



**SPC BENCHMARK 1/ENERGY™  
FULL DISCLOSURE REPORT**

**IBM CORPORATION  
IBM FLASHSYSTEM 820**

**SPC-1/E V1.14**

**Submitted for Review: August 16, 2013  
Submission Identifier: AE00006**

**First Edition – August 2013**

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## AUDIT CERTIFICATION



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

August 15, 2013

The SPC Benchmark 1/Energy™ Reported Data listed below for the IBM FlashSystem 820 was produced in compliance with the SPC Benchmark 1/Energy™ v1.14 Onsite Audit requirements.

SPC Benchmark 1/Energy™ v1.14 Reported Data	
Tested Storage Product (TSP) Name: IBM FlashSystem 820	
Metric	Reported Result
SPC-1 IOPS™	195,021.70
SPC-1 Price-Performance	\$1.55/SPC-1 IOPS™
Total ASU Capacity	12,283,606 GB
Data Protection Level	Protected 1 (RAID-5)
Total Price (including three-year maintenance)	\$302,028.00
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

Power Environment							
Average RMS Voltage: <input type="text" value="199.71"/>				Average Power Factor: <input type="text" value="0.968"/>			
Usage Profile							
	Hours of Use per Day			Nominal	Nominal	Nominal	Nominal
	Heavy	Moderate	Idle	Power, W	Traffic, IOPS	IOPS/W	Heat, BTU/hr
Low Daily Usage:	0	8	16	330.81	32501.35	98.25	1,128.76
Medium Daily Usage:	4	14	6	346.94	82881.73	238.90	1,183.78
High Daily Usage:	18	6	0	365.77	141395.68	386.57	1,248.05
Composite Metrics:				<input type="text" value="347.84"/>	<input type="text" value="85,592.92"/>	<input type="text" value="246.07"/>	
Annual Energy Use, kWh:	<input type="text" value="3,047.07"/>						
Energy Cost, \$/kWh:	<input type="text" value="\$ 0.12"/>			Annual Energy Cost, \$:	<input type="text" value="\$ 365.65"/>		

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Redwood City, CA 94062  
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## AUDIT CERTIFICATION (CONT.)

IBM FlashSystem 820  
SPC-1 Audit Certification

Page 2

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

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by physical inspection and 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.
- 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).
- Physical verification of the components to match the above diagram.
- 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 physical inspection and 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 execution of each Test, Test Phase, and Test Run was observed and found compliant with all of the requirements and constraints of Clauses 4, 5, and 11 of the SPC-1 Benchmark Specification.
- 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:
  - ✓ Idle Test
    - Conditioning Phase
    - Application Idle Phase
    - Recovery Phase
  - ✓ Primary Metrics Test:
    - Sustainability Test Phase
    - IOPS Test Phase
    - Response Time Ramp Test Phase
  - ✓ Repeatability Test
  - ✓ Data Persistence Test
- The Yokogawa WT1600 Digital Power Meter, used to record power consumption, was verified as an SPC approved "Power Extension apparatus" with a current calibration certificate.

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## AUDIT CERTIFICATION (CONT.)

IBM FlashSystem 820  
SPC-1 Audit Certification

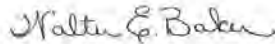
Page 3

- All power supplies present in the Tested Storage Configuration were verified as active
- IBM Corporation provided documentation of the following:
  - ✓ Voltage (220), amperage (30), and phase characteristics (*angle*) of the AC inputs used for powering the Tested Storage Configuration.
  - ✓ The configured power supplies were configured for mutual failover.
- Concurrent power measurements were taken at each active AC input so that the total power requirement of the Tested Storage Configuration was recorded.
- The ambient temperature was recorded at the following times in near proximity to the Tested Storage configuration with a precision of at least  $\pm 0.1^{\circ}\text{C}$ :
  - ✓ During the first one minute of the Idle Test (*Initial Energy Extension temperature*).
  - ✓ During the last one minute of the Primary Metrics Test (*Final Energy Extension temperature*).
- The Benchmark Configuration/Tested Storage Configuration diagram included the electrical metering, which illustrates the measurement apparatus used and the relationship between the active AC inputs and the associated measurement apparatus inputs.
- There were no differences between the Tested Storage Configuration and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-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



Vice President and Data Storage Business Line Executive

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Phone: 1-408-507-9823

June 11, 2013

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

Subject: SPC-1/E Letter of Good Faith for the IBM FlashSystem 820.

IBM Corporation is the SPC-1/E Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1/E 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, SPC-1/E 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, SPC-1/E 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	
<b>Test Sponsor Primary Contact</b>	IBM Corporation – <a href="http://www.ibm.com">http://www.ibm.com</a> Bruce McNutt – <a href="mailto:bmcnutt@us.ibm.com">bmcnutt@us.ibm.com</a> IBM ARC 650 Harry Road San Jose, CA 95120 Phone: (408) 927-2717 FAX: (408) 927-2050
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<b>Auditor</b>	Storage Performance Council – <a href="http://www.storageperformance.org">http://www.storageperformance.org</a> Walter E. Baker – <a href="mailto:AuditService@StoragePerformance.org">AuditService@StoragePerformance.org</a> 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	
<b>SPC-1 Specification revision number</b>	V1.14
<b>SPC-1 Workload Generator revision number</b>	V2.3.0
<b>Date Results were first used publicly</b>	August 16, 2013
<b>Date the FDR was submitted to the SPC</b>	August 16, 2013
<b>Date the Priced Storage Configuration is available for shipment to customers</b>	currently available
<b>Date the TSC completed audit certification</b>	August 15, 2013

### Tested Storage Product (TSP) Description

IBM FlashSystem 720 and FlashSystem 820 storage systems are external, shared flash solid state storage devices that provide high performance, density, and efficiency in small integrated rackmount footprints. FlashSystem 720 and FlashSystem 820 have a unique combination of extremely low latency and high performance that offers customers scalable usable capacity points from 5 up to 20 TB (fully protected) using either SLC or eMLC flash storage media. FlashSystem 720 and FlashSystem 820 products also incorporate advanced reliability technology, including 2D Flash RAID and Variable Stripe RAID self-healing data protection.

## Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: IBM FlashSystem 820	
Metric	Reported Result
SPC-1 IOPS™	195,021.70
SPC-1 Price-Performance™	\$1.55/SPC-1 IOPS™
Total ASU Capacity	12,283.606 GB
Data Protection Level	Protected 1 (RAID-5)
Total Price	\$302,028.00
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 **RAID-5**, which distributes check data corresponding to user data across multiple disks in the form of bit-by-bit parity.

***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 24.

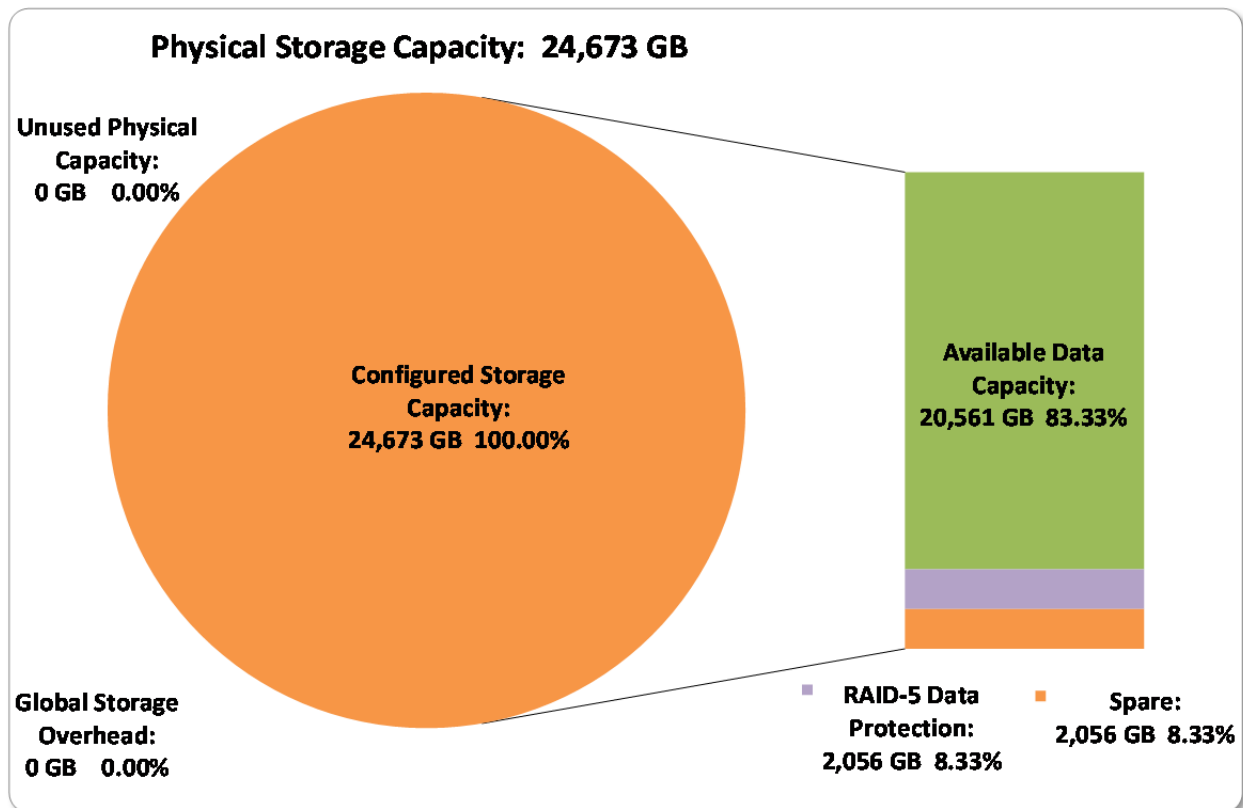
**Currency Used** is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country (*non-local currency*).

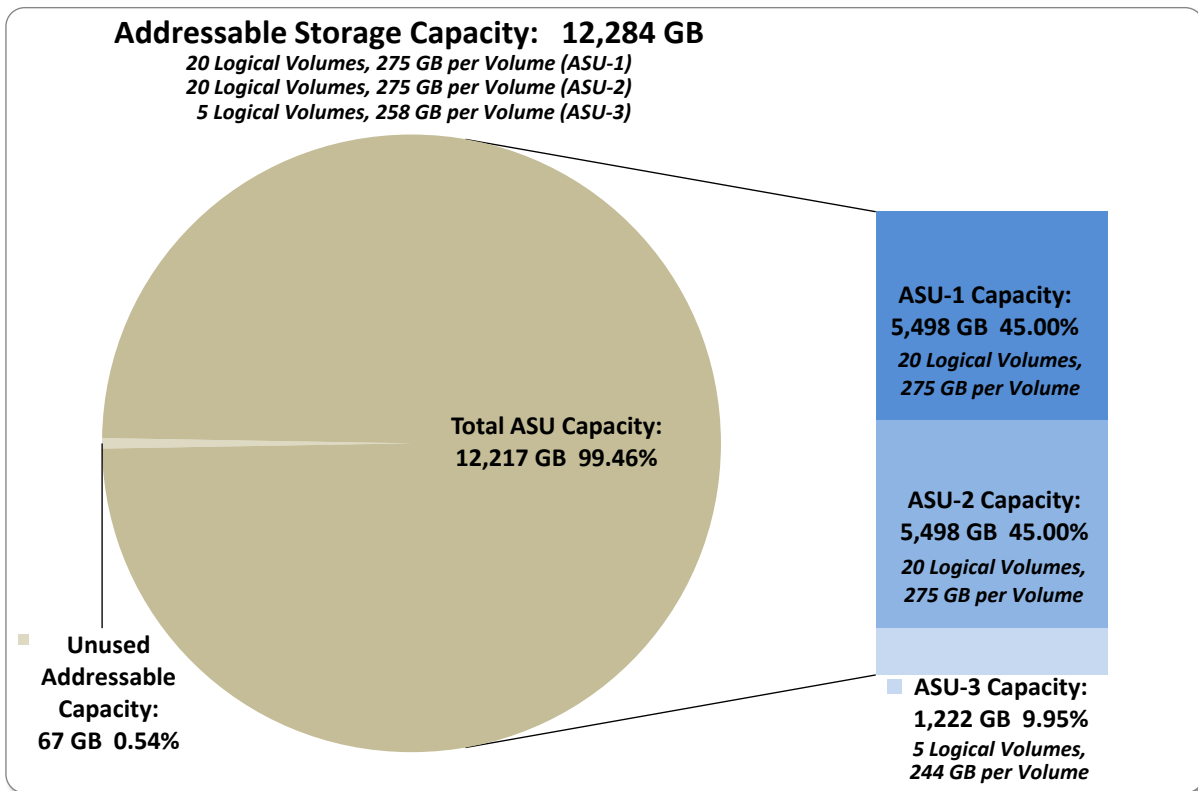
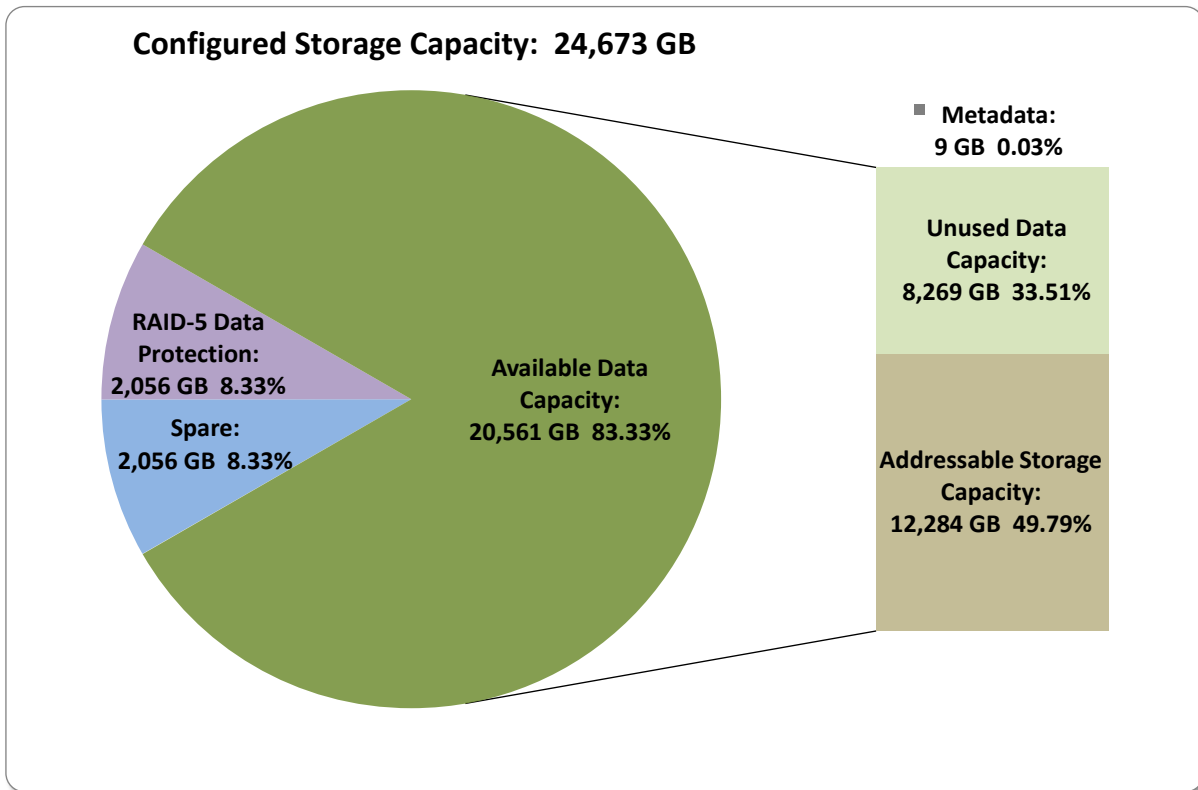
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

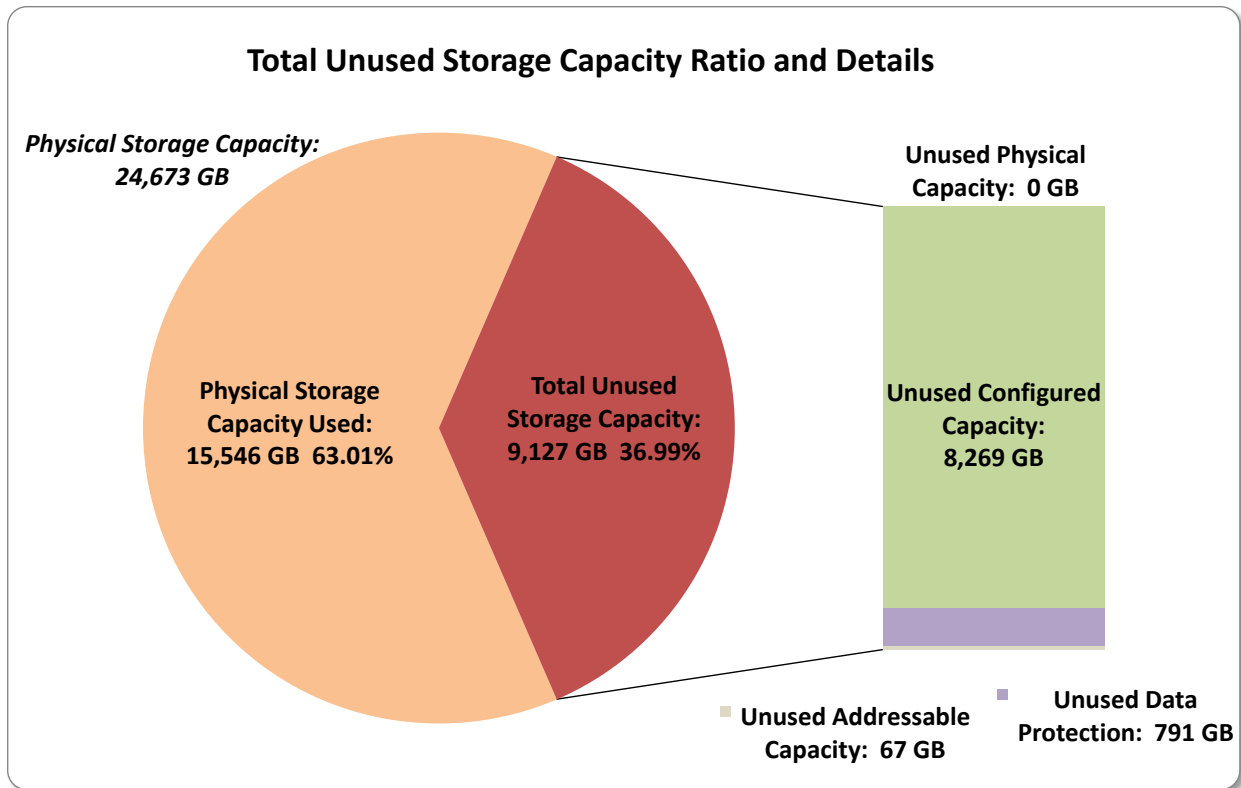
### Storage Capacities, Relationships, and Utilization

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 is listed as an integer value, for readability, rather than the decimal values listed elsewhere in this document.







SPC-1 Storage Capacity Utilization	
Application Utilization	49.51%
Protected Application Utilization	54.64%
Unused Storage Ratio	36.99%

**Application Utilization:** Total ASU Capacity (12,216.796 GB) divided by Physical Storage Capacity (24,673.041 GB)

**Protected Application Utilization:** Total ASU Capacity (12,216.796 GB) plus total Data Protection Capacity (2,056.087 GB) minus unused Data Protection Capacity (791.457 GB) divided by Physical Storage Capacity (24,673.041 GB)

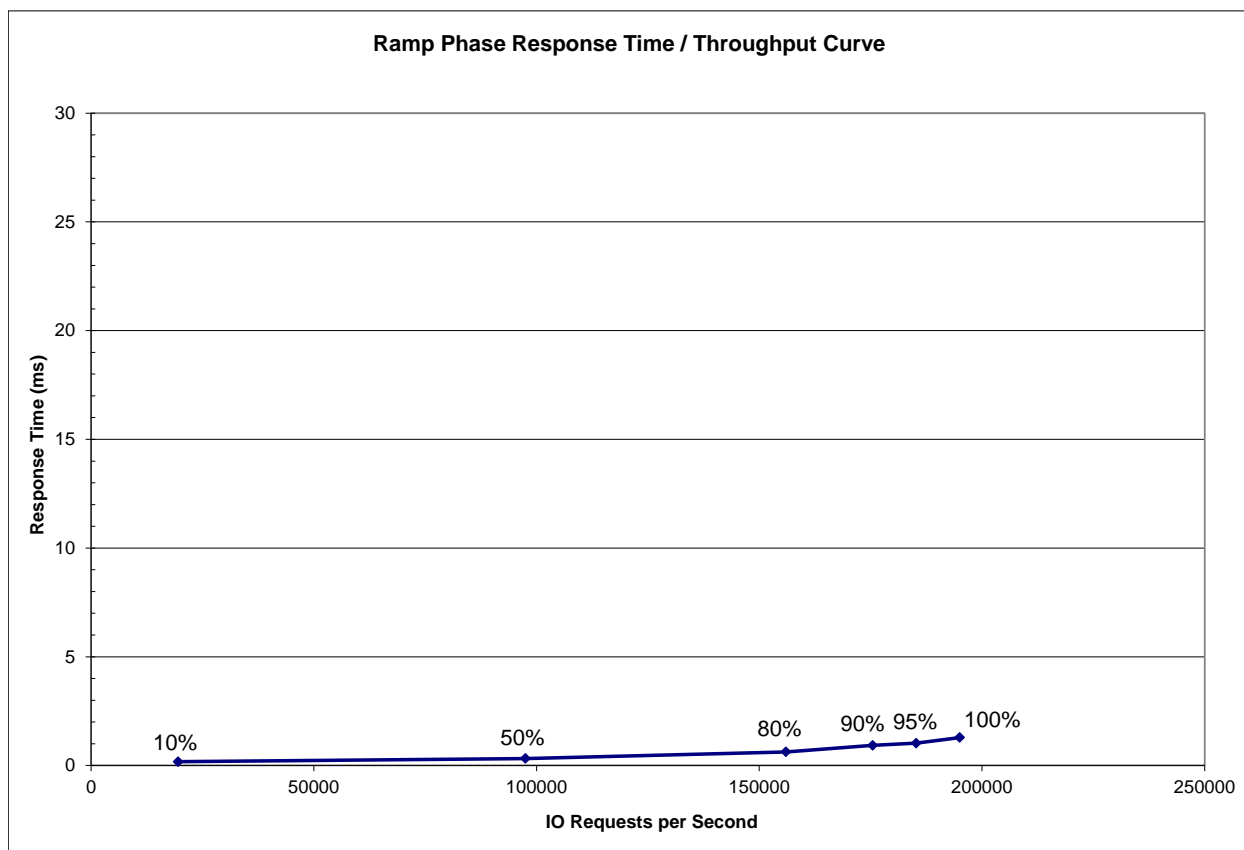
**Unused Storage Ratio:** Total Unused Capacity (9,126.939 GB) divided by Physical Storage Capacity (24,673.041 GB) and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 30-31.

