 16. The queue depth of the hdisks in the workload generator LPAR was set to 128. The specific details are described in Appendix B: Customer Tunable Parameters and Options on page 63.

The extra RAS features added with AIX 6.0 were disabled as described in Appendix B: Customer Tunable Parameters and Options on page 63.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The management console GUI was used to create one client LPAR (SPC-1 Workload Generator) and four VIOS LPAR's (VIOS1… VIOS4). Assign 32 processor cores (CPU's) to the client LPAR and 4 cores to each VIOS LPAR's. Assign 200 GB of RAM to the client LPAR and 8 GB of RAM each to the VIOS LPAR. Assign 4 PCI-X SAS adapters to each of VIOS1, 2, and 3, and 2 PCI-X SAS adapters to VIOS4.

On every partition, disable the extra RAS features of AIX 6.0 as follows:

- `raso -r mtrc_enabled=0  //disables lightweight memory trace`
- `skeyctl -k off // disable storage keys`
- `reboot`

The following steps 1-5 are performed within each VIOS LPAR in turn (VIOS1… VIOS4).

1. Define a macro for specifying queue depth per SSD in the SAS RAID adapter. This can be done as follows. In AIX, type **odmadd**. Then enter the following:

```
Knorr:
PdAt:
        uniquetype = "adapter/pci/1410c302"
        attribute = "qdpth_per_pdisk"
        deflt = "16"
        values = "1-64,1"
        width = ""
        type = "R"
        generic = "DU"
        rep = "nr"
        nls_index = 0
```

   Press **Cntl-D**. Then type **chdev -l sissasA -a qdpth_per_pdisk=16** where A is the adapter number of the SAS RAID adapter. This command changes the queue depth per SSD to 16.

2. Turn off the adapter write cache function. This is done with the command **sissasraidmgr -K 4 -l sissasA -o 1** where A is the adapter number of the SAS RAID adapter.

3. Format each SSD so it appears to AIX as a "RAID 0 SSD Array" (note: the array size is 1 SSD). This is done as follows: Type **smitty sasdam**. Select **create an array candidate pdisk and format to 528 byte sectors**. Select **sissasA** (where A is the adapter number of the SAS RAID adapter). Select **RAID-0**. Select **256K**. This results in a selection panel for selecting the individual SSD's. Select a single SSD and press enter. Repeat the selection of individual SSD's, one at a time, until six have been formatted.

4. Export each SSD (hdisk) so it is available to client partitions using the command **mkvdev -vdev hdiskX -vadapter mapX**, where X is the hdisk number (as used in this command, "map" is simply an arbitrary name).

5. Discover the exported hdisks in the client LPAR by using the command **cfgmgr**.

This procedure results in 84 SSD's being seen as hdisks by the SPC-1 LPAR. For each such hdisk, set the queue depth to 128 using the command **chdev -l hdiskX_ -a queue_depth=128** where X is the hdisk number.

Finally, organize these hdisks into a logical volume group that provides striping and mirroring for the resulting logical volumes. This is done by invoking the script **stripemirr.sh** as follows: **stripmirr.sh 210 256 1 84**. This command sets the logical volume size to 210 partitions of 256 MiB each, and creates as many striped and mirrored logical volumes as possible based upon the underlying 84 hdisks.

The resulting set of logical volumes, thin1, thin2, …, thin51, were provided for use as the SPC-1 Logical Volumes.

stripemirr.sh

```
# makes striped volume group from available hdisks; makes vols with a specified
number of specified meg partitions.
# important: assumes MPIO, assumes no. of hdisks divides no. of partitions.
# mirrors each volume
if [[ ($# -lt 4) ]]
then
    echo "usage: stripethem partitions psize firstdiskno lastdiskno.  Partitions
should be divisible by hdisks"
    exit
fi
logicalpartspervol=$1
let partspervol="logicalpartspervol*2" #volumes are mirrored
psize=$2
firstdiskno=$3
lastdiskno=$4

hfield=""
h=$firstdiskno
while [[ $h -le $lastdiskno ]]
do
hfield="$hfield hdisk$h"
let h="h+1"
done
mkvg -fy thinstripevg -S -s $psize $hfield

hnum=`echo $hfield | wc -w`
h=$firstdiskno
while [[ $h -le $lastdiskno ]]
do
let mpool="2*(h-firstdiskno)/hnum"
chpv -p mp$mpool hdisk$h
let h="h+1"
done

let width="hnum/2"
parts=`lsvg thinstripevg | grep "FREE PPs:" | awk '{print $6}'`
let numlv="parts / partspervol"
let usedparts="partspervol * numlv"
print "creating $numlv logical volumes"
print "these will use $usedparts out of $parts available partitions"
l=1
while [[ $l -le $numlv ]]
do
mklv -b n -y thin$l -x 32512 -u $width -S 256K -w n -c 2 -p copy1=mp0 -p copy2=mp1
thinstripevg $logicalpartspervol
```

```
l=$((l+1))
done
```

