SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

DOT HILL SYSTEMS CORP.
DOT HILL ASSUREDSAN™ PRO 5000

SPC-1 V1.13

Submitted for Review: February 25, 2013
Submission Identifier: A00127

First Edition – February 2013

Trademarks

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AUDIT CERTIFICATION

Michael Jensen
Dot Hill Systems Corp.
1351 S. Sunset St.
Longmont, Co 80510

February 22, 2013

The SPC Benchmark 1™ Reported Data listed below for the Dot Hill AssuredSAN™ Pro 5000 was produced in compliance with the SPC Benchmark 1™ v1.13 Onsite Audit requirements.

SPC Benchmark 1™ v1.13 Reported Data	
Tested Storage Product (TSP) Name: Dot Hill AssuredSAN™ Pro 5000	
Metric	**Reported Result**
SPC-1 IOPS™	39,041.81
SPC-1 Price-Performance	$2.96/SPC-1 IOPS™
Total ASU Capacity	17,801.966 GB
Data Protection Level	Protected 2 *(Mirroring)*
Total Price (including three-year maintenance)	$115,407.15
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

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

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

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

AUDIT CERTIFICATION *(CONT.)*

- 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 Dot Hill Systems Corp.:
  - ✓ 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 Dot Hill Systems Corp. for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- There were no differences between the Tested Storage Configuration and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,

Walter E. Baker

Walter E. Baker
SPC Auditor

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650.556.9384

LETTER OF GOOD FAITH

dot HILL

1 Feb 2013

Walter E. Baker

Gradient Systems

643 Bair Island Rd. Suite 103

Redwood City, CA 94063-2755

To: Walter E. Baker

Subject: SPC-1 Letter of Good Faith for the Dot Hill Systems Pro 5720

Dot Hill Systems Corp. is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V1.13.of the SPC-1 benchmark specification.

In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark necessary to reproduce the reported results even if the items are not explicitly required to be disclosed by the above SPC-1 benchmark specification.

Signed:

Jim. Jonez

Senior Director Product Marketing

Dot Hill Systems, 1351 S. Sunset St., Longmont, CO 80501 Page 1

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Dot Hill Systems Corp. – http://www.dothill.com Michael Jensen – mike.jensen@dothill.com 1351 S. Sunset St. Longmont, CO 80501 Phone: (303) 845-3512
Test Sponsor Alternate Contact	Dot Hill Systems Corp. – http://www.dothill.com Ian Davies – ian.davies@dothill.com 1351 S. Sunset St. Longmont, CO 80501 Phone: (303) 845-3281
Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-1 Specification revision number	V1.13
SPC-1 Workload Generator revision number	V2.3.0
Date Results were first used publicly	February 25, 2013
Date the FDR was submitted to the SPC	February 25, 2013
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	February 22, 2013

Tested Storage Product (TSP) Description

Dot Hill's new AssuredSAN Pro 5000 Series adds automated tiered storage capabilities to a smart, simple, SAN storage line-up. Using the Pro 5000 Series with integrated RealStor™ management software, IT managers can improve data responsiveness, remove provisioning and allocation guesswork, and simplify storage management and expansion. RealStor, Dot Hill's unique, patent pending software takes tiered storage to a more advanced level - beyond batch data migration to Real-Time automated tiered storage, which continuously responds to user data demands by moving 'hot' data to a high-speed SSD tier – in real time – for maximum performance.

Additional features of the AssuredSAN Pro 500 Series include:

- RealTier™ Tiering Software
- RealPool™ Automatic Pooling
- RealThin™ Provisioning
- RealQuick™ Rebuild Function
- Smart, Simple Management
- Modular Expansion of Storage Tiers
- Rapid Data Hot Spot detection
- Maximum 384 TB raw capacity
- Up to 96 LFF drives or 240 SFF drives
- SSD Drive support – 200GB and 400GB
- HDD Drive support – 600GB 10K SAS, 1TB, 3TB, & 4TB NLSAS
- 8 x 8Gb FC or 8 x 10GbE iSCSI Host Interfaces

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: Dot Hill AssuredSAN™ Pro 5000	
Metric	**Reported Result**
SPC-1 IOPS™	39,041.81
SPC-1 Price-Performance™	$2.96/SPC-1 IOPS™
Total ASU Capacity	17,801.966 GB
Data Protection Level	Protected 2 *(Mirroring)*
Total Price	$115,407.15
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 2** using ***Mirroring*** configures two or more identical copies of user data.

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

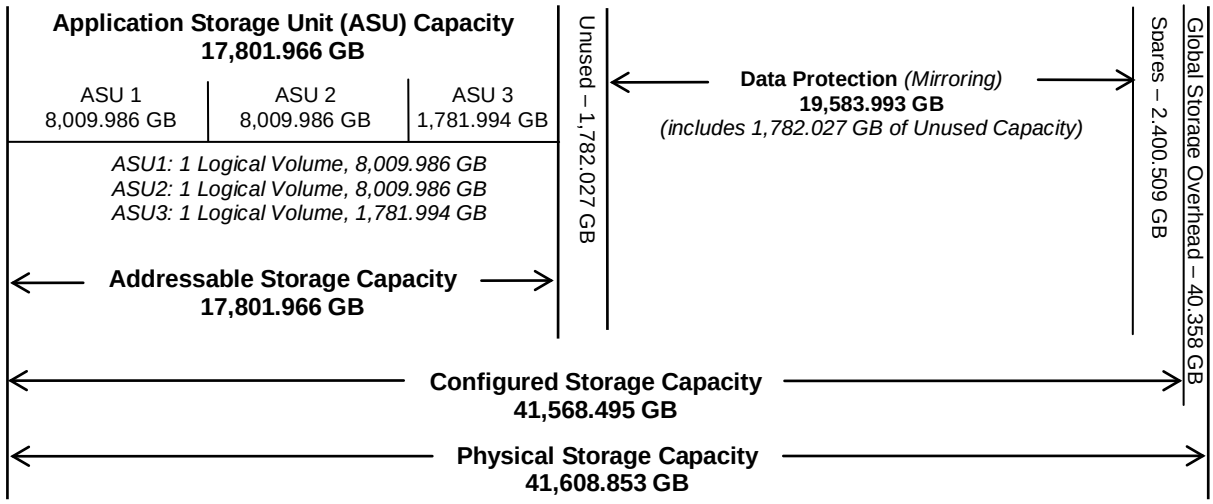
Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 15.

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

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

Storage Capacities, Relationships, and Utilization

The following diagram *(not to scale)* and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.



SPC-1 Storage Capacity Utilization	
Application Utilization	42.78%
Protected Application Utilization	85.57%
Unused Storage Ratio	8.57%

Application Utilization: Total ASU Capacity *(17,801.966 GB)* divided by Physical Storage Capacity *(41,608.853 GB)*

Protected Application Utilization: Total ASU Capacity *(17,801.966 GB)* plus total Data Protection Capacity *(19,583.993 GB)* minus unused Data Protection Capacity *(1,782.027 GB)* divided by Physical Storage Capacity *(41,608.853 GB)*

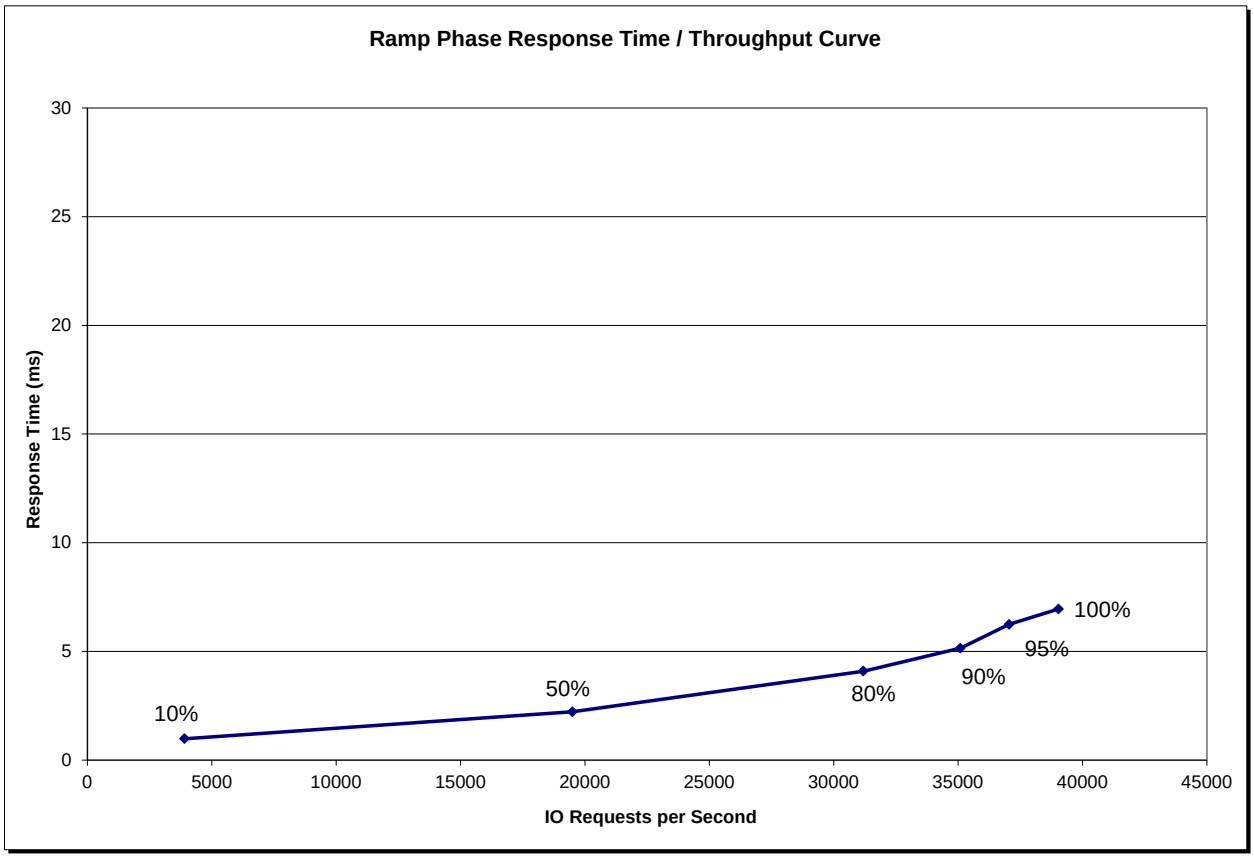
Unused Storage Ratio: Total Unused Capacity *(3,563.986 GB)* divided by Physical Storage Capacity *(41,608.853 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 23-24.