### 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
<b>I/O Request Throughput</b>	19,512.06	97,504.04	156,026.23	175,489.82	185,250.57	195,021.70
<b>Average Response Time (ms):</b>						
<b>All ASUs</b>	0.18	0.32	0.63	0.92	1.02	1.29
<b>ASU-1</b>	0.19	0.36	0.69	0.96	1.04	1.22
<b>ASU-2</b>	0.19	0.35	0.64	0.89	0.98	1.17
<b>ASU-3</b>	0.15	0.22	0.48	0.86	1.02	1.48
<b>Reads</b>	0.24	0.50	0.94	1.20	1.27	1.39
<b>Writes</b>	0.13	0.20	0.42	0.74	0.86	1.22



## SPC-1/E Reported Data

The initial SPC-1/E energy extension temperature, recorded during the first one minute of the Idle Test was 72F. The final SPC-1/E energy extension temperature, recorded during the last one minute of the Primary Metrics Test was 71F.

Power Environment							
Average RMS Voltage:		199.71		Average Power Factor:		0.968	
Usage Profile							
	Hours of Use per Day			Nominal Power, W	Nominal Traffic, IOPS	Nominal IOPS/W	Nominal Heat, BTU/hr
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	330.81	32501.35	98.25	1,128.76
Medium Daily Usage:	4	14	6	346.94	82881.73	238.90	1,183.78
High Daily Usage:	18	6	0	365.77	141395.68	386.57	1,248.05
Composite Metrics:				347.84	85,592.92	246.07	
Annual Energy Use, kWh:		3,047.07		Annual Energy Cost, \$:		\$ 365.65	
Energy Cost, \$/kWh:		\$ 0.12					

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

**HEAVY SPC-1 Workload:** 370.51W at 80% of maximum reported performance (*156,026.23 SPC-1 IOPS*).

**MODERATE SPC-1 Workload:** 351.56W at 50% of maximum reported performance (*97,504.04 SPC-1 IOPS*).

**IDLE SPC-1 Workload:** 320.44W at 0% of maximum reported performance (*0.00 SPC-1 IOPS*).

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

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

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

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

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

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

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

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

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

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

## SPC-1/E Power/Performance Profiles

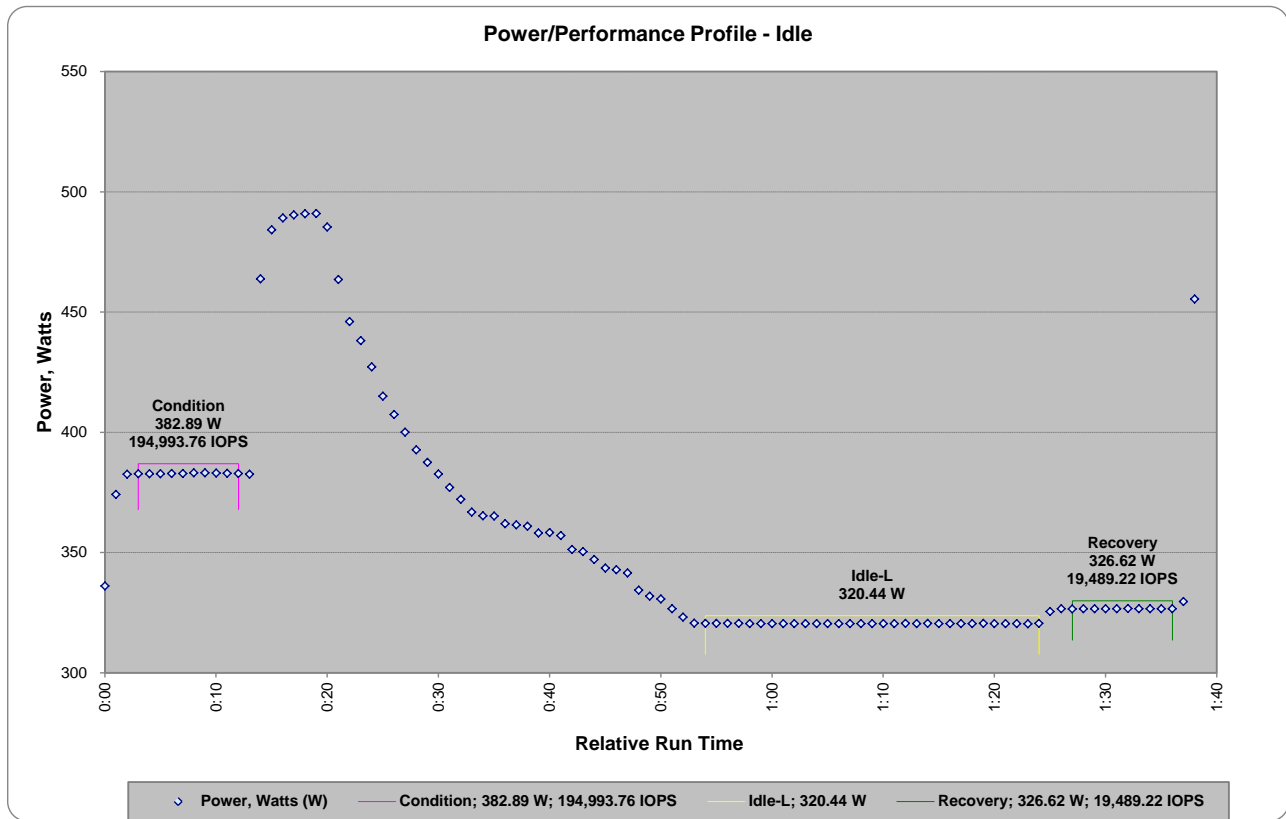
The following four SPC-1/E Power/Performance Profile charts provide a complete “at a glance” illustration and report for each SPC-1/E execution component. The power consumption at each step is reported and, where appropriate the measured SPC-1 performance (*SPC-1 IOPS™*) is also reported.

The **Load Level** value in the table represents the percentage of the maximum, specified offered load that was used for a specific execution component. Each **Execution Component** entry includes the acronym, in parenthesis, which is used in the corresponding chart to identify the execution component.

### SPC-1/E Power/Performance Profile Data

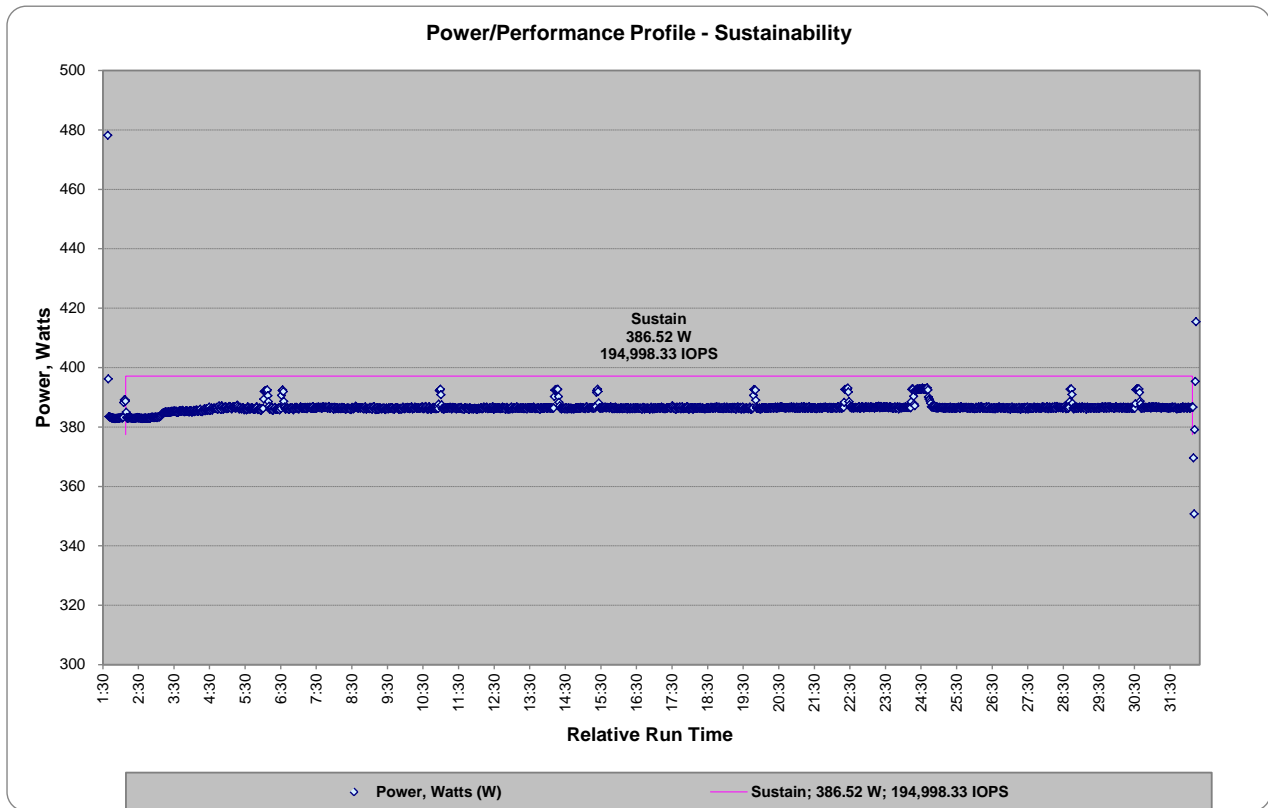
Execution Component	Load Level	SPC-1 IOPS™	Power (W)
Idle – Conditioning ( <i>Condition</i> )	100%	194,993.76	382.89
Idle ( <i>Idle-L</i> )	0%		320.44
Idle - Recovery ( <i>Recovery</i> )	10%	19,489.22	326.62
Sustainability ( <i>Sustain</i> )	100%	194,998.33	386.52
IOPS ( <i>100%</i> )	100%	195,021.70	382.82
Ramp95 ( <i>95%</i> )	95%	185,250.57	379.58
Ramp90 ( <i>90%</i> )	90%	175,489.82	379.00
Ramp80 ( <i>80%</i> )	80%	156,026.23	370.51
Ramp50 ( <i>50%</i> )	50%	97,504.04	351.56
Ramp10 ( <i>10%</i> )	10%	19,512.06	216.98
Repeat1 LRT ( <i>10%</i> )	10%	19,502.67	327.07
Repeat1 IOPS ( <i>100%</i> )	100%	194,990.44	382.61
Repeat2 LRT ( <i>10%</i> )	10%	19,499.14	327.05
Repeat2 IOPS ( <i>100%</i> )	100%	194,933.08	382.87

### Power/Performance Profile – Idle Test



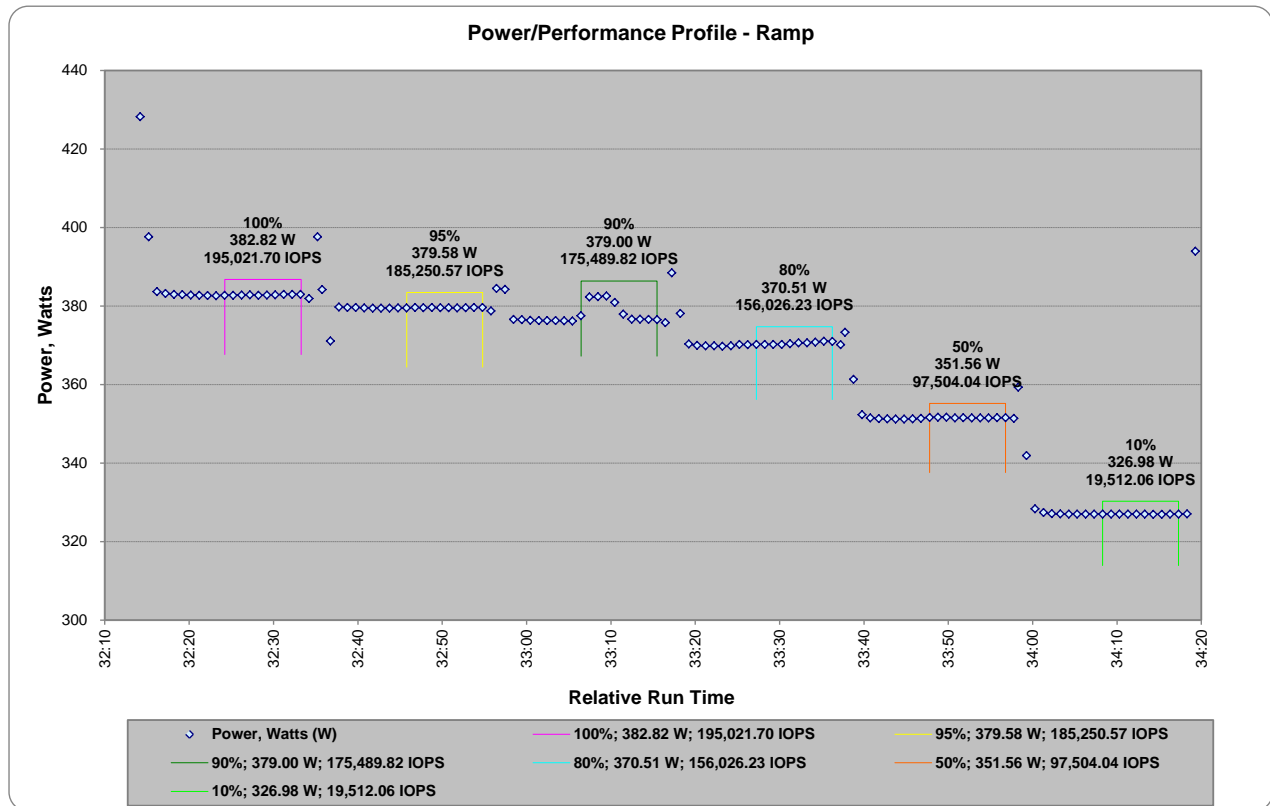
Execution Component	Load Level	SPC-1 IOPS™	Power (W)
Idle – Conditioning ( <b>Condition</b> )	100%	194,993.76	382.89
Idle ( <b>Idle-L</b> )	0%	0.00	320.44
Idle - Recovery ( <b>Recovery</b> )	10%	19,489.22	326.62

**Power/Performance Profile – Sustainability Test Run**



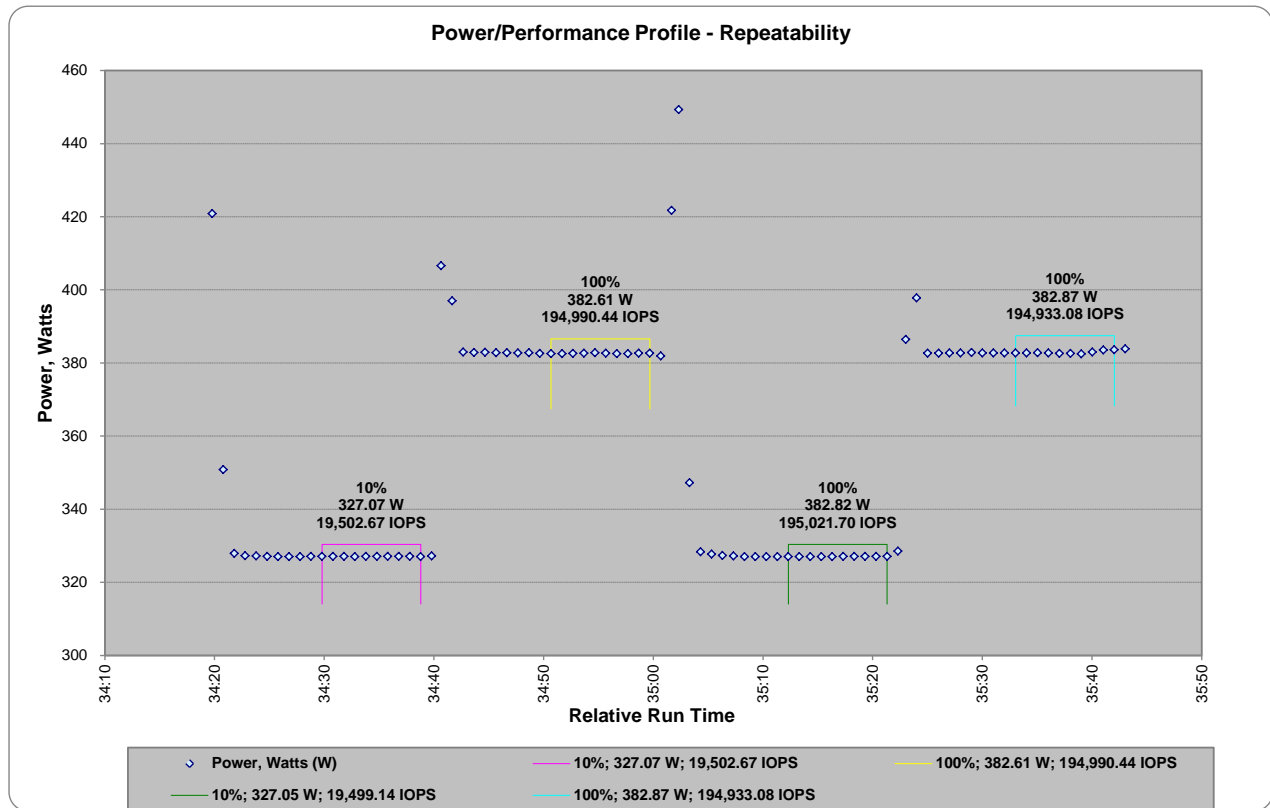
Execution Component	Load Level	SPC-1 IOPS™	Power (W)
Sustainability ( <i>Sustain</i> )	100%	194,998.33	386.52

**Power/Performance Profile – IOPS and Response Time Ramp Test Runs**



Execution Component	Load Level	SPC-1 IOPS™	Power (W)
IOPS (100%)	100%	195,021.70	382.82
Ramp95 (95%)	95%	185,250.57	379.58
Ramp90 (90%)	90%	175,489.82	379.00
Ramp80 (80%)	80%	156,026.23	370.51
Ramp50 (50%)	50%	97,504.04	351.56
Ramp10 (10%)	10%	19,512.06	216.98

**Power/Performance Profile – Repeatability Test (two phases)**



Execution Component	Load Level	SPC-1 IOPS™	Power (W)
Repeat1 LRT (10%)	10%	19,502.67	327.07
Repeat1 IOPS (100%)	100%	194,990.44	382.61
Repeat2 LRT (10%)	10%	19,499.14	327.05
Repeat2 IOPS (100%)	100%	194,933.08	382.87

## 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

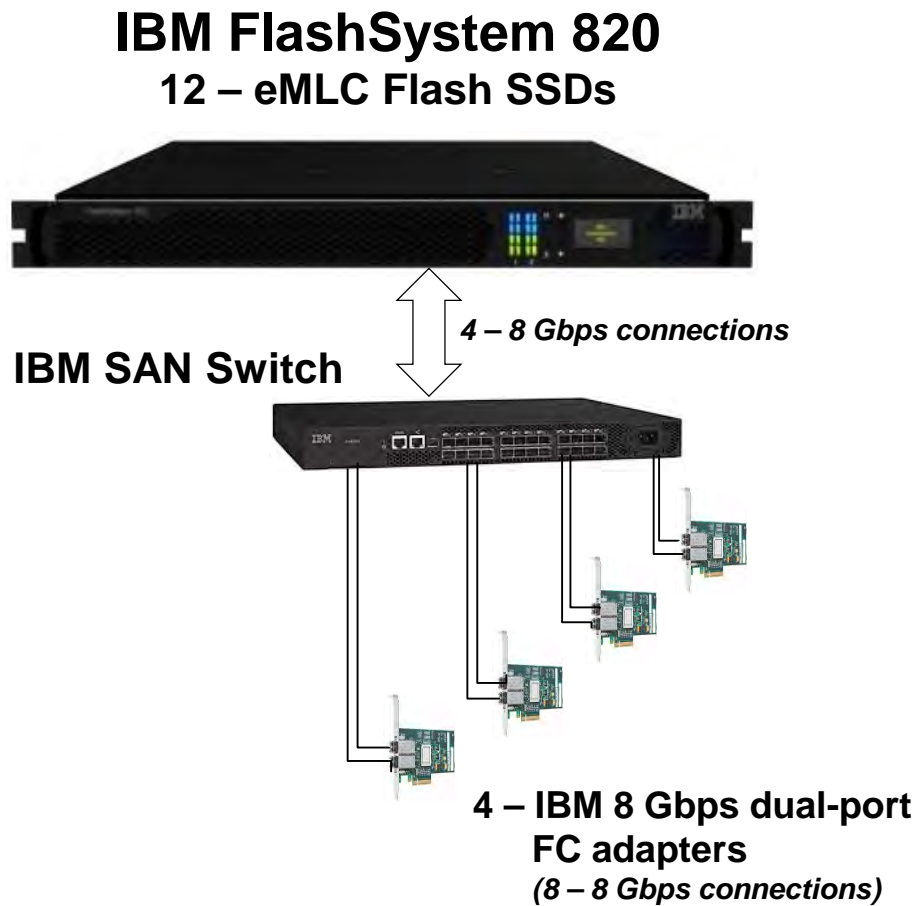
Component	Quantity	Unit Price	Unit Maint	List w/ Maint	% discount	Total Price
FlashSystem 820 (9831-AE2) w/ 4 SFPs, 1 year warranty included	1	16,000.00	40,608.00	56,608.00	30	39,625.60
eMLC 12-pack (9831-AF0F) <i>12 max capacity flash cards</i>	1	331,000.00	0.00	331,000.00	30	231,700.00
24 port fibre channel switch (2498-B24) w/ 16 SFPs, 16 ports enabled	1	10,750.00	10,800.00	21,550.00	20	17,240.00
5m fibre channel cable (9831-3701)	12	75.00	0.00	900.00	30	630.00
8 Gbps dual port FC adapter (9117-5735)	4	4,583.00	0.00	18,332.00	30	12,832.40
<b>Total Price</b>						<b>302,028.00</b>

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**



**Priced Storage Configuration Components**

<b>Priced Storage Configuration</b>
4 – IBM 8 Gbps dual-port FC adapters
1 – IBM SAN 24 port switch <i>(16 ports enabled w/16 SFPs)</i>
<b>IBM FlashSystem 820</b>
Dual controllers
4 – 8 Gbps FC front-end connections <i>(w/4 SFPs)</i> <i>(4 connections used)</i>
40 – SAMNet backend lanes available and used <i>(proprietary interconnect similar to PCIe)</i>
12 – eMLC Flash SSDs

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 [27 \(Benchmark Configuration/Tested Storage Configuration Diagram\)](#).

### **Storage Network Configuration**

#### **Clause 9.4.3.4.1**

...

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

#### **Clause 9.4.3.4.2**

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

The Tested Storage Configuration was configured with local, directly connected storage and did not utilize a storage network.

