SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

IBM CORPORATION
IBM XIV STORAGE SYSTEM GEN3 *(VERSION 11.3)*

SPC-1 V1.14

Submitted for Review: June 10, 2013
Submission Identifier: A00135

First Edition – June 2013

Trademarks

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Table of Contents

AUDIT CERTIFICATION

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

April 24, 2013

The SPC Benchmark 1™ Reported Data listed below for the IBM XIV Storage System Gen3 *(Version 11.3)*was produced in compliance with the SPC Benchmark 1™ v1.14 Remote Audit requirements.

SPC Benchmark 1™ v1.14 Reported Data	
Tested Storage Product (TSP) Name: IBM XIV Storage System Gen3 *(Version 11.3)*	
Metric	**Reported Result**
SPC-1 IOPS™	180,020.39
SPC-1 Price-Performance	$5.42/SPC-1 IOPS™
Total ASU Capacity	44,358.865 GB
Data Protection Level	Protected 1 *(Mirroring)*
Total Price (including three-year maintenance)	$976,071
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with 1.14 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by information supplied by 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.

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Redwood City, CA 94062
AuditService@storageperformance.org
650.556.9384

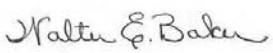
AUDIT CERTIFICATION *(CONT.)*

- The total Application Storage Unit (ASU) Capacity was filled with random data, using an auditor approved tool, prior to execution of the SPC-1 Tests.
- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by information supplied by 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 the Host System.
  - ✓ The TSC boundary within the 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
- There were no differences between the Tested Storage Configuration and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

IBM

Vice President and Disk Storage Business Line Executive

IBM Technology & Systems Group
650 Harry Road, Almaden Research Center
San Jose CA 95120-6099

Phone 1-408-927-0623

May 9, 2013

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 XIV Storage System Gen3.

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 1.14 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,

Laura Guio
Vice President, Business Line Executive Storage Systems
IBM Systems and Technology Group

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 IBM ARC 650 Harry Road San Jose, CA 95120 Phone: (408) 927-2717 FAX: (408) 927-2050
Test Sponsor Alternate Contact	IBM Corporation – http://www.ibm.com Yijie Zhang – yijie@us.ibm.com 9000 South Rita Road IBM Mail Drop 9042-1 Tucson, AZ 85744 Phone: (520) 799-5843 FAX: (520) 799-2009
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	V1.14
SPC-1 Workload Generator revision number	V2.3.0
Date Results were first used publicly	June 10, 2013
Date the FDR was submitted to the SPC	June 10, 2013
Date the Priced Storage Configuration is available for shipment to customers	June 25, 2013
Date the TSC completed audit certification	April 24, 2013

Tested Storage Product (TSP) Description

XIV is a versatile, high-end disk storage solution with an innovative grid architecture that can provide clients excellent performance and scalability while significantly reducing costs and complexity. XIV includes automated data placement that needs no tuning as application workloads change. Version 11.3 offers flash memory as cache storage *(included in this submission)*. Version 11.3 also includes capacity on demand (selection of capacity and price points implemented by software).

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: IBM XIV Storage System Gen3 *(Version 11.3)*	
Metric	**Reported Result**
SPC-1 IOPS™	180,020.29
SPC-1 Price-Performance™	$5.42/SPC-1 IOPS™
Total ASU Capacity	44,358.865 GB
Data Protection Level	Protected 1 *(Mirroring)*
Total Price	$976,071.30
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

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

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

Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 16.

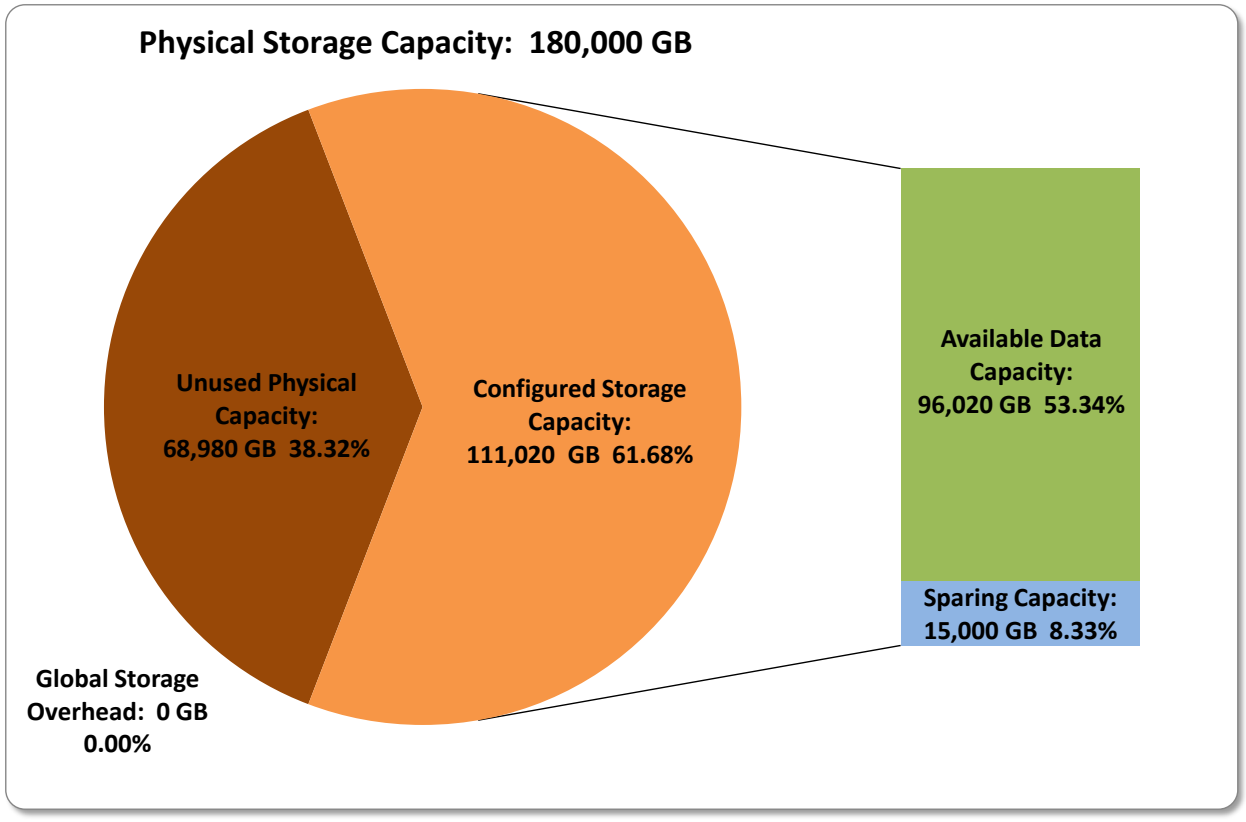
Currency Used is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country *(non-local currency).*

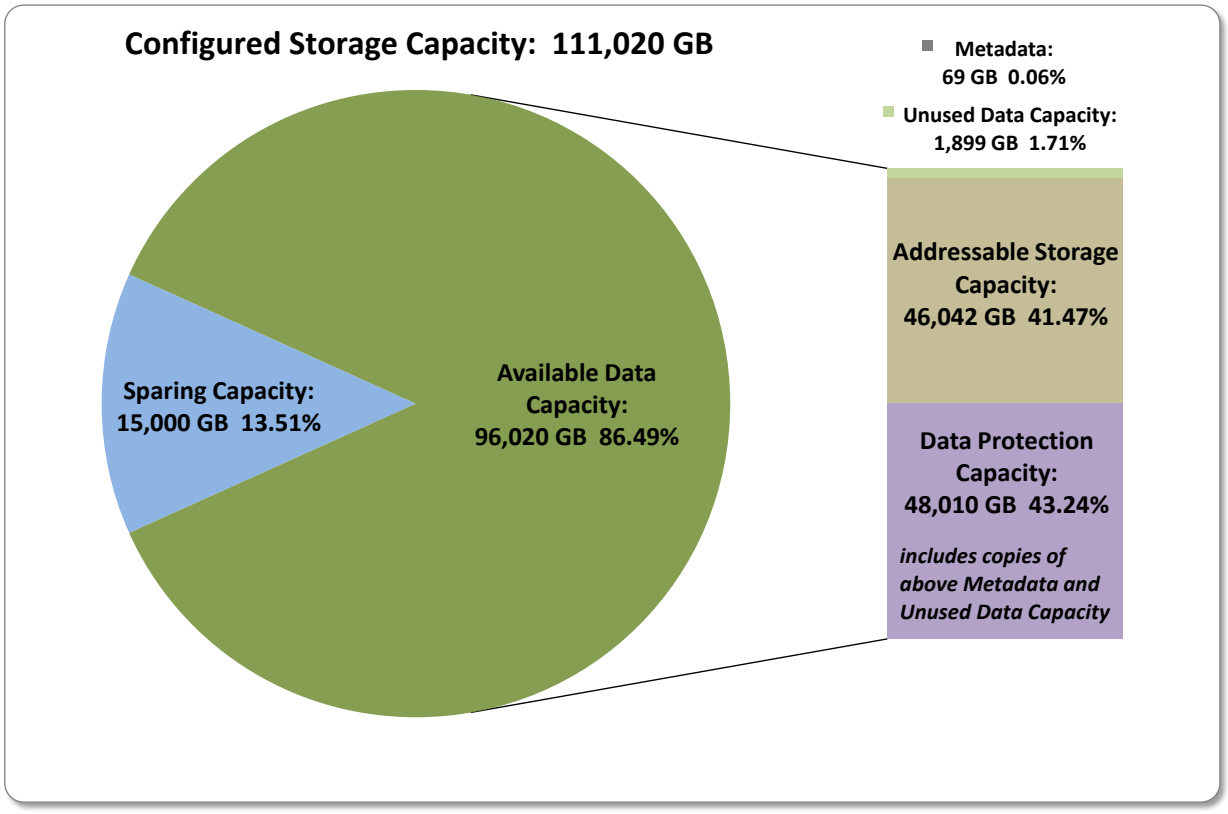
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

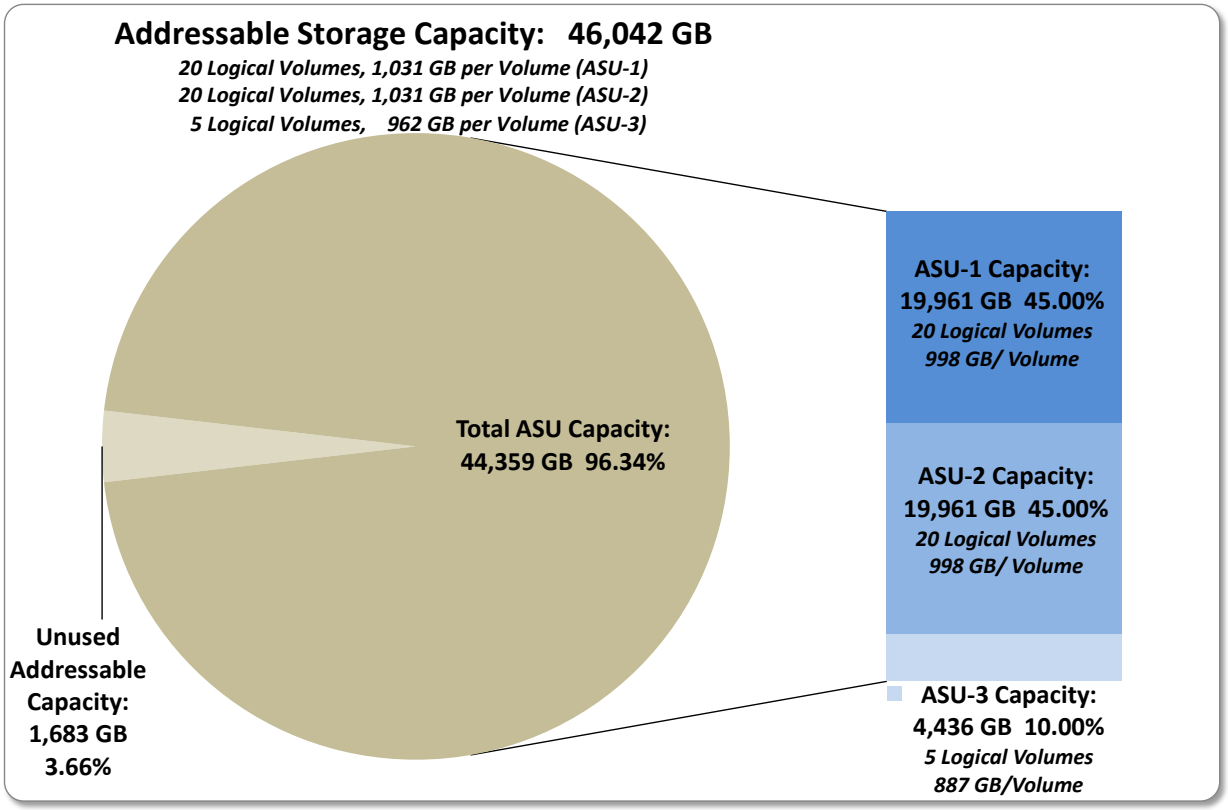
Storage Capacities, Relationships, and Utilization

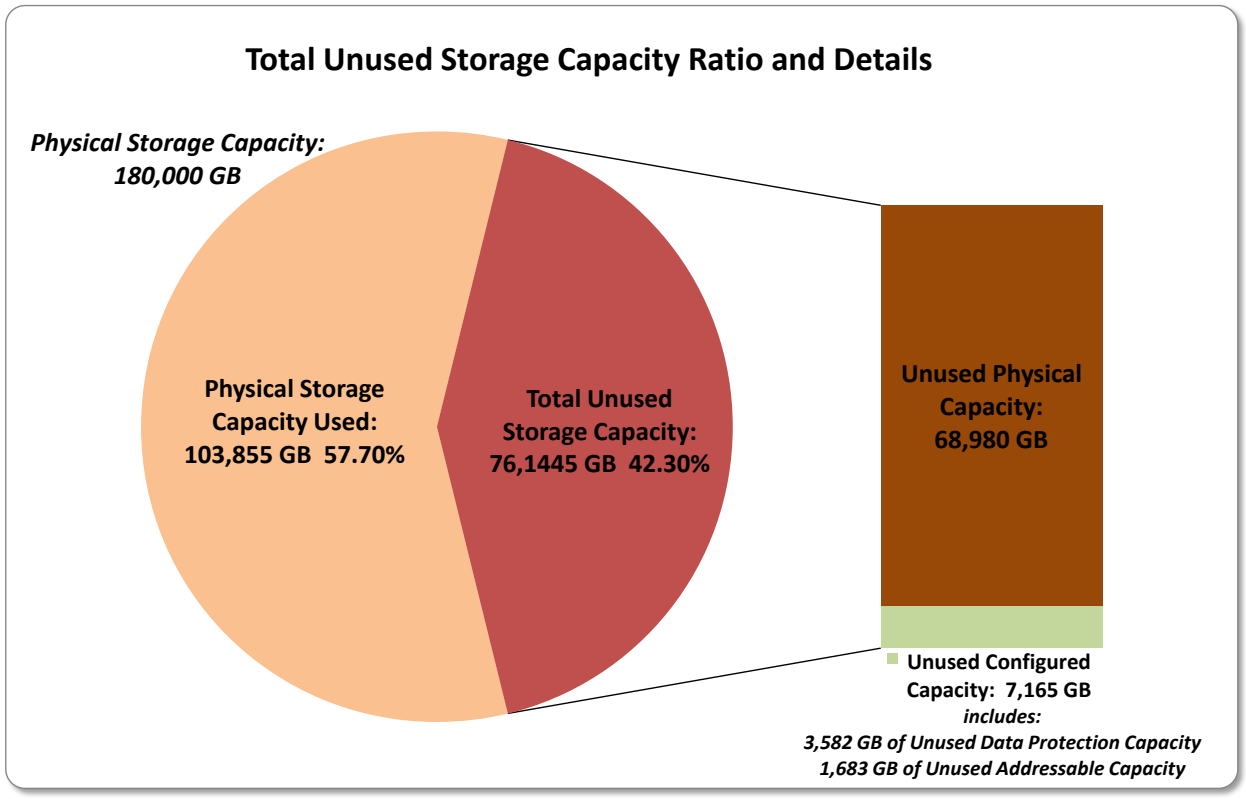
The following four charts and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.

The capacity values in each of the following four charts may be listed as an integer value, for readability, rather than the decimal values listed elsewhere in this document.




Configured Storage Capacity: 111,020 GB
Metadata:
69 GB 0.06%
Unused Data Capacity:
1,899 GB 1.71%
Addressable Storage Capacity:
46,042 GB 41.47%
Data Protection Capacity:
48,010 GB 43.24%
includes copies of above Metadata and Unused Data Capacity
Sparing Capacity:
15,000 GB 13.51%
Available Data Capacity:
96,020 GB 86.49%


Addressable Storage Capacity: 46,042 GB
20 Logical Volumes, 1,031 GB per Volume (ASU-1)
20 Logical Volumes, 1,031 GB per Volume (ASU-2)
5 Logical Volumes, 962 GB per Volume (ASU-3)
ASU-1 Capacity:
19,961 GB 45.00%
20 Logical Volumes
998 GB/ Volume
ASU-2 Capacity:
19,961 GB 45.00%
20 Logical Volumes
998 GB/ Volume
ASU-3 Capacity:
4,436 GB 10.00%
5 Logical Volumes
887 GB/Volume
Total ASU Capacity:
44,359 GB 96.34%
Unused Addressable Capacity:
1,683 GB
3.66%



SPC-1 Storage Capacity Utilization	
Application Utilization	24.64%
Protected Application Utilization	49.33%
Unused Storage Ratio	42.30%

Application Utilization: Total ASU Capacity *(44,358.865 GB)* divided by Physical Storage Capacity *(180,000.000 GB)*

Protected Application Utilization: Total ASU Capacity *(44,358.865 GB)* plus total Data Protection Capacity *(48,010.000 GB)* minus unused Data Protection Capacity *(3,582.416 GB)* divided by Physical Storage Capacity *(180,000.000 GB)*

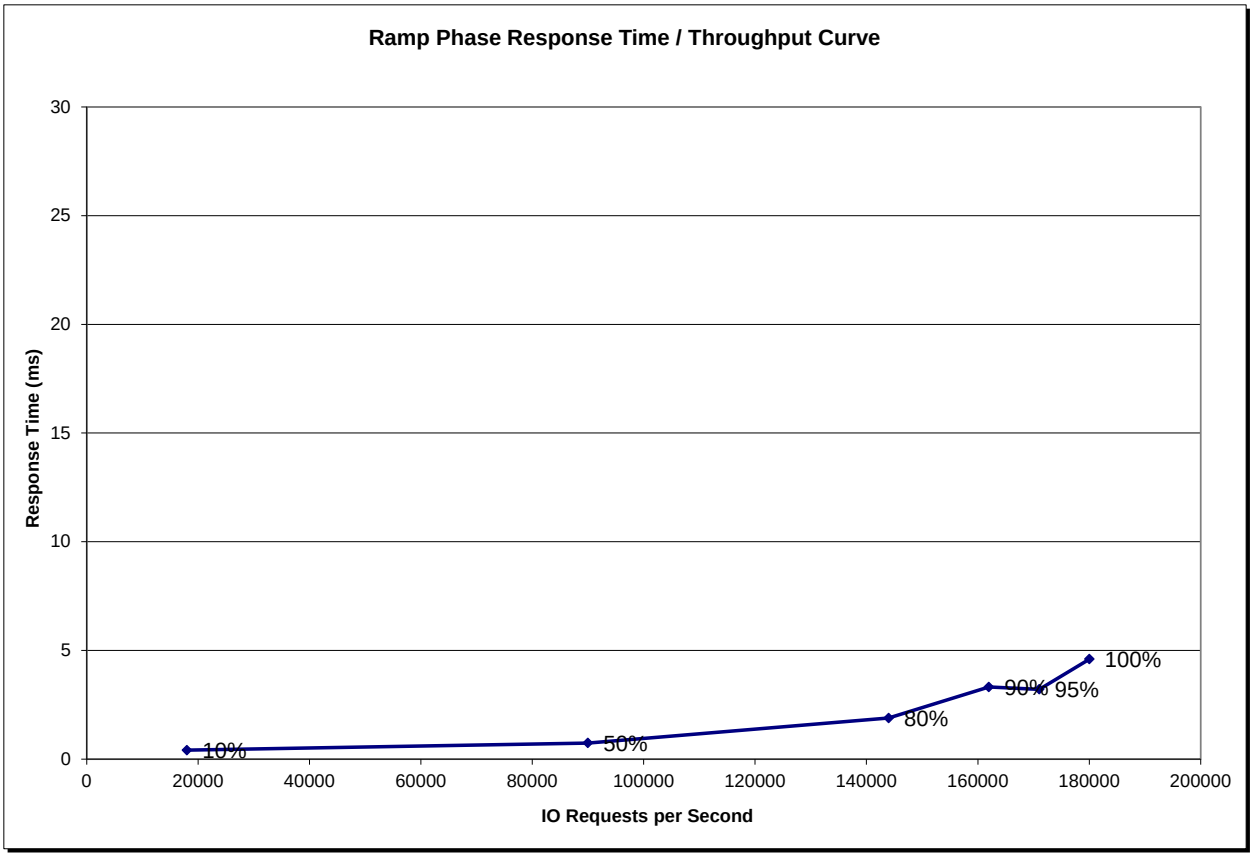
Unused Storage Ratio: Total Unused Capacity *(76,144.832 GB)* divided by Physical Storage Capacity *(180,000.000 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 22-23.