Response Time – Throughput Curve

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

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



Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	3,901.45	19,502.29	31,195.29	35,099.05	37,054.24	39,041.81
Average Response Time (ms):						
All ASUs	0.98	2.22	4.09	5.15	6.24	6.95
ASU-1	0.95	2.27	4.21	5.25	6.36	7.00
ASU-2	2.42	5.59	10.61	13.55	15.61	17.77
ASU-3	0.41	0.64	0.98	1.26	1.89	2.12
Reads	1.85	4.67	8.89	11.17	13.10	14.53
Writes	0.41	0.63	0.96	1.23	1.77	2.02

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

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

Priced Storage Configuration Pricing

Part Number	Description	Qty	MSRP	Effective Discount from MSRP	Extended Price
D57202428010MA	5420B,04x400,44x600-10,A 2U24 Controller Enclosure with 2 controllers, 8 total 8Gb FChost ports with SFPs, 2 SAS 6Gb expansion ports, 4 x 400 GB SSD and 20 x 600GB 10K HDD 2U24 Expansion Enclosure with 24 x 600GB 10K HDD	1	103,906.00	47.2%	54,862.00
D51200213610MA	5120B,04x400,20x600-10,A 2U24 Expansion Enclosure with 2 SAS 6Gb expansion ports (2 in & 2 out) includes 4 x 400GB SSD & 20 x 600GB 10K HDD and necessary SAS expansion cables	1	53,915.12	47.2%	28,467.00
SW-ATS-R010-5000	Req. RealStore base SW for Pro5000	1	17,217.63	47.2%	9,090.00
SW-ATS-R010-5K-M3	RealStor,1.0,3-Yr.Maint Ext,Pro5000	1	9,555.79	47.2%	5,045.00
DS-7x24x4-B2-3Y-A-U	On Site, 7X24x4, SFF RAID, 3 YEAR, UPG for PN D57202428010MA	1	18,898.00	47.2%	9,978.00
DS-7x24x4-J2-3Y-A-U	On Site, 7X24x4, SFF JBOD, 3 YEAR, UPG for PN D51200213610MA	1	8,319.00	47.2%	4,392.00
CBL-FC-MLC-MLC-R03	Cable Pkg,FC,MLC-MLC,3 M,R	4	107.00	47.2%	225.98
QLE2564 (Third-Party)	Qlogic QLE2564 4 port 8Gb FC PCIe HBA	1	3,347.17	N/A	3,347.17
	Total				**115,407.15**

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

Qlogic QLE2564 quad-port 8Gb/s FC HBA

Dot Hill AssuredSAN™ Pro 5000
Dual-Active Controllers with:
4 GB cache, 2 GB per controller
20 – 600GB 2.5" 10K SAS disk drives
4 – 400GB 2.5" SSD SAS disk drives

Expansion Enclosure
20 – 600GB 2.5" 10K SAS disk drives
4 – 400GB 2.5" SSD SAS disk drives

Expansion Enclosure
24 – 600GB 2.5" 10K SAS disk drives

Priced Storage Configuration Components

Priced Storage Configuration:
RealStore for Pro5000
1 – Qlogic QLE2564 4-port 8Gb PCIe FC HBA
Dot Hill AssuredSAN™ Pro 5000 2U24 Controller Enclosure Dual-Active Controllers each with: 2 GB cache *(4 GB total)* 4 – 8 Gb FC host ports *(includes SFPs)* *(8 ports total, 4 used)* 1 – 6 Gb SAS connection *(2 connections total, 2 used)*
2 – 2U24 Expansion Enclosures
64 – 600 GB 10K RPM SAS disk drives 20 disk drives in the Controller Enclosure 20 disk drives in the first Expansion Enclosure 24 disk drives in the second Expansion Enclosure
8 – 400 GB SSDs 4 – SSDs in the Controller Enclosure 4 – SSDs in the first Expansion Enclosure

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-1 benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

CONFIGURATION INFORMATION

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

Clause 9.4.3.4.1

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

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page 19 *(Benchmark Configuration/Tested Storage Configuration Diagram)*.

Storage Network Configuration

Clause 9.4.3.4.1

…

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

Clause 9.4.3.4.2

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

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

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

Clause 9.4.3.4.3

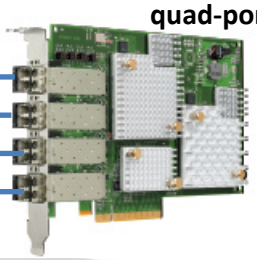
The FDR will contain a table that lists the major components of each Host System and the Tested Storage Configuration (TSC). Table 9-10 specifies the content, format, and appearance of the table.

The Host System(s) and TSC table of components may be found on page 20 *(Host Systems and Tested Storage Configuration Components)*.

Benchmark Configuration/Tested Storage Configuration Diagram

1 - Dell R610 Server
Microsoft Windows Server 2008 R2 Enterprise SP1

Qlogic QLE2564
quad-port 8Gb/s FC HBA



Dot Hill AssuredSAN™ Pro 5000
Dual-Active Controllers with:
4 GB cache, 2 GB per controller
20 – 600GB 2.5" 10K SAS disk drives
4 – 400GB 2.5" SSD SAS disk drives

Expansion Enclosure
20 – 600GB 2.5" 10K SAS disk drives
4 – 400GB 2.5" SSD SAS disk drives

Expansion Enclosure
24 – 600GB 2.5" 10K SAS disk drives

Host Systems and Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC)
Dell PowerEdge™ R610 Rack Server Dual quad core Intel® E5620 Xeon® processor; 2.4 GHz, 12 MB L3 cache per processor 12 GB main memory Microsoft Windows Server 2008 R2 Enterprise Edition SP1 PCIe	RealStore for Pro5000
	1 – Qlogic QLE2564 4-port 8Gb PCIe FC HBA
	Dot Hill AssuredSAN™ Pro 5000 2U24 Controller Enclosure Dual Active Controllers each with: 2 GB cache *(4 GB total)* 4 – 8 Gb FC host ports *(includes SFPs)* *(8 ports total, 4 used)* 1 – 6 Gb SAS connection *(2 connections total, 2 used)*
	2 – 2U24 Expansion Enclosures
	64 – 600 GB 10K RPM SAS disk drives 20 disk drives in the Controller Enclosure 20 disk drives in the first Expansion Enclosure 24 disk drives in the second Expansion Enclosure
	8 – 400 GB SSDs 4 – SSDs in the Controller Enclosure 4 – SSDs in the first Expansion Enclosure

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 63 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 64 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 67.

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 67.

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 59 contains definitions of terms specific to the SPC-1 Data Repository.

Storage Capacities and Relationships

Clause 9.4.3.6.1

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

SPC-1 Storage Capacities

The Physical Storage Capacity consisted of 41,608.853 GB distributed over 64 disk drives, each with a formatted capacity of 600.127 GB and 8 solid state devices (SSDs), each with a formatted capacity of 400.088 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 40.358 GB (0.10%) of the Physical Storage Capacity. There was 3,563.986 GB (8.57%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.00 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(Mirroring)* capacity was 19.583.993 GB of which 17,801.966 GB was utilized. The total Unused Storage capacity was 3,563.986 GB.

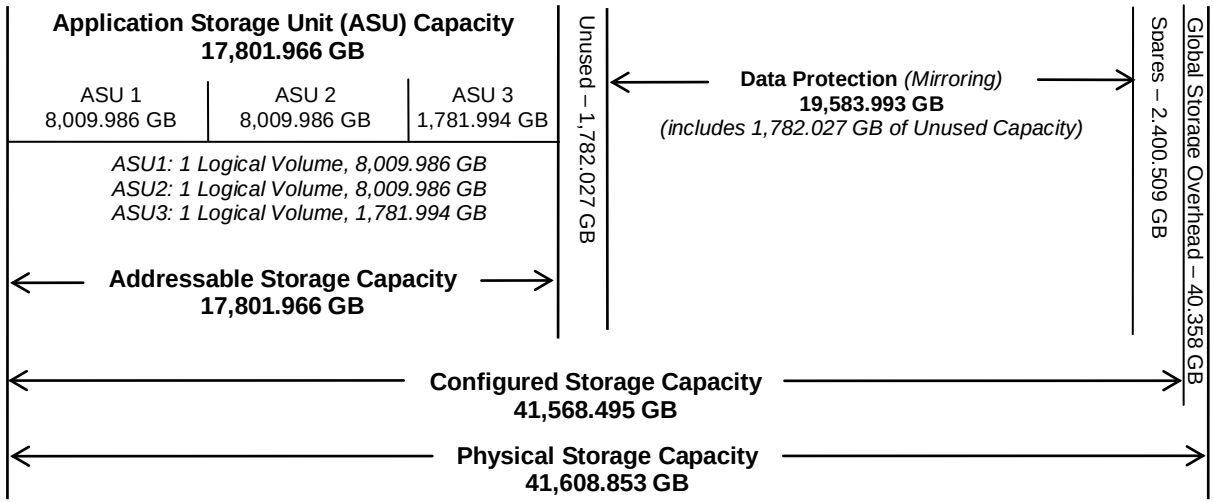
Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.

SPC-1 Storage Capacities

Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	17,801.966
Addressable Storage Capacity	Gigabytes (GB)	17,801.966
Configured Storage Capacity	Gigabytes (GB)	41,568.495
Physical Storage Capacity	Gigabytes (GB)	41,608.853
Data Protection *(Mirroring)*	Gigabytes (GB)	19,583.993
Required Storage *(spares)*	Gigabytes (GB)	2,400.509
Global Storage Overhead	Gigabytes (GB)	40.358
Total Unused Storage	Gigabytes (GB)	3,563.986

SPC-1 Storage Capacities and Relationships Illustration

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



SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	42.83%	42.78%
Required for Data Protection *(Mirroring)*		47.11%	47.07%
Addressable Storage Capacity		42.83%	42.78%
Required Storage		5.77%	5.77%
Configured Storage Capacity			99.90%
Global Storage Overhead			0.10%
Unused Storage:			
Addressable	0.00%		
Configured		8.57%	
Physical			0.00%

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	42.78%
Protected Application Utilization	85.57%
Unused Storage Ratio	8.57%

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 (8,009.986 GB)	**ASU-2 (8,009.986 GB)**	**ASU-3 (1,781.994 GB)**
1 Logical Volume 8,009.986 GB per Logical Volume (8,009.986 GB used per Logical Volume)	1 Logical Volume 8,009.986 GB per Logical Volume (8,009.986 GB used per Logical Volume)	1 Logical Volume 1,781.994 GB per Logical Volume (1,781.994 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was **Protected 2** using ***Mirroring*** as described on page 12. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. *Appendix A: SPC-1 Glossary* on page 59 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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

SPC-1 Tests, Test Phases, and Test Runs

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

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

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

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

"Ramp-Up" Test Runs

A Test Sponsor is allowed to execute one ore more Test Runs to act as a gradual, initial ramp-up for the Sustainability Test Phase. Those Test Runs must immediately precede the Sustainability Test Phase as part of an uninterrupted execution sequence.

The details for the one specified "Ramp-Up" Test Run are listed below:

	BSU Level	Duration *(Minutes)*	IOPS	Response Time *(ms)*
Test Run 1	781	1,200	34,921.14	46.27

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

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

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.4.3.7.1

For the Sustainability Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 68.