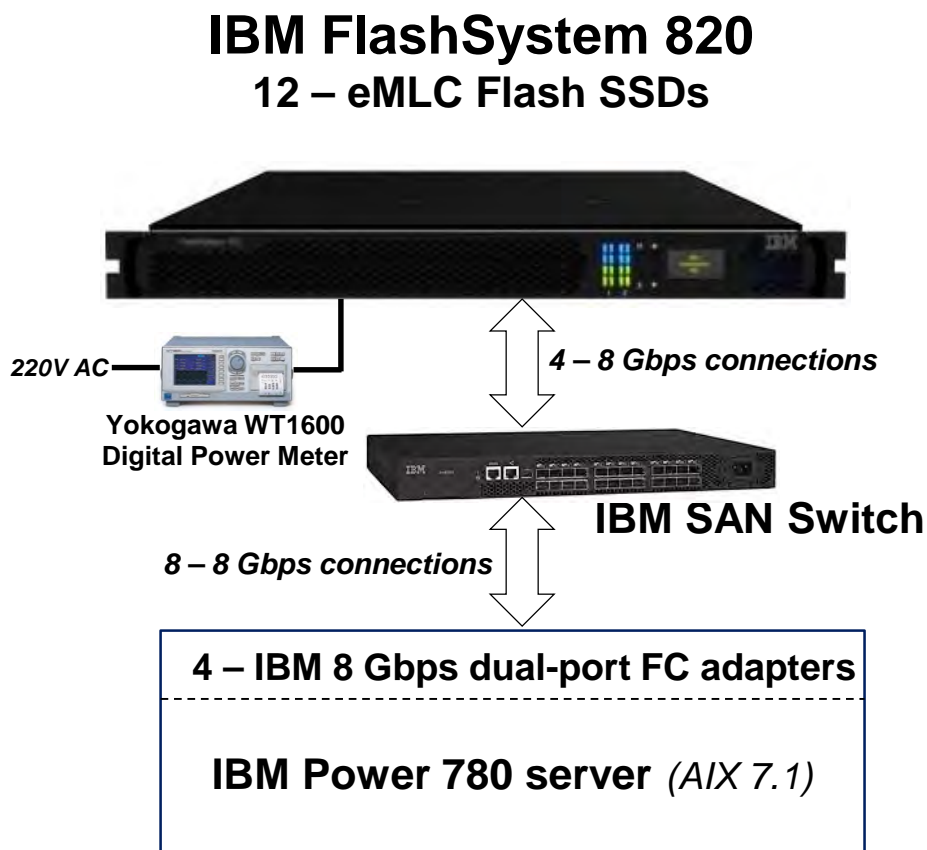
### **Host System and Tested Storage Configuration (TSC) Table of Components**

#### **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 [27 \(Host Systems and Tested Storage Configuration Components\)](#).

**Benchmark Configuration/Tested Storage Configuration Diagram**



**Host Systems and Tested Storage Configuration Components**

Host System:	Tested Storage Configuration (TSC):
<b>IBM Power 780 server</b> 16 – Power 7+ processor modules 4 – 3.1 GHz processor cores/module <i>(64 processors total)</i> 256 KB L2 cache per core 4 MB L3 cache per core  240 GB main memory AIX 7.1 PCIe	4 – IBM 8 Gbps dual-port FC adapters
	1 – IBM SAN 24 port switch <i>(16 ports enabled w/16 SFPs)</i>
	<b>IBM FlashSystem 820</b> Dual controllers 4 – 8 Gbps FC front-end connections <i>(w/4 SFPs)</i> <i>(4 connections used)</i> 40 – SAMNet backend lanes available and used <i>(proprietary interconnect similar to PCIe)</i>  12 – eMLC Flash SSDs

## 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 [71](#) 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 [72](#) 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 [80](#).

## 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 [80](#).

## **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 [67](#) 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 24,673.041 GB distributed over 12 solid state storage devices, each with a formatted capacity of 2,056.087 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0.000 GB (0.00%) of the Physical Storage Capacity. There was 8,268.671 GB (33.51%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 99.47% of the Addressable Storage Capacity resulting in 66.811 GB (0.54%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*RAID-5*) capacity was 2,056.087 GB of which 1,264.629 GB was utilized. The total Unused Storage capacity was 9,126.939 GB.

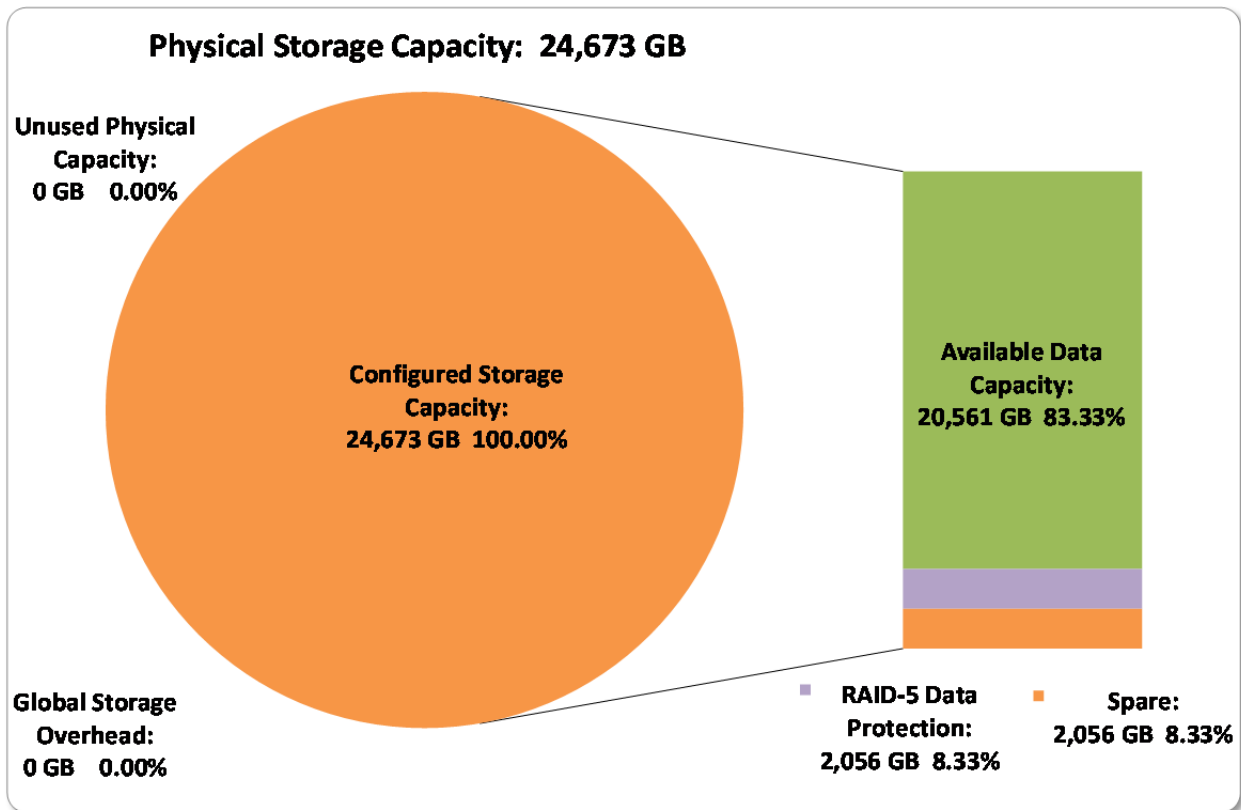
*Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.*

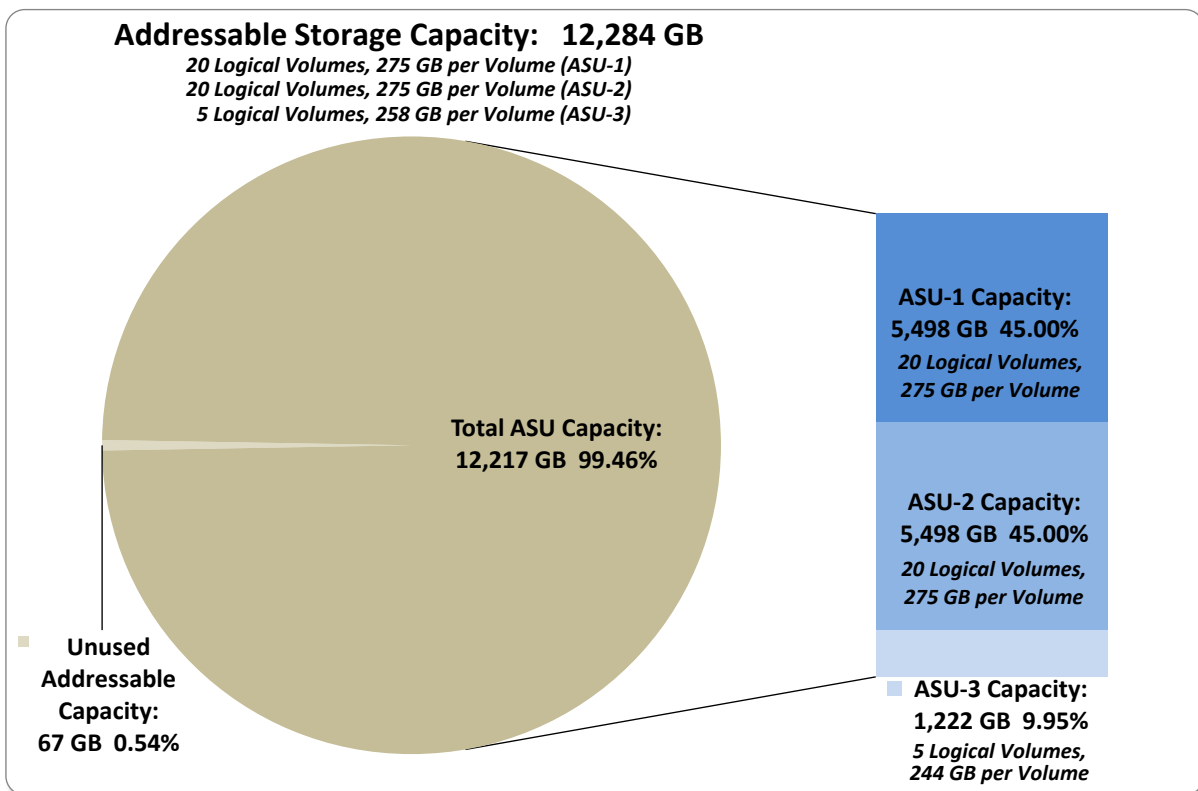
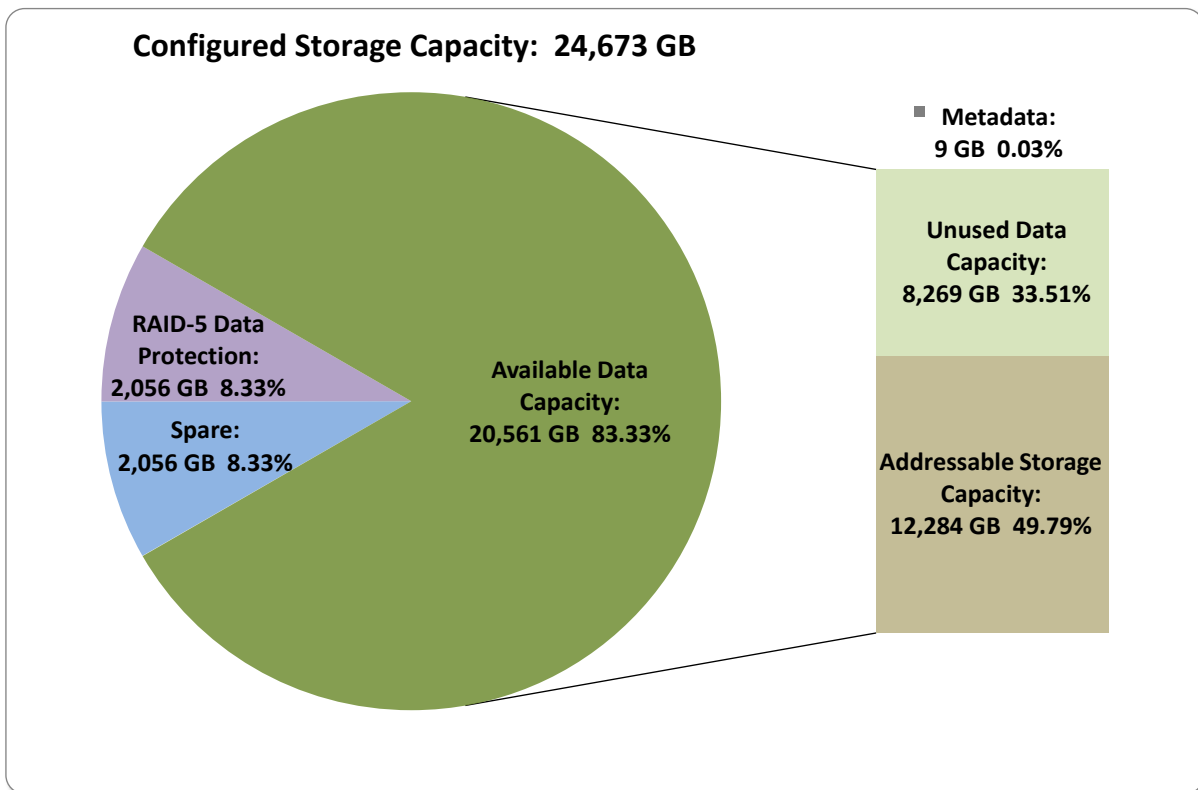
<b>SPC-1 Storage Capacities</b>		
<b>Storage Hierarchy Component</b>	<b>Units</b>	<b>Capacity</b>
Total ASU Capacity	Gigabytes (GB)	12,216.796
Addressable Storage Capacity	Gigabytes (GB)	12,283.606
Configured Storage Capacity	Gigabytes (GB)	24,673.041
Physical Storage Capacity	Gigabytes (GB)	24,673.041
Data Protection ( <i>RAID-5</i> )	Gigabytes (GB)	2,056.087
Required Storage ( <i>metadata/sparing</i> )	Gigabytes (GB)	2,056.536
Global Storage Overhead	Gigabytes (GB)	0.000
Total Unused Storage	Gigabytes (GB)	9,126.939

SPC-1 Storage Hierarchy Ratios

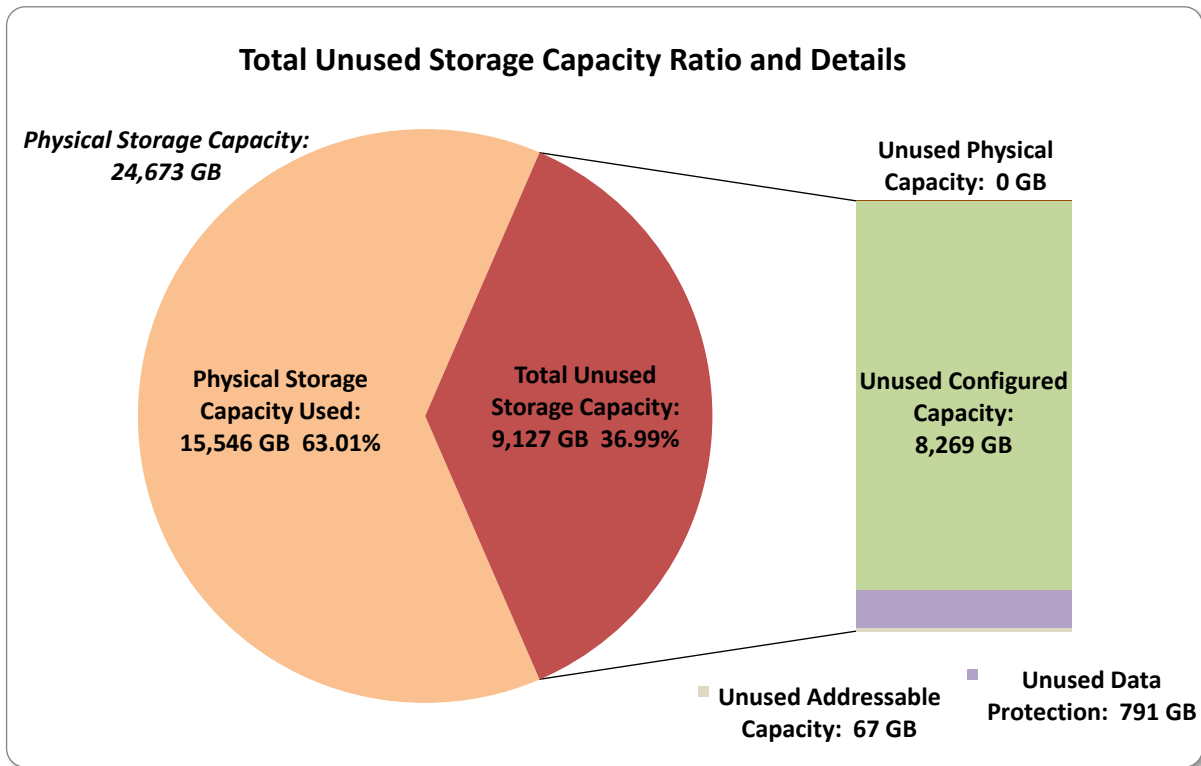
	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	99.46%	49.51%	45.51%
Required for Data Protection (RAID-5)		8.33%	8.33%
Addressable Storage Capacity		49.79%	49.79%
Required Storage (metadata/spare)		8.37%	8.37%
Configured Storage Capacity			100.00%
Global Storage Overhead			0.00%
Unused Storage:			
Addressable	0.54%		
Configured		33.51%	
Physical			0.00%

SPC-1 Storage Capacity Charts









## Storage Capacity Utilization

### Clause 9.4.3.6.2

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

### Clause 2.8.1

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

### Clause 2.8.2

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

### Clause 2.8.3

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

SPC-1 Storage Capacity Utilization	
Application Utilization	49.51%
Protected Application Utilization	54.64%
Unused Storage Ratio	36.99%

## 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 (5,497.558 GB)	ASU-2 (5,497.558 GB)	ASU-3 (1,221.680 GB)
20 Logical Volumes 274.878 GB per Logical Volume (274.878 GB used per Logical Volume)	20 Logical Volumes 274.878 GB per Logical Volume (274.878 GB used per Logical Volume)	5 Logical Volumes 257.698 GB per Logical Volume (244.336 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was [Protected 1](#) using *RAID-5* as described on page [12](#). See “ASU Configuration” in the [IOPS Test Results File](#) for more detailed configuration information.

## **SPC-1 BENCHMARK EXECUTION RESULTS**

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. “SPC-1 Test Execution Definitions” on page 68 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.*

There were no “Ramp-Up” Test Runs included in the benchmark execution.

## 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 85.

### 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 – 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

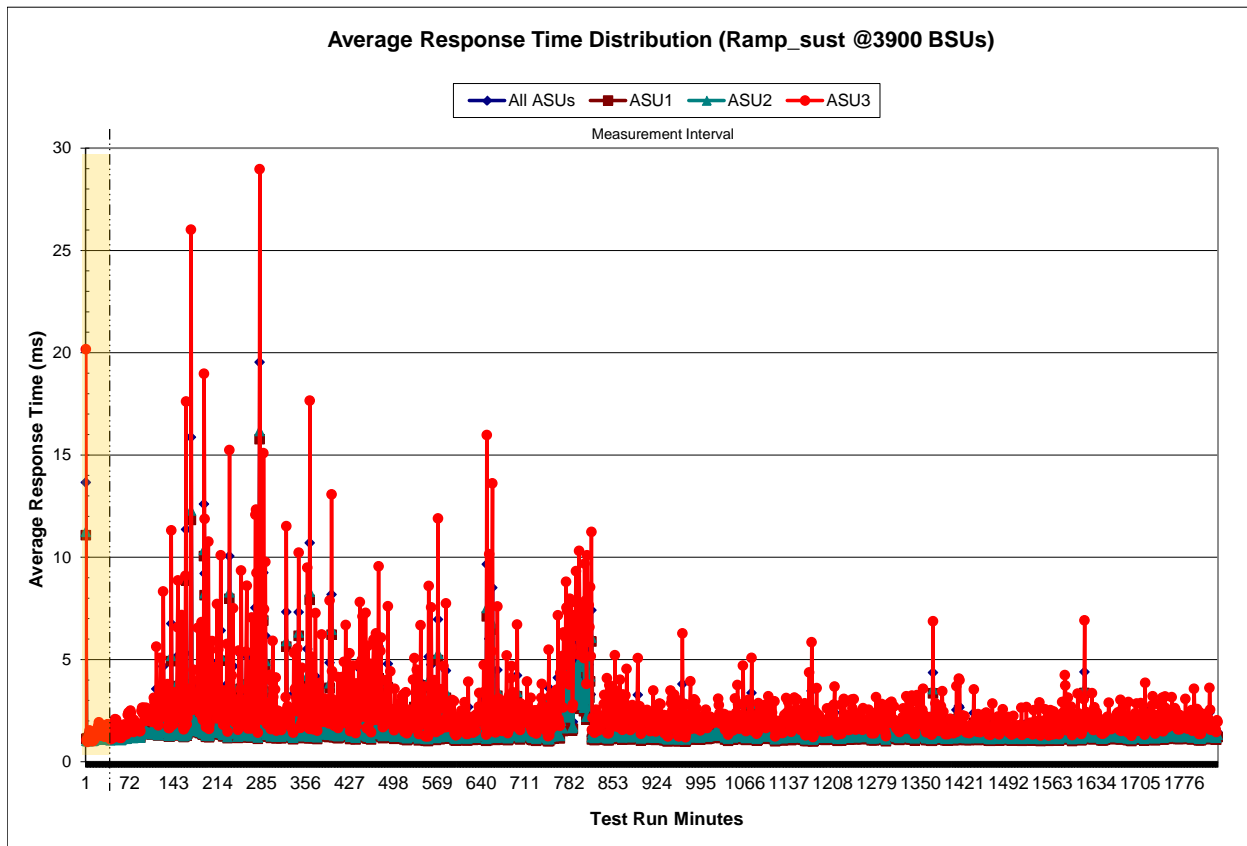


### Sustainability – Average Response Time (ms) Distribution Data

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

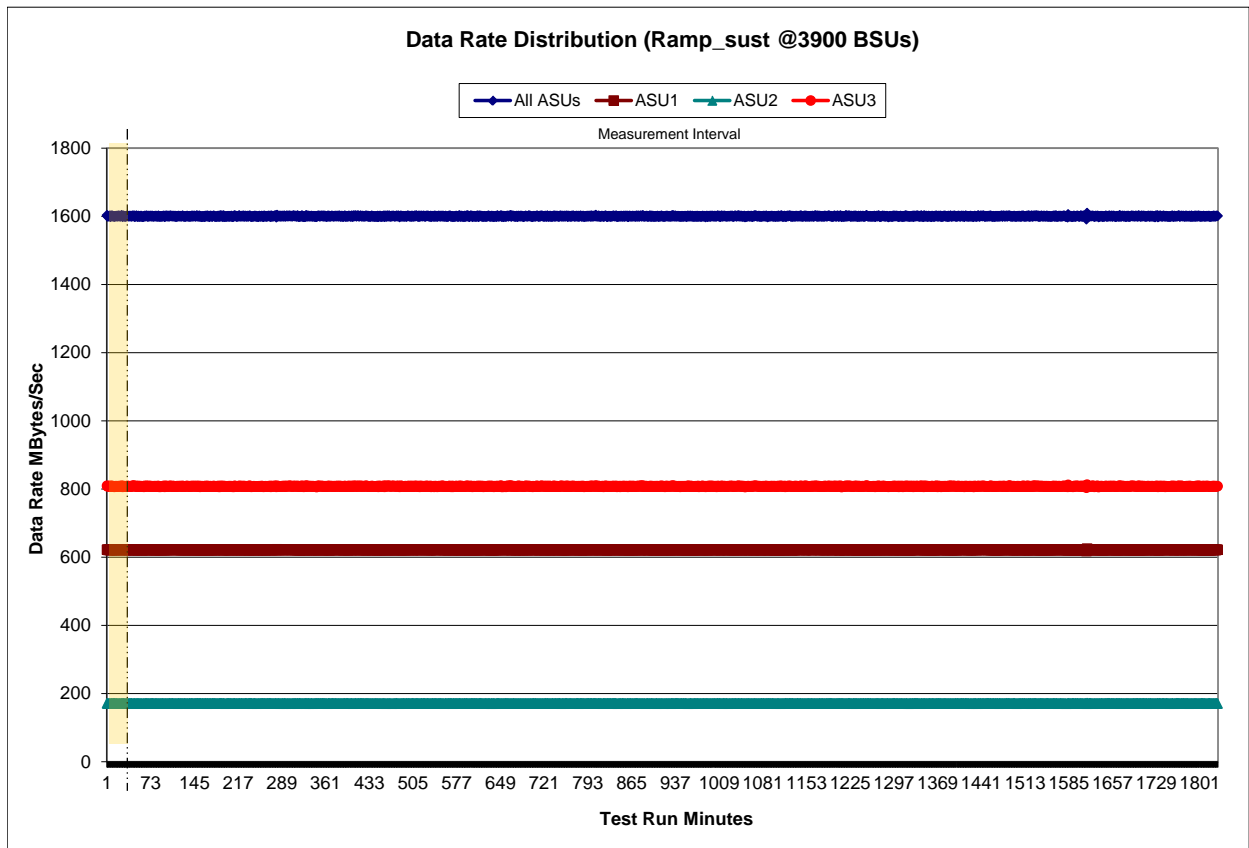


### Sustainability – Data Rate Distribution Data (MB/second)

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](#)