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	17,995.66	89,984.16	143,993.46	161,987.42	171,030.43	180,020.29
Average Response Time (ms):						
All ASUs	0.41	0.74	1.89	3.32	3.21	4.60
ASU-1	0.41	0.78	1.81	3.51	3.25	5.05
ASU-2	0.51	1.26	5.46	8.74	9.12	11.65
ASU-3	0.37	0.42	0.49	0.53	0.52	0.56
Reads	0.51	1.27	4.08	7.17	7.38	10.85
Writes	0.34	0.39	0.45	0.81	0.49	0.52

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

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

Priced Storage Configuration Pricing

Description	Quanity	Unit Price	Discount	Extended price with Discount
2812-214 IBM XIV Storage System Model 214, all HW includes 3 year warranty.	1	$187,195.00	70%	$ 56,158.50
Interface/Data modules, w/ 12 x 1 TB disk option.	15	$ 101,250.00	70%	$ 455,625.00
SSD cache (6TB)	1	$405,000.00	70%	$ 121,500.00
5639-YYB XIV Software	1	$516,750.00	60%	$ 206,700.00
5639-XX3 XIV Software Support (3 years)	1	$206,700.00	60%	$ 82,680.00
IBM SAN24B-5 8Gb FC Switch	1	$ 33,503.00	20%	$ 26,802.40
Warranty extension for switch (add 2x1 year)	2	$ 2,330.00	20%	$ 3,728.00
Short wave 25m Fibre Channel cable	24	$ 189.00	20%	$ 3,628.80
8Gbps Dual Port FC adapter (HBA)	6	$ 4,583.00	30%	$ 19,248.60
Total Price				**$ 976,071.30**

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

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

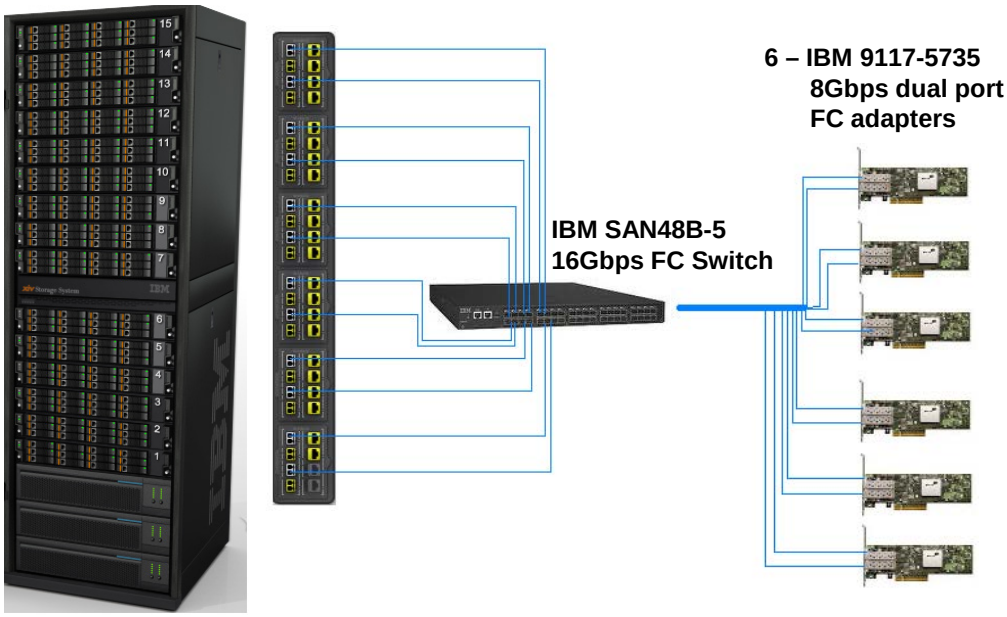
Priced Storage Configuration Diagram

IBM XIV® System Storage Gen3
(Version 11.3)

6 – 2TB Interface Modules

9 – 2TB Data Modules

180 – 2 TB 7200 RPM SAS disk drives
(12 – disk drives per module)



Priced Storage Configuration Components

Priced Storage Configuration
8 – IBM 9117-5735 8 Gbps dual-port FC adapters
IBM XIV® Storage System Gen3 *(Version 11.3)* 360 GiB RAM memory/cache 6,000 GB Flash cache *(15 – 400 GB Flash modules)* 6 – 2 TB Interface Modules 9 – 2 TB Data Modules 24 – 8 Gbps FC front-end connections *(12 used)* 30 – 4x6 Gbps SAS backend connections *(30 used)*
180 – 2 TB 7200 RPM SAS disk drive *(12 per interface and data module)*
1 – IBM SAN48B-5 16Gbps FC switch
24 – Short Wave 25m fibre channel cables

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 19 *(Benchmark Configuration/Tested Storage Configuration Diagram)*.

Storage Network Configuration

Clause 9.4.3.4.1

…

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

Clause 9.4.3.4.2

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

The storage network configuration is illustrated on page 19 *(Benchmark Configuration/Tested Storage Configuration Diagram)*.

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

Clause 9.4.3.4.3

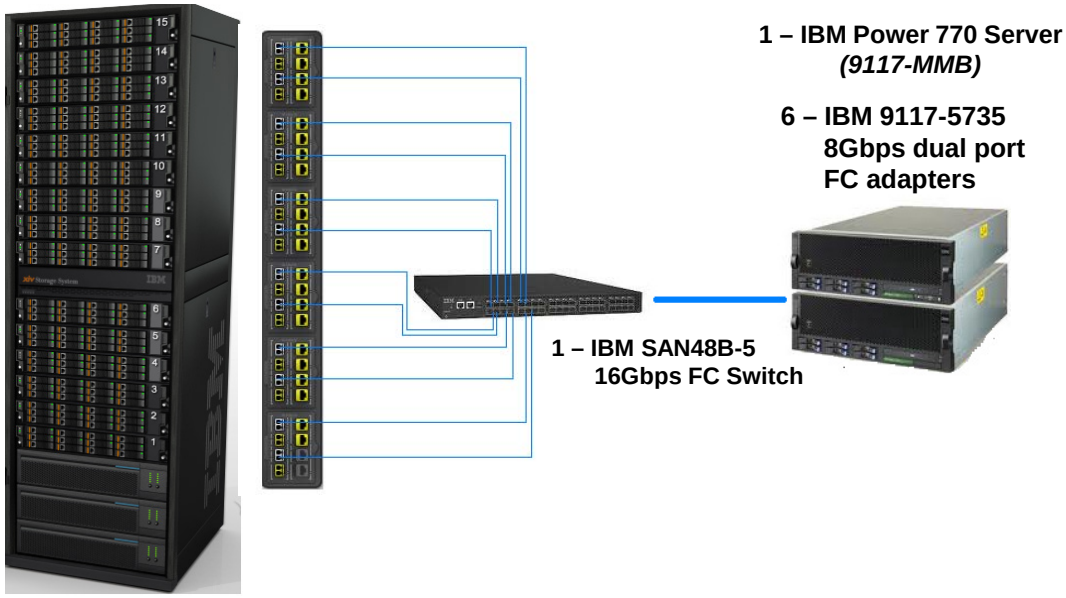
The FDR will contain a table that lists the major components of each Host System and the Tested Storage Configuration (TSC). Table 9-10 specifies the content, format, and appearance of the table.

The Host System and TSC table of components may be found on page 19 *(Host Systems and Tested Storage Configuration Components)*.

Benchmark Configuration/Tested Storage Configuration Diagram

IBM XIV® System Storage Gen3
(Version 11.3)

6 – 2TB Interface Modules
9 – 2TB Data Modules
180 – 2 TB 7200 RPM SAS disk drives
(12 – disk drives per module)



Host Systems and Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):
IBM Power 770 server, with 4 – 3.1 GHz Power7 processor modules 8 cores per processor modules 256 KB L2 cache per core 4 MB L3 cache per core (eDram) 256 GiB main memory AIX 7.1 PCIe	8 – IBM 9117-5735 8 Gbps dual-port FC adapters
	IBM XIV® Storage System Gen3 *(Version 11.3)* 360 GiB RAM memory/cache 6,000 GB Flash cache *(15 –400 GB Flash modules)* 6 – 2 TB Interface Modules 9 – 2 TB Data Modules 24 – 8 Gbps FC front-end connections *(12 used)* 30 – 4x6 Gbps SAS backend connection *(30 used)*
	180 – 2 TB, 7200 RPM, SAS disk drives *(12 disk drives per interface and data module)*
	1 – IBM SAN48B-5 16Gbps switche
	24 – Short Wave 25m fibre channel cables

Customer Tunable Parameters and Options

Clause 9.4.3.5.1

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

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

Tested Storage Configuration (TSC) Description

Clause 9.4.3.5.2

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

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

Appendix C: Tested Storage Configuration (TSC) Creation on page 65 contains the detailed information that describes how to create and configure the logical TSC.

SPC-1 Workload Generator Storage Configuration

Clause 9.4.3.5.3

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

The SPC-1 Workload Generator storage configuration commands and parameters for this measurement appear in *Appendix D: SPC-1 Workload Generator Storage Commands and Parameters* on page 69.

ASU Pre-Fill

Clause 5.3.3

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

The configuration file used to complete the required ASU pre-fill appears in *Appendix D: SPC-1 Workload Generator Storage Commands and Parameters* on page 69.

SPC-1 DATA REPOSITORY

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-1 storage capacities and mappings used in the Tested Storage Configuration. *SPC-1 Data Repository Definitions* on page 60 contains definitions of terms specific to the SPC-1 Data Repository.

Storage Capacities and Relationships

Clause 9.4.3.6.1

Two tables and four charts documenting the storage capacities and relationships of the SPC-1 Storage Hierarchy (Clause 2.1) shall be included in the FDR. … The capacity value in each chart may be listed as an integer value, for readability, rather than the decimal value listed in [the table below].

SPC-1 Storage Capacities

The Physical Storage Capacity consisted of 354,580.106 GB distributed over 180 disk drives, each with a formatted capacity of 2,000.399 GB. One TB (1,000 GB) of that formatted disk drive capacity was priced and available for use, so the effective Physical Storage Capacity was 180,000.000 GB. There was 68,980.000 GB (38.32%) of Unused Storage within the effective Physical Storage Capacity. Global Storage Overhead consisted of 0.000 GB (0.00%) of the effective Physical Storage Capacity. There was 7,164.832 GB (6.45%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 96.34% of the Addressable Storage Capacity resulting in 1,683.185 GB (3.66%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(Mirroring)* capacity was 48,010.000 GB of which 44,427.584 GB was utilized. The total Unused Storage capacity was 76,144.832 GB.

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

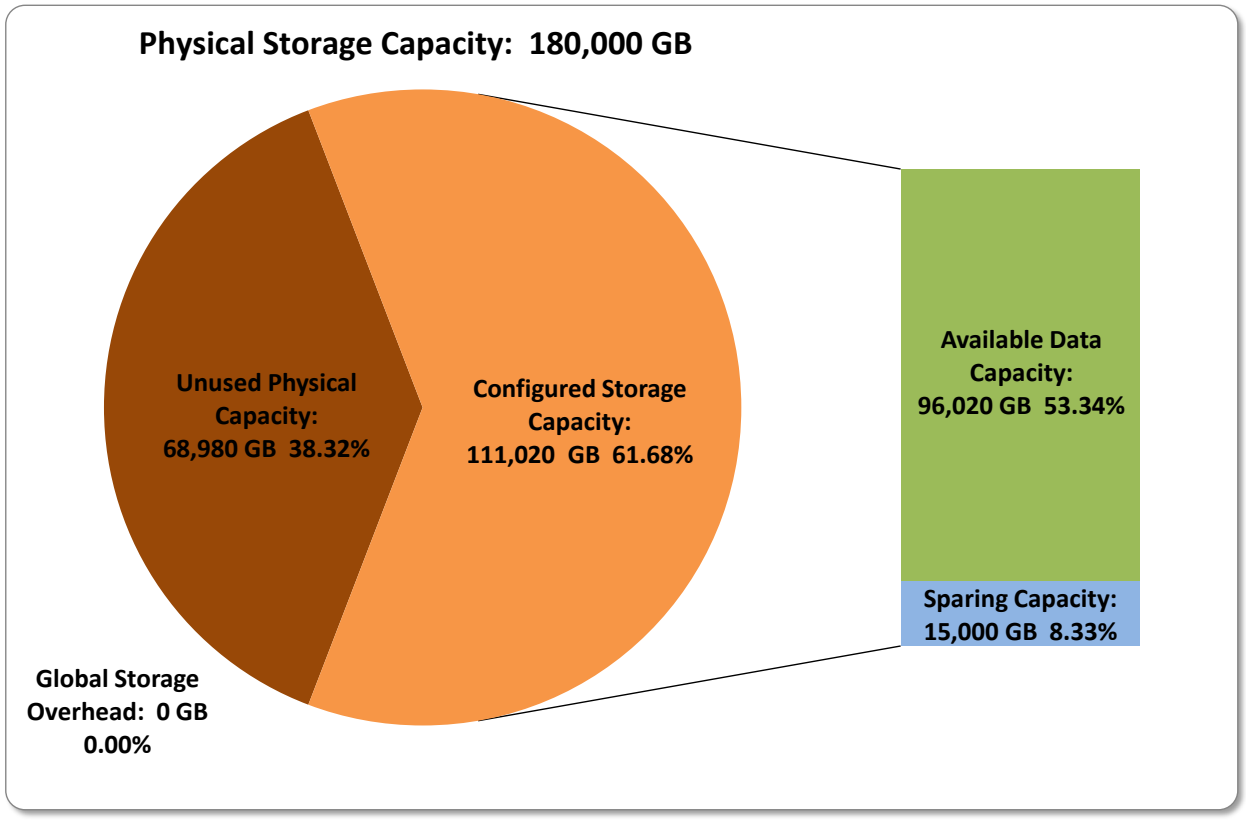
SPC-1 Storage Capacities

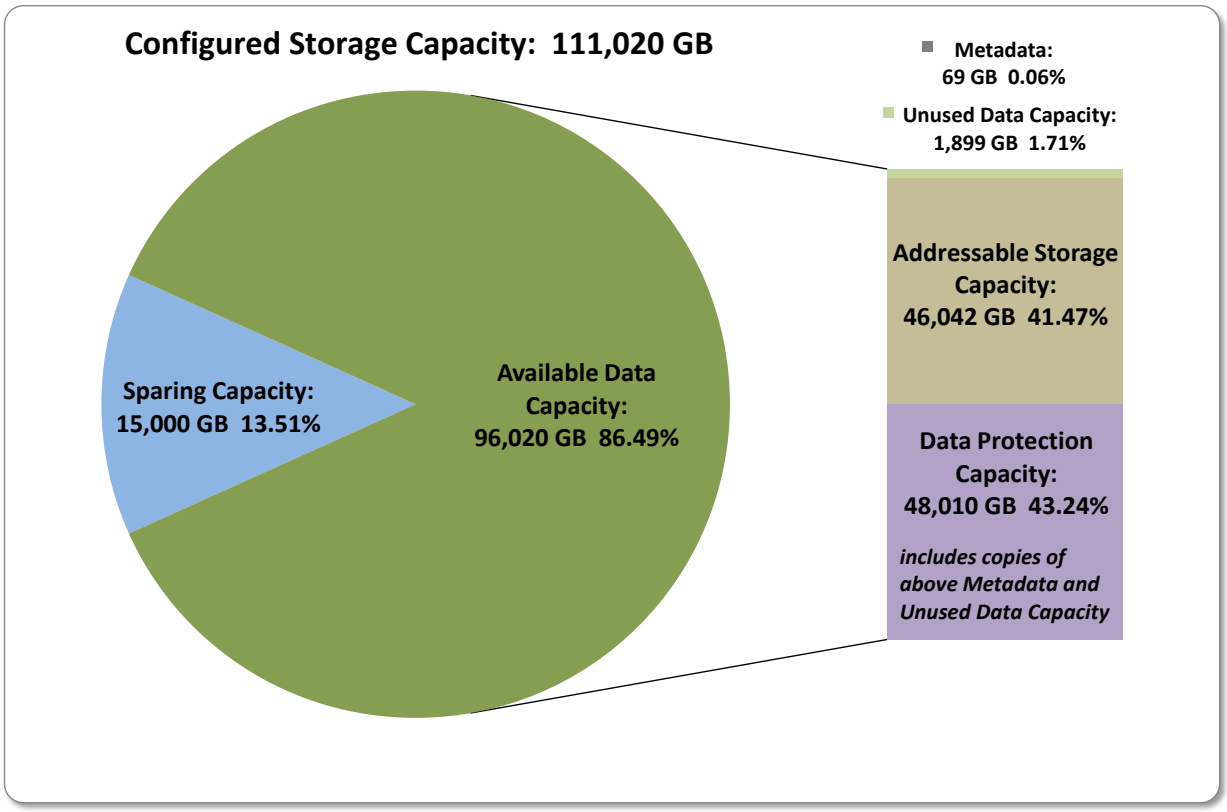
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	44,358.865
Addressable Storage Capacity	Gigabytes (GB)	46,042.049
Configured Storage Capacity	Gigabytes (GB)	111,020.000
Physical Storage Capacity *(effective)*	Gigabytes (GB)	180,000.000
Data Protection *(Mirrored)*	Gigabytes (GB)	48,010.000
Required Storage *(overhead/metadata/sparing)*	Gigabytes (GB)	15,137.439
Global Storage Overhead	Gigabytes (GB)	0.000
Total Unused Storage	Gigabytes (GB)	76,144.832