Sustainability Test Results File

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

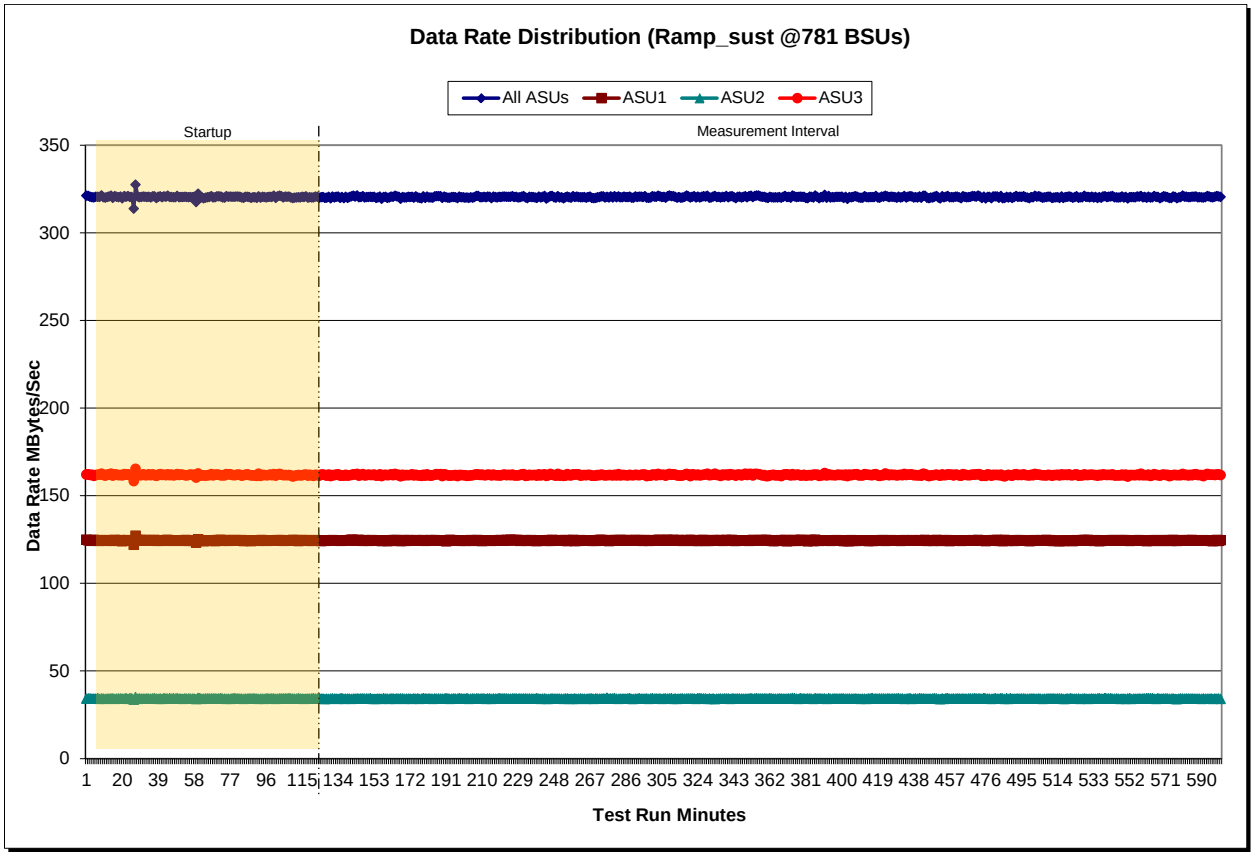
Sustainability Test Results File

Sustainability – Data Rate Distribution Data (MB/second)