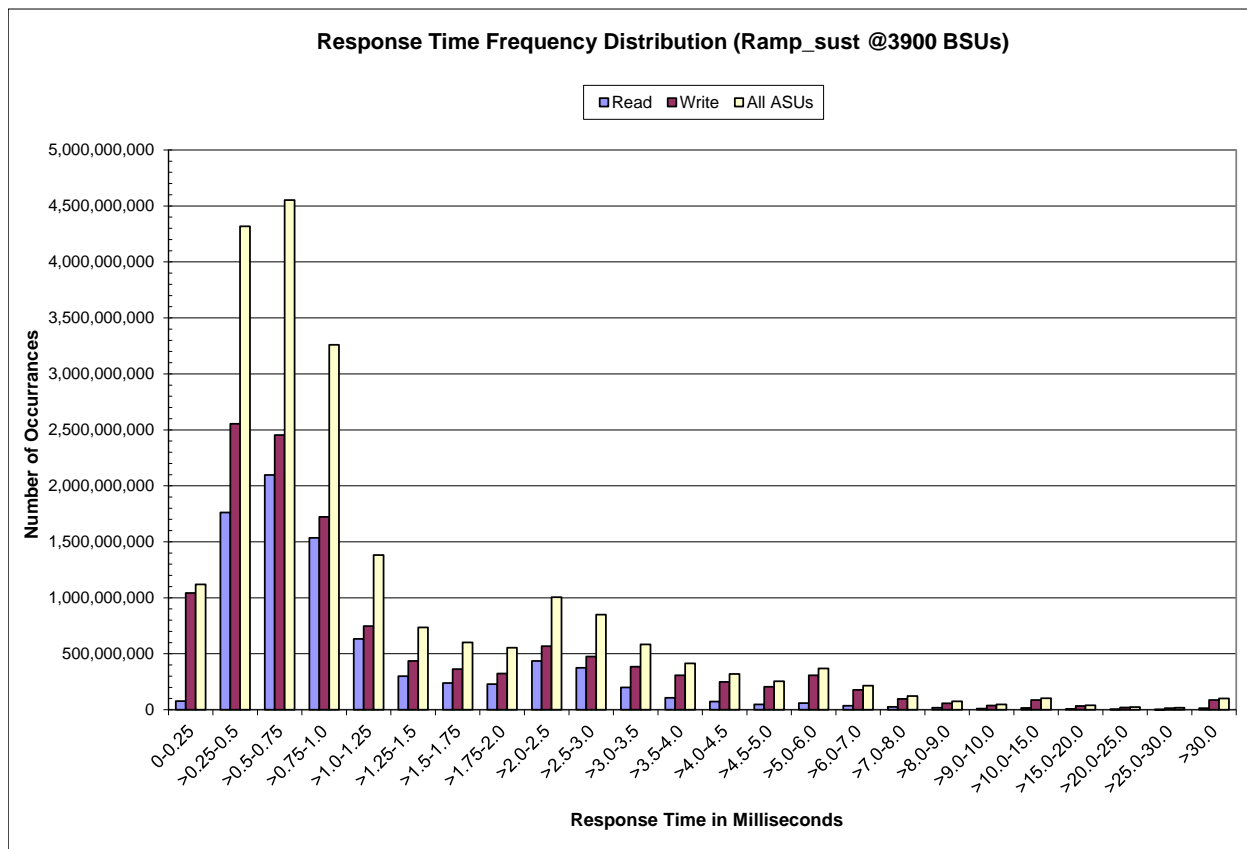
### Sustainability – Data Rate Distribution Graph



### Sustainability – 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	76,293,681	1,762,609,522	2,097,604,620	1,536,184,669	633,794,435	300,155,940	238,695,656	228,969,985
Write	1,042,823,211	2,554,965,330	2,454,110,240	1,723,503,093	747,247,900	435,689,001	361,866,933	324,270,414
All ASUs	1,119,116,892	4,317,574,852	4,551,714,860	3,259,687,762	1,381,042,335	735,844,941	600,562,589	553,240,399
ASU1	591,739,967	2,714,805,145	3,080,873,896	2,222,825,080	879,444,097	403,210,585	307,168,226	283,039,594
ASU2	132,661,754	523,966,385	595,833,222	434,920,667	177,628,833	86,725,758	68,722,780	64,692,487
ASU3	394,715,171	1,078,803,322	875,007,742	601,942,015	323,969,405	245,908,598	224,671,583	205,508,318
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	436,323,286	374,641,926	199,164,166	107,268,691	72,596,413	48,335,012	59,877,357	36,592,873
Write	568,250,993	475,599,599	384,427,011	307,160,641	247,714,023	206,129,229	308,174,659	178,100,547
All ASUs	1,004,574,279	850,241,525	583,591,177	414,429,332	320,310,436	254,464,241	368,052,016	214,693,420
ASU1	520,050,493	438,069,281	269,585,191	173,910,841	129,138,395	98,431,942	138,551,450	82,504,227
ASU2	122,690,554	108,344,888	68,000,227	43,414,496	32,140,846	24,340,432	34,037,993	20,368,004
ASU3	361,833,232	303,827,356	246,005,759	197,103,995	159,031,195	131,691,867	195,462,573	111,821,189
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	26,284,838	17,952,371	9,401,540	16,040,793	5,799,296	3,914,837	3,163,216	13,808,080
Write	96,426,138	56,493,835	38,349,471	87,606,361	34,219,753	20,045,396	14,947,714	86,224,912
All ASUs	122,710,976	74,446,206	47,751,011	103,647,154	40,019,049	23,960,233	18,110,930	100,032,992
ASU1	50,304,122	31,687,244	19,639,315	41,789,934	16,712,543	10,423,593	8,017,214	39,597,558
ASU2	12,602,589	8,004,545	4,849,118	9,950,373	3,758,297	2,284,908	1,747,811	8,675,377
ASU3	59,804,265	34,754,417	23,262,578	51,906,847	19,548,209	11,251,732	8,345,905	51,760,057

### 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
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.000	0.001	0.001	0.002	0.001	0.001	0.000

## 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 [85](#).

## IOPS Test Results File

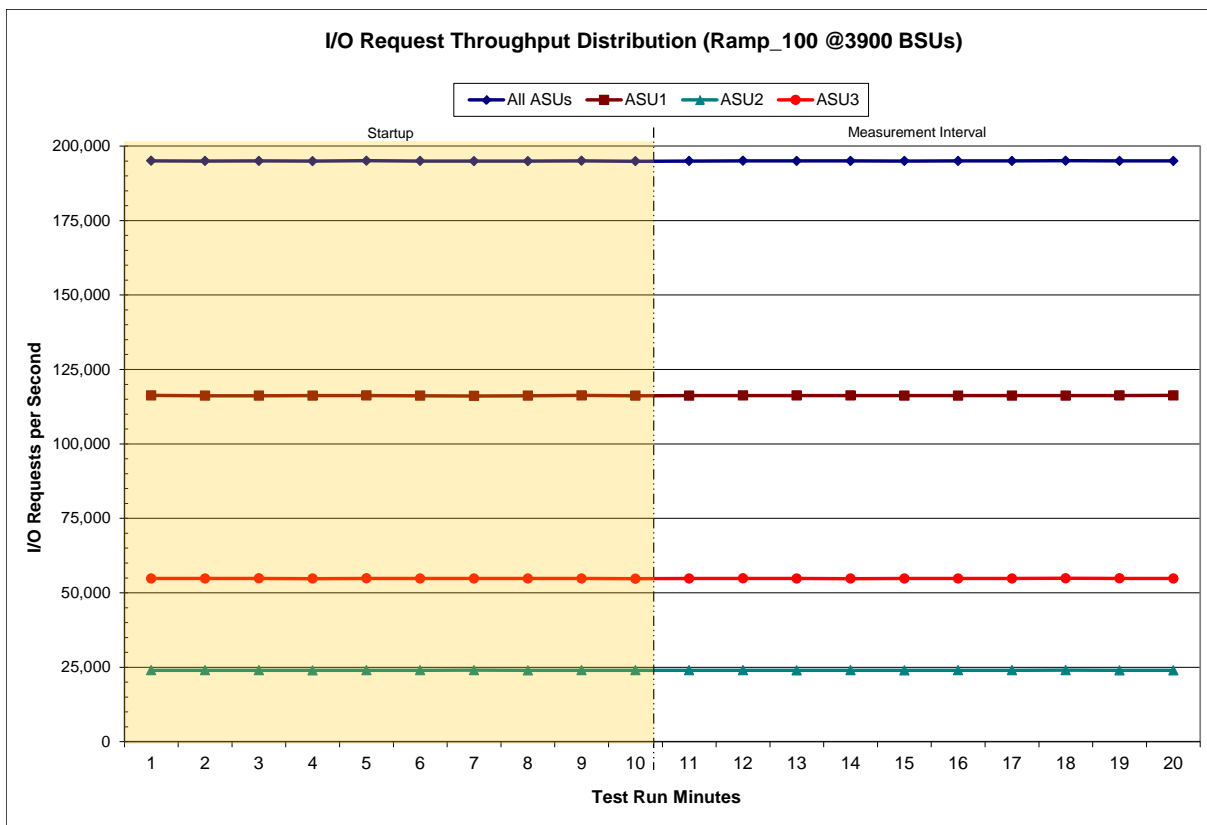
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

### IOPS Test Run – I/O Request Throughput Distribution Data

3,900 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	23:34:12	23:44:13	0-9	0:10:01
<i>Measurement Interval</i>	23:44:13	23:54:16	9-19	0:10:03
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	195,070.90	116,279.48	23,986.60	54,804.82
1	194,994.15	116,192.93	23,989.45	54,811.77
2	195,016.52	116,179.10	24,002.72	54,834.70
3	194,942.77	116,199.43	23,960.63	54,782.70
4	195,074.40	116,260.95	23,984.77	54,828.68
5	194,980.67	116,174.52	23,985.72	54,820.43
6	194,929.60	116,108.17	24,012.50	54,808.93
7	194,935.47	116,167.20	23,972.45	54,795.82
8	195,067.62	116,277.45	23,994.42	54,795.75
9	194,897.68	116,160.92	24,005.28	54,731.48
10	194,987.82	116,198.23	23,985.22	54,804.37
11	195,071.55	116,253.63	23,982.05	54,835.87
12	195,002.22	116,235.63	23,973.13	54,793.45
13	195,009.03	116,237.30	23,994.38	54,777.35
14	194,975.45	116,205.98	23,963.30	54,806.17
15	195,023.05	116,205.87	24,006.02	54,811.17
16	195,026.95	116,201.00	24,009.45	54,816.50
17	195,082.88	116,197.07	24,012.78	54,873.03
18	195,006.37	116,235.22	23,940.63	54,830.52
19	195,031.67	116,270.68	23,962.32	54,798.67
<b>Average</b>	<b>195,021.70</b>	<b>116,224.06</b>	<b>23,982.93</b>	<b>54,814.71</b>

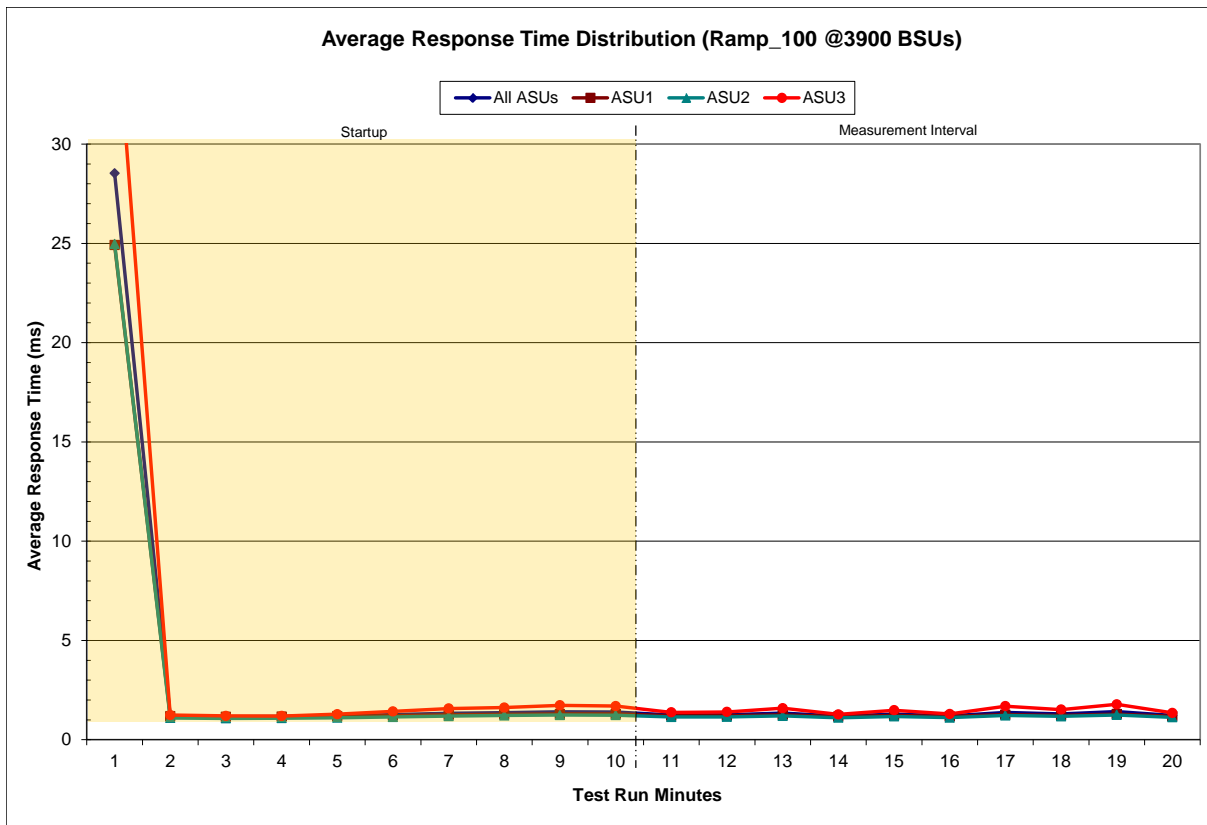
### IOPS Test Run – I/O Request Throughput Distribution Graph



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

3,900 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:34:12	23:44:13	0-9	0:10:01
Measurement Interval	23:44:13	23:54:16	9-19	0:10:03
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	28.53	24.91	24.97	37.76
1	1.19	1.19	1.10	1.24
2	1.16	1.16	1.08	1.20
3	1.16	1.17	1.08	1.20
4	1.20	1.19	1.11	1.28
5	1.27	1.22	1.15	1.42
6	1.34	1.25	1.19	1.57
7	1.37	1.28	1.22	1.62
8	1.41	1.30	1.24	1.73
9	1.40	1.30	1.24	1.70
10	1.25	1.21	1.15	1.38
11	1.26	1.21	1.15	1.40
12	1.34	1.26	1.20	1.59
13	1.19	1.17	1.11	1.28
14	1.29	1.23	1.17	1.49
15	1.20	1.18	1.11	1.30
16	1.38	1.27	1.22	1.69
17	1.30	1.23	1.18	1.52
18	1.42	1.29	1.25	1.78
19	1.22	1.18	1.13	1.35
<b>Average</b>	<b>1.29</b>	<b>1.22</b>	<b>1.17</b>	<b>1.48</b>

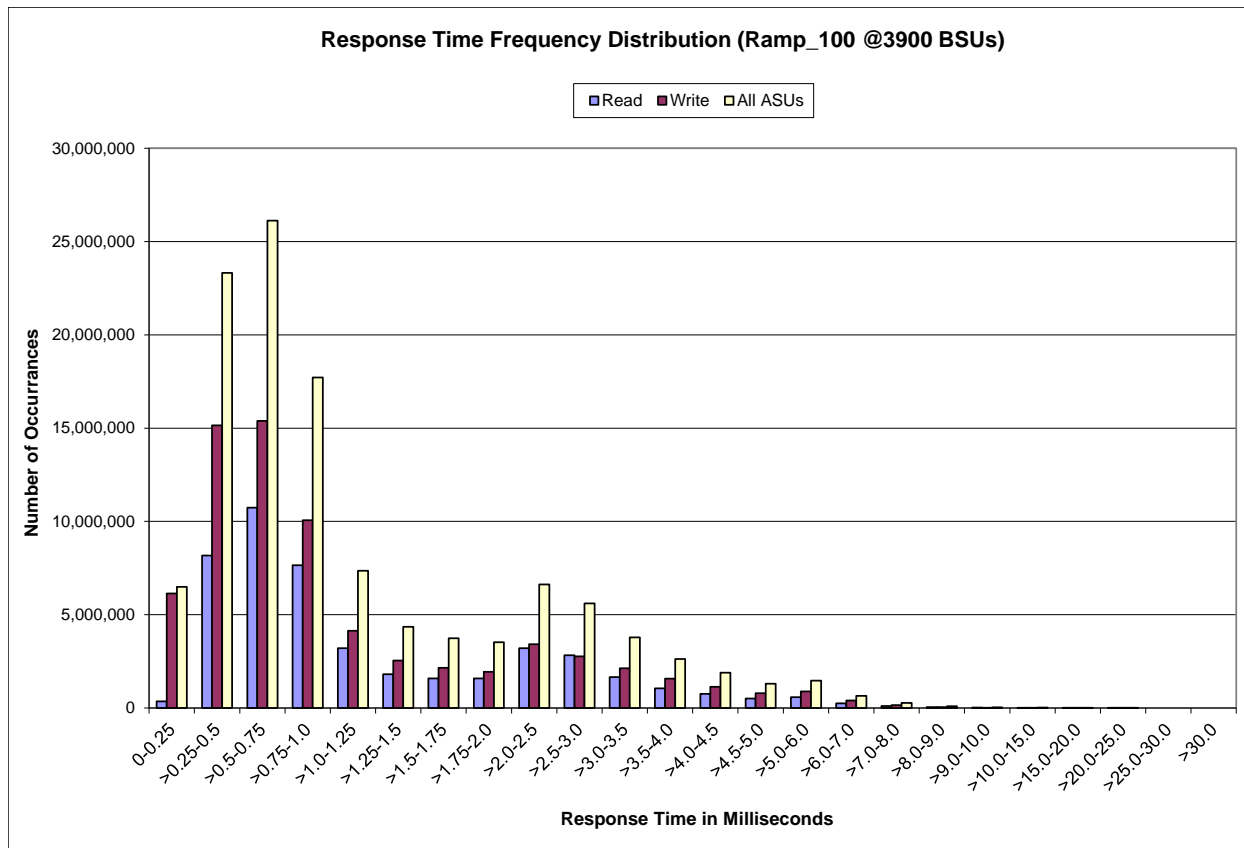
**IOPS Test Run – Average Response Time (ms) Distribution Graph**



**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	358,160	8,176,246	10,739,904	7,655,255	3,205,419	1,807,592	1,583,956	1,588,092
Write	6,134,587	15,147,607	15,387,078	10,064,085	4,144,965	2,546,973	2,148,770	1,940,365
All ASUs	6,492,747	23,323,853	26,126,982	17,719,340	7,350,384	4,354,565	3,732,726	3,528,457
ASU1	3,380,223	13,924,095	16,991,272	11,649,111	4,488,844	2,364,742	1,961,753	1,888,054
ASU2	775,284	2,955,314	3,589,732	2,417,420	908,620	468,063	386,979	370,400
ASU3	2,337,240	6,444,444	5,545,978	3,652,809	1,952,920	1,521,760	1,383,994	1,270,003
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	3,202,892	2,832,474	1,654,844	1,049,528	760,185	510,519	576,949	253,339
Write	3,414,499	2,768,052	2,128,058	1,579,031	1,136,671	795,316	892,969	401,315
All ASUs	6,617,391	5,600,526	3,782,902	2,628,559	1,896,856	1,305,835	1,469,918	654,654
ASU1	3,656,209	3,138,210	1,990,940	1,342,578	974,458	665,141	749,769	333,644
ASU2	723,793	641,189	392,496	248,406	175,750	117,073	128,138	55,181
ASU3	2,237,389	1,821,127	1,399,466	1,037,575	746,648	523,621	592,011	265,829
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	109,244	45,703	19,358	14,394	696	94	-	-
Write	159,228	46,718	16,014	14,578	907	13	-	-
All ASUs	268,472	92,421	35,372	28,972	1,603	107	-	-
ASU1	141,296	54,178	21,648	17,007	959	91	-	-
ASU2	22,657	7,845	3,011	2,248	108	9	-	-
ASU3	104,519	30,398	10,713	9,717	536	7	-	-

**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
117,012,642	117,012,642	0

### 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
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2810	0.0700	0.2099	0.0180	0.0700	0.0350	0.2811
COV	0.001	0.001	0.002	0.001	0.003	0.001	0.002	0.000

## Primary Metrics Test – Response Time Ramp Test Phase

### Clause 5.4.4.3

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

*The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 16.*

*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 [85](#).