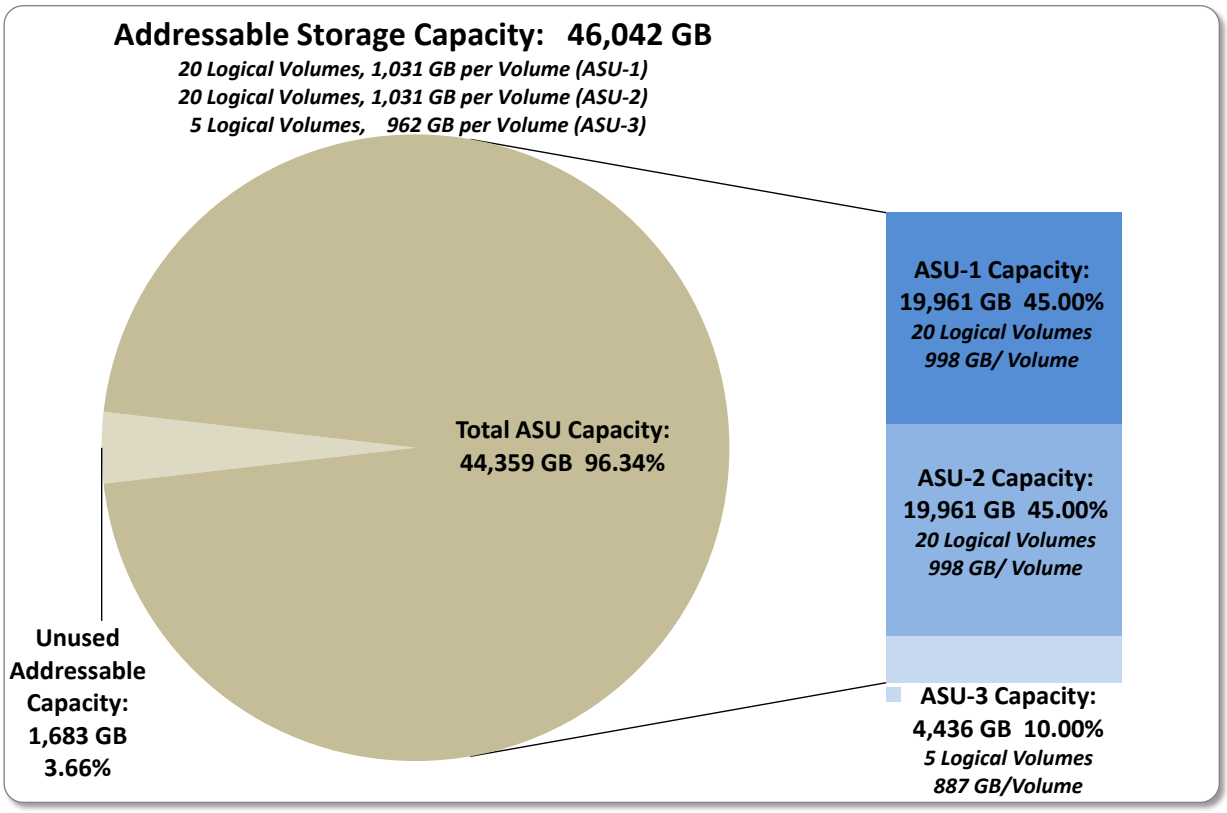
SPC-1 Storage Hierarchy Ratios

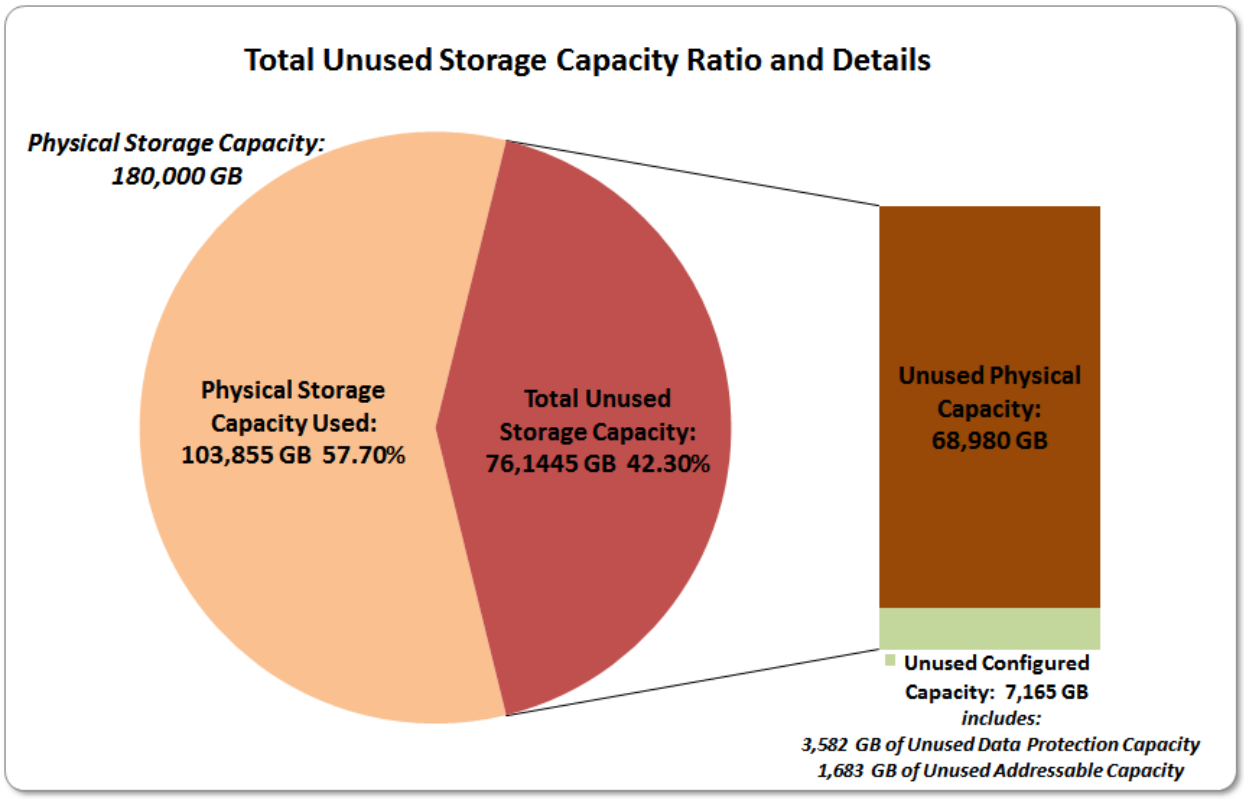
	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	96.34%	39.96%	24.64%
Required for Data Protection *(Mirrored)*		43.24%	26.67%
Addressable Storage Capacity		41.47%	25.58%
Required Storage *(overhead/metadata/sparing)*		13.63%	8.41%
Configured Storage Capacity			61.68%
Global Storage Overhead			0.00%
Unused Storage:			
Addressable	3.66%		
Configured		6.45%	
Physical			38.32%

SPC-1 Storage Capacity Charts




Configured Storage Capacity: 111,020 GB
Metadata:
69 GB 0.06%
Unused Data Capacity:
1,899 GB 1.71%
Addressable Storage Capacity:
46,042 GB 41.47%
Data Protection Capacity:
48,010 GB 43.24%
includes copies of above Metadata and Unused Data Capacity
Sparing Capacity:
15,000 GB 13.51%
Available Data Capacity:
96,020 GB 86.49%


Addressable Storage Capacity: 46,042 GB
20 Logical Volumes, 1,031 GB per Volume (ASU-1)
20 Logical Volumes, 1,031 GB per Volume (ASU-2)
5 Logical Volumes, 962 GB per Volume (ASU-3)
ASU-1 Capacity:
19,961 GB 45.00%
20 Logical Volumes
998 GB/ Volume
ASU-2 Capacity:
19,961 GB 45.00%
20 Logical Volumes
998 GB/ Volume
ASU-3 Capacity:
4,436 GB 10.00%
5 Logical Volumes
887 GB/Volume
Total ASU Capacity:
44,359 GB 96.34%
Unused Addressable Capacity:
1,683 GB
3.66%



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	26.64%
Protected Application Utilization	50.06%
Unused Storage Ratio	42.30%

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 (19,961.490 GB)	**ASU-2 (19,961.490 GB)**	**ASU-3 (4,435.885 GB)**
20 Logical Volumes 1,030.792 GB per Logical Volume (998.074 GB used per Logical Volume)	20 Logical Volumes 1,030.792 GB per Logical Volume (998.074 GB used per Logical Volume)	5 Logical Volumes 962.073 GB per Logical Volume (887.177 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was **Protected 1** using ***Mirroring*** as described on page 11. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. "SPC-1 Test Execution Definitions" on page 61 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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

SPC-1 Tests, Test Phases, and Test Runs

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

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

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

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

"Ramp-Up" Test Runs

Clause 5.3.13

In order to warm-up caches or perform the initial ASU data migration in a multi-tier configuration, a Test Sponsor may perform a series of "Ramp-Up" Test Runs as a substitute for an initial, gradual Ramp-Up.

Clause 5.3.13.3

The "Ramp-Up" Test Runs will immediately precede the Primary Metrics Test as part of the uninterrupted SPC-1 measurement sequence.

Clause 9.4.3.7.1

If a series of "Ramp-Up" Test Runs were included in the SPC-1 measurement sequence, the FDR shall report the duration (ramp-up and measurement interval), BSU level, SPC-1 IOPS and average response time for each "Ramp-Up" Test Run in an appropriate table.

The details for the three specified "Ramp-Up" Test Runs are listed below:

	BSU Level	Duration *(Minutes)*	IOPS	Response Time *(ms)*
Test Run 1	2,000	120	100,001.57	12.42
Test Run 2	2,600	120	130,005.48	2.21
Test Run 3	3,400	120	169,998.06	2.66

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

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

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.4.3.7.2

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 72.

Sustainability Test Results File

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

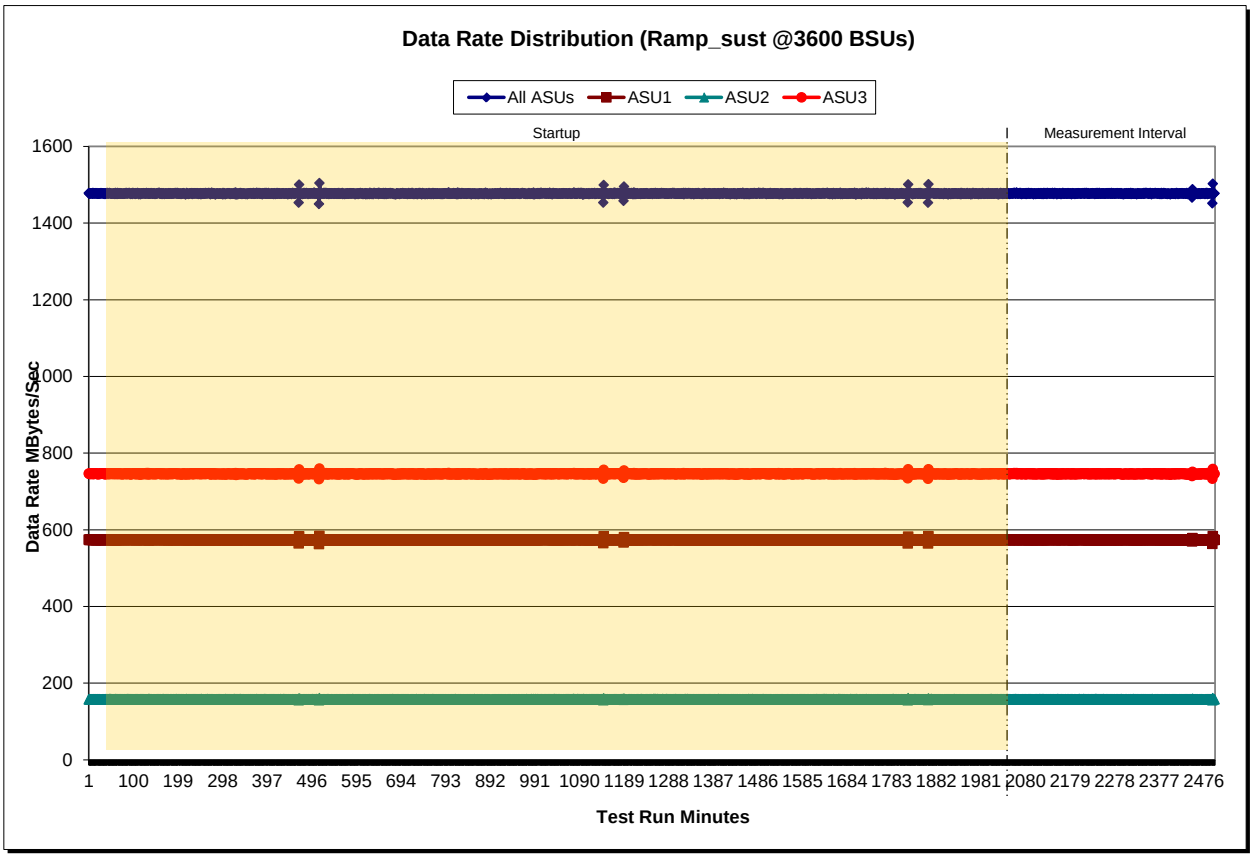
Sustainability Test Results File

Sustainability – Data Rate Distribution Data (MB/second)