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

Sustainability Data Rate Table

Sustainability – Data Rate Distribution Graph

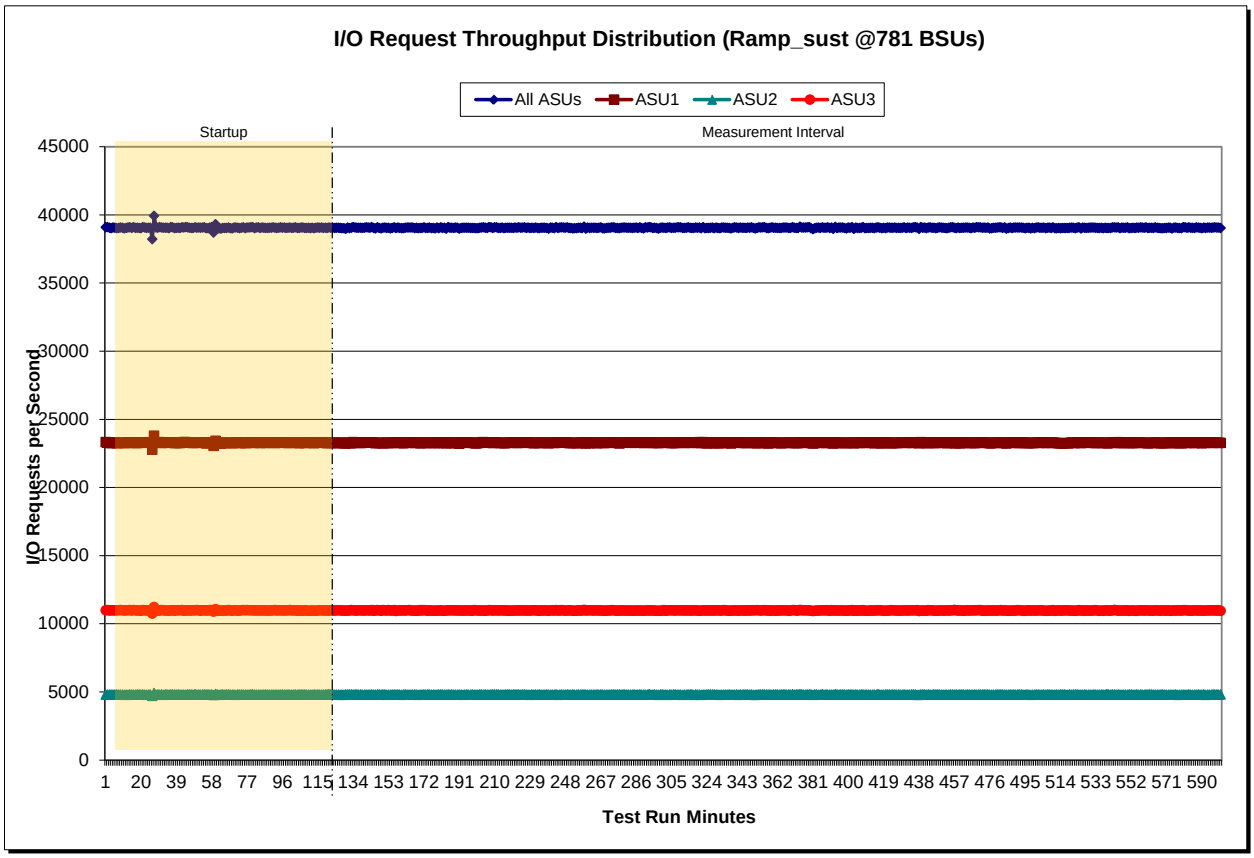


Sustainability – I/O Request Throughput Distribution Data

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

Sustainability I/O Request Throughput Table

Sustainability – I/O Request Throughput Distribution Graph

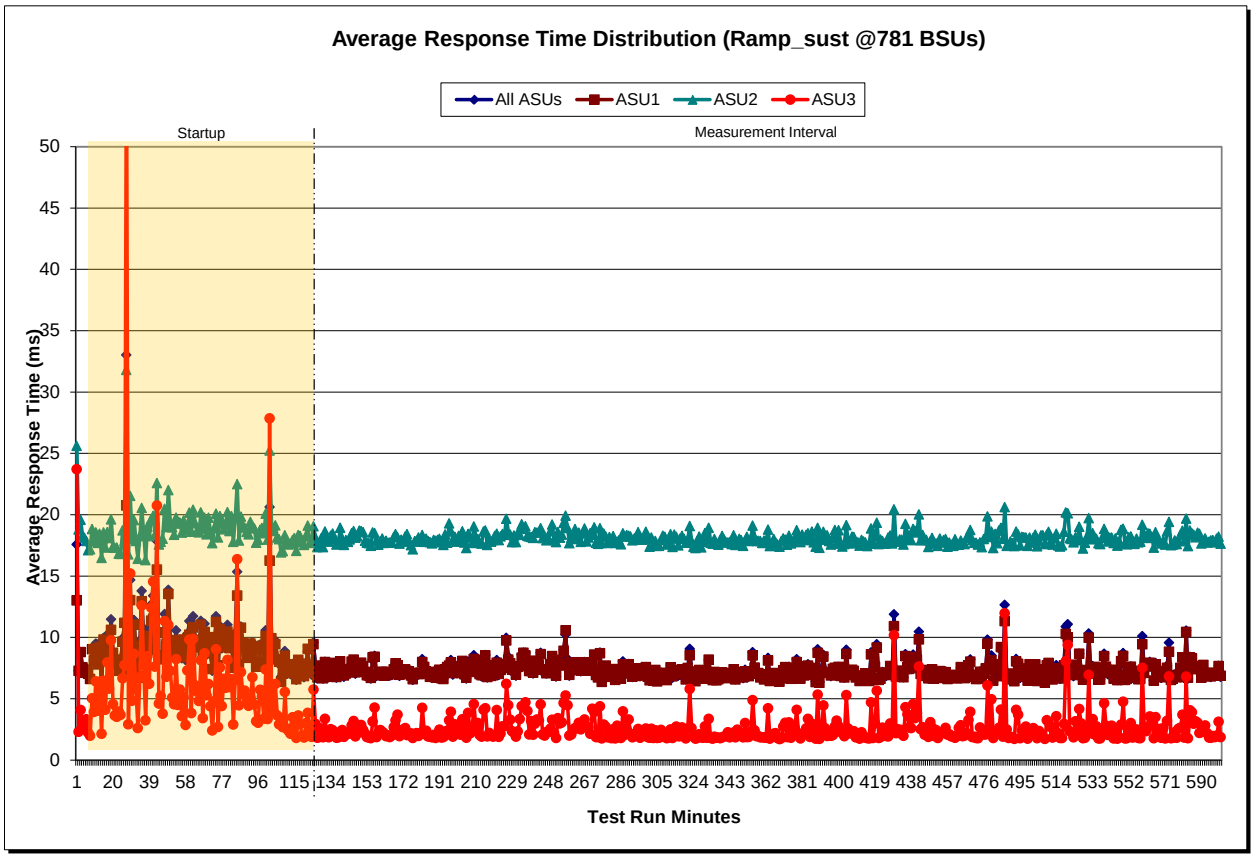


Sustainability – Average Response Time (ms) Distribution Data

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

Sustainability Average Response Time Table

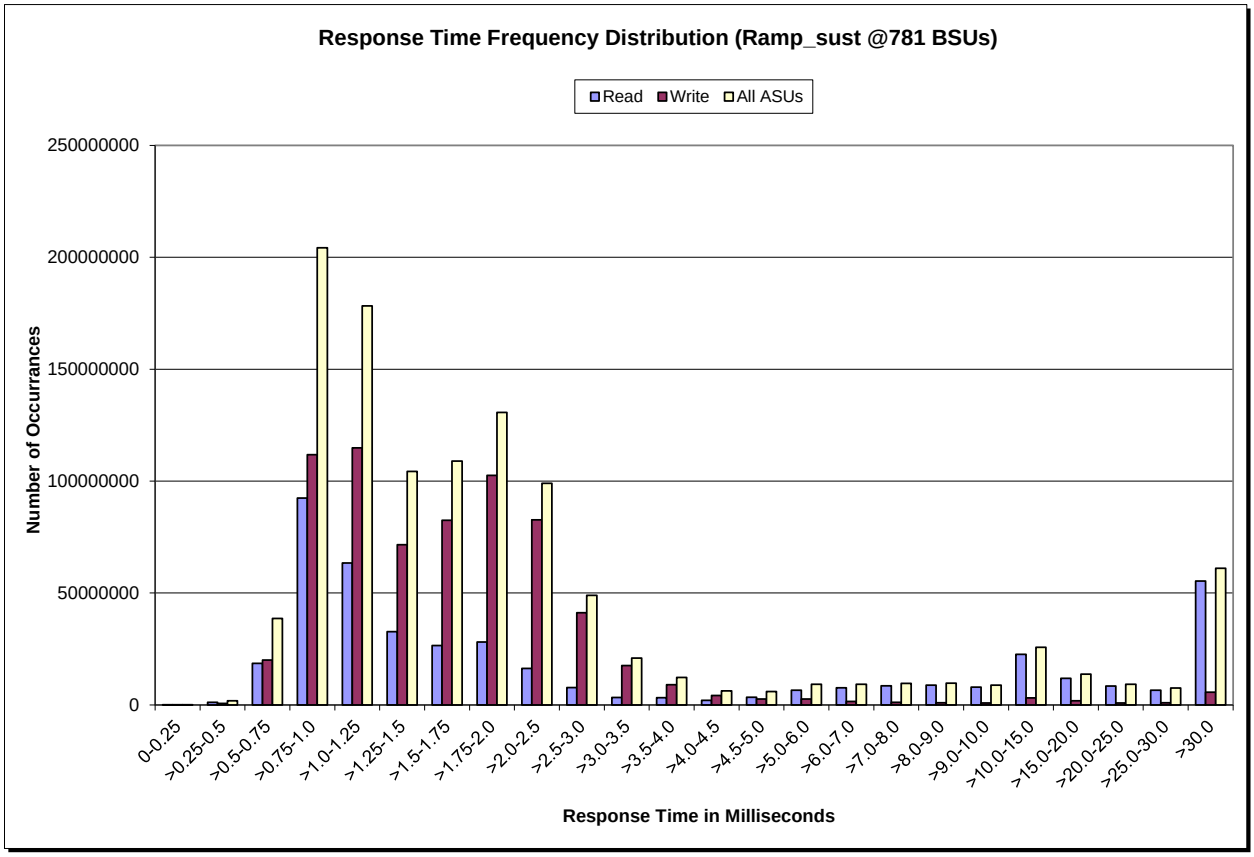
Sustainability – Average Response Time (ms) Distribution Graph



Sustainability – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	32,765	1,154,992	18,610,126	92,467,378	63,468,642	32,737,390	26,514,100	28,113,428
Write	51,021	706,829	20,057,367	111,823,258	114,853,855	71,606,582	82,464,440	102,599,691
All ASUs	83,786	1,861,821	38,667,493	204,290,636	178,322,497	104,343,972	108,978,540	130,713,119
ASU1	56,669	1,476,055	28,430,346	142,770,590	113,204,223	62,959,966	60,099,603	68,741,720
ASU2	8,307	164,713	3,262,525	15,521,959	14,047,357	8,431,976	9,158,642	11,193,091
ASU3	18,810	221,053	6,974,622	45,998,087	51,070,917	32,952,030	39,720,295	50,778,308
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	26,514,100	28,113,428	16,305,621	7,790,170	3,326,481	3,184,188	2,000,902	3,410,220
Write	82,464,440	102,599,691	82,728,460	41,181,634	17,626,077	9,040,697	4,225,953	2,602,596
All ASUs	108,978,540	130,713,119	99,034,081	48,971,804	20,952,558	12,224,885	6,226,855	6,012,816
ASU1	60,099,603	68,741,720	48,961,022	24,041,460	10,101,300	6,150,712	3,159,549	3,215,951
ASU2	9,158,642	11,193,091	8,516,610	4,556,710	2,020,818	1,631,334	985,834	1,497,620
ASU3	39,720,295	50,778,308	41,556,449	20,373,634	8,830,440	4,442,839	2,081,472	1,299,245
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	6,573,963	7,692,946	8,524,612	8,803,821	7,992,850	22,568,837	11,879,055	8,425,912
Write	2,674,990	1,512,979	1,140,376	947,037	846,521	3,135,004	1,822,621	816,430
All ASUs	9,248,953	9,205,925	9,664,988	9,750,858	8,839,371	25,703,841	13,701,676	9,242,342
ASU1	5,135,730	5,261,687	5,569,734	5,654,676	5,179,180	15,070,608	8,108,421	5,708,853
ASU2	2,780,493	3,187,788	3,521,414	3,618,828	3,233,908	9,063,185	4,690,663	3,165,448
ASU3	1,332,730	756,450	573,840	477,354	426,283	1,570,048	902,592	368,041

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

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

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

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

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

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

Clause 9.4.3.7.2

For the IOPS Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 68.

IOPS Test Results File

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

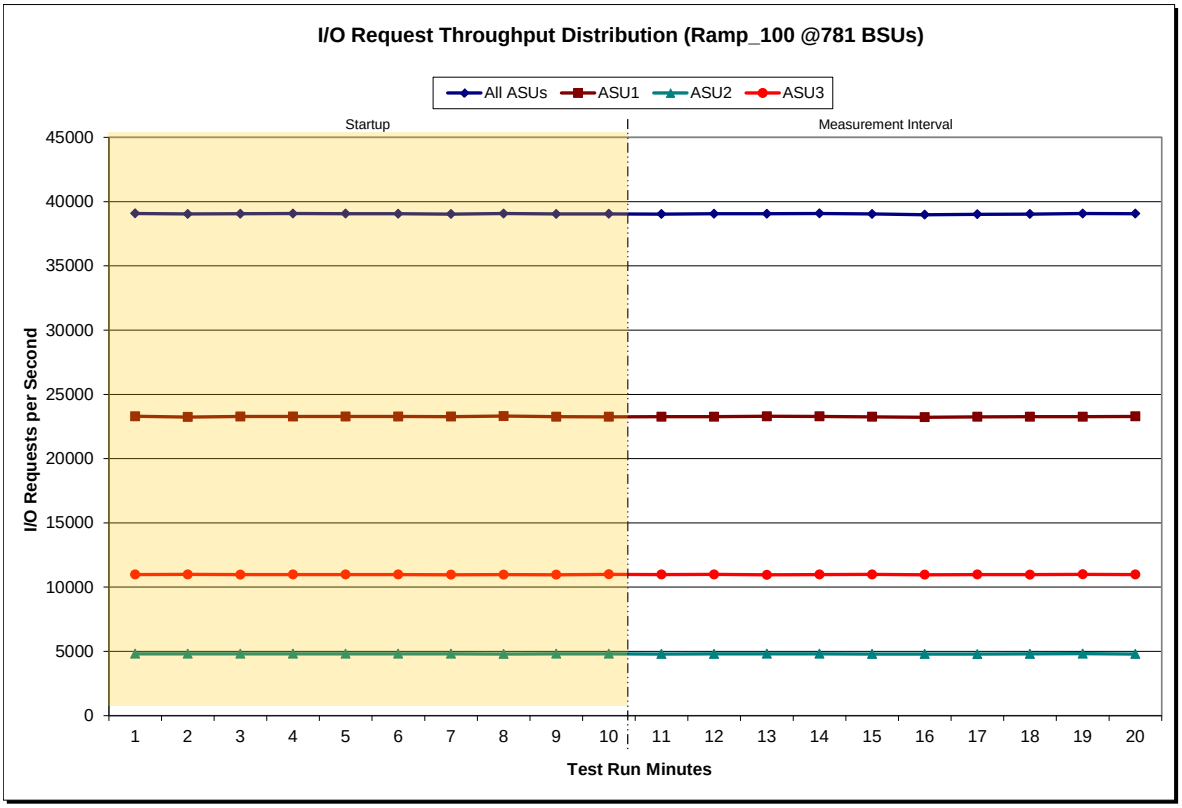
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

781 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:01:38	22:11:39	0-9	0:10:01
Measurement Interval	22:11:39	22:21:39	10-19	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	39,082.23	23,295.03	4,811.22	10,975.98
1	39,036.78	23,239.03	4,810.12	10,987.63
2	39,051.07	23,274.65	4,810.05	10,966.37
3	39,068.87	23,276.90	4,810.95	10,981.02
4	39,061.88	23,272.92	4,812.22	10,976.75
5	39,058.77	23,275.20	4,806.48	10,977.08
6	39,032.38	23,266.70	4,805.18	10,960.50
7	39,071.72	23,309.32	4,790.63	10,971.77
8	39,036.18	23,263.45	4,810.65	10,962.08
9	39,050.18	23,249.45	4,809.12	10,991.62
10	39,033.10	23,264.32	4,791.43	10,977.35
11	39,054.52	23,262.60	4,803.42	10,988.50
12	39,051.62	23,294.77	4,805.43	10,951.42
13	39,076.22	23,285.87	4,812.07	10,978.28
14	39,034.78	23,252.87	4,795.43	10,986.48
15	38,980.02	23,222.57	4,791.75	10,965.70
16	39,018.23	23,254.37	4,783.85	10,980.02
17	39,033.25	23,261.78	4,802.48	10,968.98
18	39,069.68	23,261.15	4,816.43	10,992.10
19	39,066.65	23,287.58	4,797.07	10,982.00
Average	***39,041.81***	***23,264.79***	***4,799.94***	***10,977.08***