## 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.

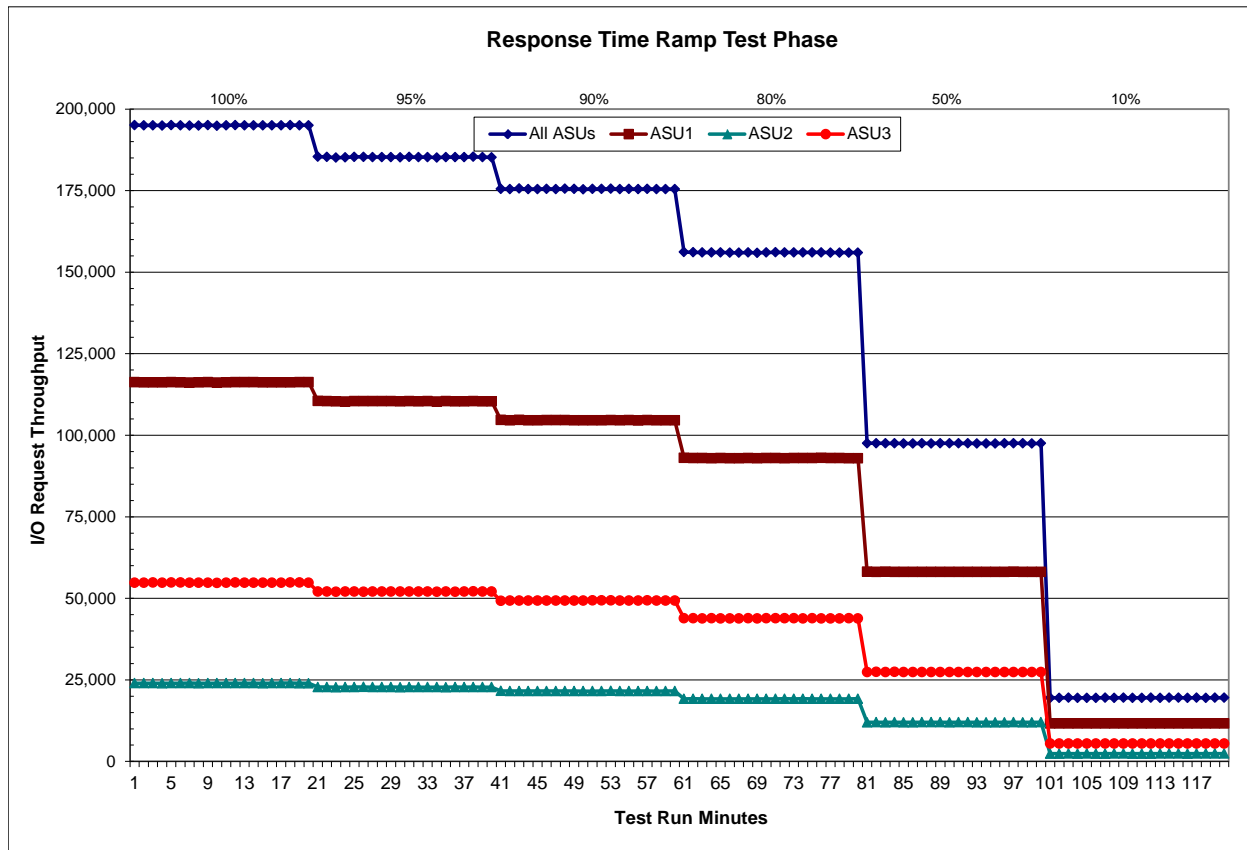
100% Load Level - 3,900 BSUs					95% Load Level - 3,705 BSUs				
Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration	Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	195,070.90	116,279.48	23,986.60	54,804.82	0	185,413.72	110,528.43	22,821.48	52,063.80
1	194,994.15	116,192.93	23,989.45	54,811.77	1	185,306.83	110,452.57	22,793.08	52,061.18
2	195,016.52	116,179.10	24,002.72	54,834.70	2	185,123.93	110,386.38	22,738.13	51,999.42
3	194,942.77	116,199.43	23,960.63	54,782.70	3	185,159.45	110,323.77	22,783.35	52,052.33
4	195,074.40	116,260.95	23,984.77	54,828.68	4	185,327.77	110,469.43	22,805.48	52,052.85
5	194,980.67	116,174.52	23,985.72	54,820.43	5	185,337.43	110,482.22	22,824.93	52,030.28
6	194,929.60	116,108.17	24,012.50	54,808.93	6	185,280.40	110,421.27	22,774.65	52,084.48
7	194,935.47	116,167.20	23,972.45	54,795.82	7	185,274.28	110,428.65	22,792.70	52,061.93
8	195,067.62	116,277.45	23,994.42	54,795.75	8	185,272.57	110,423.83	22,792.63	52,056.10
9	194,897.68	116,160.92	24,005.28	54,731.48	9	185,214.12	110,374.30	22,742.77	52,097.05
10	194,987.82	116,198.23	23,985.22	54,804.37	10	185,302.33	110,440.85	22,792.50	52,068.98
11	195,071.55	116,253.63	23,982.05	54,835.87	11	185,237.45	110,399.33	22,775.85	52,062.27
12	195,002.22	116,235.63	23,973.13	54,793.45	12	185,286.60	110,437.72	22,782.93	52,065.95
13	195,009.03	116,237.30	23,994.38	54,777.35	13	185,102.77	110,324.42	22,763.13	52,015.22
14	194,975.45	116,205.98	23,963.30	54,806.17	14	185,277.75	110,475.32	22,751.45	52,050.98
15	195,023.05	116,205.87	24,006.02	54,811.17	15	185,228.07	110,366.75	22,822.45	52,038.87
16	195,026.95	116,201.00	24,009.45	54,816.50	16	185,236.45	110,414.62	22,772.20	52,049.63
17	195,082.88	116,197.07	24,012.78	54,873.03	17	185,362.55	110,423.05	22,803.83	52,135.67
18	195,006.37	116,235.22	23,940.63	54,830.52	18	185,247.80	110,393.22	22,769.70	52,084.88
19	195,031.67	116,270.68	23,962.32	54,798.67	19	185,223.90	110,401.98	22,776.17	52,045.75
<b>Average</b>	<b>195,021.70</b>	<b>116,224.06</b>	<b>23,982.93</b>	<b>54,814.71</b>	<b>Average</b>	<b>185,250.57</b>	<b>110,407.73</b>	<b>22,781.02</b>	<b>52,061.82</b>
90% Load Level - 3,510 BSUs					80% Load Level - 3,120 BSUs				
Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration	Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	175,540.08	104,673.37	21,605.97	49,260.75	0	156,150.82	93,077.43	19,198.13	43,875.25
1	175,442.60	104,582.90	21,579.62	49,280.08	1	156,100.17	93,001.60	19,233.13	43,865.43
2	175,627.67	104,702.03	21,590.93	49,334.70	2	156,017.33	92,967.23	19,195.38	43,854.72
3	175,481.60	104,581.93	21,592.03	49,307.63	3	156,036.72	92,960.50	19,201.52	43,874.70
4	175,462.73	104,539.72	21,587.00	49,336.02	4	156,060.60	93,027.63	19,185.13	43,847.83
5	175,547.12	104,651.27	21,578.37	49,317.48	5	155,964.48	92,917.15	19,197.63	43,849.70
6	175,482.38	104,605.18	21,583.08	49,294.12	6	155,942.18	92,952.50	19,180.73	43,808.95
7	175,583.27	104,666.73	21,583.85	49,332.68	7	156,038.17	92,979.20	19,179.82	43,879.15
8	175,513.07	104,590.32	21,605.22	49,317.53	8	155,917.08	92,908.33	19,188.40	43,820.35
9	175,388.17	104,532.28	21,568.02	49,287.87	9	156,034.90	92,970.10	19,192.50	43,872.30
10	175,486.28	104,593.53	21,550.97	49,341.78	10	156,081.95	93,016.38	19,195.63	43,869.93
11	175,487.98	104,544.07	21,583.45	49,360.47	11	156,023.82	92,943.90	19,215.25	43,864.67
12	175,580.28	104,609.60	21,625.78	49,344.90	12	156,065.98	93,023.52	19,181.78	43,860.68
13	175,466.28	104,545.17	21,585.52	49,335.60	13	156,018.75	92,980.78	19,208.43	43,829.53
14	175,551.90	104,647.85	21,567.42	49,336.63	14	156,051.77	92,975.98	19,193.17	43,882.62
15	175,437.88	104,528.78	21,578.03	49,331.07	15	156,044.68	93,058.78	19,191.85	43,794.05
16	175,526.67	104,603.67	21,584.27	49,338.73	16	155,974.55	92,996.28	19,178.20	43,800.07
17	175,437.12	104,581.73	21,553.02	49,302.37	17	155,998.35	92,970.73	19,172.53	43,855.08
18	175,478.52	104,582.08	21,595.15	49,301.28	18	155,997.78	92,928.05	19,196.55	43,873.18
19	175,445.27	104,541.08	21,584.58	49,319.60	19	156,004.63	92,947.42	19,216.08	43,841.13
<b>Average</b>	<b>175,489.82</b>	<b>104,577.76</b>	<b>21,580.82</b>	<b>49,331.24</b>	<b>Average</b>	<b>156,026.23</b>	<b>92,984.18</b>	<b>19,194.95</b>	<b>43,847.10</b>



**Response Time Ramp Distribution (IOPS) Data (continued)**

50% Load Level - 1,950 BSUs					10% Load Level - 390 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
0:57:46	1:07:47	0-9	0:10:01		1:18:17	1:28:18	0-9	0:10:01	
1:07:47	1:17:47	10-19	0:10:00		1:28:18	1:38:18	10-19	0:10:00	
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
	All ASUs	ASU-1	ASU-2	ASU-3		All ASUs	ASU-1	ASU-2	ASU-3
0	97,556.97	58,157.80	11,986.13	27,413.03	0	19,500.13	11,613.62	2,390.92	5,495.60
1	97,559.30	58,116.55	12,014.78	27,427.97	1	19,479.85	11,618.07	2,388.02	5,473.77
2	97,512.72	58,137.25	11,987.35	27,388.12	2	19,523.28	11,632.33	2,412.42	5,478.53
3	97,513.72	58,074.98	12,008.77	27,429.97	3	19,501.68	11,626.92	2,395.75	5,479.02
4	97,484.98	58,099.88	11,991.48	27,393.62	4	19,500.95	11,627.50	2,396.97	5,476.48
5	97,452.25	58,091.02	11,968.93	27,392.30	5	19,484.43	11,620.65	2,391.30	5,472.48
6	97,515.40	58,101.37	12,009.08	27,404.95	6	19,514.18	11,629.20	2,393.30	5,491.68
7	97,487.02	58,109.82	12,007.93	27,369.27	7	19,479.68	11,605.30	2,396.78	5,477.60
8	97,537.62	58,119.98	12,002.70	27,414.93	8	19,520.52	11,628.22	2,397.68	5,494.62
9	97,507.23	58,119.98	11,990.53	27,396.72	9	19,493.78	11,619.75	2,391.83	5,482.20
10	97,515.62	58,094.90	12,015.40	27,405.32	10	19,498.80	11,602.35	2,393.27	5,503.18
11	97,522.80	58,087.13	12,025.75	27,409.92	11	19,511.93	11,637.18	2,394.47	5,480.28
12	97,495.05	58,121.72	11,975.53	27,397.80	12	19,499.38	11,626.17	2,400.52	5,472.70
13	97,478.22	58,066.78	11,991.82	27,419.62	13	19,533.85	11,638.97	2,409.15	5,485.73
14	97,443.03	58,090.20	11,987.13	27,365.70	14	19,517.68	11,637.02	2,405.40	5,475.27
15	97,522.82	58,125.62	11,990.92	27,406.28	15	19,497.00	11,610.35	2,387.35	5,499.30
16	97,556.55	58,155.22	12,006.75	27,394.58	16	19,510.25	11,622.60	2,404.42	5,483.23
17	97,527.43	58,124.48	11,996.05	27,406.90	17	19,501.78	11,617.40	2,399.82	5,484.57
18	97,459.87	58,074.05	11,990.82	27,395.00	18	19,532.78	11,636.33	2,405.32	5,491.13
19	97,519.05	58,105.25	12,014.88	27,398.92	19	19,517.17	11,637.80	2,400.37	5,479.00
<b>Average</b>	<b>97,504.04</b>	<b>58,104.54</b>	<b>11,999.51</b>	<b>27,400.00</b>	<b>Average</b>	<b>19,512.06</b>	<b>11,626.62</b>	<b>2,400.01</b>	<b>5,485.44</b>

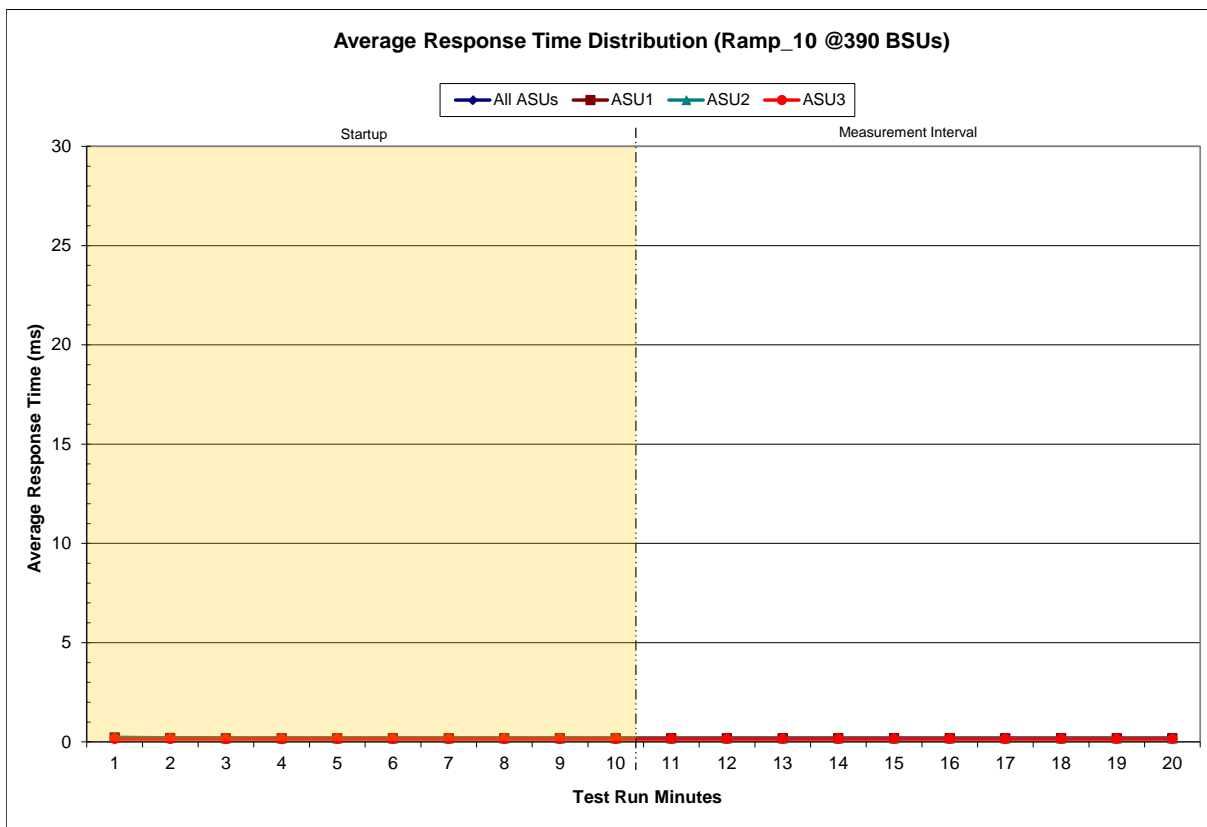
**Response Time Ramp Distribution (IOPS) Graph**



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

390 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	1:18:17	1:28:18	0-9	0:10:01
<i>Measurement Interval</i>	1:28:18	1:38:18	10-19	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.20	0.22	0.23	0.15
1	0.18	0.20	0.21	0.15
2	0.18	0.19	0.19	0.14
3	0.17	0.19	0.19	0.14
4	0.18	0.19	0.19	0.15
5	0.17	0.19	0.19	0.14
6	0.17	0.19	0.19	0.15
7	0.18	0.19	0.19	0.15
8	0.17	0.19	0.19	0.15
9	0.18	0.19	0.19	0.15
10	0.17	0.19	0.19	0.15
11	0.18	0.19	0.19	0.15
12	0.18	0.19	0.19	0.15
13	0.18	0.19	0.19	0.15
14	0.18	0.19	0.19	0.15
15	0.17	0.19	0.19	0.15
16	0.18	0.19	0.19	0.15
17	0.18	0.19	0.19	0.15
18	0.18	0.19	0.19	0.15
19	0.17	0.19	0.19	0.15
<b>Average</b>	<b>0.18</b>	<b>0.19</b>	<b>0.19</b>	<b>0.15</b>

**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
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2809	0.0700	0.2100	0.0179	0.0701	0.0350	0.2811
COV	0.004	0.001	0.004	0.001	0.0003	0.003	0.004	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 85.

**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™
<b>Primary Metrics</b>	<b>195,021.70</b>
<b>Repeatability Test Phase 1</b>	194,990.44
<b>Repeatability Test Phase 2</b>	194,933.08

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 be greater than 95% of the reported SPC-1 IOPS™ Primary Metric.

Average Response Time	
<b>Primary Metrics (SPC-1 LRT™)</b>	<b>0.18 ms</b>
<b>Repeatability Test Phase 1</b>	0.17ms
<b>Repeatability Test Phase 2</b>	0.17 ms

The average response time values were generated using 10% of the maximum 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).

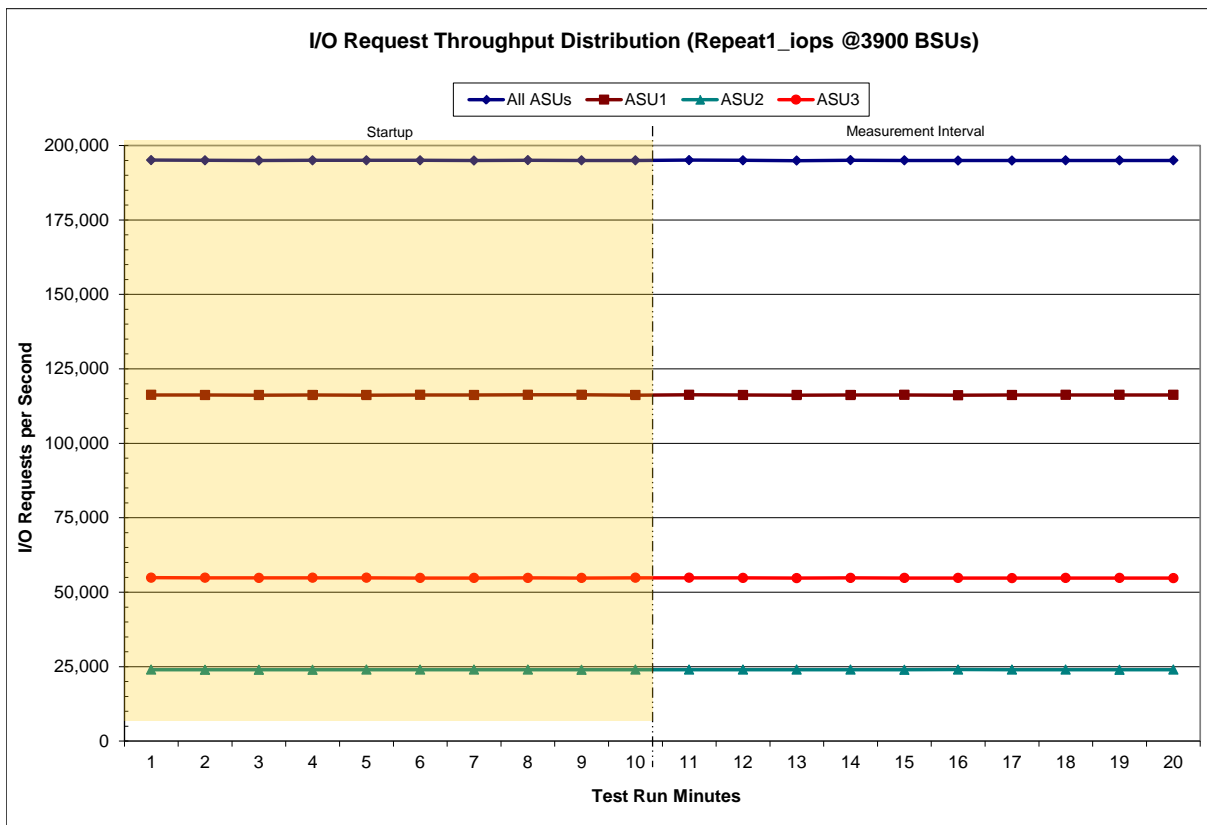
A link to the test result file generated from each Repeatability Test Run is listed below.