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

Sustainability Data Rate Table

Sustainability – Data Rate Distribution Graph

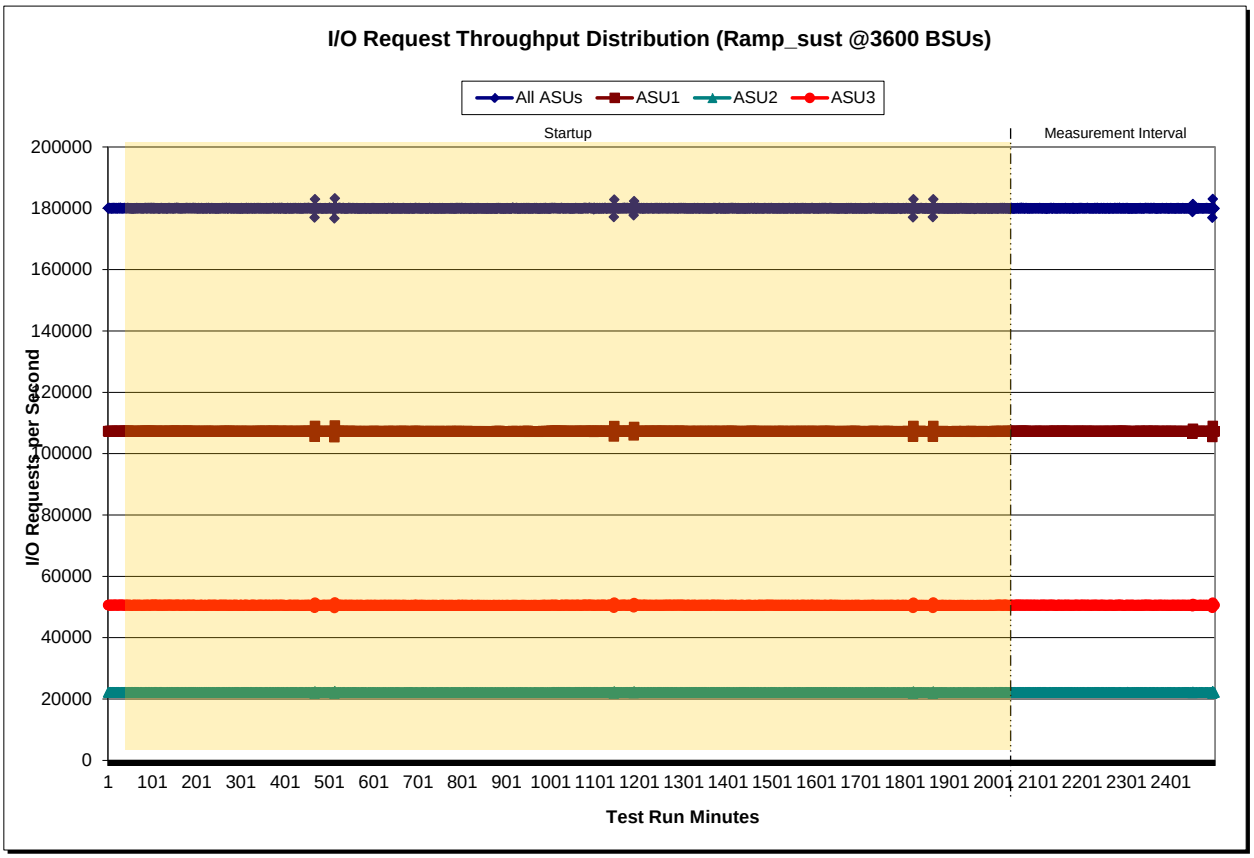


Sustainability – I/O Request Throughput Distribution Data

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

Sustainability I/O Request Throughput Table

Sustainability – I/O Request Throughput Distribution Graph

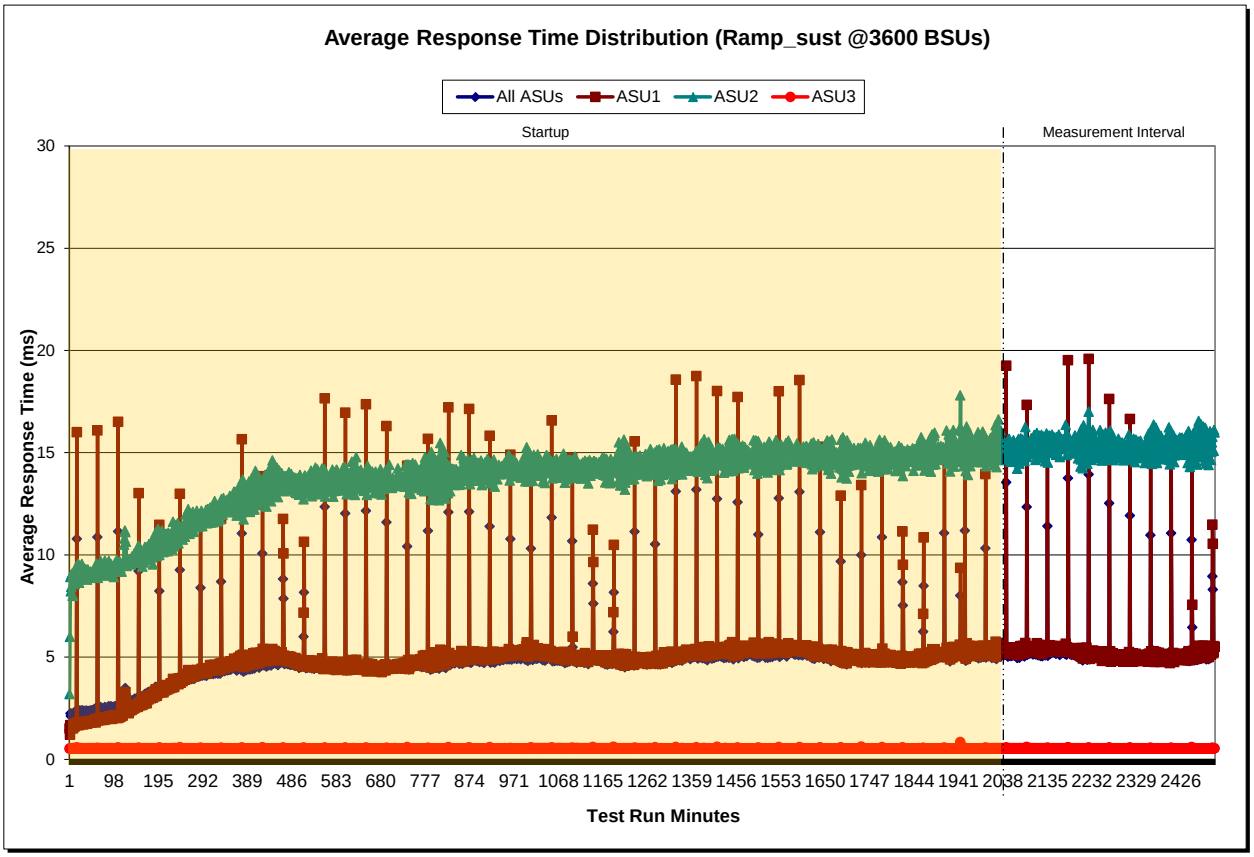


Sustainability – Average Response Time (ms) Distribution Data

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

Sustainability Average Response Time Table

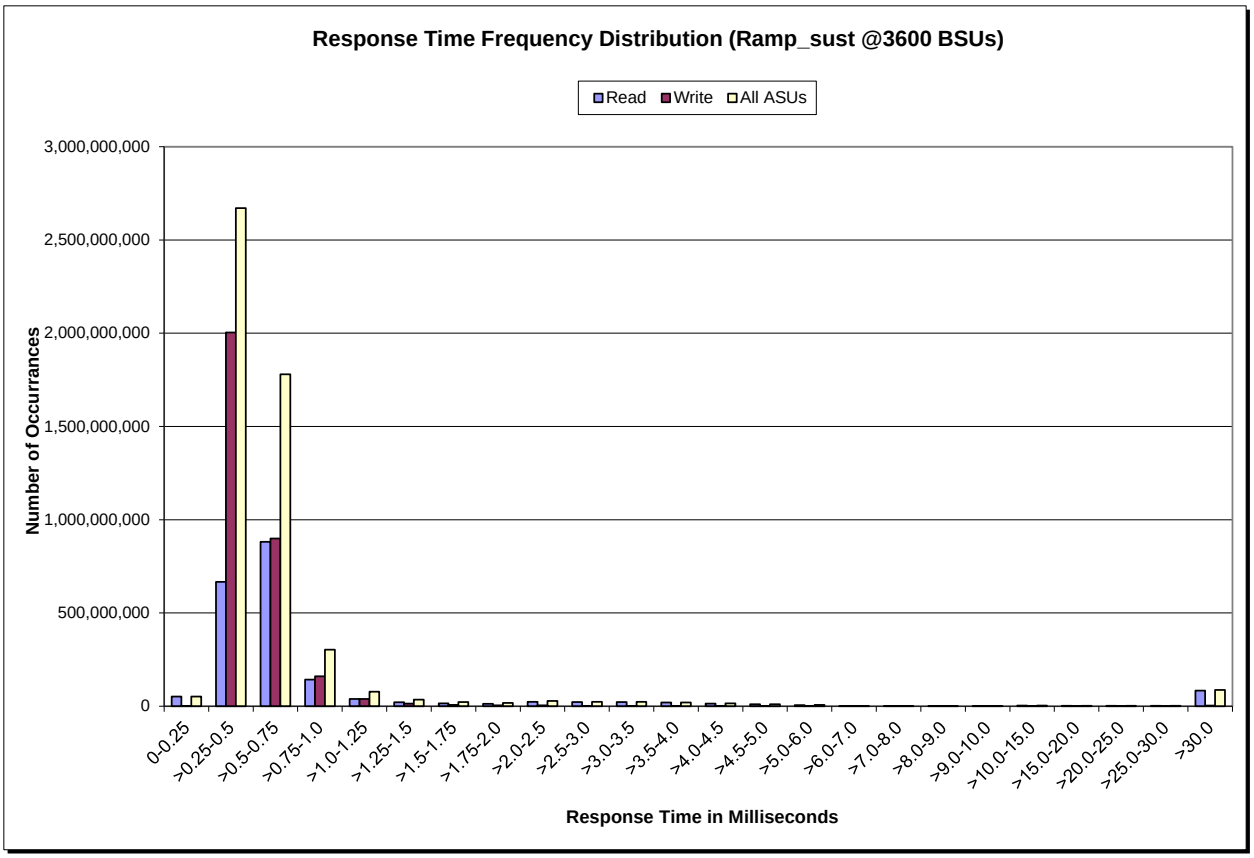
Sustainability – Average Response Time (ms) Distribution Graph



Sustainability – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	51,794,327	666,940,487	881,310,866	143,014,996	39,095,747	20,490,277	14,799,642	12,980,935
Write	5,682	2,004,229,697	898,772,057	160,572,387	38,516,264	14,293,915	7,081,912	4,623,673
All ASUs	51,800,009	2,671,170,184	1,780,082,923	303,587,383	77,612,011	34,784,192	21,881,554	17,604,608
ASU1	42,411,597	1,515,626,539	1,089,096,572	169,713,498	46,829,629	23,596,431	16,178,586	13,691,514
ASU2	9,386,308	367,257,413	170,432,238	26,419,505	7,269,110	3,418,503	2,152,855	1,743,094
ASU3	2,104	788,286,232	520,554,113	107,454,380	23,513,272	7,769,258	3,550,113	2,170,000
Response Time (ms)	**>2.0-2.5**	**>2.5-3.0**	**>3.0-3.5**	**>3.5-4.0**	**>4.0-4.5**	**>4.5-5.0**	**>5.0-6.0**	**>6.0-7.0**
Read	23,405,949	21,826,118	22,216,857	19,876,222	14,365,527	10,145,080	6,184,839	888,978
Write	4,360,113	1,306,417	583,779	327,771	207,754	140,346	181,119	119,559
All ASUs	27,766,062	23,132,535	22,800,636	20,203,993	14,573,281	10,285,426	6,365,958	1,008,537
ASU1	23,010,809	20,308,621	20,319,867	18,060,234	13,013,228	9,171,726	5,564,293	738,780
ASU2	2,701,526	2,262,115	2,259,534	2,018,436	1,476,618	1,054,958	721,803	214,939
ASU3	2,053,727	561,799	221,235	125,323	83,435	58,742	79,862	54,818
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	681,843	638,677	600,116	2,738,190	2,547,424	2,348,429	2,194,384	83,283,004
Write	78,499	53,353	41,893	110,000	61,394	62,312	63,406	3,747,148
All ASUs	760,342	692,030	642,009	2,848,190	2,608,818	2,410,741	2,257,790	87,030,152
ASU1	508,690	441,038	390,701	1,675,002	1,529,432	1,418,428	1,345,618	54,957,259
ASU2	215,876	227,522	233,623	1,132,183	1,060,070	973,407	893,424	32,055,642
ASU3	35,776	23,470	17,685	41,005	19,316	18,906	18,748	17,251

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.007	0.0350	0.2810
COV	0.002	0.000	0.0010	0.001	0.001	0.001	0.002	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 9.4.3.7.3

For the IOPS Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 72.

IOPS Test Results File

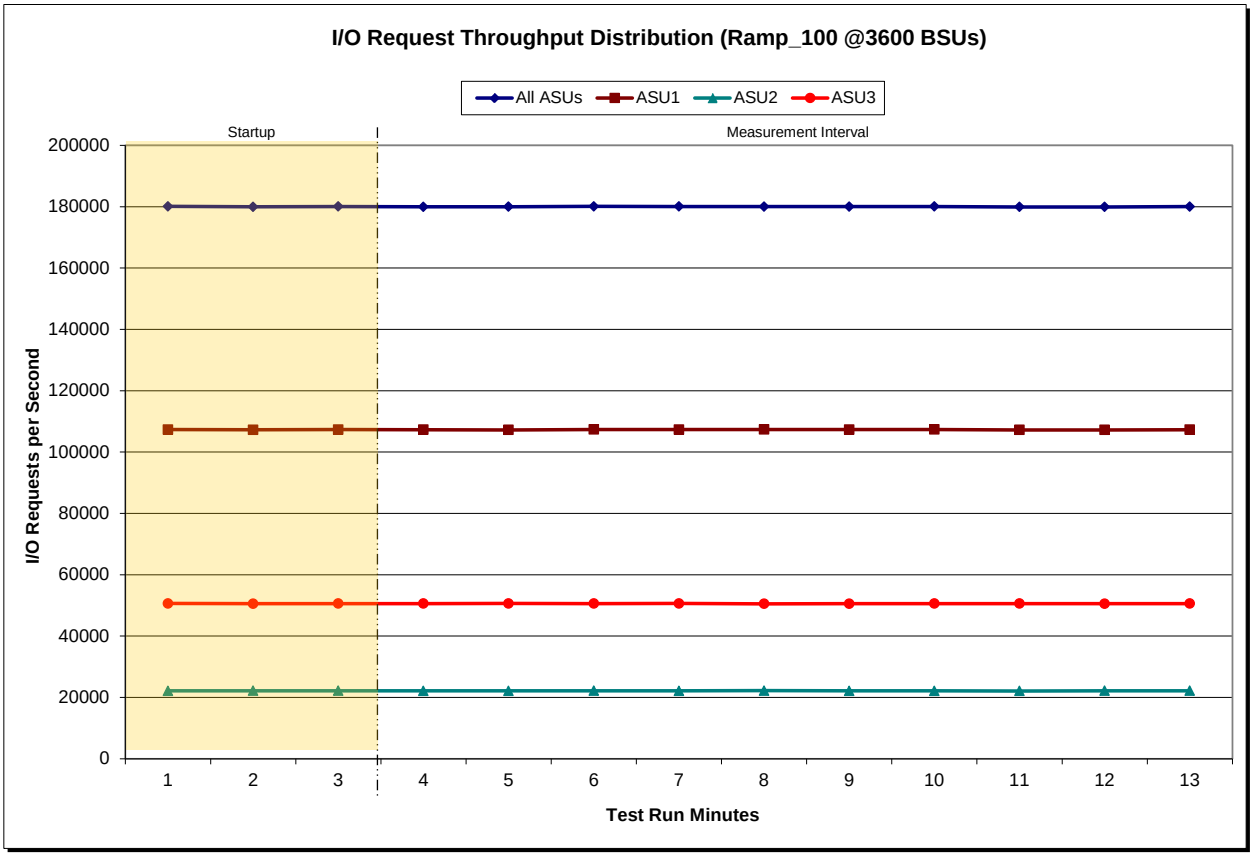
A link to the test results file generated from the IOPS Test Run is listed below.

IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

3,600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:56:36	14:59:37	0-2	0:03:01
Measurement Interval	14:59:37	15:09:37	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	180,100.12	107,340.18	22,139.85	50,620.08
1	179,980.65	107,263.98	22,148.62	50,568.05
2	180,071.52	107,317.78	22,156.62	50,597.12
3	179,967.23	107,273.85	22,118.98	50,574.40
4	179,990.17	107,213.30	22,145.07	50,631.80
5	180,095.88	107,347.58	22,163.18	50,585.12
6	180,061.60	107,313.78	22,120.13	50,627.68
7	180,046.67	107,352.60	22,188.63	50,505.43
8	180,022.73	107,311.90	22,143.23	50,567.60
9	180,083.53	107,353.20	22,126.20	50,604.13
10	179,933.85	107,223.52	22,109.47	50,600.87
11	179,946.90	107,236.05	22,153.98	50,556.87
12	180,054.35	107,301.58	22,164.03	50,588.73
Average	***180,020.29***	***107,292.74***	***22,143.29***	***50,584.26***

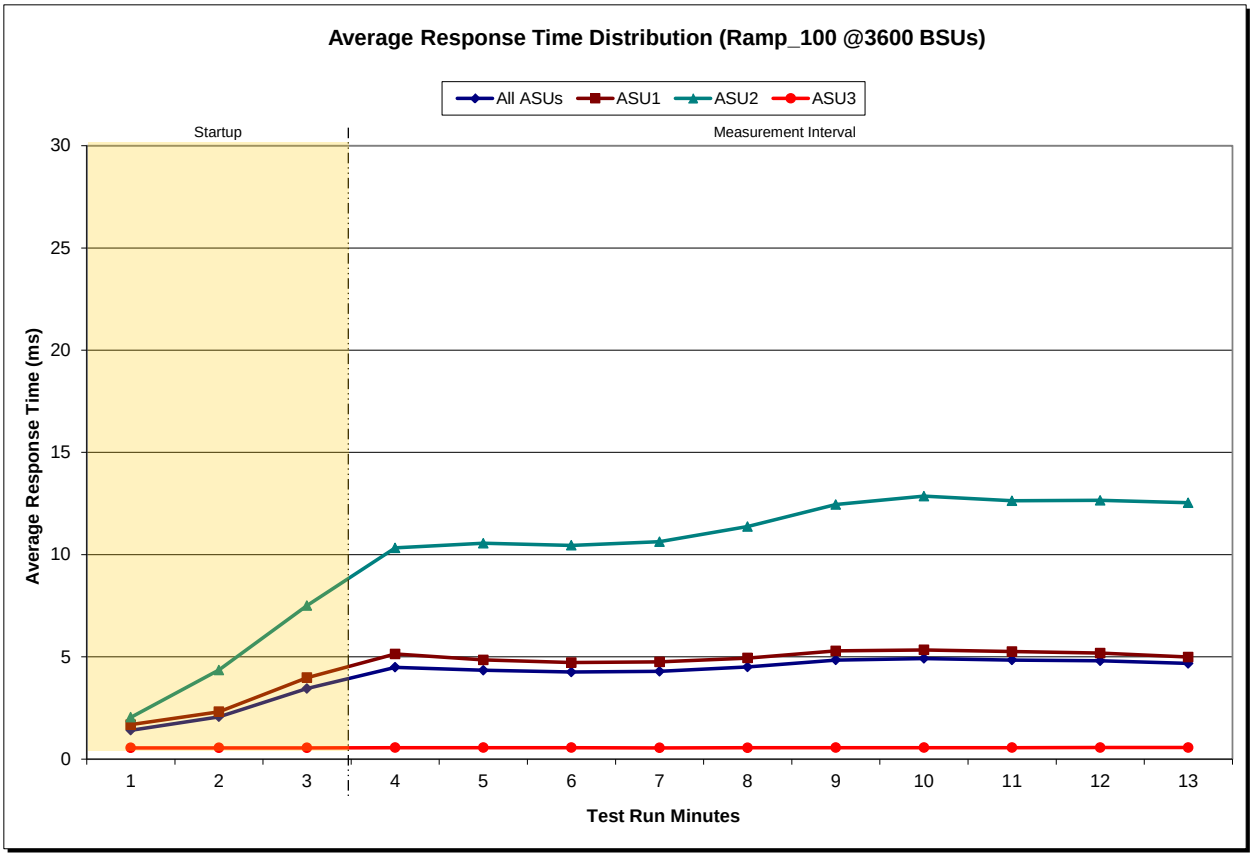
IOPS Test Run – I/O Request Throughput Distribution Graph



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

3,600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:56:36	14:59:37	0-2	0:03:01
Measurement Interval	14:59:37	15:09:37	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.41	1.68	2.04	0.55
1	2.07	2.31	4.35	0.54
2	3.45	3.98	7.51	0.55
3	4.49	5.14	10.33	0.56
4	4.34	4.85	10.56	0.56
5	4.25	4.72	10.45	0.56
6	4.29	4.75	10.63	0.55
7	4.50	4.94	11.38	0.55
8	4.84	5.29	12.45	0.56
9	4.92	5.34	12.86	0.56
10	4.84	5.26	12.63	0.56
11	4.81	5.18	12.65	0.56
12	4.67	4.99	12.54	0.56
Average	***4.60***	***5.05***	***11.65***	***0.56***

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



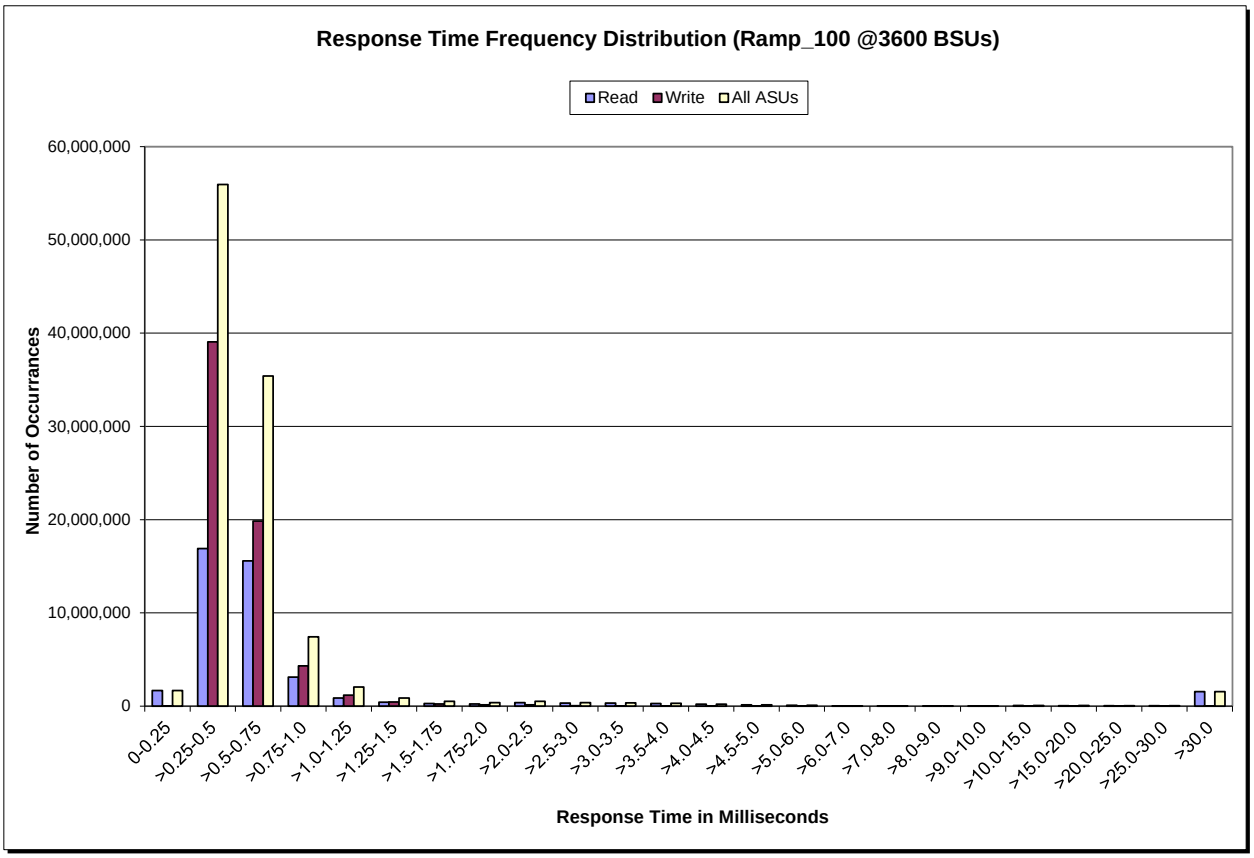
IOPS Test Run – Response Time Frequency Distribution Data

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	1,669,641	16,891,404	15,569,262	3,105,712	876,678	427,054	281,013	226,564
Write	161	39,053,050	19,844,783	4,316,443	1,164,847	450,312	223,963	138,365
All ASUs	1,669,802	55,944,454	35,414,045	7,422,155	2,041,525	877,366	504,976	364,929
ASU1	1,471,659	33,261,413	20,580,672	3,957,491	1,131,944	539,169	338,990	260,881
ASU2	198,093	7,341,067	3,785,486	722,511	203,567	91,287	53,502	39,356
ASU3	50	15,341,974	11,047,887	2,742,153	706,014	246,910	112,484	64,692

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	372,875	325,890	322,256	282,007	202,719	143,431	89,882	15,957
Write	131,516	44,062	17,697	9,487	4,681	3,143	2,767	1,435
All ASUs	504,391	369,952	339,953	291,494	207,400	146,574	92,649	17,392
ASU1	390,909	312,304	294,667	254,067	180,508	127,565	79,212	13,065
ASU2	54,678	41,635	40,350	35,305	25,678	18,219	12,441	3,731
ASU3	58,804	16,013	4,936	2,122	1,214	790	996	596

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	13,514	12,949	12,570	57,971	53,936	49,331	44,870	1,550,921
Write	815	703	610	1,345	773	855	781	275
All ASUs	14,329	13,652	13,180	59,316	54,709	50,186	45,651	1,551,196
ASU1	10,039	9,162	8,634	38,248	35,449	32,314	29,418	1,017,297
ASU2	3,892	4,171	4,243	20,448	18,904	17,468	15,869	533,764
ASU3	398	319	303	620	356	404	364	135

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
108,011,276	106,460,080	1,551,196

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.001	0.003	0.001	0.001	0.001

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.4.3

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

The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 15.