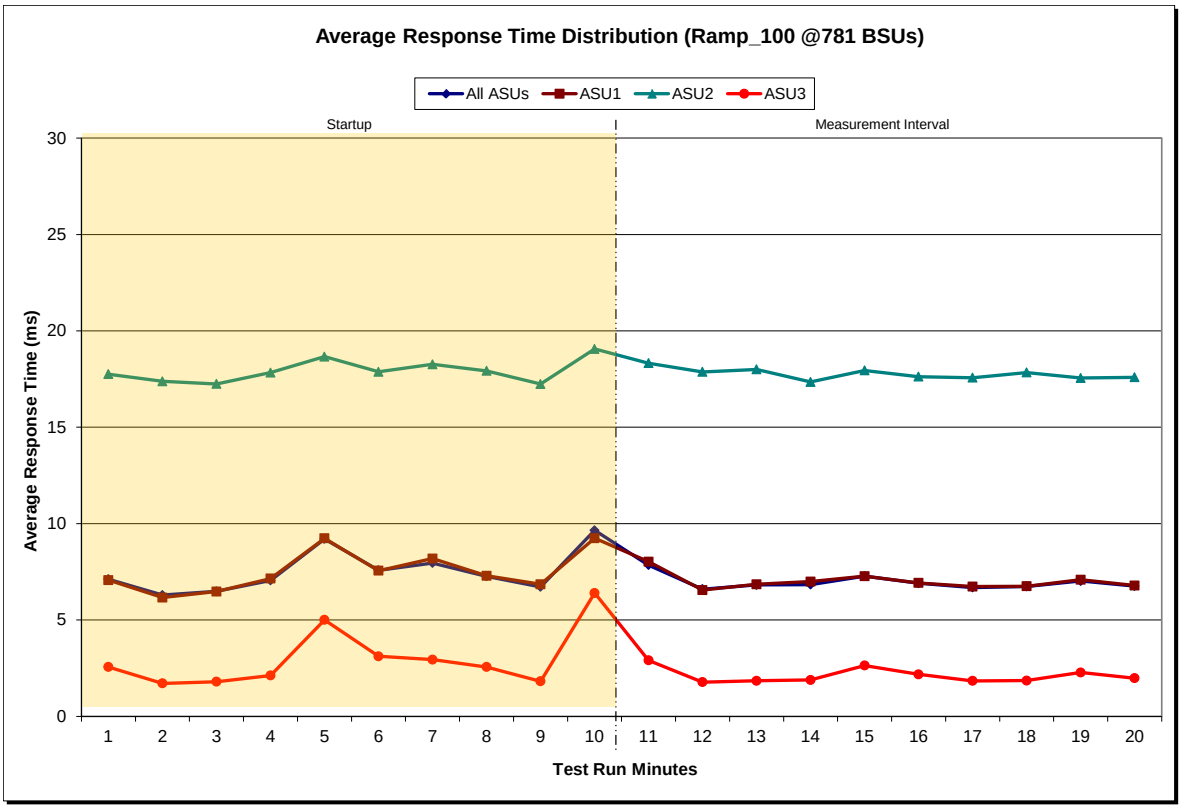
IOPS Test Run – I/O Request Throughput Distribution Graph



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

781 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:01:38	22:11:39	0-9	0:10:01
Measurement Interval	22:11:39	22:21:39	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	7.12	7.07	17.75	2.56
1	6.29	6.16	17.38	1.71
2	6.49	6.47	17.25	1.79
3	7.05	7.15	17.83	2.12
4	9.21	9.23	18.66	5.00
5	7.58	7.56	17.87	3.11
6	7.95	8.18	18.26	2.94
7	7.27	7.29	17.92	2.56
8	6.72	6.85	17.24	1.82
9	9.65	9.24	19.06	6.40
10	7.85	8.02	18.32	2.91
11	6.60	6.55	17.87	1.77
12	6.82	6.85	18.00	1.85
13	6.83	6.99	17.35	1.89
14	7.28	7.27	17.95	2.64
15	6.90	6.92	17.62	2.18
16	6.68	6.73	17.57	1.84
17	6.74	6.75	17.84	1.85
18	7.02	7.09	17.55	2.27
19	6.76	6.78	17.59	1.98
Average	***6.95***	***7.00***	***17.77***	***2.12***

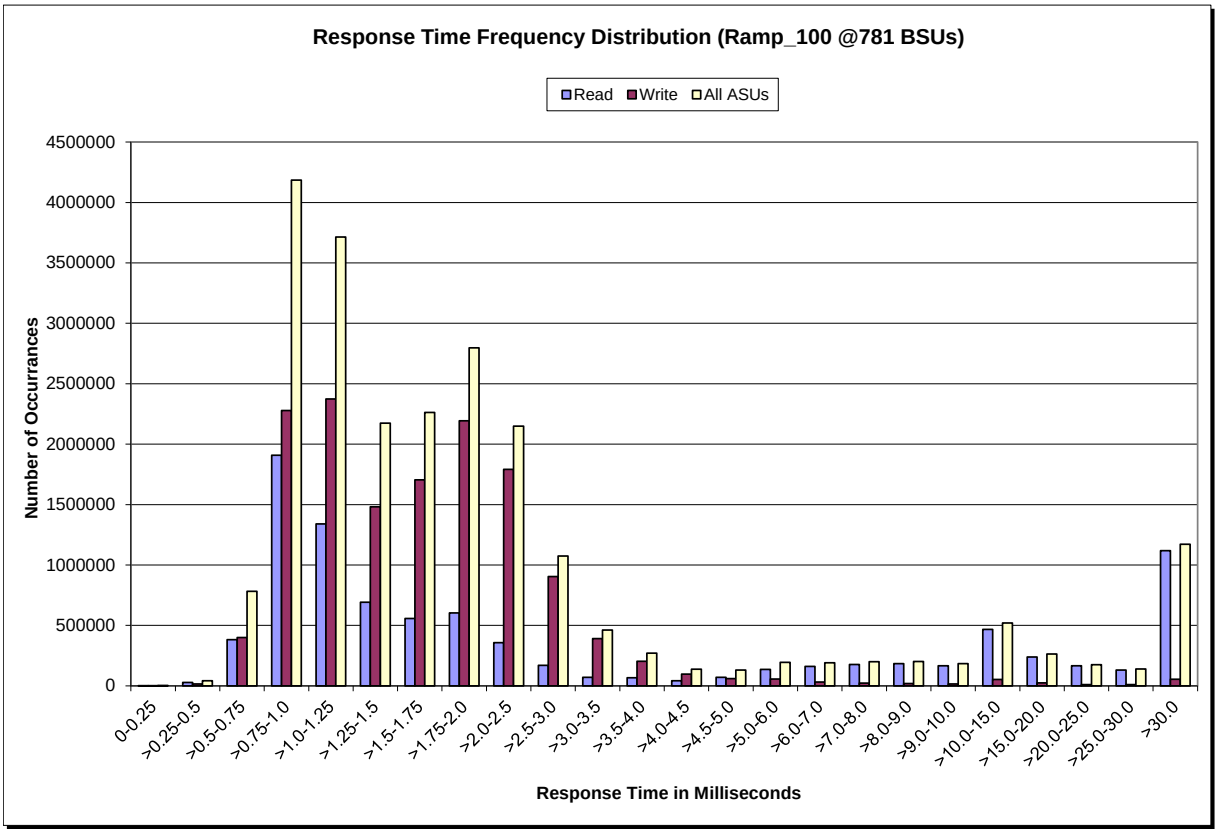
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	811	27,111	382,211	1,907,665	1,340,535	692,561	558,134	602,743
Write	1,493	15,072	400,178	2,277,408	2,373,747	1,481,781	1,704,288	2,194,058
All ASUs	2,304	42,183	782,389	4,185,073	3,714,282	2,174,342	2,262,422	2,796,801
ASU1	1,536	34,030	579,397	2,936,077	2,369,548	1,317,985	1,253,026	1,471,598
ASU2	233	3,495	64,936	310,778	288,282	175,129	190,729	242,295
ASU3	535	4,658	138,056	938,218	1,056,452	681,228	818,667	1,082,908
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	356,710	168,991	71,301	66,885	42,208	71,130	136,738	160,566
Write	1,791,453	904,757	391,028	203,112	96,196	59,607	56,954	31,110
All ASUs	2,148,163	1,073,748	462,329	269,997	138,404	130,737	193,692	191,676
ASU1	1,060,641	524,851	220,359	134,474	69,327	68,830	107,267	108,921
ASU2	186,770	102,565	45,688	36,310	21,577	32,290	58,229	66,712
ASU3	900,752	446,332	196,282	99,213	47,500	29,617	28,196	16,043
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	177,509	184,069	166,636	467,061	238,428	165,708	130,495	1,118,551
Write	22,417	18,222	16,338	53,199	24,480	9,631	9,792	53,656
All ASUs	199,926	202,291	182,974	520,260	262,908	175,339	140,287	1,172,207
ASU1	114,629	117,241	107,007	304,146	154,764	106,447	85,170	711,395
ASU2	73,673	75,781	67,655	189,498	96,060	64,476	51,659	435,031
ASU3	11,624	9,269	8,312	26,616	12,084	4,416	3,458	25,781

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
23,424,734	22,252,527	1,172,207

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2811	0.0699	0.02099	0.0180	0.0699	0.0350	0.2812
COV	0.003	0.001	0.002	0.001	0.006	0.001	0.004	0.001

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.4.3

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

The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 14.

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

Clause 9.4.3.7.3

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 68.

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 - 781 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:01:38	22:11:39	0-9	0:10:01
Measurement Interval	22:11:39	22:21:39	10-19	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	39,082.23	23,295.03	4,811.22	10,975.98
1	39,036.78	23,239.03	4,810.12	10,987.63
2	39,051.07	23,274.65	4,810.05	10,966.37
3	39,068.87	23,276.90	4,810.95	10,981.02
4	39,061.88	23,272.92	4,812.22	10,976.75
5	39,058.77	23,275.20	4,806.48	10,977.08
6	39,032.38	23,266.70	4,805.18	10,960.50
7	39,071.72	23,309.32	4,790.63	10,971.77
8	39,036.18	23,263.45	4,810.65	10,962.08
9	39,050.18	23,249.45	4,809.12	10,991.62
10	39,033.10	23,264.32	4,791.43	10,977.35
11	39,054.52	23,262.60	4,803.42	10,988.50
12	39,051.62	23,294.77	4,805.43	10,951.42
13	39,076.22	23,285.87	4,812.07	10,978.28
14	39,034.78	23,252.87	4,795.43	10,986.48
15	38,980.02	23,222.57	4,791.75	10,965.70
16	39,018.23	23,254.37	4,783.85	10,980.02
17	39,033.25	23,261.78	4,802.48	10,968.98
18	39,069.68	23,261.15	4,816.43	10,992.10
19	39,066.65	23,287.58	4,797.07	10,982.00
Average	***39,041.81***	***23,264.79***	***4,799.94***	***10,977.08***

95% Load Level - 741 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:21:45	22:31:46	0-9	0:10:01
Measurement Interval	22:31:46	22:41:46	10-19	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	37,033.70	22,073.73	4,553.58	10,406.38
1	37,056.60	22,105.27	4,545.67	10,405.67
2	37,081.05	22,091.88	4,557.95	10,431.22
3	37,056.92	22,083.17	4,554.23	10,419.52
4	37,011.28	22,062.73	4,550.45	10,398.10
5	37,065.28	22,079.67	4,561.03	10,424.58
6	37,031.85	22,076.12	4,549.67	10,406.07
7	37,045.80	22,071.00	4,563.52	10,411.28
8	37,106.73	22,134.35	4,562.72	10,409.67
9	37,052.33	22,071.40	4,557.02	10,423.92
10	37,034.12	22,073.58	4,559.58	10,400.95
11	37,073.40	22,118.90	4,545.67	10,408.83
12	37,054.72	22,099.05	4,552.25	10,403.42
13	37,052.85	22,091.15	4,559.43	10,402.27
14	37,081.90	22,119.87	4,539.13	10,422.90
15	37,035.32	22,074.13	4,549.45	10,411.73
16	37,046.58	22,086.30	4,548.42	10,411.87
17	37,084.30	22,081.12	4,564.15	10,439.03
18	37,027.52	22,068.62	4,558.15	10,400.75
19	37,051.65	22,073.87	4,555.17	10,422.62
Average	***37,054.24***	***22,088.66***	***4,553.14***	***10,412.44***