- [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

390 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:39:48	1:49:48	0-9	0:10:00
Measurement Interval	1:49:48	1:59:48	9-19	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	19,534.92	11,644.37	2,394.23	5,496.32
1	19,489.17	11,617.80	2,394.37	5,477.00
2	19,445.35	11,594.70	2,386.93	5,463.72
3	19,529.20	11,646.02	2,405.05	5,478.13
4	19,491.83	11,616.28	2,389.90	5,485.65
5	19,488.98	11,622.60	2,394.97	5,471.42
6	19,476.10	11,604.92	2,387.60	5,483.58
7	19,506.37	11,632.52	2,399.90	5,473.95
8	19,484.20	11,629.02	2,385.52	5,469.67
9	19,500.12	11,627.57	2,400.18	5,472.37
10	19,500.00	11,603.08	2,407.13	5,489.78
11	19,515.05	11,640.93	2,393.07	5,481.05
12	19,503.67	11,610.72	2,403.73	5,489.22
13	19,515.38	11,632.07	2,399.28	5,484.03
14	19,511.57	11,633.30	2,400.05	5,478.22
15	19,475.38	11,592.58	2,402.17	5,480.63
16	19,519.88	11,643.47	2,396.10	5,480.32
17	19,507.40	11,619.32	2,405.42	5,482.67
18	19,473.07	11,612.32	2,399.15	5,461.60
19	19,505.33	11,640.97	2,390.38	5,473.98
<b>Average</b>	<b>19,502.67</b>	<b>11,622.88</b>	<b>2,399.65</b>	<b>5,480.15</b>

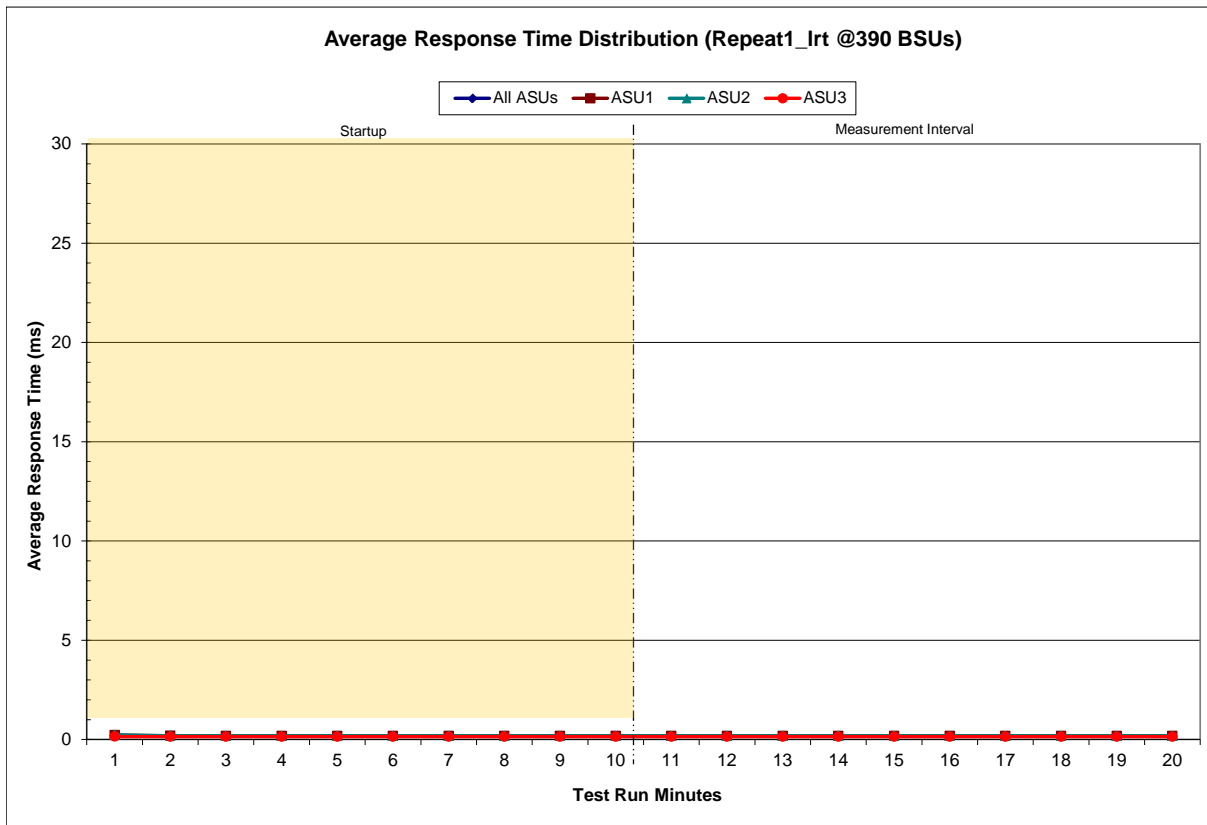
### Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

390 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:39:48	1:49:48	0-9	0:10:00
Measurement Interval	1:49:48	1:59:48	9-19	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.20	0.22	0.24	0.15
1	0.18	0.19	0.19	0.14
2	0.17	0.18	0.18	0.14
3	0.17	0.19	0.18	0.14
4	0.17	0.18	0.18	0.14
5	0.17	0.19	0.18	0.14
6	0.17	0.19	0.18	0.14
7	0.17	0.18	0.19	0.14
8	0.17	0.18	0.19	0.14
9	0.17	0.19	0.19	0.14
10	0.17	0.19	0.19	0.14
11	0.17	0.18	0.19	0.14
12	0.17	0.19	0.19	0.14
13	0.17	0.19	0.19	0.14
14	0.17	0.19	0.19	0.14
15	0.17	0.19	0.19	0.14
16	0.17	0.19	0.19	0.14
17	0.17	0.19	0.19	0.14
18	0.17	0.19	0.19	0.14
19	0.17	0.19	0.19	0.14
<b>Average</b>	<b>0.17</b>	<b>0.19</b>	<b>0.19</b>	<b>0.14</b>

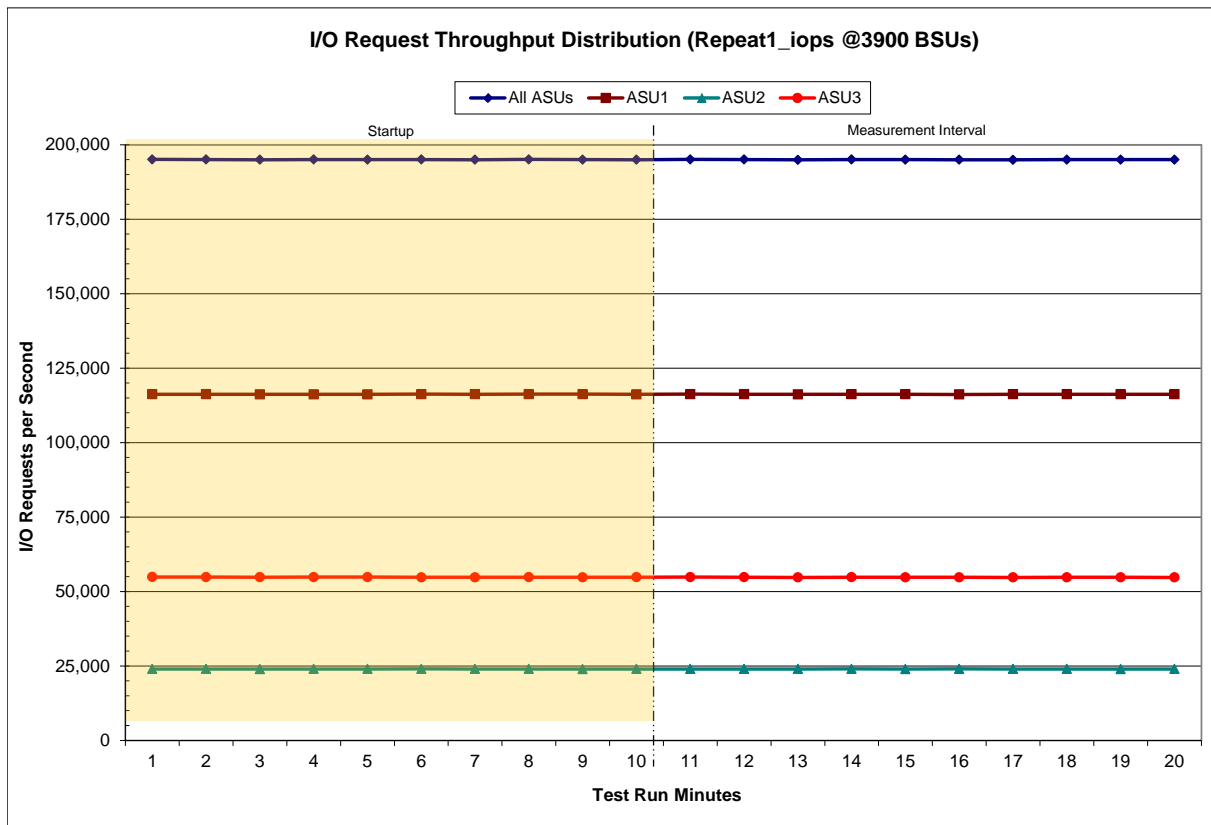
**Repeatability 1 LRT –Average Response Time (ms) Distribution Graph**



### Repeatability 1 IOPS – I/O Request Throughput Distribution Data

3,900 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	2:00:40	2:10:41	0-9	0:10:01
<i>Measurement Interval</i>	2:10:41	2:20:41	9-19	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	195,079.68	116,231.00	23,980.60	54,868.08
1	195,023.13	116,217.88	23,970.42	54,834.83
2	194,942.37	116,184.87	23,962.07	54,795.43
3	195,018.10	116,203.40	23,971.35	54,843.35
4	195,012.27	116,174.98	24,000.07	54,837.22
5	195,035.68	116,257.70	24,008.48	54,769.50
6	194,960.67	116,209.28	23,978.47	54,772.92
7	195,070.63	116,280.03	23,997.00	54,793.60
8	194,998.28	116,269.33	23,945.83	54,783.12
9	194,975.85	116,176.65	23,975.78	54,823.42
10	195,081.32	116,267.55	23,989.45	54,824.32
11	195,014.20	116,222.32	23,985.18	54,806.70
12	194,919.75	116,186.92	23,987.78	54,745.05
13	195,038.52	116,215.40	24,008.92	54,814.20
14	194,992.85	116,238.35	23,968.80	54,785.70
15	194,953.28	116,149.27	24,018.13	54,785.88
16	194,939.98	116,211.57	23,984.20	54,744.22
17	194,991.83	116,232.20	23,978.57	54,781.07
18	194,986.70	116,236.82	23,968.28	54,781.60
19	194,985.92	116,243.13	23,993.43	54,749.35
<b>Average</b>	<b>194,990.44</b>	<b>116,220.35</b>	<b>23,988.28</b>	<b>54,781.81</b>

### Repeatability 1 IOPS – I/O Request Throughput Distribution Graph

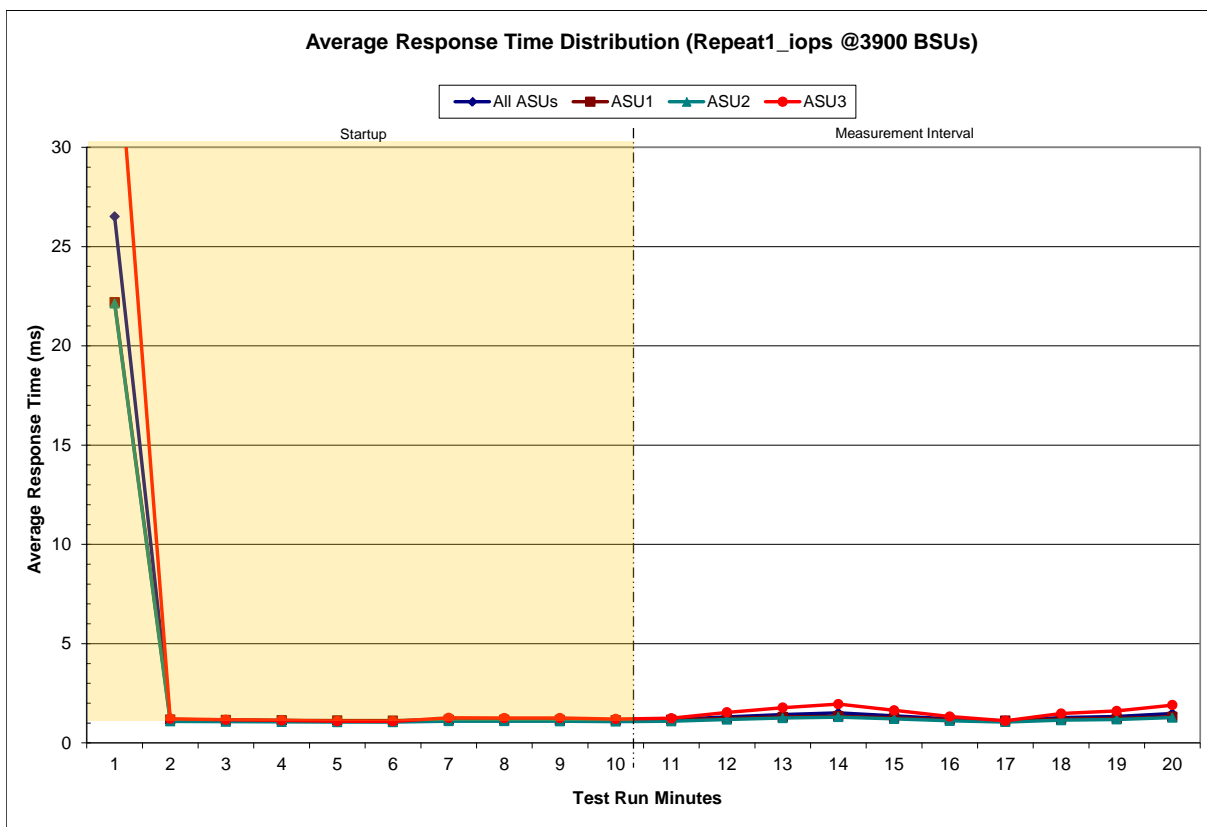




**Repeatability 1 IOPS –Average Response Time (ms) Distribution Data**

3,900 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	2:00:40	2:10:41	0-9	0:10:01
	2:10:41	2:20:41	9-19	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	26.51	22.20	22.13	37.56
1	1.18	1.18	1.08	1.21
2	1.15	1.15	1.07	1.16
3	1.13	1.14	1.06	1.14
4	1.11	1.13	1.05	1.09
5	1.10	1.12	1.05	1.09
6	1.19	1.17	1.10	1.27
7	1.18	1.17	1.10	1.25
8	1.18	1.16	1.09	1.25
9	1.15	1.15	1.08	1.20
10	1.18	1.16	1.09	1.24
11	1.31	1.24	1.18	1.54
12	1.43	1.31	1.25	1.78
13	1.51	1.35	1.30	1.95
14	1.36	1.26	1.21	1.64
15	1.21	1.17	1.11	1.33
16	1.11	1.12	1.06	1.11
17	1.27	1.20	1.15	1.48
18	1.33	1.23	1.18	1.61
19	1.48	1.32	1.28	1.91
<b>Average</b>	<b>1.32</b>	<b>1.23</b>	<b>1.18</b>	<b>1.56</b>

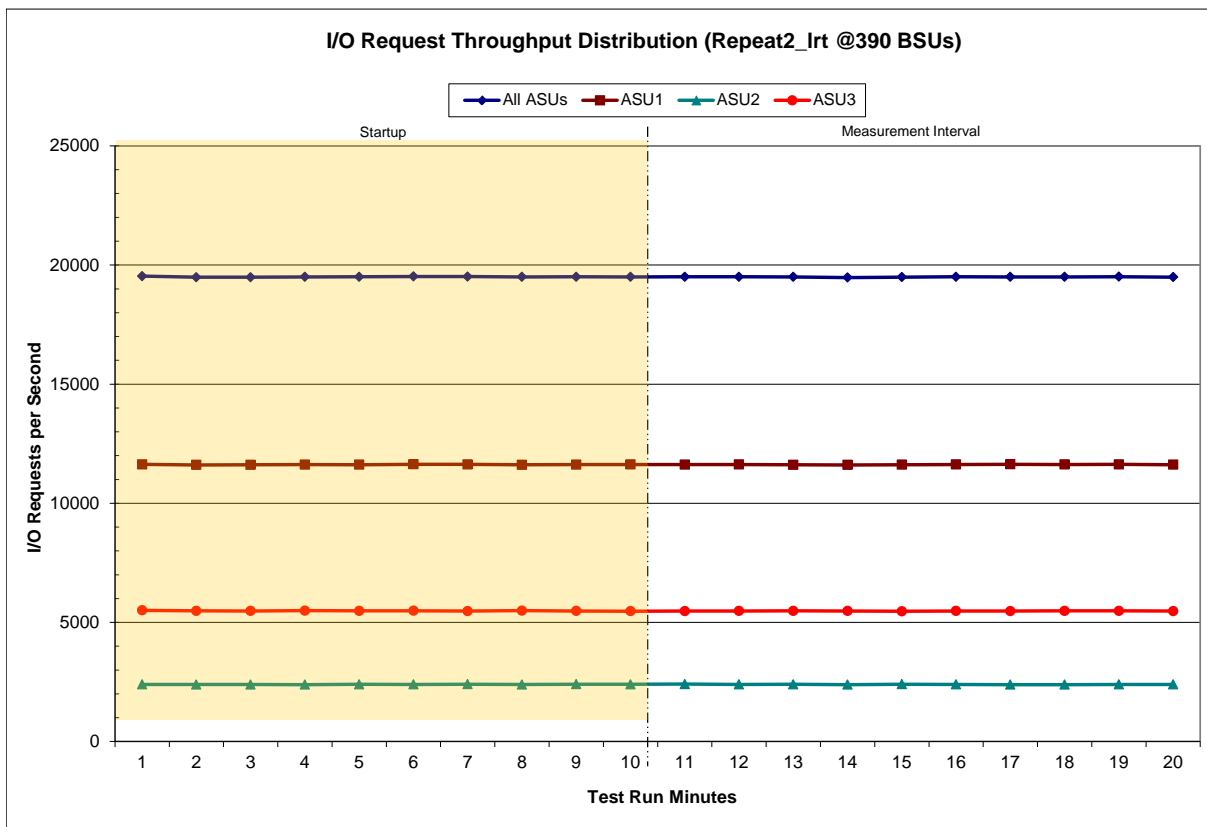
**Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph**



### Repeatability 2 LRT – I/O Request Throughput Distribution Data

390 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:22:19	2:32:19	0-9	0:10:00
Measurement Interval	2:32:19	2:42:19	9-19	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	19,532.15	11,631.53	2,395.08	5,505.53
1	19,489.33	11,610.13	2,394.13	5,485.07
2	19,487.90	11,616.33	2,390.20	5,481.37
3	19,503.42	11,623.93	2,387.10	5,492.38
4	19,504.75	11,617.55	2,402.20	5,485.00
5	19,520.45	11,635.27	2,396.82	5,488.37
6	19,513.62	11,630.50	2,407.25	5,475.87
7	19,500.15	11,613.25	2,392.20	5,494.70
8	19,506.15	11,621.42	2,406.95	5,477.78
9	19,499.35	11,626.33	2,400.45	5,472.57
10	19,507.65	11,622.12	2,408.47	5,477.07
11	19,505.13	11,627.48	2,398.45	5,479.20
12	19,501.70	11,614.93	2,401.90	5,484.87
13	19,474.48	11,608.78	2,387.93	5,477.77
14	19,491.08	11,618.93	2,404.45	5,467.70
15	19,505.25	11,628.58	2,396.53	5,480.13
16	19,501.47	11,638.53	2,387.35	5,475.58
17	19,502.92	11,628.27	2,390.00	5,484.65
18	19,509.87	11,630.67	2,396.60	5,482.60
19	19,491.88	11,616.85	2,397.53	5,477.50
<b>Average</b>	<b>19,499.14</b>	<b>11,623.52</b>	<b>2,396.92</b>	<b>5,478.71</b>

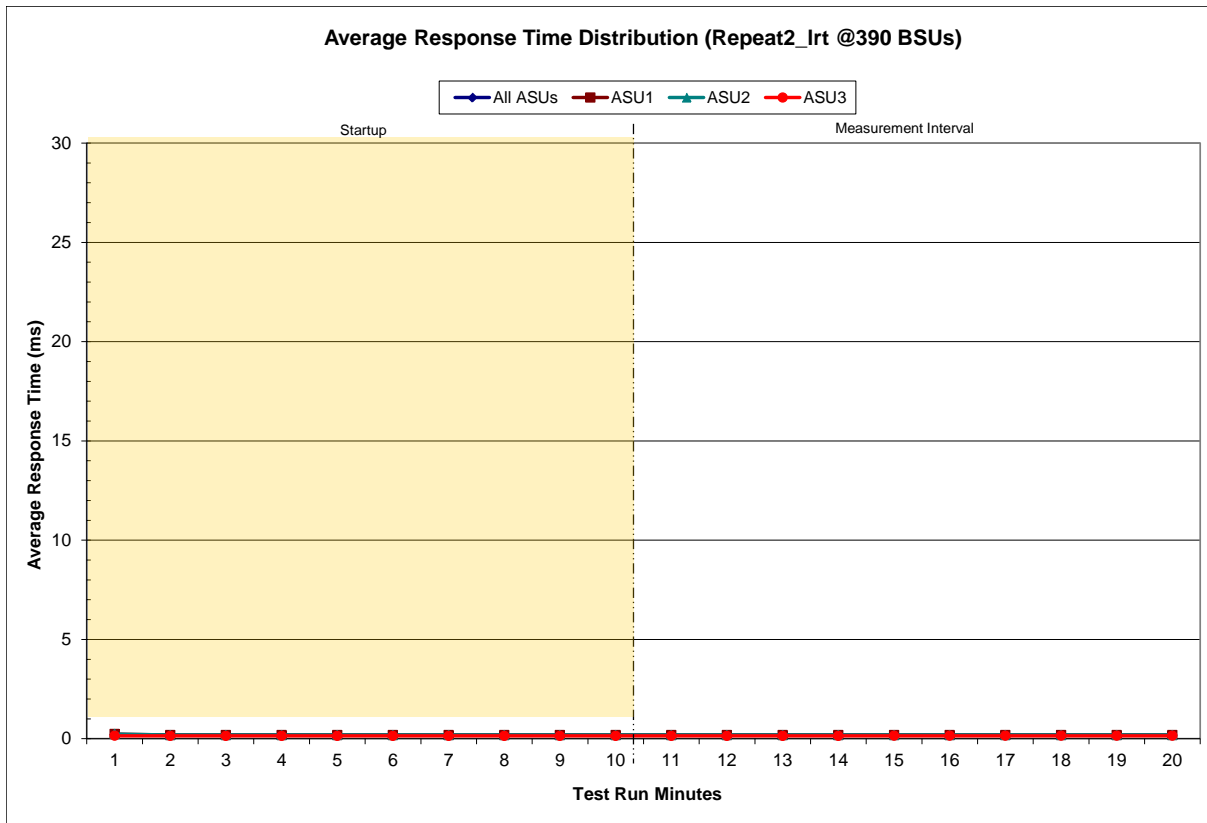
### Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

390 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:22:19	2:32:19	0-9	0:10:00
Measurement Interval	2:32:19	2:42:19	9-19	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.21	0.23	0.24	0.15
1	0.17	0.19	0.19	0.14
2	0.17	0.19	0.19	0.14
3	0.17	0.19	0.19	0.14
4	0.17	0.19	0.19	0.14
5	0.17	0.19	0.19	0.14
6	0.17	0.19	0.19	0.14
7	0.17	0.19	0.19	0.14
8	0.17	0.19	0.19	0.14
9	0.17	0.19	0.19	0.14
10	0.17	0.19	0.19	0.14
11	0.17	0.19	0.19	0.14
12	0.17	0.19	0.19	0.14
13	0.17	0.19	0.19	0.14
14	0.17	0.19	0.19	0.14
15	0.17	0.19	0.19	0.15
16	0.17	0.19	0.19	0.14
17	0.17	0.19	0.19	0.14
18	0.17	0.19	0.19	0.15
19	0.17	0.19	0.19	0.15
<b>Average</b>	<b>0.17</b>	<b>0.19</b>	<b>0.19</b>	<b>0.14</b>