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 9.4.3.7.4

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 72.

Response Time Ramp Test Results File

A link to each test result file generated from each Response Time Ramp Test Run list listed below.

95% Load Level

90% Load Level

80% Load Level

50% Load Level

10% Load Level

Response Time Ramp Distribution (IOPS) Data

The five Test Runs that comprise the Response Time Ramp Phase are executed at 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit (BSU) load level used to produce the SPC-1 IOPS™ primary metric. The 100% BSU load level is included in the following Response Time Ramp data tables and graphs for completeness.

100% Load Level - 3,600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	14:56:36	14:59:37	0-2	0:03:01
Measurement Interval	14:59:37	15:09:37	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	180,100.12	107,340.18	22,139.85	50,620.08
1	179,980.65	107,263.98	22,148.62	50,568.05
2	180,071.52	107,317.78	22,156.62	50,597.12
3	179,967.23	107,273.85	22,118.98	50,574.40
4	179,990.17	107,213.30	22,145.07	50,631.80
5	180,095.88	107,347.58	22,163.18	50,585.12
6	180,061.60	107,313.78	22,120.13	50,627.68
7	180,046.67	107,352.60	22,188.63	50,505.43
8	180,022.73	107,311.90	22,143.23	50,567.60
9	180,083.53	107,353.20	22,126.20	50,604.13
10	179,933.85	107,223.52	22,109.47	50,600.87
11	179,946.90	107,236.05	22,153.98	50,556.87
12	180,054.35	107,301.58	22,164.03	50,588.73
Average	***180,020.29***	***107,292.74***	***22,143.29***	***50,584.26***

95% Load Level - 3,420 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:10:28	15:13:29	0-2	0:03:01
Measurement Interval	15:13:29	15:23:29	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	171,192.13	102,049.63	21,040.57	48,101.93
1	170,954.07	101,923.88	21,012.68	48,017.50
2	170,961.95	101,868.78	21,015.95	48,077.22
3	171,098.02	101,966.17	21,035.83	48,096.02
4	171,021.25	101,907.05	21,018.62	48,095.58
5	171,053.97	101,911.27	21,071.18	48,071.52
6	171,084.00	101,919.60	21,003.97	48,160.43
7	171,088.33	101,993.85	21,026.52	48,067.97
8	170,960.15	101,911.77	21,014.75	48,033.63
9	170,952.38	101,912.45	21,031.27	48,008.67
10	170,919.58	101,885.27	21,002.87	48,031.45
11	171,053.48	102,002.40	21,020.60	48,030.48
12	171,073.10	101,950.35	21,021.57	48,101.18
Average	***171,030.43***	***101,936.02***	***21,024.72***	***48,069.69***

90% Load Level - 3,240 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:24:19	15:27:20	0-2	0:03:01
Measurement Interval	15:27:20	15:37:20	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	162,213.48	96,662.52	19,982.73	45,568.23
1	162,040.83	96,558.92	19,932.08	45,549.83
2	161,967.35	96,476.95	19,892.25	45,598.15
3	162,008.22	96,532.73	19,931.75	45,543.73
4	161,985.48	96,549.45	19,922.58	45,513.45
5	162,070.95	96,587.87	19,951.08	45,532.00
6	158,759.17	94,607.95	19,521.98	44,629.23
7	165,185.00	98,446.40	20,314.67	46,423.93
8	161,989.13	96,558.40	19,931.77	45,498.97
9	161,900.77	96,458.13	19,958.38	45,484.25
10	161,947.30	96,518.88	19,916.65	45,511.77
11	162,002.17	96,536.88	19,929.35	45,535.93
12	162,025.98	96,566.60	19,941.27	45,518.12
Average	***161,987.42***	***96,536.33***	***19,931.95***	***45,519.14***

80% Load Level - 2,880 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:38:08	15:41:09	0-2	0:03:01
Measurement Interval	15:41:09	15:51:09	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	144,204.38	85,938.52	17,718.50	40,547.37
1	144,115.88	85,911.77	17,721.50	40,482.62
2	144,019.18	85,823.97	17,709.15	40,486.07
3	143,967.70	85,793.53	17,713.78	40,460.38
4	144,082.48	85,867.40	17,719.87	40,495.22
5	143,997.75	85,839.83	17,723.05	40,434.87
6	144,019.08	85,821.27	17,712.48	40,485.33
7	144,050.60	85,836.87	17,734.17	40,479.57
8	144,021.15	85,802.52	17,737.47	40,481.17
9	143,943.28	85,785.62	17,715.12	40,442.55
10	143,986.88	85,800.95	17,733.98	40,451.95
11	143,911.42	85,771.47	17,709.28	40,430.67
12	143,954.23	85,813.07	17,680.90	40,460.27
Average	***143,993.46***	***85,813.25***	***17,718.01***	***40,462.20***

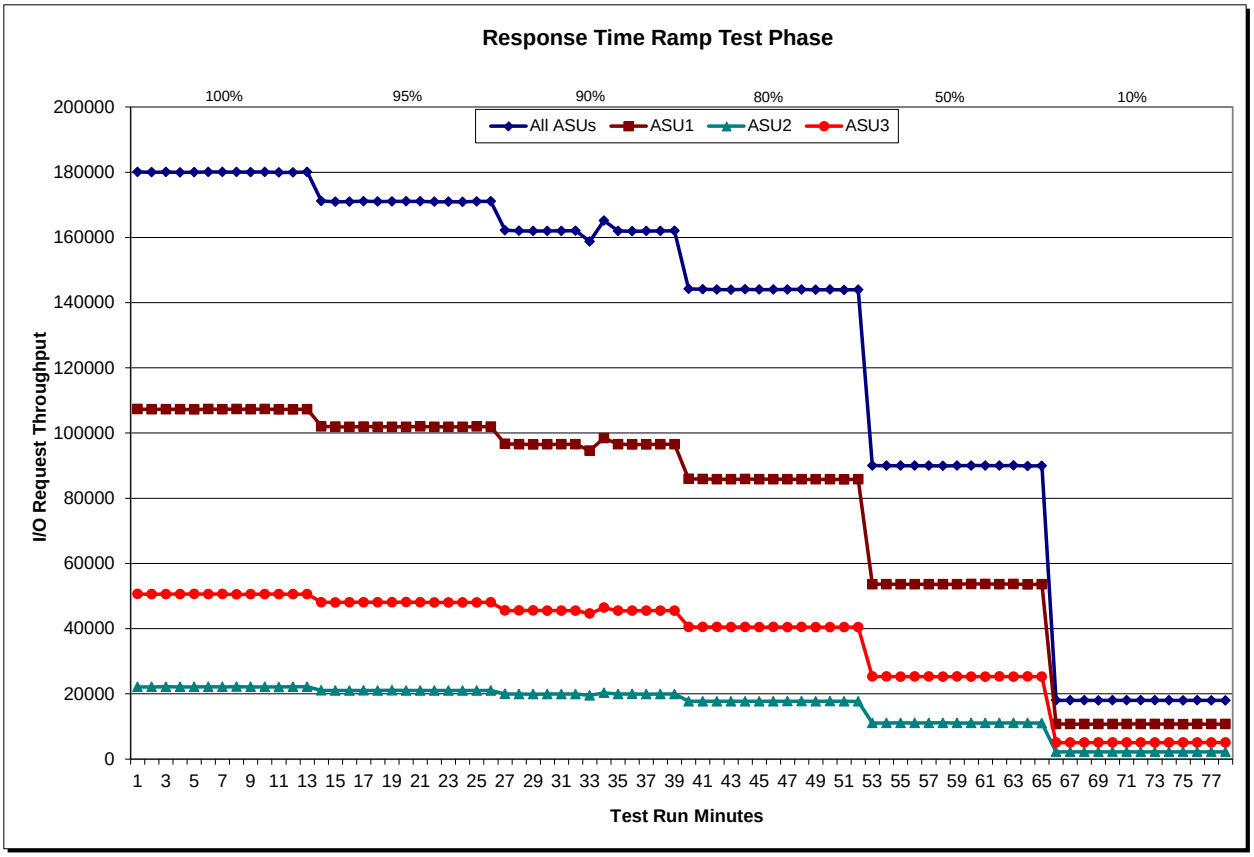
50% Load Level - 1,800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	15:51:50	15:54:51	0-2	0:03:01
Measurement Interval	15:54:51	16:04:51	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	90,020.15	53,641.55	11,069.90	25,308.70
1	89,986.17	53,639.52	11,044.37	25,302.28
2	89,975.45	53,611.75	11,092.67	25,271.03
3	90,002.12	53,623.60	11,073.32	25,305.20
4	89,988.82	53,611.93	11,079.87	25,297.02
5	89,937.43	53,611.40	11,085.80	25,240.23
6	89,976.63	53,618.95	11,058.77	25,298.92
7	90,031.80	53,707.20	11,066.00	25,258.60
8	90,036.28	53,683.07	11,073.02	25,280.20
9	89,984.38	53,630.68	11,055.93	25,297.77
10	90,045.97	53,695.62	11,078.70	25,271.65
11	89,897.38	53,530.82	11,061.13	25,305.43
12	89,940.82	53,617.15	11,039.92	25,283.75
Average	***89,984.16***	***53,633.04***	***11,067.25***	***25,283.88***

10% Load Level - 360 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:05:25	16:08:26	0-2	0:03:01
Measurement Interval	16:08:26	16:18:26	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	18,001.02	10,739.88	2,214.92	5,046.22
1	17,997.72	10,720.87	2,210.70	5,066.15
2	18,005.53	10,731.90	2,216.75	5,056.88
3	17,966.47	10,704.67	2,213.03	5,048.77
4	18,004.72	10,731.38	2,198.03	5,075.30
5	18,009.22	10,741.40	2,208.70	5,059.12
6	18,009.30	10,751.27	2,207.60	5,050.43
7	18,002.78	10,723.05	2,216.07	5,063.67
8	18,020.58	10,745.43	2,214.50	5,060.65
9	17,976.12	10,701.30	2,214.60	5,060.22
10	18,003.07	10,727.65	2,216.55	5,058.87
11	17,983.07	10,706.25	2,208.70	5,068.12
12	17,981.23	10,723.88	2,208.38	5,048.97
Average	***17,995.66***	***10,725.63***	***2,210.62***	***5,059.41***

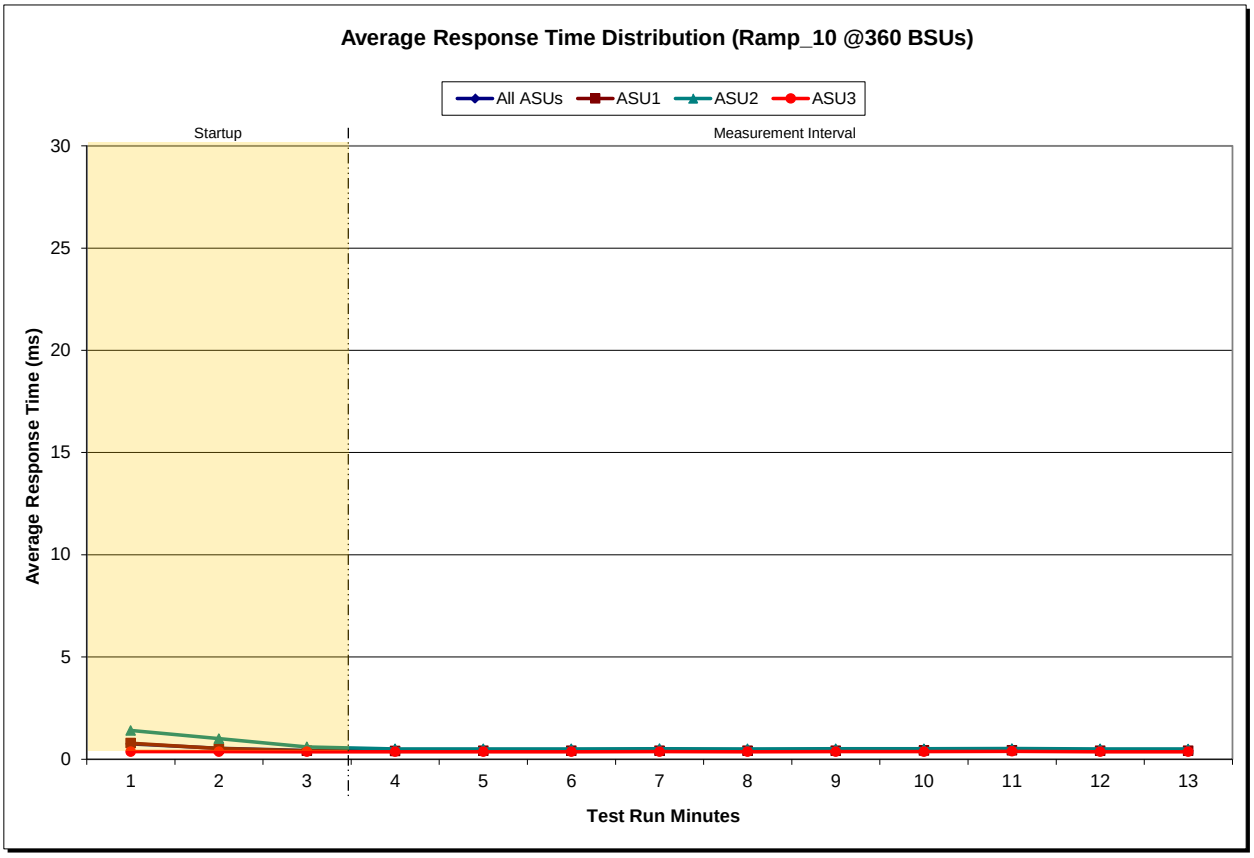
Response Time Ramp Distribution (IOPS) Graph



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

360 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:05:25	16:08:26	0-2	0:03:01
Measurement Interval	16:08:26	16:18:26	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.74	0.78	1.40	0.37
1	0.54	0.52	1.00	0.37
2	0.42	0.41	0.60	0.37
3	0.40	0.40	0.50	0.37
4	0.41	0.41	0.50	0.37
5	0.41	0.41	0.50	0.37
6	0.41	0.41	0.51	0.37
7	0.41	0.40	0.50	0.37
8	0.41	0.41	0.51	0.37
9	0.41	0.42	0.51	0.37
10	0.43	0.43	0.52	0.39
11	0.41	0.41	0.50	0.37
12	0.41	0.41	0.50	0.37
Average	***0.41***	***0.41***	***0.51***	***0.37***

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0349	0.2811	0.0699	0.2101	0.0179	0.0700	0.0350	0.2811
COV	0.004	0.001	0.003	0.002	0.007	0.004	0.006	0.002

Repeatability Test

Clause 5.4.5

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

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

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

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

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

Clause 9.4.3.7.5

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 72.

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	***180,020.29***
Repeatability Test Phase 1	180,005.68
Repeatability Test Phase 2	180,020.97

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	***0.41 ms***
Repeatability Test Phase 1	0.42 ms
Repeatability Test Phase 2	0.41 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).

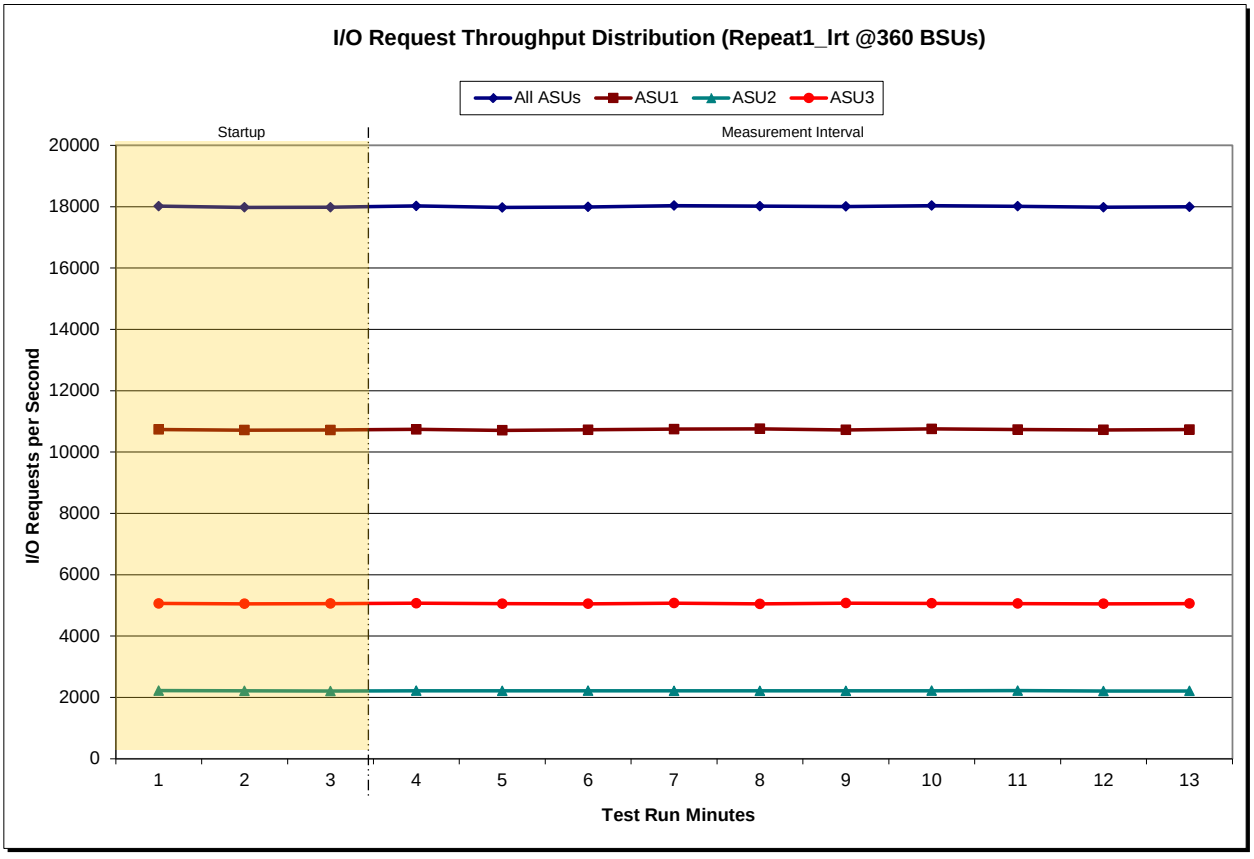
A link to the test result file generated from each Repeatability Test Run is listed below.