90% Load Level - 702 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	22:41:52	22:51:53	0-9	0:10:01
Measurement Interval	22:51:53	23:01:53	10-19	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	35,093.33	20,896.58	4,326.10	9,870.65
1	35,105.33	20,929.43	4,316.93	9,858.97
2	35,115.92	20,959.43	4,312.85	9,843.63
3	35,111.58	20,940.58	4,314.02	9,856.98
4	35,082.27	20,899.17	4,315.77	9,867.33
5	35,120.05	20,939.92	4,315.57	9,864.57
6	35,095.07	20,903.80	4,317.83	9,873.43
7	35,121.07	20,916.23	4,334.65	9,870.18
8	35,071.15	20,909.73	4,314.45	9,846.97
9	35,067.47	20,917.47	4,310.67	9,839.33
10	35,113.72	20,926.88	4,320.62	9,866.22
11	35,092.65	20,910.33	4,312.85	9,869.47
12	35,063.03	20,901.55	4,316.82	9,844.67
13	35,097.48	20,919.90	4,326.97	9,850.62
14	35,121.28	20,920.40	4,313.53	9,887.35
15	35,089.35	20,931.50	4,315.12	9,842.73
16	35,088.85	20,925.30	4,302.10	9,861.45
17	35,110.73	20,940.73	4,308.25	9,861.75
18	35,132.00	20,941.35	4,313.20	9,877.45
19	35,081.35	20,889.53	4,325.62	9,866.20
Average	***35,099.05***	***20,920.75***	***4,315.51***	***9,862.79***

80% Load Level - 624 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:02:00	23:12:01	0-9	0:10:01
Measurement Interval	23:12:01	23:22:01	10-19	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	31,207.82	18,604.57	3,831.45	8,771.80
1	31,200.30	18,609.28	3,831.28	8,759.73
2	31,196.40	18,590.47	3,850.83	8,755.10
3	31,141.57	18,567.48	3,838.82	8,735.27
4	31,196.77	18,600.20	3,840.80	8,755.77
5	31,237.50	18,644.67	3,836.63	8,756.20
6	31,210.98	18,610.47	3,842.05	8,758.47
7	31,163.05	18,574.55	3,825.18	8,763.32
8	31,188.57	18,591.73	3,826.20	8,770.63
9	31,177.63	18,564.78	3,831.85	8,781.00
10	31,162.37	18,582.72	3,830.85	8,748.80
11	31,175.85	18,575.65	3,845.77	8,754.43
12	31,198.95	18,592.75	3,828.33	8,777.87
13	31,173.77	18,579.73	3,822.95	8,771.08
14	31,200.63	18,591.55	3,836.88	8,772.20
15	31,227.43	18,609.80	3,845.77	8,771.87
16	31,209.07	18,612.05	3,835.83	8,761.18
17	31,195.53	18,596.40	3,826.40	8,772.73
18	31,181.98	18,569.28	3,832.62	8,780.08
19	31,227.27	18,602.18	3,832.82	8,792.27
Average	***31,195.29***	***18,591.21***	***3,833.82***	***8,770.25***

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

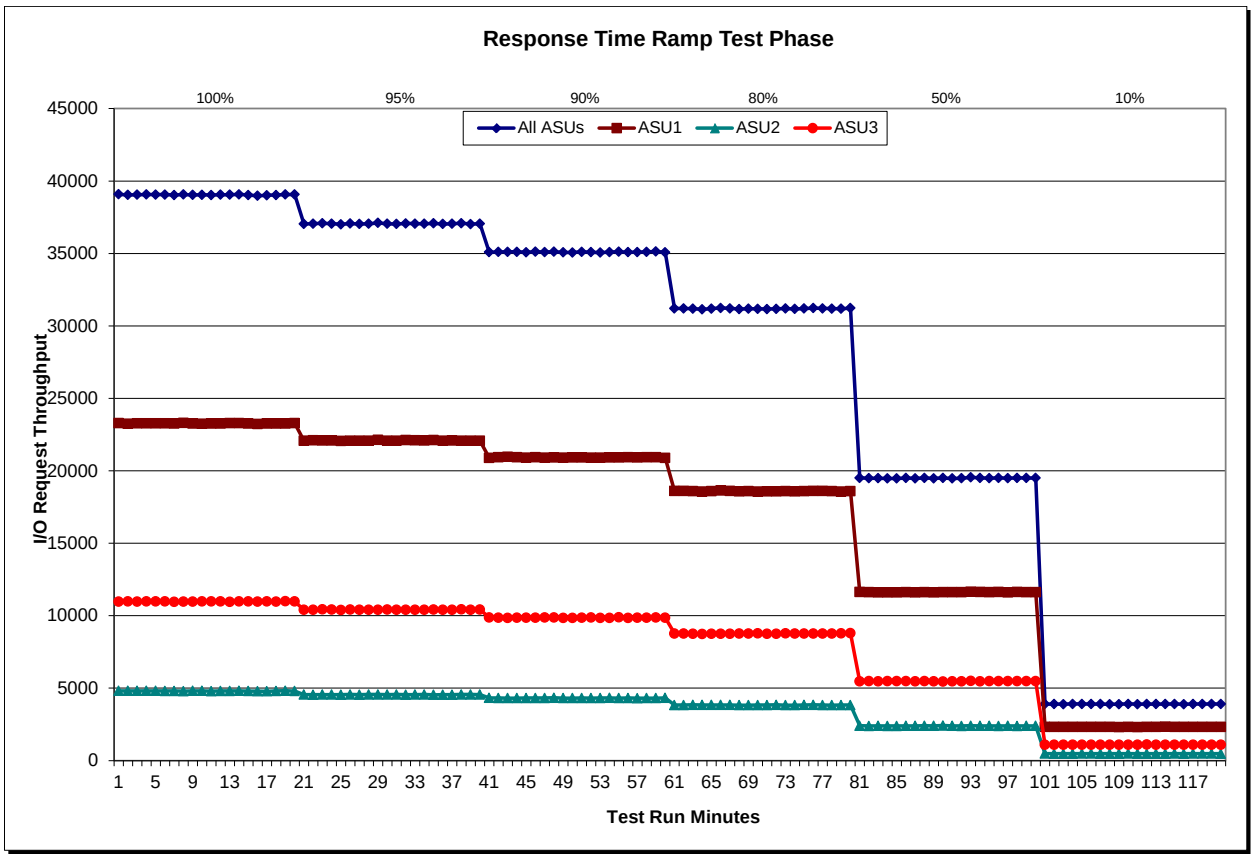
50% Load Level - 390 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:22:06	23:32:07	0-9	0:10:01
Measurement Interval	23:32:07	23:42:07	10-19	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	19,508.13	11,634.57	2,407.43	5,466.13
1	19,485.95	11,618.60	2,387.72	5,479.63
2	19,486.07	11,614.37	2,396.27	5,475.43
3	19,475.97	11,604.48	2,387.57	5,483.92
4	19,475.93	11,600.65	2,393.05	5,482.23
5	19,504.15	11,626.75	2,396.00	5,481.40
6	19,481.27	11,610.65	2,393.78	5,476.83
7	19,502.93	11,616.10	2,404.80	5,482.03
8	19,478.22	11,613.20	2,399.87	5,465.15
9	19,501.20	11,629.33	2,416.38	5,455.48
10	19,475.52	11,616.33	2,396.40	5,462.78
11	19,487.38	11,624.42	2,392.78	5,470.18
12	19,547.05	11,648.85	2,403.78	5,494.42
13	19,509.90	11,633.65	2,400.13	5,476.12
14	19,490.43	11,617.22	2,394.93	5,478.28
15	19,510.73	11,631.70	2,388.37	5,490.67
16	19,488.27	11,605.97	2,398.18	5,484.12
17	19,511.97	11,631.32	2,392.92	5,487.73
18	19,501.60	11,614.97	2,400.50	5,486.13
19	19,500.02	11,627.03	2,394.17	5,478.82
Average	***19,502.29***	***11,625.15***	***2,396.22***	***5,480.93***

10% Load Level - 78 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:42:12	23:52:13	0-9	0:10:01
Measurement Interval	23:52:13	0:02:13	10-19	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	3,899.30	2,327.22	482.42	1,089.67
1	3,899.42	2,323.95	478.67	1,096.80
2	3,891.55	2,321.73	477.82	1,092.00
3	3,906.98	2,327.20	478.92	1,100.87
4	3,907.43	2,326.93	480.92	1,099.58
5	3,903.72	2,329.85	482.25	1,091.62
6	3,898.88	2,325.83	479.10	1,093.95
7	3,889.47	2,322.32	479.02	1,088.13
8	3,892.35	2,315.20	475.22	1,101.93
9	3,905.87	2,329.27	480.35	1,096.25
10	3,896.30	2,316.82	478.53	1,100.95
11	3,898.72	2,320.58	475.17	1,102.97
12	3,899.57	2,322.73	476.87	1,099.97
13	3,903.75	2,334.95	474.98	1,093.82
14	3,909.13	2,324.80	484.78	1,099.55
15	3,886.87	2,317.93	476.48	1,092.45
16	3,906.22	2,329.77	480.97	1,095.48
17	3,904.53	2,330.10	481.48	1,092.95
18	3,907.15	2,329.30	480.65	1,097.20
19	3,902.28	2,327.23	476.90	1,098.15
Average	***3,901.45***	***2,325.42***	***478.68***	***1,097.35***