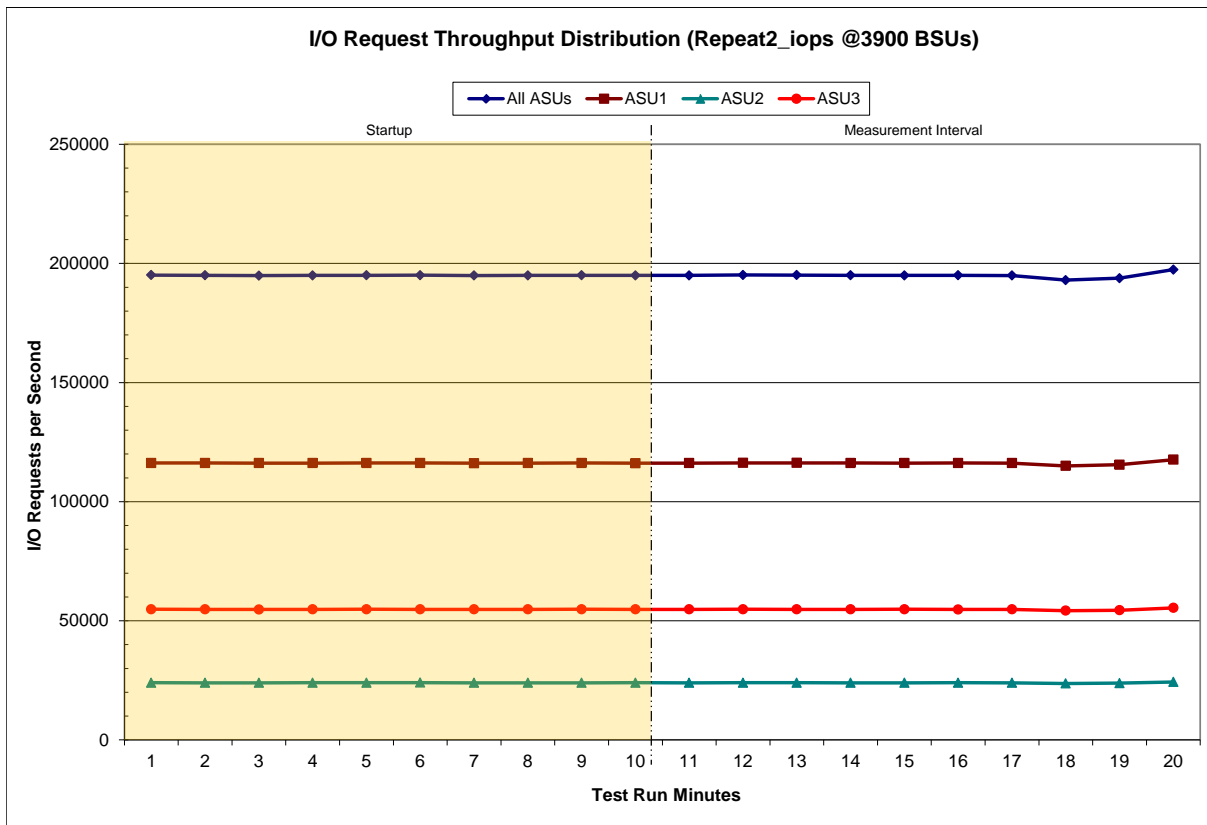
**Repeatability 2 LRT –Average Response Time (ms) Distribution Graph**



### Repeatability 2 IOPS – I/O Request Throughput Distribution Data

3,900 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:43:01	2:53:02	0-9	0:10:01
Measurement Interval	2:53:02	3:03:02	9-19	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	195,082.02	116,240.47	24,011.60	54,829.95
1	194,998.58	116,238.95	23,952.68	54,806.95
2	194,900.43	116,173.33	23,979.38	54,747.72
3	194,987.13	116,198.87	24,011.75	54,776.52
4	195,034.13	116,214.30	23,996.80	54,823.03
5	195,058.07	116,211.85	24,042.82	54,803.40
6	194,913.68	116,154.70	23,973.62	54,785.37
7	194,963.88	116,169.82	23,986.20	54,807.87
8	195,015.22	116,226.38	23,957.65	54,831.18
9	194,973.68	116,158.65	24,026.73	54,788.30
10	194,990.73	116,203.25	23,981.17	54,806.32
11	195,134.28	116,264.55	24,011.38	54,858.35
12	195,103.48	116,292.00	23,994.62	54,816.87
13	195,017.85	116,250.13	23,965.47	54,802.25
14	194,985.02	116,194.05	23,966.62	54,824.35
15	195,004.92	116,215.17	24,029.17	54,760.58
16	194,924.43	116,194.42	23,953.15	54,776.87
17	192,979.23	115,005.55	23,702.22	54,271.47
18	193,786.40	115,502.47	23,831.63	54,452.30
19	197,404.40	117,645.10	24,312.92	55,446.38
<b>Average</b>	<b>194,933.08</b>	<b>116,176.67</b>	<b>23,974.83</b>	<b>54,781.57</b>

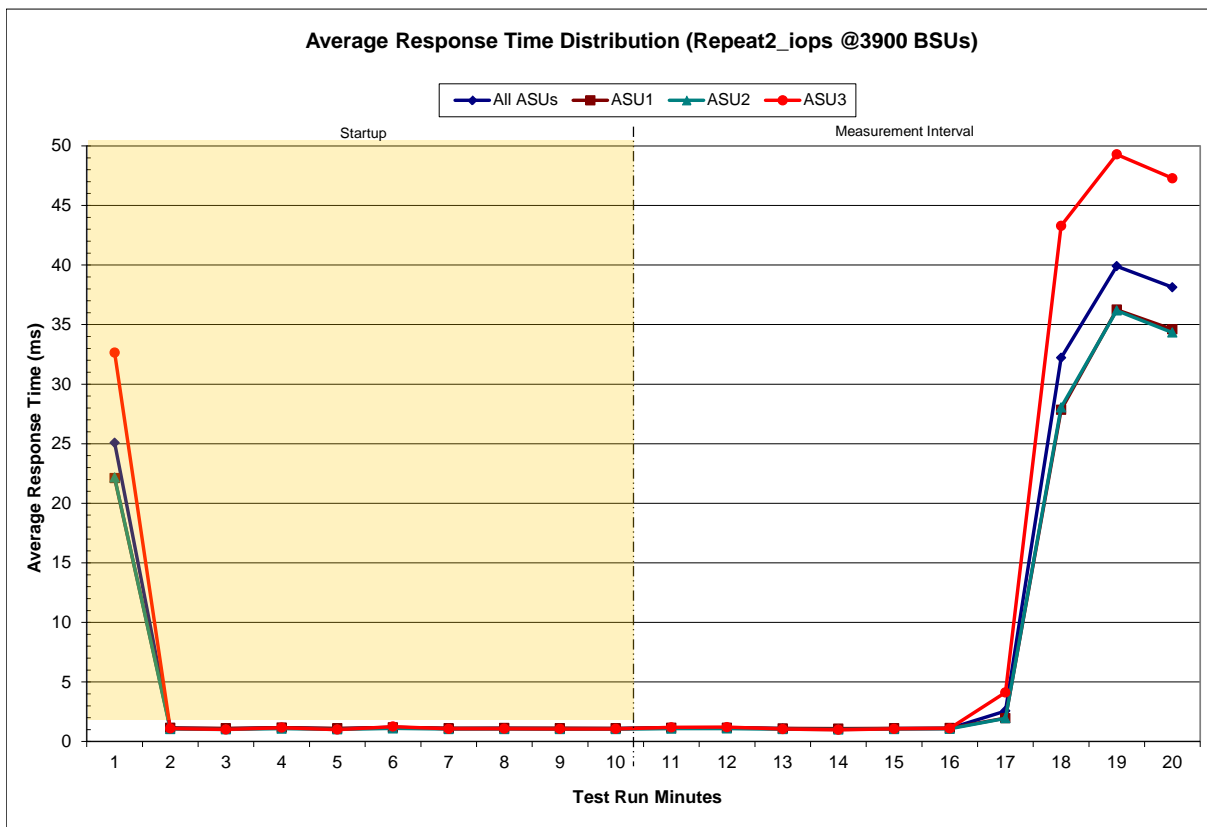
### Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

3,900 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	2:43:01	2:53:02	0-9	0:10:01
	2:53:02	3:03:02	9-19	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	25.08	22.12	22.17	32.65
1	1.11	1.14	1.05	1.09
2	1.07	1.11	1.02	1.01
3	1.15	1.16	1.08	1.16
4	1.07	1.10	1.02	1.00
5	1.19	1.18	1.10	1.25
6	1.09	1.12	1.04	1.06
7	1.10	1.12	1.05	1.07
8	1.09	1.11	1.04	1.06
9	1.09	1.11	1.04	1.05
10	1.15	1.15	1.08	1.19
11	1.16	1.16	1.09	1.21
12	1.08	1.10	1.04	1.04
13	1.04	1.08	1.01	0.98
14	1.09	1.11	1.04	1.07
15	1.11	1.12	1.06	1.10
16	2.57	1.96	1.96	4.12
17	32.21	27.84	28.04	43.29
18	39.91	36.25	36.18	49.28
19	38.13	34.60	34.33	47.28
<b>Average</b>	<b>11.94</b>	<b>10.74</b>	<b>10.68</b>	<b>15.06</b>

**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
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2811	0.0701	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.008	0.002	0.002	0.003	0.006	0.004	0.006	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
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2810	0.0700	0.2101	0.0180	0.0700	0.0350	0.2809
COV	0.001	0.000	0.001	0.001	0.002	0.001	0.001	0.000

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0351	0.2812	0.0698	0.2099	0.0180	0.0699	0.0350	0.2810
COV	0.003	0.001	0.003	0.002	0.006	0.004	0.004	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<i>IM</i>	<i>0.0350</i>	<i>0.2810</i>	<i>0.0700</i>	<i>0.2100</i>	<i>0.0180</i>	<i>0.0700</i>	<i>0.0350</i>	<i>0.2810</i>
MIM	0.0350	0.2809	0.0700	0.2100	0.0180	0.0700a	0.0350	0.2810
COV	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.000

## Data Persistence Test

### Clause 6

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

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

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

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

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

### Clause 9.4.3.8

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

1. *A listing or screen image of all input parameters supplied to the Workload Generator.*
2. *For the successful Data Persistence Test Run, a table illustrating key results. The content, appearance, and format of this table are specified in Table 9-12. Information displayed in this table shall be obtained from the Test Run Results File referenced below in #3.*
3. *For the successful Data Persistence Test Run, the human readable Test Run Results file produced by the Workload Generator (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 85.

## 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	1,152,457
Total Number of Logical Blocks Verified	1,096,606
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 FlashSystem 820 as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

## **PRICING INFORMATION**

### **Clause 9.4.3.3.6**

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

Pricing information may be found in the Priced Storage Configuration Pricing section on page [17](#).

## **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 [17](#).

## **ANOMALIES OR IRREGULARITIES**

### **Clause 9.4.3.10**

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

There were no anomalies or irregularities encountered during the SPC-1 Onsite Audit of the IBM FlashSystem 820.

## **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 gibibyte (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.

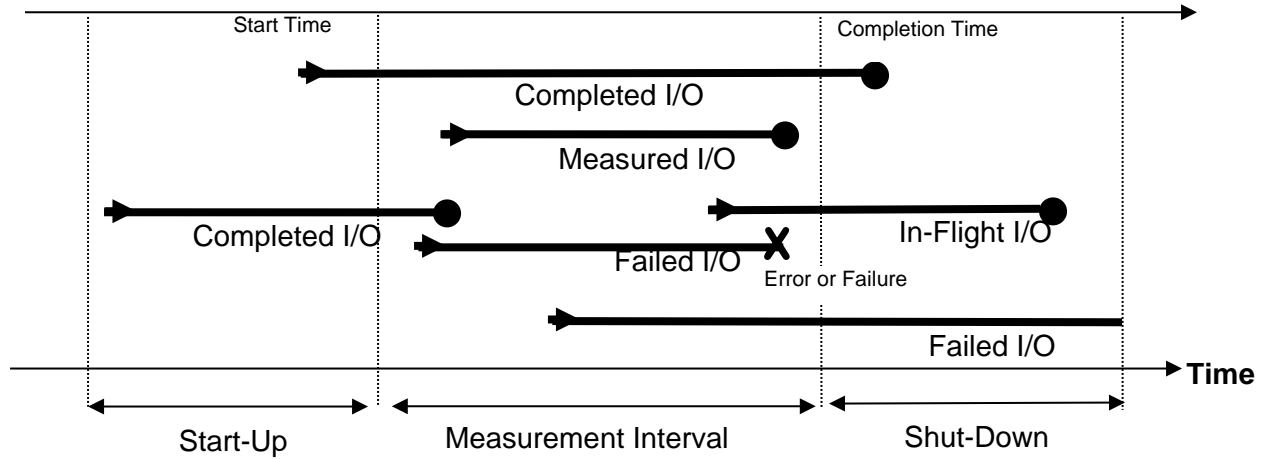
**Steady State:** The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

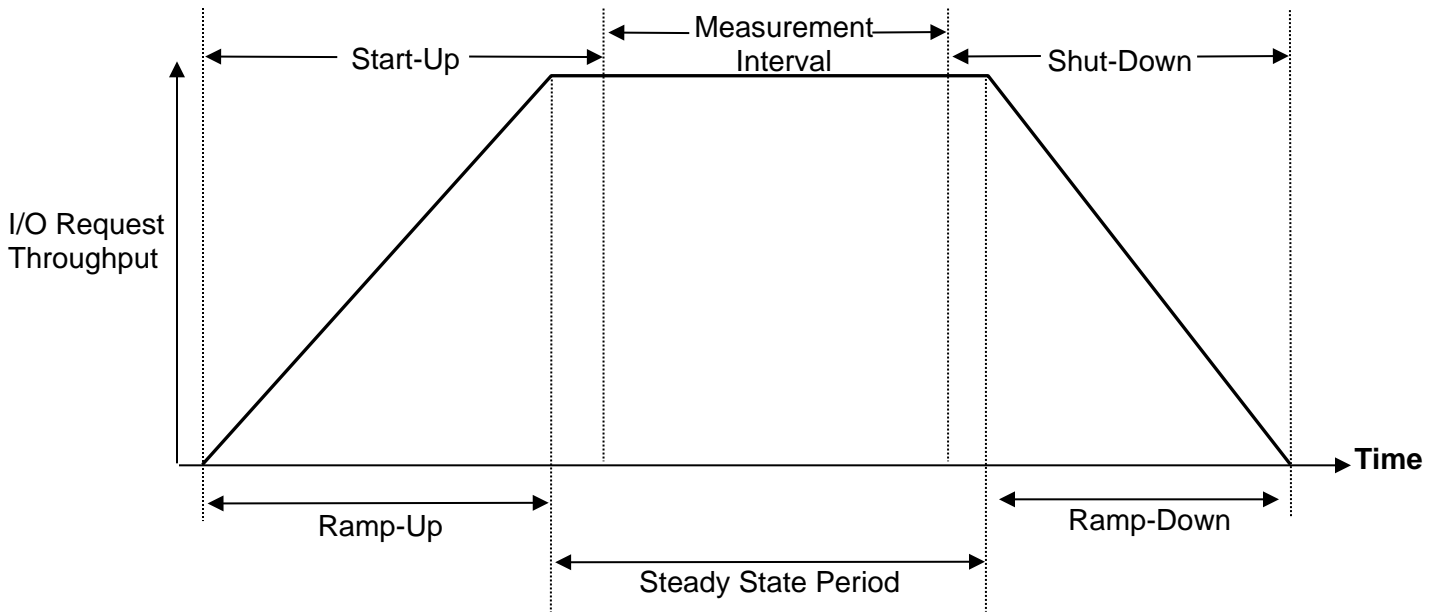
**Test Run:** The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the [SPC-1 Test Run Components](#) below. All SPC-1 Test Runs 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 64. 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 commands documented in [AIX Configuration](#) section on page [72](#).

## APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The FlashSystem 820 was configured using CLI, which is a login shell interface accessed via PuTTY. The CLI provides a restricted shell that accepts certain defined commands needed to configure the TSC.

The first configuration step was the creation of 64 volumes (LUs) each of size 185 GiB. The volumes were named **yijie1...yijie64**. The second step was to map each LU to permit access through any of the four Fibre Channel Ports of the FlashSystem 820, which are named **fc-1a**, **fc-1b**, **fc-2a**, and **fc-2b**.

A file was created with the commands to complete those first two steps. The content of that command file was “cut and pasted” into the CLI restricted shell to complete the first two steps. The [CLI commands](#) command in that command file are listed at the end of this appendix.

### AIX Configuration

The SPC-1 Logical Volumes, which comprised the three SPC-1 ASUs, were configured using an AIX command shell on the same AIX Host System.

The first step of configuring the volumes was to execute the command **cfgmgr**, causing 64 hdisks (*LUs created in the first configuration step*) named **hdisk2**, **hisk3**, .., **hdisk65** to be discovered.

The queue depth and transfer size of each hdisk were set respectively to 256 and 1 MiB using the following commands:

```
#Change IBM FlashSystem hdisk attributes
let i=2
while ((i<66))
do
chdev -l hdisk$i -a queue_depth=256
chdev -l hdisk$i -a max_transfer=0x100000
cfgmgr -l hdisk$i
let i=i+1
done
```

The 64 volumes were then placed into a striped logical volume group (LVG) with the following commands:

```
#use 64 x 185 GiB hdisks in an LVG with PP size 128 MiB
hfield=$(lsdev -Cc disk | grep 'FlashSystem' | awk '{print $1}')
mkvg -fy thinstripevg -S -P 2048 -s 128 $hfield
```

From the storage of the LVG, 40 logical volumes named **thin1**, **thin2**, ... **thin40** were created with a size of 2048 PPs using the following commands:

```
#create 40 X 2048PP logical volumes, stripe across all hdisks with striped size 32MB
let i=1;while ((i<41));do
mklv -b n -y thin$i -x 32512 -u 64 -S 32M thinstripevg 2048
let i=i+1;done
```



Five additional logical volumes named **thin41**, **thin42**, ..., **thin45** were created with a size of 1920 PPs using the following commands:

```
#create 5 X 1920PP logical volumes, stripe across all hdisks with striped size 32MB
let i=41;while ((i<46));do
mklv -b n -y thin$i -x 32512 -u 64 -S 32M thinstripevg 1920
let i=i+1;done
```