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

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

```
javaparms="-Xms384m -Xmx768m -Xss128k -Xgcpolicy:optavgpause"
sd=default,size=56371445760
sd=asu1_1,lun=/dev/rthin1
sd=asu1_2,lun=/dev/rthin2
sd=asu1_3,lun=/dev/rthin3
sd=asu1_4,lun=/dev/rthin4
sd=asu1_5,lun=/dev/rthin5
sd=asu1_6,lun=/dev/rthin6
sd=asu1_7,lun=/dev/rthin7
sd=asu1_8,lun=/dev/rthin8
sd=asu1_9,lun=/dev/rthin9
sd=asu1_10,lun=/dev/rthin10
sd=asu1_11,lun=/dev/rthin11
sd=asu1_12,lun=/dev/rthin12
sd=asu1_13,lun=/dev/rthin13
sd=asu1_14,lun=/dev/rthin14
sd=asu1_15,lun=/dev/rthin15
sd=asu1_16,lun=/dev/rthin16
sd=asu1_17,lun=/dev/rthin17
sd=asu1_18,lun=/dev/rthin18
sd=asu1_19,lun=/dev/rthin19
sd=asu1_20,lun=/dev/rthin20
sd=asu1_21,lun=/dev/rthin21
sd=asu1_22,lun=/dev/rthin22
sd=asu1_23,lun=/dev/rthin23
sd=asu2_1,lun=/dev/rthin24
sd=asu2_2,lun=/dev/rthin25
sd=asu2_3,lun=/dev/rthin26
sd=asu2_4,lun=/dev/rthin27
sd=asu2_5,lun=/dev/rthin28
sd=asu2_6,lun=/dev/rthin29
sd=asu2_7,lun=/dev/rthin30
sd=asu2_8,lun=/dev/rthin31
sd=asu2_9,lun=/dev/rthin32
sd=asu2_10,lun=/dev/rthin33
sd=asu2_11,lun=/dev/rthin34
sd=asu2_12,lun=/dev/rthin35
sd=asu2_13,lun=/dev/rthin36
sd=asu2_14,lun=/dev/rthin37
sd=asu2_15,lun=/dev/rthin38
sd=asu2_16,lun=/dev/rthin39
sd=asu2_17,lun=/dev/rthin40
sd=asu2_18,lun=/dev/rthin41
sd=asu2_19,lun=/dev/rthin42
sd=asu2_20,lun=/dev/rthin43
sd=asu2_21,lun=/dev/rthin44
sd=asu2_22,lun=/dev/rthin45
sd=asu2_23,lun=/dev/rthin46
sd=asu3_1,lun=/dev/rthin47
sd=asu3_2,lun=/dev/rthin48
sd=asu3_3,lun=/dev/rthin49
sd=asu3_4,lun=/dev/rthin50
sd=asu3_5,lun=/dev/rthin51
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

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

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

```
export PATH=$PATH:/usr/java14/bin
export SPC1HOME=/home/spc1install
export CLASSPATH=$SPC1HOME
export LIBPATH=$SPC1HOME/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaopts.cfg metrics -s 900 -b 6020
java -Xoptionsfile=javaopts.cfg repeat1 -s 900 -b 6020
java -Xoptionsfile=javaopts.cfg repeat2 -s 900 -b 6020
java -Xoptionsfile=javaoptsp.cfg persist1 -b 6020
```

javaopts.cfg

```
-Xms384m -Xmx768m -Xss128k -Xgcpolicy:optavgpause
```

Persistence Test Run 2

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

```
export PATH=$PATH:/usr/java14/bin
export SPC1HOME=/home/spc1install
export CLASSPATH=$SPC1HOME
export LIBPATH=$SPC1HOME/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaoptsp.cfg persist2
```

javaoptsp.cfg

```
-Xms384m -Xmx1024m -Xss64k -Xgcpolicy:optavgpause
```