Response Time Ramp Distribution (IOPS) Graph

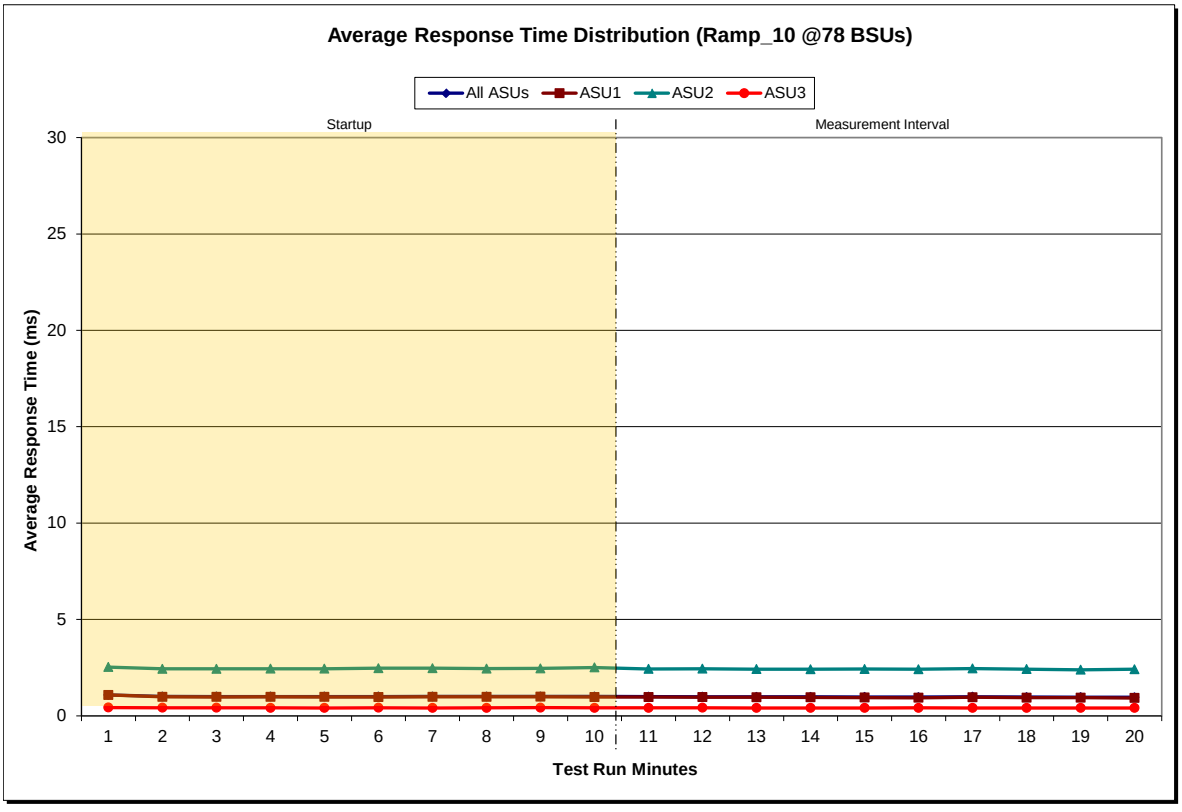


SPC-1 LRT™ Average Response Time (ms) Distribution Data

78 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	23:42:12	23:52:13	0-9	0:10:01
Measurement Interval	23:52:13	0:02:13	10-19	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	1.08	1.08	2.53	0.43
1	1.00	0.98	2.44	0.42
2	1.00	0.98	2.44	0.42
3	1.00	0.98	2.44	0.41
4	1.00	0.98	2.44	0.41
5	1.00	0.97	2.47	0.42
6	1.00	0.98	2.47	0.41
7	1.00	0.98	2.45	0.41
8	1.01	0.99	2.46	0.42
9	1.00	0.97	2.51	0.41
10	0.99	0.97	2.43	0.41
11	0.99	0.96	2.44	0.42
12	0.98	0.96	2.42	0.41
13	0.98	0.96	2.42	0.41
14	0.98	0.94	2.42	0.41
15	0.97	0.94	2.42	0.41
16	0.99	0.96	2.45	0.40
17	0.97	0.94	2.42	0.41
18	0.97	0.94	2.39	0.41
19	0.96	0.92	2.42	0.41
Average	***0.98***	***0.95***	***2.42***	***0.41***

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0351	0.2807	0.0703	0.2101	0.0179	0.0702	0.0346	0.2813
COV	0.007	0.004	0.004	0.004	0.009	0.008	0.009	0.004

Repeatability Test

Clause 5.4.5

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

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

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

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

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

Clause 9.4.3.7.4

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 68.

Repeatability Test Results File

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

	SPC-1 IOPS™
Primary Metrics	***39,041.81***
Repeatability Test Phase 1	39,050.04
Repeatability Test Phase 2	39,044.06

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

	SPC-1 LRT™
Primary Metrics	***0.98 ms***
Repeatability Test Phase 1	0.87 ms
Repeatability Test Phase 2	0.96 ms

The average response time values in the SPC-1 LRT™ column were generated using 10% of the specified Business Scaling Unit (BSU) load level. Each of the Repeatability Test Phase values for SPC-1 LRT™ must be less than 105% of the reported SPC-1 LRT™ Primary Metric or less than the reported SPC-1 LRT™ Primary Metric minus one (1) millisecond (ms).

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

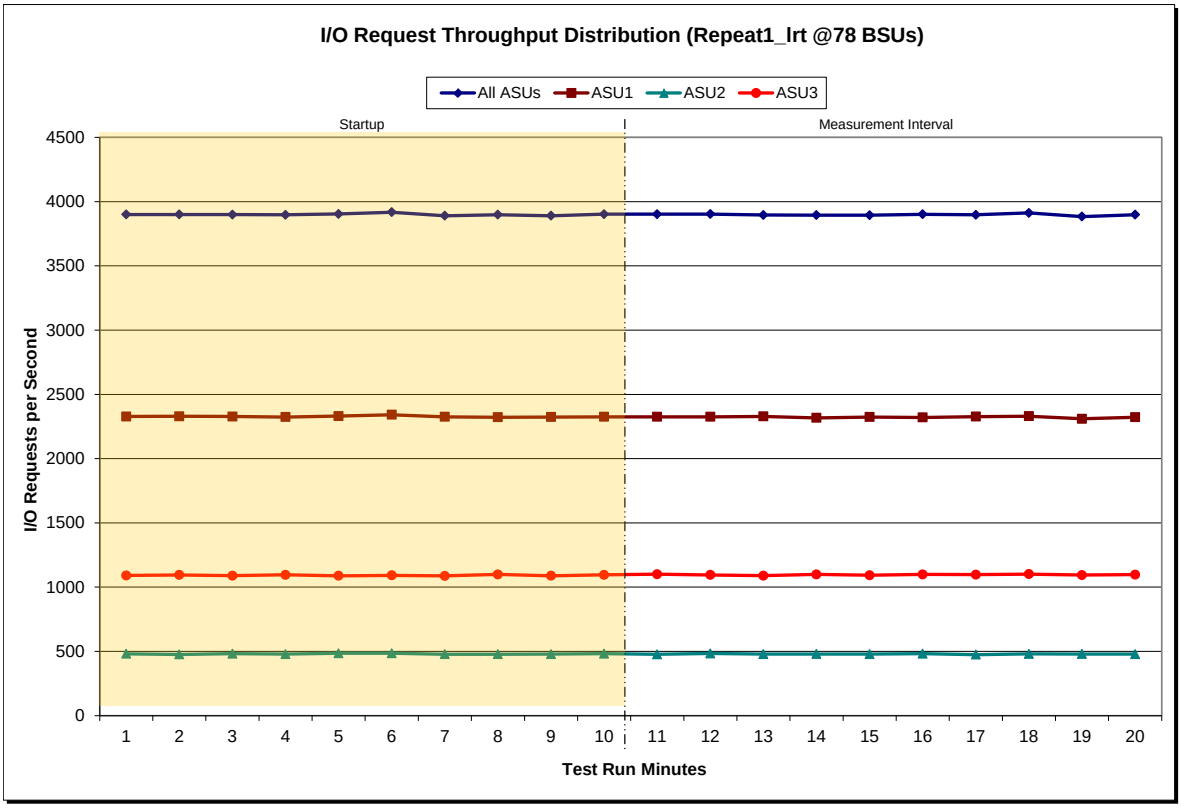
Repeatability Test Phase 1, Test Run 1 (LRT)
Repeatability Test Phase 1, Test Run 2 (IOPS)
Repeatability Test Phase 2, Test Run 1 (LRT)
Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

78 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:02:22	0:12:22	0-9	0:10:00
Measurement Interval	0:12:22	0:22:22	10-19	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	3,899.50	2,327.67	481.08	1,090.75
1	3,900.10	2,329.22	476.43	1,094.45
2	3,898.88	2,327.78	482.05	1,089.05
3	3,897.63	2,323.45	478.83	1,095.35
4	3,904.22	2,330.92	484.80	1,088.50
5	3,917.43	2,341.10	485.27	1,091.07
6	3,890.17	2,325.18	477.80	1,087.18
7	3,898.32	2,322.22	477.77	1,098.33
8	3,890.43	2,323.62	478.55	1,088.27
9	3,901.95	2,325.52	481.40	1,095.03
10	3,902.38	2,325.58	476.88	1,099.92
11	3,902.88	2,325.30	482.98	1,094.60
12	3,895.88	2,328.62	478.15	1,089.12
13	3,895.22	2,316.80	479.62	1,098.80
14	3,893.95	2,323.57	478.35	1,092.03
15	3,901.47	2,320.63	482.12	1,098.72
16	3,897.65	2,326.45	474.27	1,096.93
17	3,911.78	2,330.28	480.13	1,101.37
18	3,884.00	2,310.25	479.62	1,094.13
19	3,898.43	2,322.27	478.90	1,097.27
Average	***3,898.37***	***2,322.98***	***479.10***	***1,096.29***

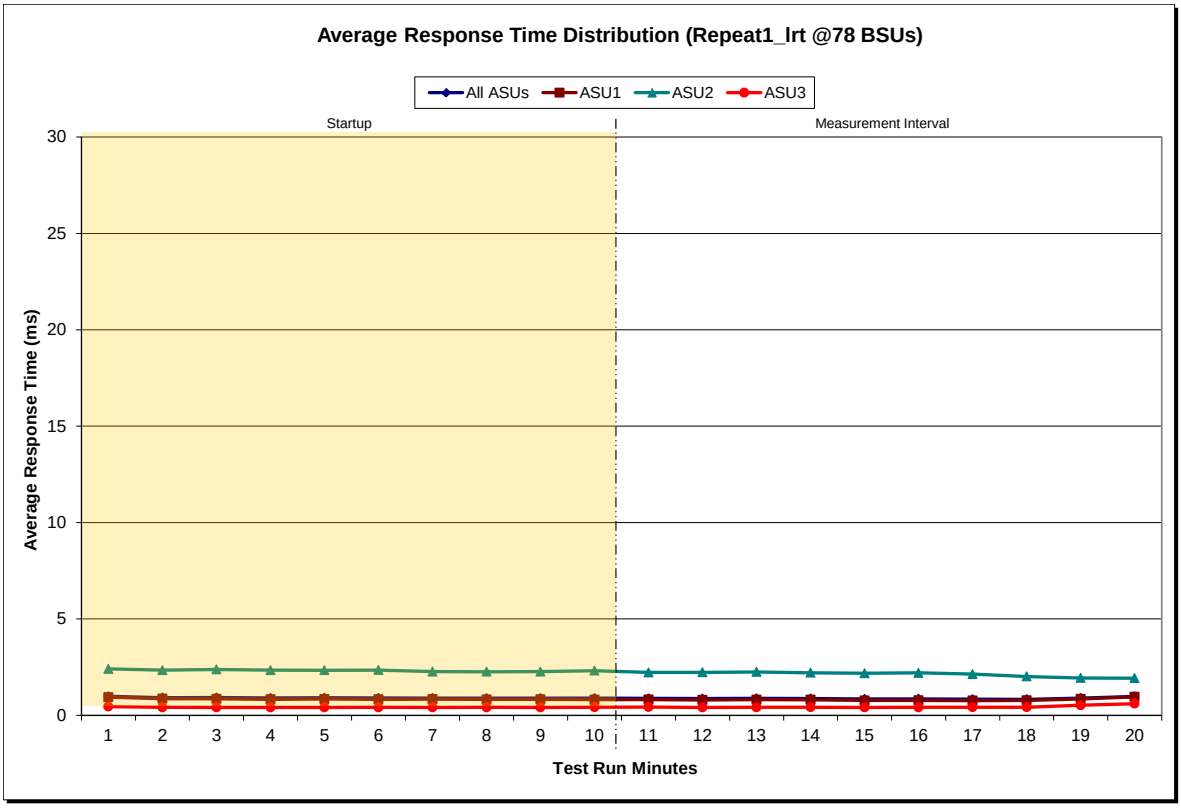
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