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

360 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:19:28	16:22:28	0-2	0:03:00
Measurement Interval	16:22:28	16:32:28	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	18,016.60	10,734.82	2,220.95	5,060.83
1	17,978.42	10,714.87	2,213.72	5,049.83
2	17,982.32	10,716.57	2,206.43	5,059.32
3	18,025.60	10,738.77	2,215.58	5,071.25
4	17,975.95	10,709.30	2,212.75	5,053.90
5	17,992.72	10,723.83	2,216.20	5,052.68
6	18,035.45	10,747.83	2,213.90	5,073.72
7	18,017.33	10,758.32	2,211.32	5,047.70
8	18,007.95	10,721.30	2,212.92	5,073.73
9	18,035.03	10,752.67	2,217.00	5,065.37
10	18,013.33	10,732.60	2,221.37	5,059.37
11	17,982.02	10,721.92	2,206.78	5,053.32
12	17,998.22	10,731.17	2,208.53	5,058.52
Average	***18,008.36***	***10,733.77***	***2,213.64***	***5,060.96***

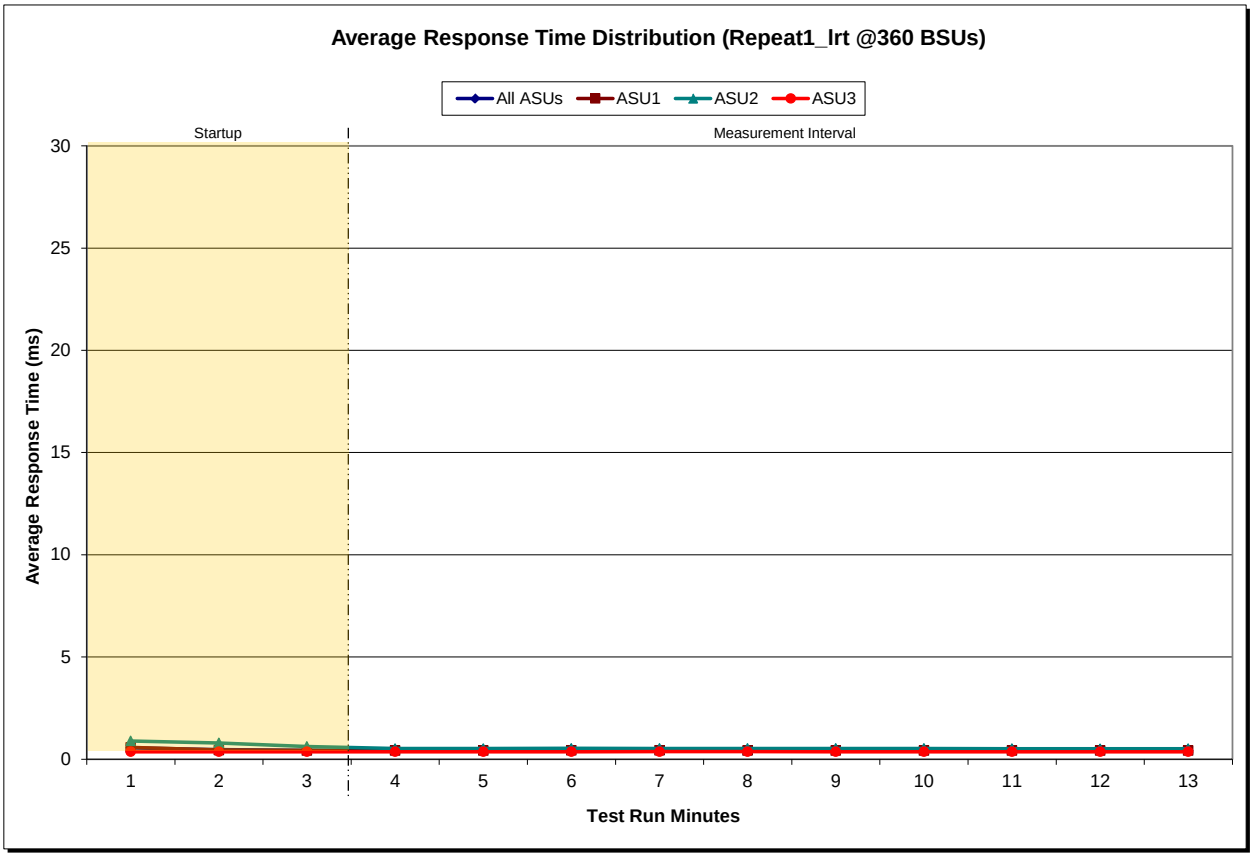
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

360 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:19:28	16:22:28	0-2	0:03:00
Measurement Interval	16:22:28	16:32:28	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.55	0.57	0.89	0.36
1	0.46	0.44	0.79	0.36
2	0.43	0.42	0.62	0.36
3	0.42	0.42	0.52	0.36
4	0.42	0.42	0.52	0.36
5	0.43	0.43	0.53	0.36
6	0.43	0.43	0.53	0.37
7	0.42	0.42	0.53	0.37
8	0.42	0.42	0.53	0.36
9	0.42	0.42	0.53	0.36
10	0.42	0.42	0.51	0.36
11	0.41	0.42	0.51	0.36
12	0.41	0.42	0.51	0.36
Average	***0.42***	***0.42***	***0.52***	***0.36***

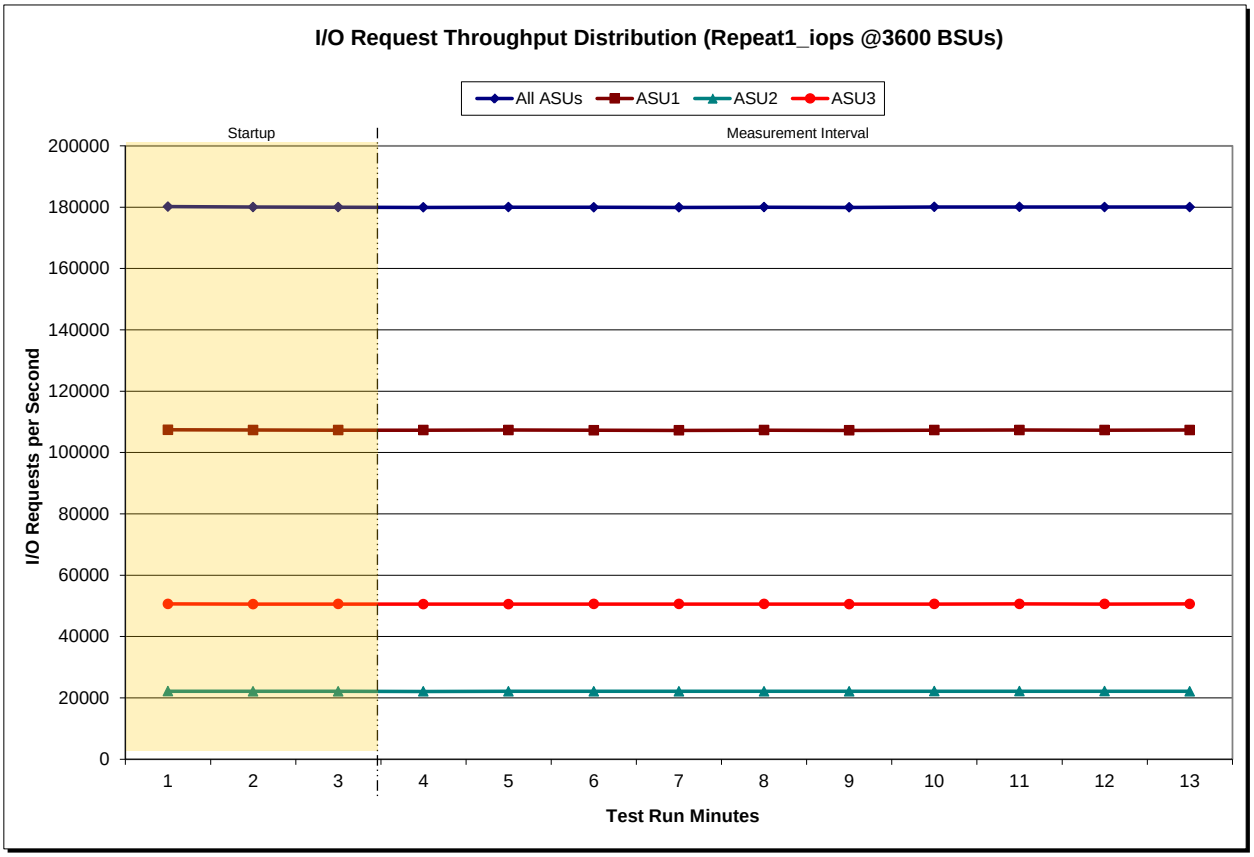
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

3600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:33:21	16:36:22	0-2	0:03:01
Measurement Interval	16:36:22	16:46:22	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	180,185.38	107,394.98	22,153.63	50,636.77
1	180,035.50	107,339.27	22,141.17	50,555.07
2	180,012.98	107,304.73	22,132.50	50,575.75
3	179,945.92	107,280.00	22,099.20	50,566.72
4	180,000.50	107,309.33	22,145.52	50,545.65
5	179,979.90	107,253.87	22,136.38	50,589.65
6	179,944.78	107,215.62	22,132.52	50,596.65
7	180,017.50	107,275.93	22,143.70	50,597.87
8	179,919.32	107,220.37	22,130.10	50,568.85
9	180,063.78	107,308.72	22,173.97	50,581.10
10	180,089.50	107,312.33	22,168.45	50,608.72
11	180,045.57	107,297.88	22,156.28	50,591.40
12	180,050.07	107,317.92	22,121.02	50,611.13
Average	***180,005.68***	***107,279.20***	***22,140.71***	***50,585.77***

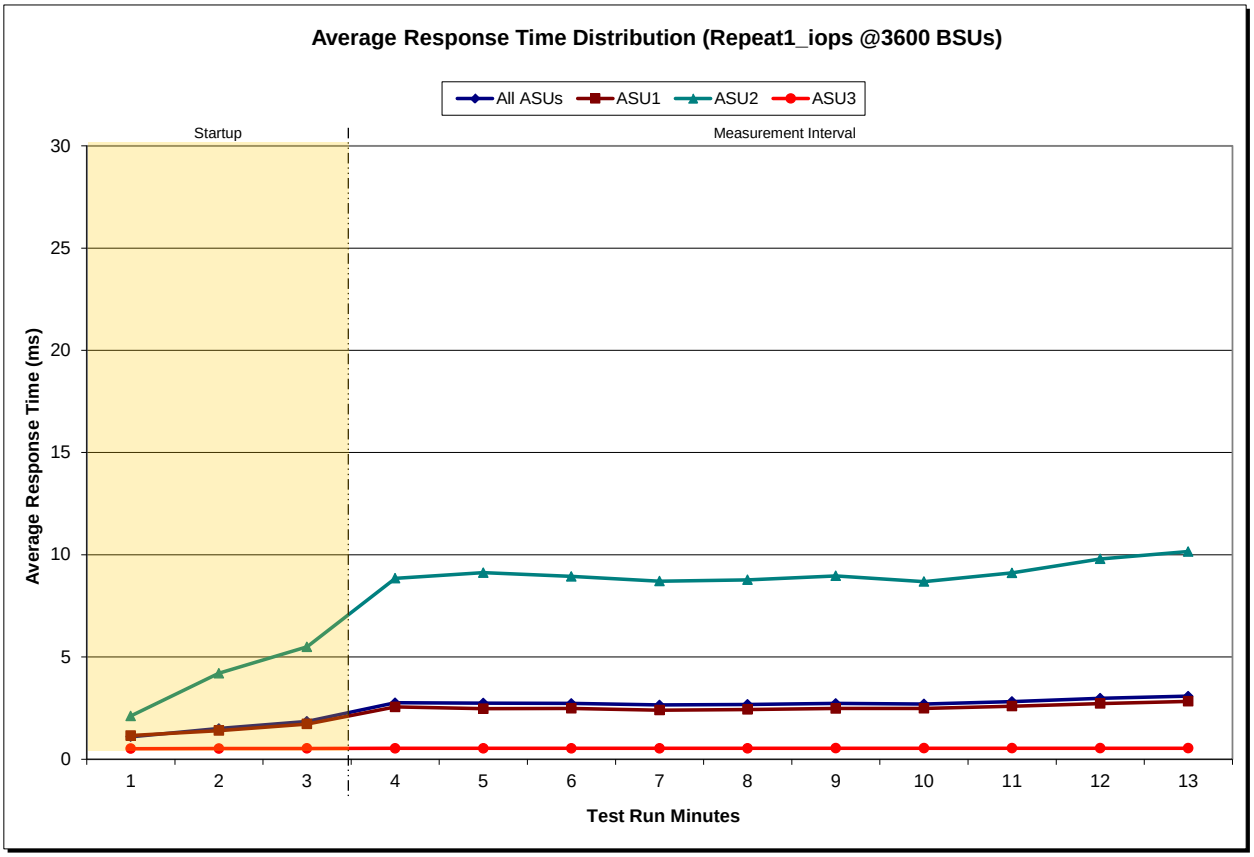
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

3600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:33:21	16:36:22	0-2	0:03:01
Measurement Interval	16:36:22	16:46:22	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.09	1.16	2.11	0.51
1	1.50	1.40	4.20	0.52
2	1.85	1.72	5.49	0.52
3	2.76	2.55	8.85	0.53
4	2.74	2.47	9.12	0.53
5	2.73	2.48	8.94	0.53
6	2.65	2.40	8.71	0.53
7	2.68	2.43	8.77	0.53
8	2.73	2.48	8.96	0.53
9	2.70	2.48	8.69	0.54
10	2.82	2.59	9.11	0.54
11	2.98	2.72	9.79	0.54
12	3.08	2.83	10.16	0.54
Average	***2.79***	***2.54***	***9.11***	***0.53***

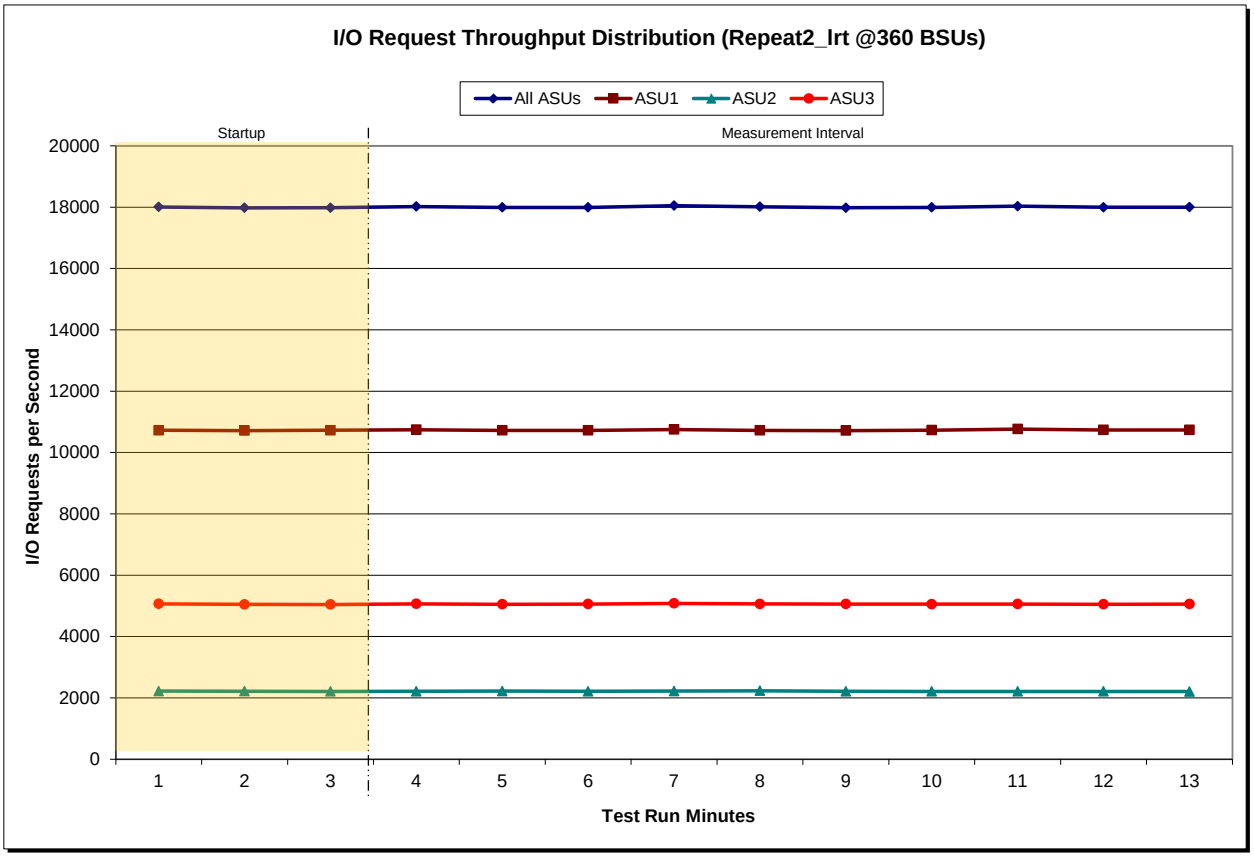
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

3600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:47:25	16:50:25	0-2	0:03:00
Measurement Interval	16:50:25	17:00:25	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	18,008.02	10,724.85	2,218.35	5,064.82
1	17,979.03	10,713.52	2,215.83	5,049.68
2	17,982.02	10,726.68	2,210.95	5,044.38
3	18,021.88	10,742.25	2,214.35	5,065.28
4	17,993.48	10,721.62	2,220.80	5,051.07
5	17,992.33	10,721.18	2,213.62	5,057.53
6	18,051.77	10,751.50	2,220.23	5,080.03
7	18,014.45	10,722.00	2,230.37	5,062.08
8	17,983.27	10,713.07	2,211.82	5,058.38
9	17,992.95	10,729.82	2,208.62	5,054.52
10	18,033.18	10,765.62	2,209.35	5,058.22
11	17,996.35	10,734.80	2,209.32	5,052.23
12	18,001.40	10,737.23	2,205.57	5,058.60
Average	***18,008.11***	***10,733.91***	***2,214.40***	***5,059.80***

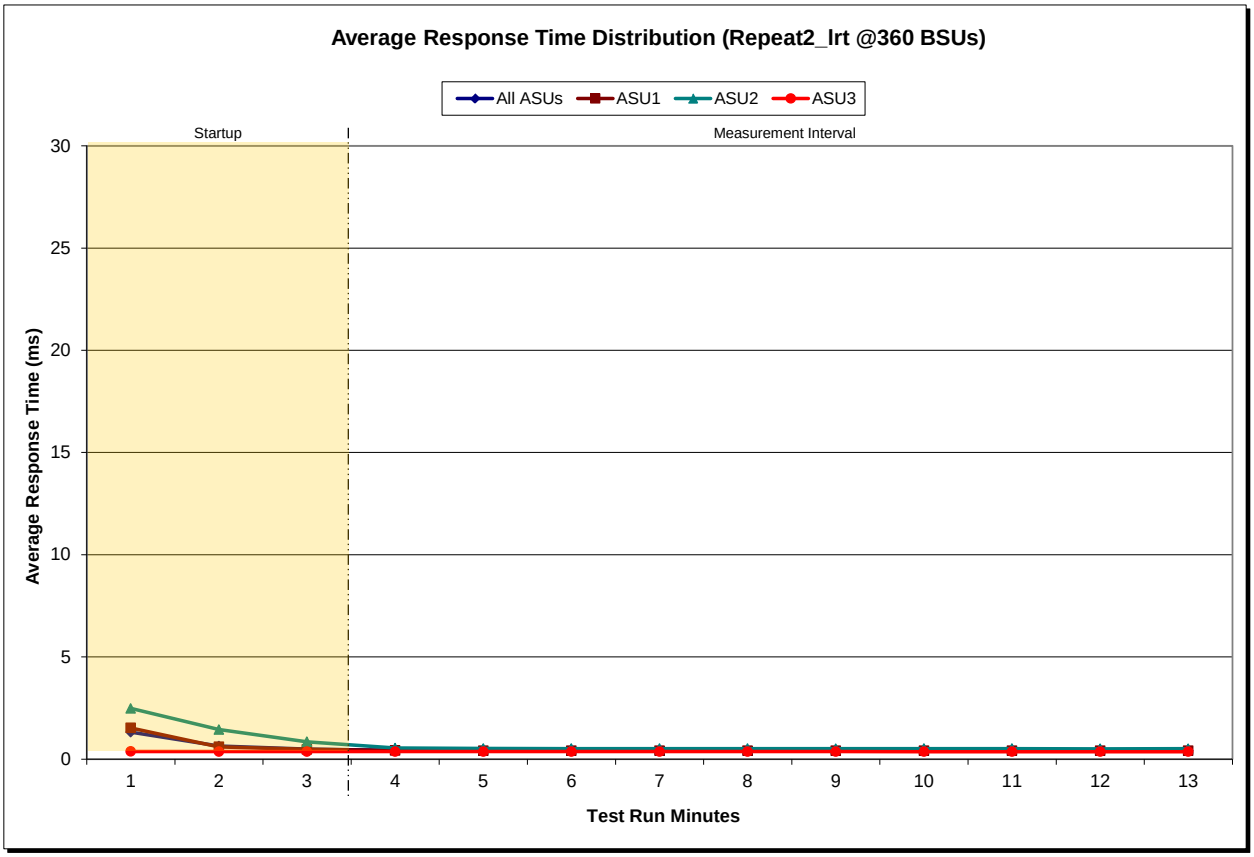
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