## CLI Commands

```
# create 64 X 185GiB Lus (aca indicates AIX host)
lu create yijie1 185g 1
lu aca yijie1 enable
lu create yijie2 185g 2
lu aca yijie2 enable
lu create yijie3 185g 3
lu aca yijie3 enable
lu create yijie4 185g 4
lu aca yijie4 enable
lu create yijie5 185g 5
lu aca yijie5 enable
lu create yijie6 185g 6
lu aca yijie6 enable
lu create yijie7 185g 7
lu aca yijie7 enable
lu create yijie8 185g 8
lu aca yijie8 enable
lu create yijie9 185g 9
lu aca yijie9 enable
lu create yijie10 185g 10
lu aca yijie10 enable
lu create yijie11 185g 11
lu aca yijie11 enable
lu create yijie12 185g 12
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lu create yijie14 185g 14
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lu create yijie15 185g 15
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lu aca yijie20 enable
lu create yijie21 185g 21
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lu create yijie22 185g 22
lu aca yijie22 enable
lu create yijie23 185g 23
lu aca yijie23 enable
lu create yijie24 185g 24
lu aca yijie24 enable
lu create yijie25 185g 25
lu aca yijie25 enable
```

```
lu create yijie26 185g 26
lu aca yijie26 enable
lu create yijie27 185g 27
lu aca yijie27 enable
lu create yijie28 185g 28
lu aca yijie28 enable
lu create yijie29 185g 29
lu aca yijie29 enable
lu create yijie30 185g 30
lu aca yijie30 enable
lu create yijie31 185g 31
lu aca yijie31 enable
lu create yijie32 185g 32
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lu create yijie42 185g 42
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lu create yijie55 185g 55
lu aca yijie55 enable
lu create yijie56 185g 56
lu aca yijie56 enable
lu create yijie57 185g 57
```

```
lu aca yijie57 enable
lu create yijie58 185g 58
lu aca yijie58 enable
lu create yijie59 185g 59
lu aca yijie59 enable
lu create yijie60 185g 60
lu aca yijie60 enable
lu create yijie61 185g 61
lu aca yijie61 enable
lu create yijie62 185g 62
lu aca yijie62 enable
lu create yijie63 185g 63
lu aca yijie63 enable
lu create yijie64 185g 64
lu aca yijie64 enable

# map all LUs to all 4 FC ports
lu access add Policy-1 yijie1 fc-la
lu access add Policy-2 yijie2 fc-la
lu access add Policy-3 yijie3 fc-la
lu access add Policy-4 yijie4 fc-la
lu access add Policy-5 yijie5 fc-la
lu access add Policy-6 yijie6 fc-la
lu access add Policy-7 yijie7 fc-la
lu access add Policy-8 yijie8 fc-la
lu access add Policy-9 yijie9 fc-la
lu access add Policy-10 yijie10 fc-la
lu access add Policy-11 yijie11 fc-la
lu access add Policy-12 yijie12 fc-la
lu access add Policy-13 yijie13 fc-la
lu access add Policy-14 yijie14 fc-la
lu access add Policy-15 yijie15 fc-la
lu access add Policy-16 yijie16 fc-la
lu access add Policy-17 yijie17 fc-la
lu access add Policy-18 yijie18 fc-la
lu access add Policy-19 yijie19 fc-la
lu access add Policy-20 yijie20 fc-la
lu access add Policy-21 yijie21 fc-la
lu access add Policy-22 yijie22 fc-la
lu access add Policy-23 yijie23 fc-la
lu access add Policy-24 yijie24 fc-la
lu access add Policy-25 yijie25 fc-la
lu access add Policy-26 yijie26 fc-la
lu access add Policy-27 yijie27 fc-la
lu access add Policy-28 yijie28 fc-la
lu access add Policy-29 yijie29 fc-la
lu access add Policy-30 yijie30 fc-la
lu access add Policy-31 yijie31 fc-la
lu access add Policy-32 yijie32 fc-la
lu access add Policy-33 yijie33 fc-la
lu access add Policy-34 yijie34 fc-la
lu access add Policy-35 yijie35 fc-la
lu access add Policy-36 yijie36 fc-la
lu access add Policy-37 yijie37 fc-la
lu access add Policy-38 yijie38 fc-la
lu access add Policy-39 yijie39 fc-la
lu access add Policy-40 yijie40 fc-la
lu access add Policy-41 yijie41 fc-la
lu access add Policy-42 yijie42 fc-la
lu access add Policy-43 yijie43 fc-la
lu access add Policy-44 yijie44 fc-la
lu access add Policy-45 yijie45 fc-la
lu access add Policy-46 yijie46 fc-la
```

```
lu access add Policy-47 yijie47 fc-1a
lu access add Policy-48 yijie48 fc-1a
lu access add Policy-49 yijie49 fc-1a
lu access add Policy-50 yijie50 fc-1a
lu access add Policy-51 yijie51 fc-1a
lu access add Policy-52 yijie52 fc-1a
lu access add Policy-53 yijie53 fc-1a
lu access add Policy-54 yijie54 fc-1a
lu access add Policy-55 yijie55 fc-1a
lu access add Policy-56 yijie56 fc-1a
lu access add Policy-57 yijie57 fc-1a
lu access add Policy-58 yijie58 fc-1a
lu access add Policy-59 yijie59 fc-1a
lu access add Policy-60 yijie60 fc-1a
lu access add Policy-61 yijie61 fc-1a
lu access add Policy-62 yijie62 fc-1a
lu access add Policy-63 yijie63 fc-1a
lu access add Policy-64 yijie64 fc-1a
lu access add Policy-65 yijie1 fc-1b
lu access add Policy-66 yijie2 fc-1b
lu access add Policy-67 yijie3 fc-1b
lu access add Policy-68 yijie4 fc-1b
lu access add Policy-69 yijie5 fc-1b
lu access add Policy-70 yijie6 fc-1b
lu access add Policy-71 yijie7 fc-1b
lu access add Policy-72 yijie8 fc-1b
lu access add Policy-73 yijie9 fc-1b
lu access add Policy-74 yijie10 fc-1b
lu access add Policy-75 yijie11 fc-1b
lu access add Policy-76 yijie12 fc-1b
lu access add Policy-77 yijie13 fc-1b
lu access add Policy-78 yijie14 fc-1b
lu access add Policy-79 yijie15 fc-1b
lu access add Policy-80 yijie16 fc-1b
lu access add Policy-81 yijie17 fc-1b
lu access add Policy-82 yijie18 fc-1b
lu access add Policy-83 yijie19 fc-1b
lu access add Policy-84 yijie20 fc-1b
lu access add Policy-85 yijie21 fc-1b
lu access add Policy-86 yijie22 fc-1b
lu access add Policy-87 yijie23 fc-1b
lu access add Policy-88 yijie24 fc-1b
lu access add Policy-89 yijie25 fc-1b
lu access add Policy-90 yijie26 fc-1b
lu access add Policy-91 yijie27 fc-1b
lu access add Policy-92 yijie28 fc-1b
lu access add Policy-93 yijie29 fc-1b
lu access add Policy-94 yijie30 fc-1b
lu access add Policy-95 yijie31 fc-1b
lu access add Policy-96 yijie32 fc-1b
lu access add Policy-97 yijie33 fc-1b
lu access add Policy-98 yijie34 fc-1b
lu access add Policy-99 yijie35 fc-1b
lu access add Policy-100 yijie36 fc-1b
lu access add Policy-101 yijie37 fc-1b
lu access add Policy-102 yijie38 fc-1b
lu access add Policy-103 yijie39 fc-1b
lu access add Policy-104 yijie40 fc-1b
lu access add Policy-105 yijie41 fc-1b
lu access add Policy-106 yijie42 fc-1b
lu access add Policy-107 yijie43 fc-1b
lu access add Policy-108 yijie44 fc-1b
lu access add Policy-109 yijie45 fc-1b
```

```
lu access add Policy-110 yijie46 fc-1b
lu access add Policy-111 yijie47 fc-1b
lu access add Policy-112 yijie48 fc-1b
lu access add Policy-113 yijie49 fc-1b
lu access add Policy-114 yijie50 fc-1b
lu access add Policy-115 yijie51 fc-1b
lu access add Policy-116 yijie52 fc-1b
lu access add Policy-117 yijie53 fc-1b
lu access add Policy-118 yijie54 fc-1b
lu access add Policy-119 yijie55 fc-1b
lu access add Policy-120 yijie56 fc-1b
lu access add Policy-121 yijie57 fc-1b
lu access add Policy-122 yijie58 fc-1b
lu access add Policy-123 yijie59 fc-1b
lu access add Policy-124 yijie60 fc-1b
lu access add Policy-125 yijie61 fc-1b
lu access add Policy-126 yijie62 fc-1b
lu access add Policy-127 yijie63 fc-1b
lu access add Policy-128 yijie64 fc-1b
lu access add Policy-129 yijie1 fc-2a
lu access add Policy-130 yijie2 fc-2a
lu access add Policy-131 yijie3 fc-2a
lu access add Policy-132 yijie4 fc-2a
lu access add Policy-133 yijie5 fc-2a
lu access add Policy-134 yijie6 fc-2a
lu access add Policy-135 yijie7 fc-2a
lu access add Policy-136 yijie8 fc-2a
lu access add Policy-137 yijie9 fc-2a
lu access add Policy-138 yijie10 fc-2a
lu access add Policy-139 yijie11 fc-2a
lu access add Policy-140 yijie12 fc-2a
lu access add Policy-141 yijie13 fc-2a
lu access add Policy-142 yijie14 fc-2a
lu access add Policy-143 yijie15 fc-2a
lu access add Policy-144 yijie16 fc-2a
lu access add Policy-145 yijie17 fc-2a
lu access add Policy-146 yijie18 fc-2a
lu access add Policy-147 yijie19 fc-2a
lu access add Policy-148 yijie20 fc-2a
lu access add Policy-149 yijie21 fc-2a
lu access add Policy-150 yijie22 fc-2a
lu access add Policy-151 yijie23 fc-2a
lu access add Policy-152 yijie24 fc-2a
lu access add Policy-153 yijie25 fc-2a
lu access add Policy-154 yijie26 fc-2a
lu access add Policy-155 yijie27 fc-2a
lu access add Policy-156 yijie28 fc-2a
lu access add Policy-157 yijie29 fc-2a
lu access add Policy-158 yijie30 fc-2a
lu access add Policy-159 yijie31 fc-2a
lu access add Policy-160 yijie32 fc-2a
lu access add Policy-161 yijie33 fc-2a
lu access add Policy-162 yijie34 fc-2a
lu access add Policy-163 yijie35 fc-2a
lu access add Policy-164 yijie36 fc-2a
lu access add Policy-165 yijie37 fc-2a
lu access add Policy-166 yijie38 fc-2a
lu access add Policy-167 yijie39 fc-2a
lu access add Policy-168 yijie40 fc-2a
lu access add Policy-169 yijie41 fc-2a
lu access add Policy-170 yijie42 fc-2a
lu access add Policy-171 yijie43 fc-2a
lu access add Policy-172 yijie44 fc-2a
```

```
lu access add Policy-173 yijie45 fc-2a
lu access add Policy-174 yijie46 fc-2a
lu access add Policy-175 yijie47 fc-2a
lu access add Policy-176 yijie48 fc-2a
lu access add Policy-177 yijie49 fc-2a
lu access add Policy-178 yijie50 fc-2a
lu access add Policy-179 yijie51 fc-2a
lu access add Policy-180 yijie52 fc-2a
lu access add Policy-181 yijie53 fc-2a
lu access add Policy-182 yijie54 fc-2a
lu access add Policy-183 yijie55 fc-2a
lu access add Policy-184 yijie56 fc-2a
lu access add Policy-185 yijie57 fc-2a
lu access add Policy-186 yijie58 fc-2a
lu access add Policy-187 yijie59 fc-2a
lu access add Policy-188 yijie60 fc-2a
lu access add Policy-189 yijie61 fc-2a
lu access add Policy-190 yijie62 fc-2a
lu access add Policy-191 yijie63 fc-2a
lu access add Policy-192 yijie64 fc-2a
lu access add Policy-193 yijie1 fc-2b
lu access add Policy-194 yijie2 fc-2b
lu access add Policy-195 yijie3 fc-2b
lu access add Policy-196 yijie4 fc-2b
lu access add Policy-197 yijie5 fc-2b
lu access add Policy-198 yijie6 fc-2b
lu access add Policy-199 yijie7 fc-2b
lu access add Policy-200 yijie8 fc-2b
lu access add Policy-201 yijie9 fc-2b
lu access add Policy-202 yijie10 fc-2b
lu access add Policy-203 yijie11 fc-2b
lu access add Policy-204 yijie12 fc-2b
lu access add Policy-205 yijie13 fc-2b
lu access add Policy-206 yijie14 fc-2b
lu access add Policy-207 yijie15 fc-2b
lu access add Policy-208 yijie16 fc-2b
lu access add Policy-209 yijie17 fc-2b
lu access add Policy-210 yijie18 fc-2b
lu access add Policy-211 yijie19 fc-2b
lu access add Policy-212 yijie20 fc-2b
lu access add Policy-213 yijie21 fc-2b
lu access add Policy-214 yijie22 fc-2b
lu access add Policy-215 yijie23 fc-2b
lu access add Policy-216 yijie24 fc-2b
lu access add Policy-217 yijie25 fc-2b
lu access add Policy-218 yijie26 fc-2b
lu access add Policy-219 yijie27 fc-2b
lu access add Policy-220 yijie28 fc-2b
lu access add Policy-221 yijie29 fc-2b
lu access add Policy-222 yijie30 fc-2b
lu access add Policy-223 yijie31 fc-2b
lu access add Policy-224 yijie32 fc-2b
lu access add Policy-225 yijie33 fc-2b
lu access add Policy-226 yijie34 fc-2b
lu access add Policy-227 yijie35 fc-2b
lu access add Policy-228 yijie36 fc-2b
lu access add Policy-229 yijie37 fc-2b
lu access add Policy-230 yijie38 fc-2b
lu access add Policy-231 yijie39 fc-2b
lu access add Policy-232 yijie40 fc-2b
lu access add Policy-233 yijie41 fc-2b
lu access add Policy-234 yijie42 fc-2b
lu access add Policy-235 yijie43 fc-2b
```

```
lu access add Policy-236 yijie44 fc-2b
lu access add Policy-237 yijie45 fc-2b
lu access add Policy-238 yijie46 fc-2b
lu access add Policy-239 yijie47 fc-2b
lu access add Policy-240 yijie48 fc-2b
lu access add Policy-241 yijie49 fc-2b
lu access add Policy-242 yijie50 fc-2b
lu access add Policy-243 yijie51 fc-2b
lu access add Policy-244 yijie52 fc-2b
lu access add Policy-245 yijie53 fc-2b
lu access add Policy-246 yijie54 fc-2b
lu access add Policy-247 yijie55 fc-2b
lu access add Policy-248 yijie56 fc-2b
lu access add Policy-249 yijie57 fc-2b
lu access add Policy-250 yijie58 fc-2b
lu access add Policy-251 yijie59 fc-2b
lu access add Policy-252 yijie60 fc-2b
lu access add Policy-253 yijie61 fc-2b
lu access add Policy-254 yijie62 fc-2b
lu access add Policy-255 yijie63 fc-2b
lu access add Policy-256 yijie64 fc-2b
```

## 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 LFSR 32bit
*
compratio=1
sd=default,threads=1

sd=sd1,size=274877906944,lun=/dev/rthin1
sd=sd2,size=274877906944,lun=/dev/rthin2
sd=sd3,size=274877906944,lun=/dev/rthin3
sd=sd4,size=274877906944,lun=/dev/rthin4
sd=sd5,size=274877906944,lun=/dev/rthin5
sd=sd6,size=274877906944,lun=/dev/rthin6
sd=sd7,size=274877906944,lun=/dev/rthin7
sd=sd8,size=274877906944,lun=/dev/rthin8
sd=sd9,size=274877906944,lun=/dev/rthin9
sd=sd10,size=274877906944,lun=/dev/rthin10
sd=sd11,size=274877906944,lun=/dev/rthin11
sd=sd12,size=274877906944,lun=/dev/rthin12
sd=sd13,size=274877906944,lun=/dev/rthin13
sd=sd14,size=274877906944,lun=/dev/rthin14
sd=sd15,size=274877906944,lun=/dev/rthin15
sd=sd16,size=274877906944,lun=/dev/rthin16
sd=sd17,size=274877906944,lun=/dev/rthin17
sd=sd18,size=274877906944,lun=/dev/rthin18
sd=sd19,size=274877906944,lun=/dev/rthin19
sd=sd20,size=274877906944,lun=/dev/rthin20
sd=sd21,size=274877906944,lun=/dev/rthin21
sd=sd22,size=274877906944,lun=/dev/rthin22
sd=sd23,size=274877906944,lun=/dev/rthin23
sd=sd24,size=274877906944,lun=/dev/rthin24
sd=sd25,size=274877906944,lun=/dev/rthin25
sd=sd26,size=274877906944,lun=/dev/rthin26
sd=sd27,size=274877906944,lun=/dev/rthin27
sd=sd28,size=274877906944,lun=/dev/rthin28
sd=sd29,size=274877906944,lun=/dev/rthin29
sd=sd30,size=274877906944,lun=/dev/rthin30
sd=sd31,size=274877906944,lun=/dev/rthin31
sd=sd32,size=274877906944,lun=/dev/rthin32
sd=sd33,size=274877906944,lun=/dev/rthin33
sd=sd34,size=274877906944,lun=/dev/rthin34
sd=sd35,size=274877906944,lun=/dev/rthin35
sd=sd36,size=274877906944,lun=/dev/rthin36
sd=sd37,size=274877906944,lun=/dev/rthin37
sd=sd38,size=274877906944,lun=/dev/rthin38
sd=sd39,size=274877906944,lun=/dev/rthin39
sd=sd40,size=274877906944,lun=/dev/rthin40
sd=sd41,size=244335917284,lun=/dev/rthin41
sd=sd42,size=244335917284,lun=/dev/rthin42
sd=sd43,size=244335917284,lun=/dev/rthin43
sd=sd44,size=244335917284,lun=/dev/rthin44
sd=sd45,size=244335917284,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 20 hours as a maximum elapsed time,
* which should ensure the entire LBA range
* will be written before the time elapses
*=====
```

```
*
*20 hours for XIV 45TB prefill
rd=FILLIT,wd=wd*,iorate=max,elapsed=72000,interval=10
*
```

```
* The above "elapsed=72000" 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 a reduced level SPC-1 Persistence Test Run 1, is listed below.

```
javaparms="-Xms1280m -Xmx1280m -Xss256k -Xgcpolicy:optavgpause"  
sd=default  
sd=asu1_1,size=274877906944,lun=/dev/rthin1  
sd=asu1_2,size=274877906944,lun=/dev/rthin2  
sd=asu1_3,size=274877906944,lun=/dev/rthin3  
sd=asu1_4,size=274877906944,lun=/dev/rthin4  
sd=asu1_5,size=274877906944,lun=/dev/rthin5  
sd=asu1_6,size=274877906944,lun=/dev/rthin6  
sd=asu1_7,size=274877906944,lun=/dev/rthin7  
sd=asu1_8,size=274877906944,lun=/dev/rthin8  
sd=asu1_9,size=274877906944,lun=/dev/rthin9  
sd=asu1_10,size=274877906944,lun=/dev/rthin10  
sd=asu1_11,size=274877906944,lun=/dev/rthin11  
sd=asu1_12,size=274877906944,lun=/dev/rthin12  
sd=asu1_13,size=274877906944,lun=/dev/rthin13  
sd=asu1_14,size=274877906944,lun=/dev/rthin14  
sd=asu1_15,size=274877906944,lun=/dev/rthin15  
sd=asu1_16,size=274877906944,lun=/dev/rthin16  
sd=asu1_17,size=274877906944,lun=/dev/rthin17  
sd=asu1_18,size=274877906944,lun=/dev/rthin18  
sd=asu1_19,size=274877906944,lun=/dev/rthin19  
sd=asu1_20,size=274877906944,lun=/dev/rthin20  
sd=asu2_1,size=274877906944,lun=/dev/rthin21  
sd=asu2_2,size=274877906944,lun=/dev/rthin22  
sd=asu2_3,size=274877906944,lun=/dev/rthin23  
sd=asu2_4,size=274877906944,lun=/dev/rthin24  
sd=asu2_5,size=274877906944,lun=/dev/rthin25  
sd=asu2_6,size=274877906944,lun=/dev/rthin26  
sd=asu2_7,size=274877906944,lun=/dev/rthin27  
sd=asu2_8,size=274877906944,lun=/dev/rthin28  
sd=asu2_9,size=274877906944,lun=/dev/rthin29  
sd=asu2_10,size=274877906944,lun=/dev/rthin30  
sd=asu2_11,size=274877906944,lun=/dev/rthin31  
sd=asu2_12,size=274877906944,lun=/dev/rthin32  
sd=asu2_13,size=274877906944,lun=/dev/rthin33  
sd=asu2_14,size=274877906944,lun=/dev/rthin34  
sd=asu2_15,size=274877906944,lun=/dev/rthin35  
sd=asu2_16,size=274877906944,lun=/dev/rthin36  
sd=asu2_17,size=274877906944,lun=/dev/rthin37  
sd=asu2_18,size=274877906944,lun=/dev/rthin38  
sd=asu2_19,size=274877906944,lun=/dev/rthin39  
sd=asu2_20,size=274877906944,lun=/dev/rthin40  
sd=asu3_1,size=244335917284,lun=/dev/rthin41  
sd=asu3_2,size=244335917284,lun=/dev/rthin42  
sd=asu3_3,size=244335917284,lun=/dev/rthin43  
sd=asu3_4,size=244335917284,lun=/dev/rthin44  
sd=asu3_5,size=244335917284,lun=/dev/rthin45
```

## SPC-2 Persistence Test

### Common Command Lines – SPC-2 Persistence Test

The following command lines appear at the beginning of each command and parameter file for the two SPC-2 Persistence Test Runs. The command lines are only listed below to eliminate redundancy.

```
host=localhost , jvms=16 , maxstreams=200

sd=default
sd=sd1 , size=274877906944 , lun=/dev/rthin1
sd=sd2 , size=274877906944 , lun=/dev/rthin2
sd=sd3 , size=274877906944 , lun=/dev/rthin3
sd=sd4 , size=274877906944 , lun=/dev/rthin4
sd=sd5 , size=274877906944 , lun=/dev/rthin5
sd=sd6 , size=274877906944 , lun=/dev/rthin6
sd=sd7 , size=274877906944 , lun=/dev/rthin7
sd=sd8 , size=274877906944 , lun=/dev/rthin8
sd=sd9 , size=274877906944 , lun=/dev/rthin9
sd=sd10 , size=274877906944 , lun=/dev/rthin10
sd=sd11 , size=274877906944 , lun=/dev/rthin11
sd=sd12 , size=274877906944 , lun=/dev/rthin12
sd=sd13 , size=274877906944 , lun=/dev/rthin13
sd=sd14 , size=274877906944 , lun=/dev/rthin14
sd=sd15 , size=274877906944 , lun=/dev/rthin15
sd=sd16 , size=274877906944 , lun=/dev/rthin16
sd=sd17 , size=274877906944 , lun=/dev/rthin17
sd=sd18 , size=274877906944 , lun=/dev/rthin18
sd=sd19 , size=274877906944 , lun=/dev/rthin19
sd=sd20 , size=274877906944 , lun=/dev/rthin20
sd=sd21 , size=274877906944 , lun=/dev/rthin21
sd=sd22 , size=274877906944 , lun=/dev/rthin22
sd=sd23 , size=274877906944 , lun=/dev/rthin23
sd=sd24 , size=274877906944 , lun=/dev/rthin24
sd=sd25 , size=274877906944 , lun=/dev/rthin25
sd=sd26 , size=274877906944 , lun=/dev/rthin26
sd=sd27 , size=274877906944 , lun=/dev/rthin27
sd=sd28 , size=274877906944 , lun=/dev/rthin28
sd=sd29 , size=274877906944 , lun=/dev/rthin29
sd=sd30 , size=274877906944 , lun=/dev/rthin30
sd=sd31 , size=274877906944 , lun=/dev/rthin31
sd=sd32 , size=274877906944 , lun=/dev/rthin32
sd=sd33 , size=274877906944 , lun=/dev/rthin33
sd=sd34 , size=274877906944 , lun=/dev/rthin34
sd=sd35 , size=274877906944 , lun=/dev/rthin35
sd=sd36 , size=274877906944 , lun=/dev/rthin36
sd=sd37 , size=274877906944 , lun=/dev/rthin37
sd=sd38 , size=274877906944 , lun=/dev/rthin38
sd=sd39 , size=274877906944 , lun=/dev/rthin39
sd=sd40 , size=274877906944 , lun=/dev/rthin40
sd=sd41 , size=244335917284 , lun=/dev/rthin41
sd=sd42 , size=244335917284 , lun=/dev/rthin42
sd=sd43 , size=244335917284 , lun=/dev/rthin43
sd=sd44 , size=244335917284 , lun=/dev/rthin44
sd=sd45 , size=244335917284 , lun=/dev/rthin45
```

### SPC-2 Persistence Test Run 1 (*write phase*)

\* Persistence Test Run 1, maxstreams should be greater than target BSU divided by 30

#### [common command lines](#)

```
maxlatestart=1  
reportinginterval=5  
segmentlength=512m
```

```
rd=default,rampup=180,periods=90,measurement=300,runout=0,rampdown=0,buffers=1
```

```
rd=default,rdpct=0,xfersize=1024k  
rd=TR1-5s_SPC-2-persist-w,streams=256
```

### SPC-2 Persistence Test Run 2 (*read phase*)

\* Persistence Test Run 2

#### [common command lines](#)

```
maxlatestart=1  
reportinginterval=5  
segmentlength=512m
```

```
maxpersistenceerrors=10  
*corruptstreams=3
```

```
rd=default,buffers=1,rdpct=100,xfersize=1024k  
rd=TR1-5s_SPC-2-persist-r
```

## **APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS**

### **ASU Pre-Fill, SPC-1/E Idle Test, Primary Metrics Test, Repeatability Test and SPC-1 Persistence Test Run 1**

The following script was used to execute the required ASU pre-fill, SPC-1E Idle Test, 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*), a reduced BSU level SPC-1 Persistence Test Run 1 (*write phase*) and SPC-2 Persistence Test Run 1 (*write phase*) in an uninterrupted sequence. The script also included commands to capture various TSC profile listings used for audit documentation.

```
rundir=`pwd`
cd /perform/spc1runs/RAMSAN820/Prefill_45LVM_rs820
./runfill.sh
cd $rundir
export PATH=$PATH:/usr/java6/bin
export SPC1HOME=/perform/spc1_2_3_install
export CLASSPATH=$SPC1HOME
export LIBPATH=$SPC1HOME
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false

#Energy measurement pre-condition
java -Xoptionsfile=javaopts.cfg range -b 3900 -t 600
mv rangetest energy_precondition_100pct
sleep 4200
java -Xoptionsfile=javaopts.cfg range -b 390 -t 600
mv rangetest energy_precondition_10pct

java -Xoptionsfile=javaopts.cfg metrics -b 3900 -s 1800:600 -t 108000
java -Xoptionsfile=javaopts.cfg repeat1 -b 3900 -s 600
java -Xoptionsfile=javaopts.cfg repeat2 -b 3900 -s 600
./runpersist1.sh

#SPC2 persist test
cd
/perform/spc1runs/RAMSAN820/jun5_RS820_64lu_sh9a_1host64cpu_6.3.0_p7_formal_run_persist
./runpersist1.sh

cd $rundir
getlvmdata.sh
```

### **ASU Pre-Fill**

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

```
#!/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
```

### SPC-1 Persistence Test Run 1 (*reduced BSU level*)

The following script, invoked from the above 'master' script, was used to execute the reduced BSU level SPC-1 Persistence Test Run 1 (*write phase*).

```
export PATH=$PATH:/usr/java6/bin
export SPC1HOME=/perform/spc1_2_3_install
export CLASSPATH=$SPC1HOME
export LIBPATH=$SPC1HOME
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaoptsp.cfg persist1 -b 390
```

### SPC-2 Persistence Test Run 1

The following script, invoked from the above 'master' script, was used to execute the SPC-2 Persistence Test Run 1 (*write phase*).

```
export PATH=$PATH:/usr/java6/bin
export SPC2HOME=/perform/spc2install
export CLASSPATH=$SPC2HOME
export LIBPATH=$SPC2HOME/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaopts.cfg vdbench -f persistw.cfg -init -o persistinit
rm -fr persistw
java -Xoptionsfile=javaopts.cfg vdbench -f persistw.cfg -o persist
```

### SPC-2 Persistence Test Run 2

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

```
export PATH=$PATH:/usr/java6/bin
export SPC2HOME=/perform/spc2install
export CLASSPATH=$SPC2HOME
export LIBPATH=$SPC2HOME/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
rm -fr persistr
java -Xoptionsfile=javaopts.cfg vdbench -f persistr.cfg -o persist
```