3600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:47:25	16:50:25	0-2	0:03:00
Measurement Interval	16:50:25	17:00:25	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.32	1.52	2.48	0.37
1	0.64	0.60	1.45	0.37
2	0.49	0.48	0.85	0.37
3	0.42	0.42	0.54	0.37
4	0.41	0.41	0.52	0.37
5	0.41	0.41	0.52	0.37
6	0.41	0.41	0.52	0.37
7	0.41	0.41	0.51	0.37
8	0.41	0.41	0.51	0.37
9	0.41	0.40	0.51	0.37
10	0.41	0.41	0.52	0.37
11	0.41	0.41	0.51	0.37
12	0.41	0.41	0.51	0.37
Average	***0.41***	***0.41***	***0.52***	***0.37***

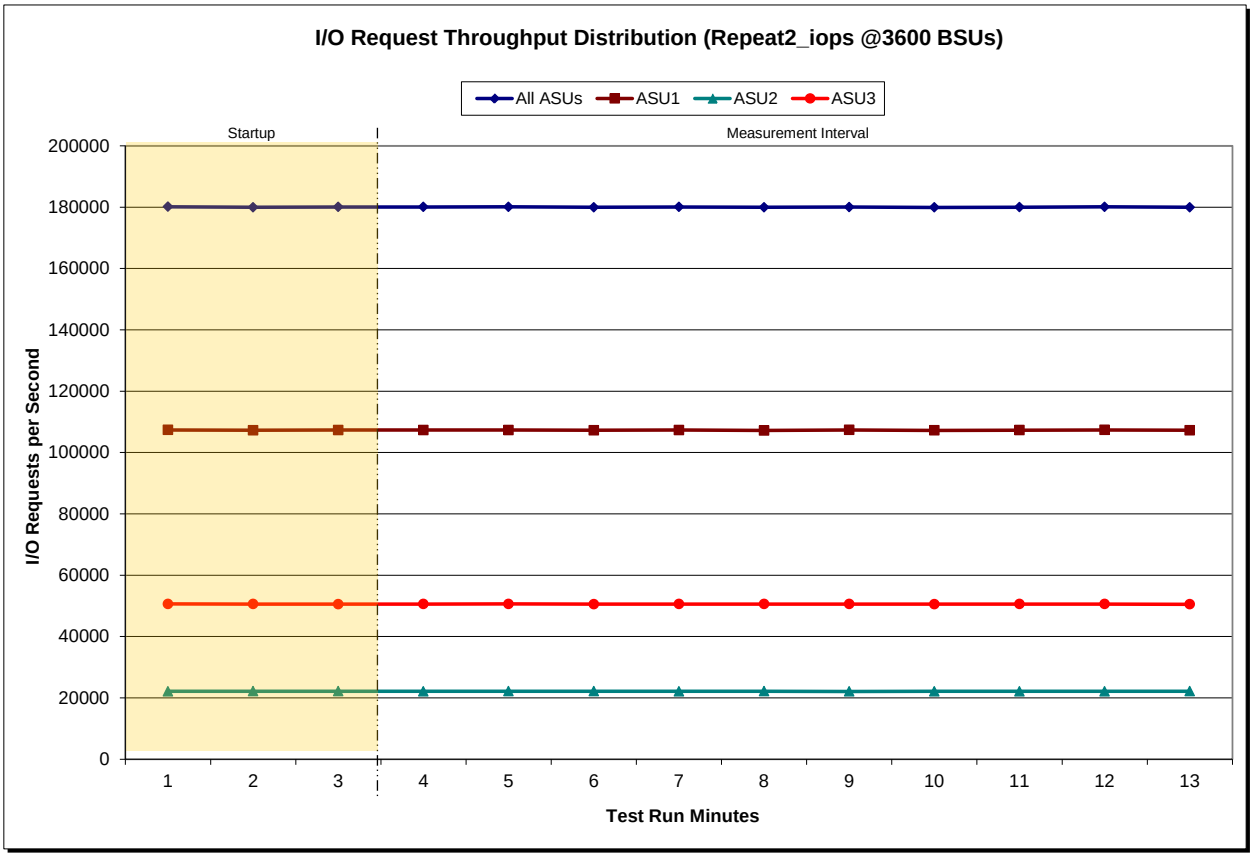
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

3600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:01:19	17:04:20	0-2	0:03:01
Measurement Interval	17:04:20	17:14:20	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	180,136.23	107,369.62	22,140.23	50,626.38
1	179,977.72	107,237.77	22,158.40	50,581.55
2	180,062.20	107,335.67	22,159.10	50,567.43
3	180,070.53	107,326.63	22,139.83	50,604.07
4	180,097.35	107,329.52	22,158.70	50,609.13
5	179,967.48	107,250.73	22,147.45	50,569.30
6	180,083.63	107,341.68	22,139.83	50,602.12
7	179,952.83	107,192.83	22,166.25	50,593.75
8	180,052.80	107,373.35	22,109.15	50,570.30
9	179,918.63	107,234.57	22,136.97	50,547.10
10	180,015.27	107,308.62	22,129.12	50,577.53
11	180,097.27	107,374.02	22,143.38	50,579.87
12	179,953.88	107,270.48	22,169.22	50,514.18
Average	***180,020.97***	***107,300.24***	***22,143.99***	***50,576.74***

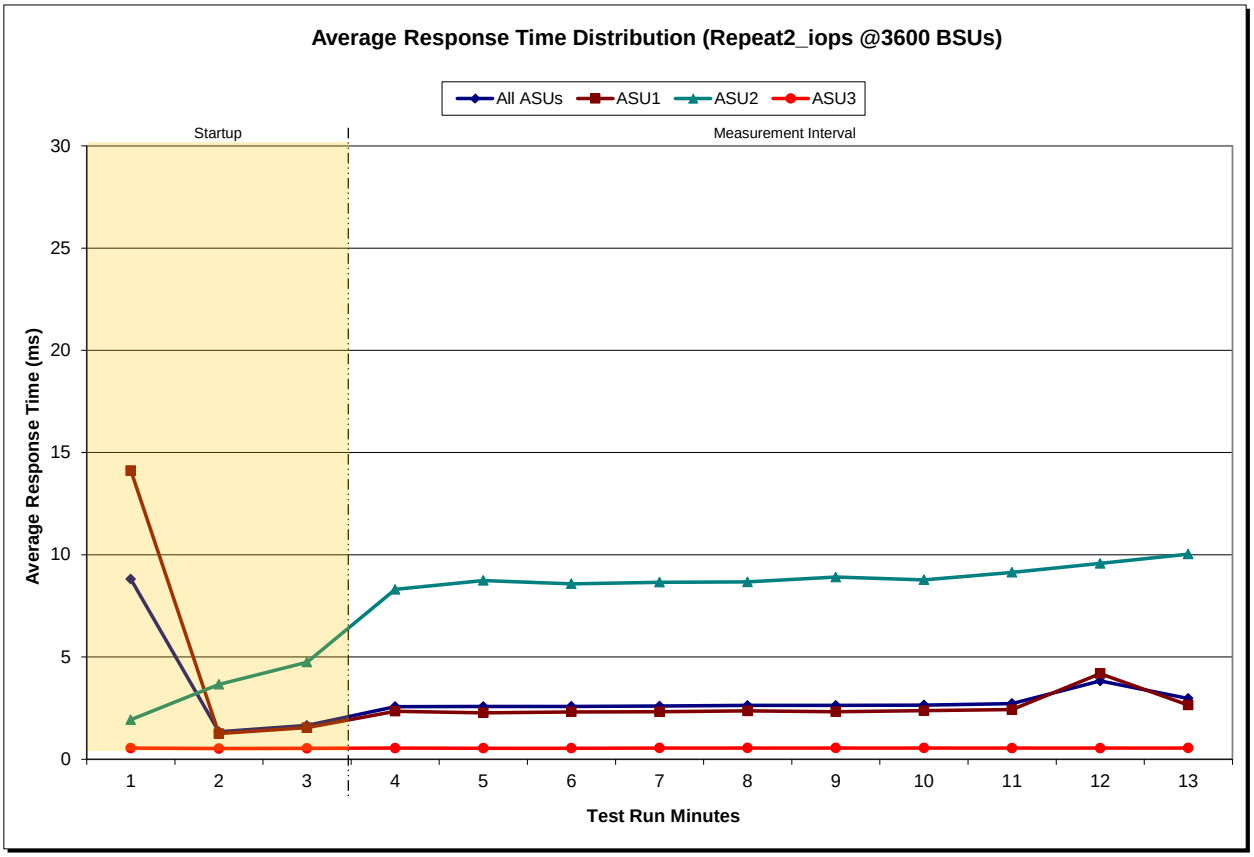
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

3600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:01:19	17:04:20	0-2	0:03:01
Measurement Interval	17:04:20	17:14:20	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	8.80	14.12	1.93	0.54
1	1.34	1.25	3.66	0.52
2	1.65	1.54	4.75	0.53
3	2.57	2.35	8.31	0.54
4	2.58	2.27	8.74	0.54
5	2.58	2.31	8.58	0.54
6	2.60	2.32	8.66	0.54
7	2.63	2.36	8.67	0.55
8	2.63	2.32	8.91	0.55
9	2.65	2.37	8.77	0.55
10	2.72	2.42	9.14	0.54
11	3.82	4.18	9.57	0.54
12	2.97	2.65	10.03	0.55
Average	***2.78***	***2.56***	***8.94***	***0.54***

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0351	0.2810	0.0700	0.2099	0.0180	0.0700	0.0349	0.2810
COV	0.005	0.002	0.005	0.002	0.008	0003	0.003	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	0.2809	0.0700	0.02100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.000	0.001	0.001	0.003	0.001	0.001	0.000

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0701	0.0349	0.2810
COV	0.004	0.002	0.003	0.001	0.007	0.003	0.005	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2809
COV	0.002	0.000	0.001	0.001	0.003	0.001	0.002	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 (may be contained in an appendix).*

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 72.

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	2,447,559
Total Number of Logical Blocks Verified	2,337,571
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	5 minutes
Size in bytes of each Logical Block	1,024
Number of Failed I/O Requests in the process of the Test	0

If approved by the SPC Auditor, the SPC-2 Persistence Test may be used to meet the SPC-1 persistence requirements. Both the SPC-1 and SPC-2 Persistence Tests provide the same level of functionality and verification of data integrity. The SPC-2 Persistence Test may be easily configured to address an SPC-1 storage configuration. The SPC-2 Persistence Test extends the size of storage configurations that may be tested and significantly reduces the test duration of such configurations.

The SPC-2 Persistence Test was approved for use in this set of audited measurements.

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

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 9.4.3.9

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

The IBM XIV Storage System Gen3 as documented in this Full Disclosure Report will become June 25, 2013 for customer purchase and shipment.

PRICING INFORMATION

Clause 9.4.3.3.6

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

Pricing information may be found in the Priced Storage Configuration Pricing section on page 16.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.8

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

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration may be found in the Executive Summary portion of this document on page 16.

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the IBM XIV Storage System Gen3.

APPENDIX A: SPC-1 GLOSSARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

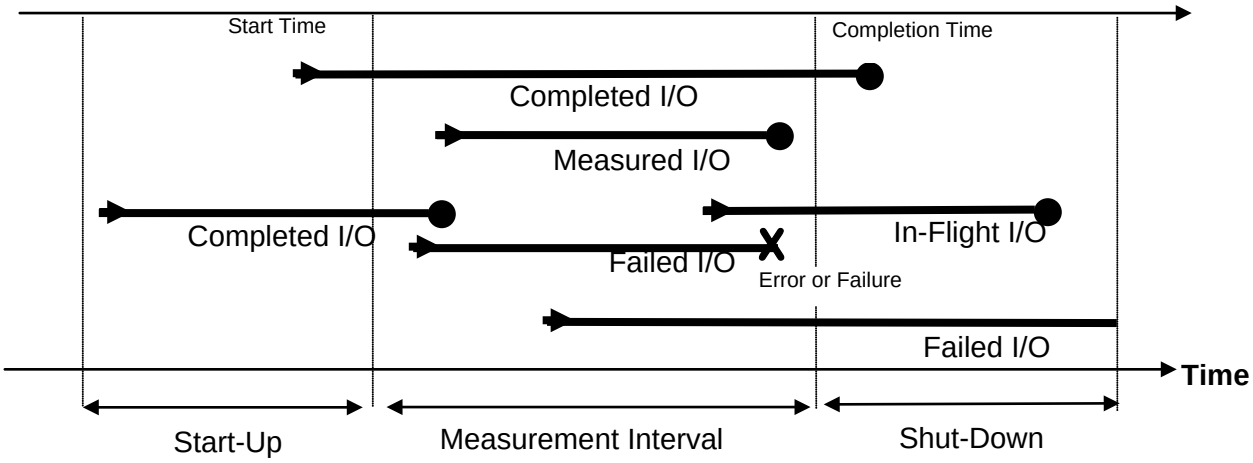
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

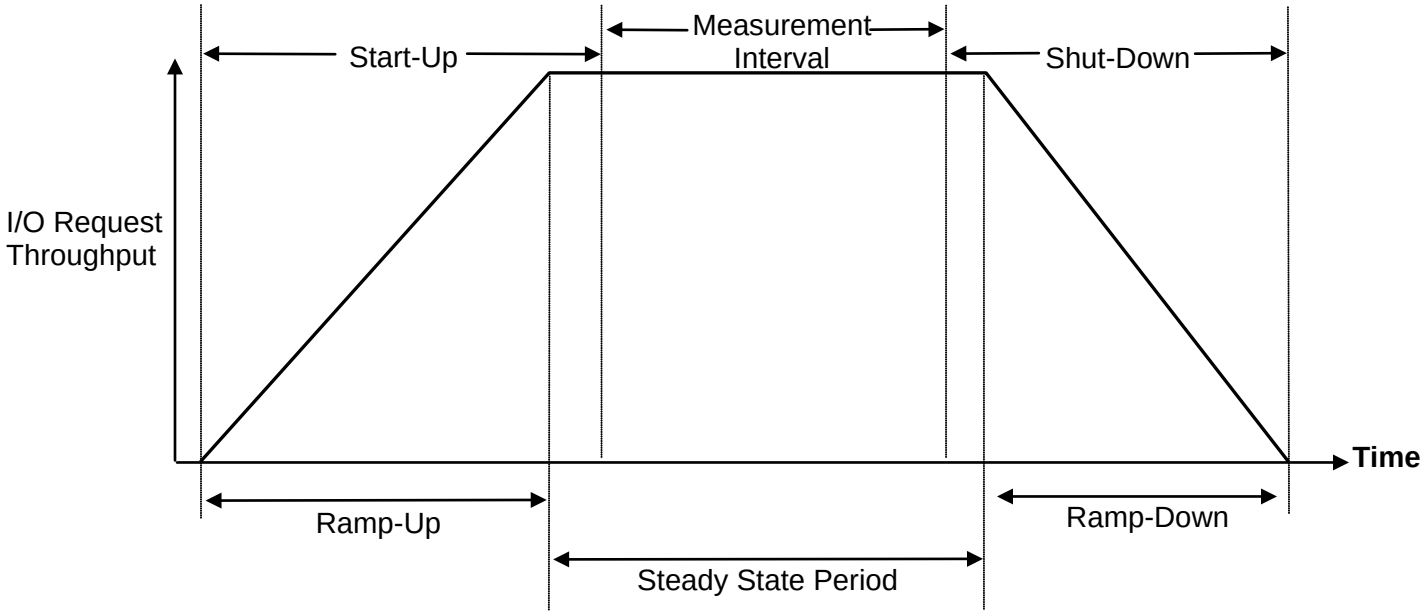
Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the SPC-1 Test Run Components below. All SPC-1 Test Runs shall have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

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

I/O Completion Types



SPC-1 Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

The queue depth of each LUN was set to 256 from a default value of 32. The maximum transfer size of LUN was explicitly set to 1 MiB, which is the default value of the parameter.

The two parameters were changed by execution of the script documented in **AIX Configuration** section on page 68.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The creation and configuration of the TSC was done with XCLI, which is a command line interface utility for XIV management. The utility must be executed on a supported host platform (AXI, Linux or Windows) that can communicate with the XIV system via TCP/IP.

The following are the specific steps and XCLI commands used:

Step 1. Create a storage pool with a capacity of 48010 GB.

```
pool_create pool=pool1 size=48010 snapshot_size=0
```

Step 2. Create 64 volumes in the storage pool *(volume capacity 722 GB)*.

```
vol_create vol=regress_01 size=722 pool=pool1
vol_create vol=regress_02 size=722 pool=pool1
vol_create vol=regress_03 size=722 pool=pool1
vol_create vol=regress_04 size=722 pool=pool1
vol_create vol=regress_05 size=722 pool=pool1
vol_create vol=regress_06 size=722 pool=pool1
vol_create vol=regress_07 size=722 pool=pool1
vol_create vol=regress_08 size=722 pool=pool1
vol_create vol=regress_09 size=722 pool=pool1
vol_create vol=regress_10 size=722 pool=pool1
vol_create vol=regress_11 size=722 pool=pool1
vol_create vol=regress_12 size=722 pool=pool1
vol_create vol=regress_13 size=722 pool=pool1
vol_create vol=regress_14 size=722 pool=pool1
vol_create vol=regress_15 size=722 pool=pool1
vol_create vol=regress_16 size=722 pool=pool1
vol_create vol=regress_17 size=722 pool=pool1
vol_create vol=regress_18 size=722 pool=pool1
vol_create vol=regress_19 size=722 pool=pool1
vol_create vol=regress_20 size=722 pool=pool1
vol_create vol=regress_21 size=722 pool=pool1
vol_create vol=regress_22 size=722 pool=pool1
vol_create vol=regress_23 size=722 pool=pool1
vol_create vol=regress_24 size=722 pool=pool1
vol_create vol=regress_25 size=722 pool=pool1
vol_create vol=regress_26 size=722 pool=pool1
vol_create vol=regress_27 size=722 pool=pool1
vol_create vol=regress_28 size=722 pool=pool1
vol_create vol=regress_29 size=722 pool=pool1
vol_create vol=regress_30 size=722 pool=pool1
vol_create vol=regress_31 size=722 pool=pool1
vol_create vol=regress_32 size=722 pool=pool1
vol_create vol=regress_33 size=722 pool=pool1
vol_create vol=regress_34 size=722 pool=pool1
vol_create vol=regress_35 size=722 pool=pool1
vol_create vol=regress_36 size=722 pool=pool1
vol_create vol=regress_37 size=722 pool=pool1
vol_create vol=regress_38 size=722 pool=pool1
vol_create vol=regress_39 size=722 pool=pool1
vol_create vol=regress_40 size=722 pool=pool1
vol_create vol=regress_41 size=722 pool=pool1
vol_create vol=regress_42 size=722 pool=pool1
vol_create vol=regress_43 size=722 pool=pool1
vol_create vol=regress_44 size=722 pool=pool1
vol_create vol=regress_45 size=722 pool=pool1
```

```
vol_create vol=regress_46 size=722 pool=pool1
vol_create vol=regress_47 size=722 pool=pool1
vol_create vol=regress_48 size=722 pool=pool1
vol_create vol=regress_49 size=722 pool=pool1
vol_create vol=regress_50 size=722 pool=pool1
vol_create vol=regress_51 size=722 pool=pool1
vol_create vol=regress_52 size=722 pool=pool1
vol_create vol=regress_53 size=722 pool=pool1
vol_create vol=regress_54 size=722 pool=pool1
vol_create vol=regress_55 size=722 pool=pool1
vol_create vol=regress_56 size=722 pool=pool1
vol_create vol=regress_57 size=722 pool=pool1
vol_create vol=regress_58 size=722 pool=pool1
vol_create vol=regress_59 size=722 pool=pool1
vol_create vol=regress_60 size=722 pool=pool1
vol_create vol=regress_61 size=722 pool=pool1
vol_create vol=regress_62 size=722 pool=pool1
vol_create vol=regress_63 size=722 pool=pool1
vol_create vol=regress_64 size=722 pool=pool1
```

Step 3. Define the host which will have access to the volumes.

```
host_define host=perfsh6
```

Step 4. Define mappings so that the host has access to all volumes via all available paths.

```
map_vol host=perfsh6 vol=regress_01 lun=1
map_vol host=perfsh6 vol=regress_02 lun=2
map_vol host=perfsh6 vol=regress_03 lun=3
map_vol host=perfsh6 vol=regress_04 lun=4
map_vol host=perfsh6 vol=regress_05 lun=5
map_vol host=perfsh6 vol=regress_06 lun=6
map_vol host=perfsh6 vol=regress_07 lun=7
map_vol host=perfsh6 vol=regress_08 lun=8
map_vol host=perfsh6 vol=regress_09 lun=9
map_vol host=perfsh6 vol=regress_10 lun=10
map_vol host=perfsh6 vol=regress_11 lun=11
map_vol host=perfsh6 vol=regress_12 lun=12
map_vol host=perfsh6 vol=regress_13 lun=13
map_vol host=perfsh6 vol=regress_14 lun=14
map_vol host=perfsh6 vol=regress_15 lun=15
map_vol host=perfsh6 vol=regress_16 lun=16
map_vol host=perfsh6 vol=regress_17 lun=17
map_vol host=perfsh6 vol=regress_18 lun=18
map_vol host=perfsh6 vol=regress_19 lun=19
map_vol host=perfsh6 vol=regress_20 lun=20
map_vol host=perfsh6 vol=regress_21 lun=21
map_vol host=perfsh6 vol=regress_22 lun=22
map_vol host=perfsh6 vol=regress_23 lun=23
map_vol host=perfsh6 vol=regress_24 lun=24
map_vol host=perfsh6 vol=regress_25 lun=25
map_vol host=perfsh6 vol=regress_26 lun=26
map_vol host=perfsh6 vol=regress_27 lun=27
map_vol host=perfsh6 vol=regress_28 lun=28
map_vol host=perfsh6 vol=regress_29 lun=29
map_vol host=perfsh6 vol=regress_30 lun=30
map_vol host=perfsh6 vol=regress_31 lun=31
map_vol host=perfsh6 vol=regress_32 lun=32
map_vol host=perfsh6 vol=regress_33 lun=33
map_vol host=perfsh6 vol=regress_34 lun=34
```

```
map_vol host=perfsh6 vol=regress_35 lun=35
map_vol host=perfsh6 vol=regress_36 lun=36
map_vol host=perfsh6 vol=regress_37 lun=37
map_vol host=perfsh6 vol=regress_38 lun=38
map_vol host=perfsh6 vol=regress_39 lun=39
map_vol host=perfsh6 vol=regress_40 lun=40
map_vol host=perfsh6 vol=regress_41 lun=41
map_vol host=perfsh6 vol=regress_42 lun=42
map_vol host=perfsh6 vol=regress_43 lun=43
map_vol host=perfsh6 vol=regress_44 lun=44
map_vol host=perfsh6 vol=regress_45 lun=45
map_vol host=perfsh6 vol=regress_46 lun=46
map_vol host=perfsh6 vol=regress_47 lun=47
map_vol host=perfsh6 vol=regress_48 lun=48
map_vol host=perfsh6 vol=regress_49 lun=49
map_vol host=perfsh6 vol=regress_50 lun=50
map_vol host=perfsh6 vol=regress_51 lun=51
map_vol host=perfsh6 vol=regress_52 lun=52
map_vol host=perfsh6 vol=regress_53 lun=53
map_vol host=perfsh6 vol=regress_54 lun=54
map_vol host=perfsh6 vol=regress_55 lun=55
map_vol host=perfsh6 vol=regress_56 lun=56
map_vol host=perfsh6 vol=regress_57 lun=57
map_vol host=perfsh6 vol=regress_58 lun=58
map_vol host=perfsh6 vol=regress_59 lun=59
map_vol host=perfsh6 vol=regress_60 lun=60
map_vol host=perfsh6 vol=regress_61 lun=61
map_vol host=perfsh6 vol=regress_62 lun=62
map_vol host=perfsh6 vol=regress_63 lun=63
map_vol host=perfsh6 vol=regress_64 lun=64
```

Step 5. Add host ports *(WWNNs)* to the defined XIV host.

```
host_add_port host=perfsh6 fcaddress=10000000C9A9F186
host_add_port host=perfsh6 fcaddress=10000000C9A9F187
host_add_port host=perfsh6 fcaddress=10000000C9A9F5DB
host_add_port host=perfsh6 fcaddress=10000000C9A9EEA2
host_add_port host=perfsh6 fcaddress=10000000C9A9EEA3
host_add_port host=perfsh6 fcaddress=10000000C9A9F5DA
host_add_port host=perfsh6 fcaddress=10000000C9A9F048
host_add_port host=perfsh6 fcaddress=10000000C9A9F049
host_add_port host=perfsh6 fcaddress=10000000C9A9EF1A
host_add_port host=perfsh6 fcaddress=10000000C9A9EF1B
host_add_port host=perfsh6 fcaddress=10000000C9A928D8
host_add_port host=perfsh6 fcaddress=10000000C9A928D9
```

Step 6. Enable SSD caching for the entire storage system

```
ssd_caching_enable
component_phasein component=1:SSD:1:1
component_phasein component=1:SSD:2:1
component_phasein component=1:SSD:3:1
component_phasein component=1:SSD:4:1
component_phasein component=1:SSD:5:1
component_phasein component=1:SSD:6:1
component_phasein component=1:SSD:7:1
component_phasein component=1:SSD:8:1
component_phasein component=1:SSD:9:1
component_phasein component=1:SSD:10:1
component_phasein component=1:SSD:11:1
component_phasein component=1:SSD:12:1
```

```
component_phasein component=1:SSD:13:1
component_phasein component=1:SSD:14:1
component_phasein component=1:SSD:15:1
```

AIX Configuration

After Steps 1-6 were completed, the resulting volumes were detected by AIX by issuing the command **cfgmgr** on the Host System.

The queue depth and maximum transfer size of each volume, documented in Appendix B, were set by executing the script in Step 7 on the Host System.

The SPC-1 Logical Volumes were created by executing the script in Step 8 on the Host System.

Step 7. Set volume characteristics

```
luns=$(lsdev -Cc disk | grep XIV | awk '{ print $1 }')
for i in $luns
do
    rmdev -l hdisk$i
    chdev -l hdisk$i -a queue_depth=256
    chdev -l hdisk$i -a max_transfer=0x100000
    mkdev -l hdisk$i
    let i="i+1"
done
```

Step 8. Create logical volumes (ASUs) using AIX LVM

```
#create 64 X 738495MB XIV volumes (48TB pool)
#create 1024MB physical partitions with 64 hdisks
hfield=$(lsdev -Cc disk | grep '2810 XIV' | awk '{print $1}')
mkvg -fy thinstripevg -S -P 2048 -s 1024 $hfield
#create 40 X 960GB logical volumes for ASU-1 and ASU-2, stripe across all hdisks
with striped size 128MB
let i=1;while ((i<41));do
mklv -b n -y thin$i -x 32512 -u 64 -S 128M thinstripevg 960
let i=i+1;done
#create 5 X 896GB logical volumes for ASU-3, stripe across all hdisks with striped
size 128MB
let i=41;while ((i<46));do
mklv -b n -y thin$i -x 32512 -u 64 -S 128M thinstripevg 896
let i=i+1;done
```

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

ASU Pre-Fill

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

```
*
* This will produce a random data pattern of the entire LBA range using LSFR 32bit
*
compratio=1
sd=default,threads=1

sd=sd1,size=998074482688,lun=/dev/rthin1
sd=sd2,size=998074482688,lun=/dev/rthin2
sd=sd3,size=998074482688,lun=/dev/rthin3
sd=sd4,size=998074482688,lun=/dev/rthin4
sd=sd5,size=998074482688,lun=/dev/rthin5
sd=sd6,size=998074482688,lun=/dev/rthin6
sd=sd7,size=998074482688,lun=/dev/rthin7
sd=sd8,size=998074482688,lun=/dev/rthin8
sd=sd9,size=998074482688,lun=/dev/rthin9
sd=sd10,size=998074482688,lun=/dev/rthin10
sd=sd11,size=998074482688,lun=/dev/rthin11
sd=sd12,size=998074482688,lun=/dev/rthin12
sd=sd13,size=998074482688,lun=/dev/rthin13
sd=sd14,size=998074482688,lun=/dev/rthin14
sd=sd15,size=998074482688,lun=/dev/rthin15
sd=sd16,size=998074482688,lun=/dev/rthin16
sd=sd17,size=998074482688,lun=/dev/rthin17
sd=sd18,size=998074482688,lun=/dev/rthin18
sd=sd19,size=998074482688,lun=/dev/rthin19
sd=sd20,size=998074482688,lun=/dev/rthin20
sd=sd21,size=998074482688,lun=/dev/rthin21
sd=sd22,size=998074482688,lun=/dev/rthin22
sd=sd23,size=998074482688,lun=/dev/rthin23
sd=sd24,size=998074482688,lun=/dev/rthin24
sd=sd25,size=998074482688,lun=/dev/rthin25
sd=sd26,size=998074482688,lun=/dev/rthin26
sd=sd27,size=998074482688,lun=/dev/rthin27
sd=sd28,size=998074482688,lun=/dev/rthin28
sd=sd29,size=998074482688,lun=/dev/rthin29
sd=sd30,size=998074482688,lun=/dev/rthin30
sd=sd31,size=998074482688,lun=/dev/rthin31
sd=sd32,size=998074482688,lun=/dev/rthin32
sd=sd33,size=998074482688,lun=/dev/rthin33
sd=sd34,size=998074482688,lun=/dev/rthin34
sd=sd35,size=998074482688,lun=/dev/rthin35
sd=sd36,size=998074482688,lun=/dev/rthin36
sd=sd37,size=998074482688,lun=/dev/rthin37
sd=sd38,size=998074482688,lun=/dev/rthin38
sd=sd39,size=998074482688,lun=/dev/rthin39
sd=sd40,size=998074482688,lun=/dev/rthin40
sd=sd41,size=887177084928,lun=/dev/rthin41
sd=sd42,size=887177084928,lun=/dev/rthin42
sd=sd43,size=887177084928,lun=/dev/rthin43
sd=sd44,size=887177084928,lun=/dev/rthin44
sd=sd45,size=887177084928,lun=/dev/rthin45
```

```
wd=default,rdpct=0,seek=-1,xfersize=256K
wd=wd1,sd=sd1
wd=wd2,sd=sd2
wd=wd3,sd=sd3
wd=wd4,sd=sd4
wd=wd5,sd=sd5
wd=wd6,sd=sd6
wd=wd7,sd=sd7
wd=wd8,sd=sd8
wd=wd9,sd=sd9
wd=wd10,sd=sd10
wd=wd11,sd=sd11
wd=wd12,sd=sd12
wd=wd13,sd=sd13
wd=wd14,sd=sd14
wd=wd15,sd=sd15
wd=wd16,sd=sd16
wd=wd17,sd=sd17
wd=wd18,sd=sd18
wd=wd19,sd=sd19
wd=wd20,sd=sd20
wd=wd21,sd=sd21
wd=wd22,sd=sd22
wd=wd23,sd=sd23
wd=wd24,sd=sd24
wd=wd25,sd=sd25
wd=wd26,sd=sd26
wd=wd27,sd=sd27
wd=wd28,sd=sd28
wd=wd29,sd=sd29
wd=wd30,sd=sd30
wd=wd31,sd=sd31
wd=wd32,sd=sd32
wd=wd33,sd=sd33
wd=wd34,sd=sd34
wd=wd35,sd=sd35
wd=wd36,sd=sd36
wd=wd37,sd=sd37
wd=wd38,sd=sd38
wd=wd39,sd=sd39
wd=wd40,sd=sd40
wd=wd41,sd=sd41
wd=wd42,sd=sd42
wd=wd43,sd=sd43
wd=wd44,sd=sd44
wd=wd45,sd=sd45

*==================================
* Use 10 hours as a maximum elapsed time,
* which should ensure the entire LBA range
* will be written before the time elapses
*==================================
*
*10 hours for XIV 45TB prefill
rd=FILLIT,wd=wd*,iorate=max,elapsed=31000,interval=10
*
* The above "elapsed=36000" may have to be increased to ensure that the utility will
reach
* the end of the LUN ("seek=-1") prior to the end of the specified elapsed time
```

Primary Metrics, Repeatability and Persistence Tests

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

```
javaparms="-Xms1280m -Xmx1280m -Xss256k -Xgcpolicy:optavgpause"
sd=default
sd=asu1_1,size=998074482688,lun=/dev/rthin1
sd=asu1_2,size=998074482688,lun=/dev/rthin2
sd=asu1_3,size=998074482688,lun=/dev/rthin3
sd=asu1_4,size=998074482688,lun=/dev/rthin4
sd=asu1_5,size=998074482688,lun=/dev/rthin5
sd=asu1_6,size=998074482688,lun=/dev/rthin6
sd=asu1_7,size=998074482688,lun=/dev/rthin7
sd=asu1_8,size=998074482688,lun=/dev/rthin8
sd=asu1_9,size=998074482688,lun=/dev/rthin9
sd=asu1_10,size=998074482688,lun=/dev/rthin10
sd=asu1_11,size=998074482688,lun=/dev/rthin11
sd=asu1_12,size=998074482688,lun=/dev/rthin12
sd=asu1_13,size=998074482688,lun=/dev/rthin13
sd=asu1_14,size=998074482688,lun=/dev/rthin14
sd=asu1_15,size=998074482688,lun=/dev/rthin15
sd=asu1_16,size=998074482688,lun=/dev/rthin16
sd=asu1_17,size=998074482688,lun=/dev/rthin17
sd=asu1_18,size=998074482688,lun=/dev/rthin18
sd=asu1_19,size=998074482688,lun=/dev/rthin19
sd=asu1_20,size=998074482688,lun=/dev/rthin20
sd=asu2_1,size=998074482688,lun=/dev/rthin21
sd=asu2_2,size=998074482688,lun=/dev/rthin22
sd=asu2_3,size=998074482688,lun=/dev/rthin23
sd=asu2_4,size=998074482688,lun=/dev/rthin24
sd=asu2_5,size=998074482688,lun=/dev/rthin25
sd=asu2_6,size=998074482688,lun=/dev/rthin26
sd=asu2_7,size=998074482688,lun=/dev/rthin27
sd=asu2_8,size=998074482688,lun=/dev/rthin28
sd=asu2_9,size=998074482688,lun=/dev/rthin29
sd=asu2_10,size=998074482688,lun=/dev/rthin30
sd=asu2_11,size=998074482688,lun=/dev/rthin31
sd=asu2_12,size=998074482688,lun=/dev/rthin32
sd=asu2_13,size=998074482688,lun=/dev/rthin33
sd=asu2_14,size=998074482688,lun=/dev/rthin34
sd=asu2_15,size=998074482688,lun=/dev/rthin35
sd=asu2_16,size=998074482688,lun=/dev/rthin36
sd=asu2_17,size=998074482688,lun=/dev/rthin37
sd=asu2_18,size=998074482688,lun=/dev/rthin38
sd=asu2_19,size=998074482688,lun=/dev/rthin39
sd=asu2_20,size=998074482688,lun=/dev/rthin40
sd=asu3_1,size=887177084928,lun=/dev/rthin41
sd=asu3_2,size=887177084928,lun=/dev/rthin42
sd=asu3_3,size=887177084928,lun=/dev/rthin43
sd=asu3_4,size=887177084928,lun=/dev/rthin44
sd=asu3_5,size=887177084928,lun=/dev/rthin45
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

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

The following script was used to execute the required ASU pre-fill, Primary Metrics Test *(Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase)*, Repeatability Test *(Repeatability Test Phase 1 and Repeatability Test Phase 2)*, and SPC-1 Persistence Test Run 1 *(write phase)* in an uninterrupted sequence. The script also included the appropriate commands to capture the detailed TSC profile listings required for a Remote Audit.

```
rundir=`pwd`
cd /perform/spc1runs/XIV11.1.1/fill.45LVM.sh6
./runfill.sh
cd $rundir
export PATH=$PATH:/usr/java6/bin
export SPC1HOME=/perform/spc1_2_3install
export CLASSPATH=$SPC1HOME
export LIBPATH=$SPC1HOME
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false

# initial ramp up test run. 100K 130K, and 170K each for 2 hours
java -Xoptionsfile=javaopts.cfg range -b 2000 -t 7200
mv rangetest rangetest100K
java -Xoptionsfile=javaopts.cfg range -b 2600 -t 7200
mv rangetest rangetest130K
java -Xoptionsfile=javaopts.cfg range -b 3400 -t 7200
mv rangetest rangetest170K

java -Xoptionsfile=javaopts.cfg metrics -b 3600 -s 121200:180 -t 28800
java -Xoptionsfile=javaopts.cfg repeat1 -b 3600
java -Xoptionsfile=javaopts.cfg repeat2 -b 3600
getxivdata.sh
getaixdata.sh

java -Xoptionsfile=javaoptsp.cfg persist1 -b 2880
```

ASU Pre-Fill

The following script, invoked from the above 'master' script, was used to execute the required ASU pre-file.

```
#!/usr/bin/ksh
export PATH=$PATH:/usr/java6/bin:/perform/vdbench503
export VDBHOME=/perform/vdbench503
export CLASSPATH=$VDBHOME
export LIBPATH=$VDBHOME/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
vdbench -f fill.cfg -o fill_output
```

Persistence Test Run 2

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

```
export PATH=$PATH:/usr/java6/bin
export SPC1HOME=/perform/spc1_2_3install
export CLASSPATH=$SPC1HOME
export LIBPATH=$SPC1HOME
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaoptsp.cfg persist2
```