78 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:02:22	0:12:22	0-9	0:10:00
Measurement Interval	0:12:22	0:22:22	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.98	0.94	2.41	0.45
1	0.91	0.86	2.34	0.41
2	0.92	0.85	2.37	0.41
3	0.90	0.83	2.34	0.41
4	0.91	0.84	2.33	0.41
5	0.90	0.83	2.34	0.41
6	0.89	0.84	2.26	0.41
7	0.88	0.82	2.26	0.41
8	0.89	0.83	2.26	0.41
9	0.89	0.81	2.31	0.41
10	0.88	0.81	2.22	0.43
11	0.86	0.79	2.23	0.41
12	0.88	0.81	2.25	0.41
13	0.87	0.80	2.21	0.42
14	0.84	0.77	2.18	0.41
15	0.85	0.77	2.20	0.41
16	0.83	0.76	2.13	0.41
17	0.82	0.77	2.01	0.42
18	0.89	0.85	1.93	0.52
19	0.98	0.96	1.92	0.60
Average	***0.87***	***0.81***	***2.13***	***0.44***

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

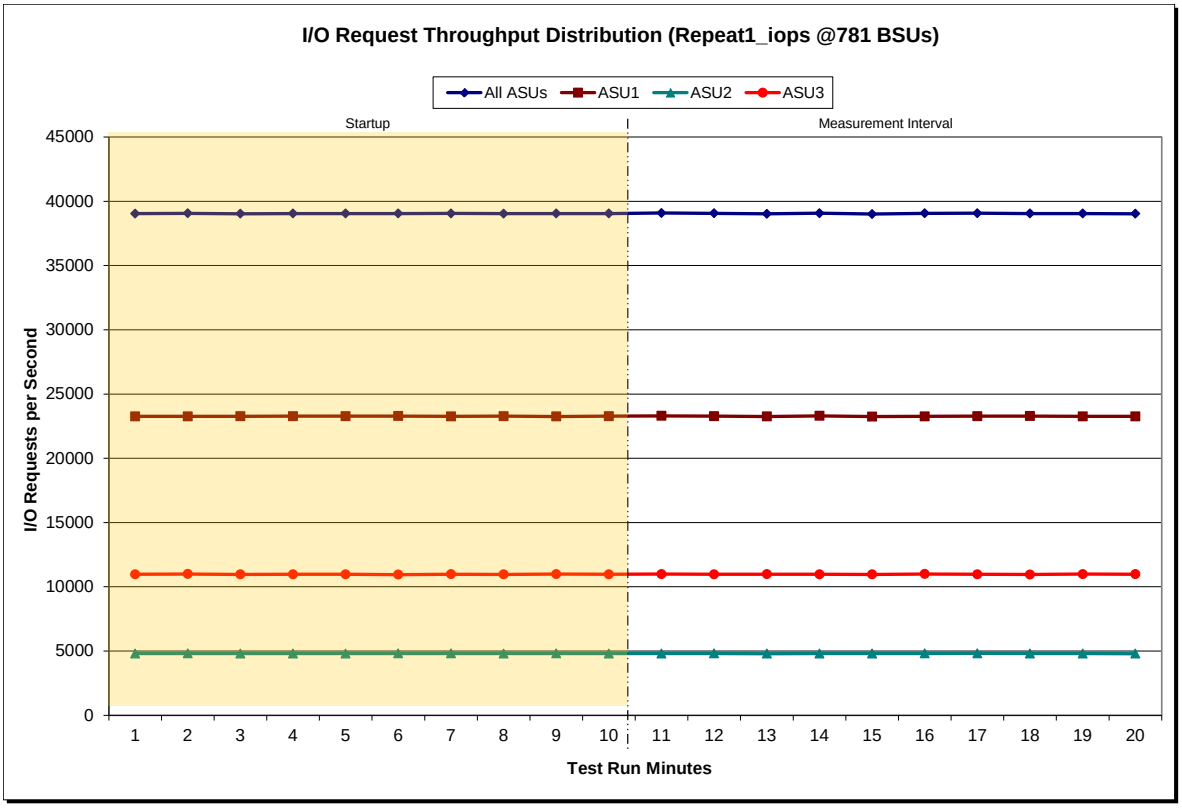


Repeatability 1 IOPS – I/O Request Throughput Distribution Data

781 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:22:29	0:32:30	0-9	0:10:01
Measurement Interval	0:32:30	0:42:30	10-19	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	39,038.43	23,263.17	4,804.70	10,970.57
1	39,061.67	23,261.28	4,807.77	10,992.62
2	39,032.95	23,271.38	4,797.73	10,963.83
3	39,043.33	23,276.15	4,799.45	10,967.73
4	39,046.45	23,276.20	4,800.87	10,969.38
5	39,044.63	23,284.65	4,811.42	10,948.57
6	39,055.58	23,261.17	4,812.28	10,982.13
7	39,034.88	23,274.87	4,801.03	10,958.98
8	39,047.58	23,248.27	4,808.82	10,990.50
9	39,049.73	23,279.13	4,797.67	10,972.93
10	39,084.82	23,296.95	4,801.82	10,986.05
11	39,058.93	23,277.62	4,807.38	10,973.93
12	39,021.98	23,248.68	4,792.38	10,980.92
13	39,072.60	23,296.73	4,804.07	10,971.80
14	39,010.02	23,242.90	4,803.85	10,963.27
15	39,060.40	23,264.05	4,805.50	10,990.85
16	39,068.50	23,279.95	4,819.95	10,968.60
17	39,043.28	23,285.53	4,802.03	10,955.72
18	39,047.40	23,257.42	4,803.97	10,986.02
19	39,032.43	23,259.48	4,796.92	10,976.03
Average	***39,050.04***	***23,270.93***	***4,803.79***	***10,975.32***

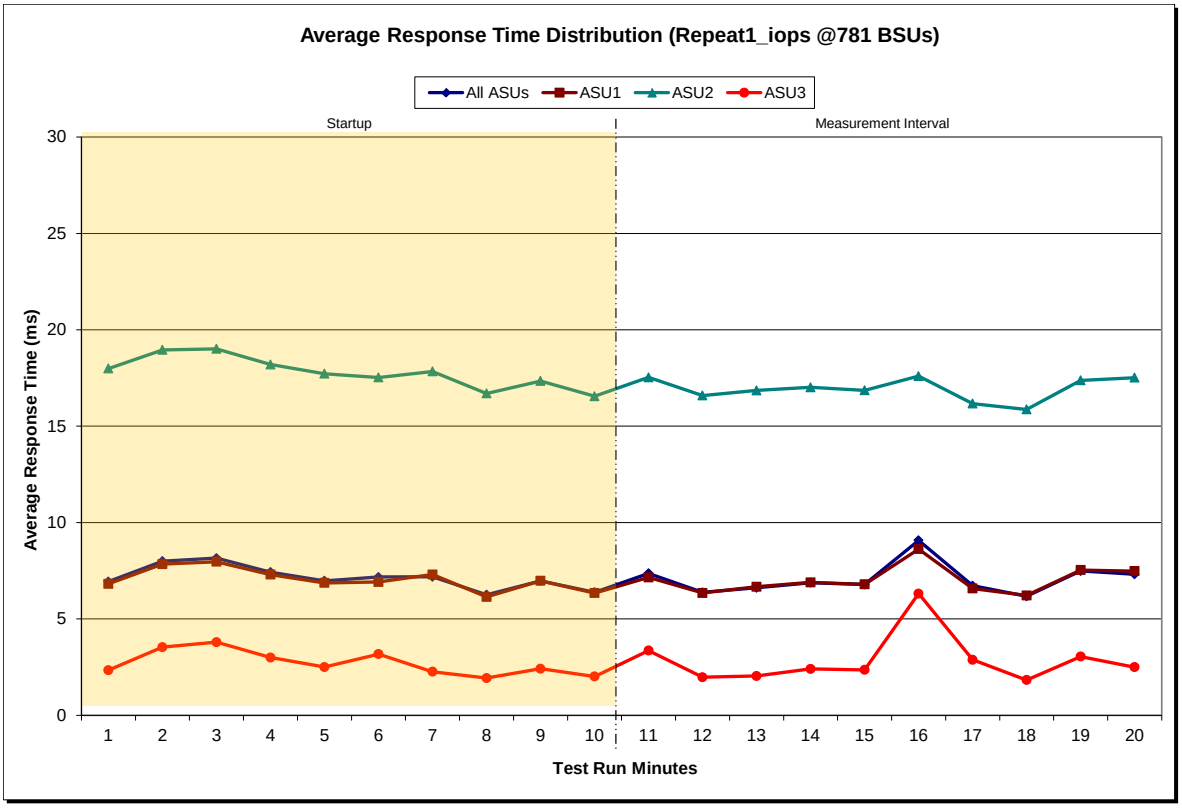
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

781 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:22:29	0:32:30	0-9	0:10:01
Measurement Interval	0:32:30	0:42:30	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	6.94	6.82	17.99	2.34
1	8.00	7.84	18.96	3.54
2	8.15	7.97	19.01	3.79
3	7.43	7.30	18.20	3.00
4	6.97	6.87	17.72	2.50
5	7.17	6.91	17.53	3.17
6	7.18	7.30	17.84	2.26
7	6.25	6.14	16.70	1.93
8	6.97	6.97	17.34	2.41
9	6.38	6.34	16.55	2.01
10	7.36	7.15	17.53	3.36
11	6.38	6.34	16.59	1.97
12	6.61	6.67	16.85	2.04
13	6.88	6.90	17.01	2.41
14	6.78	6.79	16.86	2.36
15	9.07	8.62	17.60	6.31
16	6.72	6.58	16.17	2.88
17	6.17	6.22	15.87	1.83
18	7.48	7.54	17.37	3.05
19	7.31	7.48	17.52	2.50
Average	***7.08***	***7.03***	***16.94***	***2.87***

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

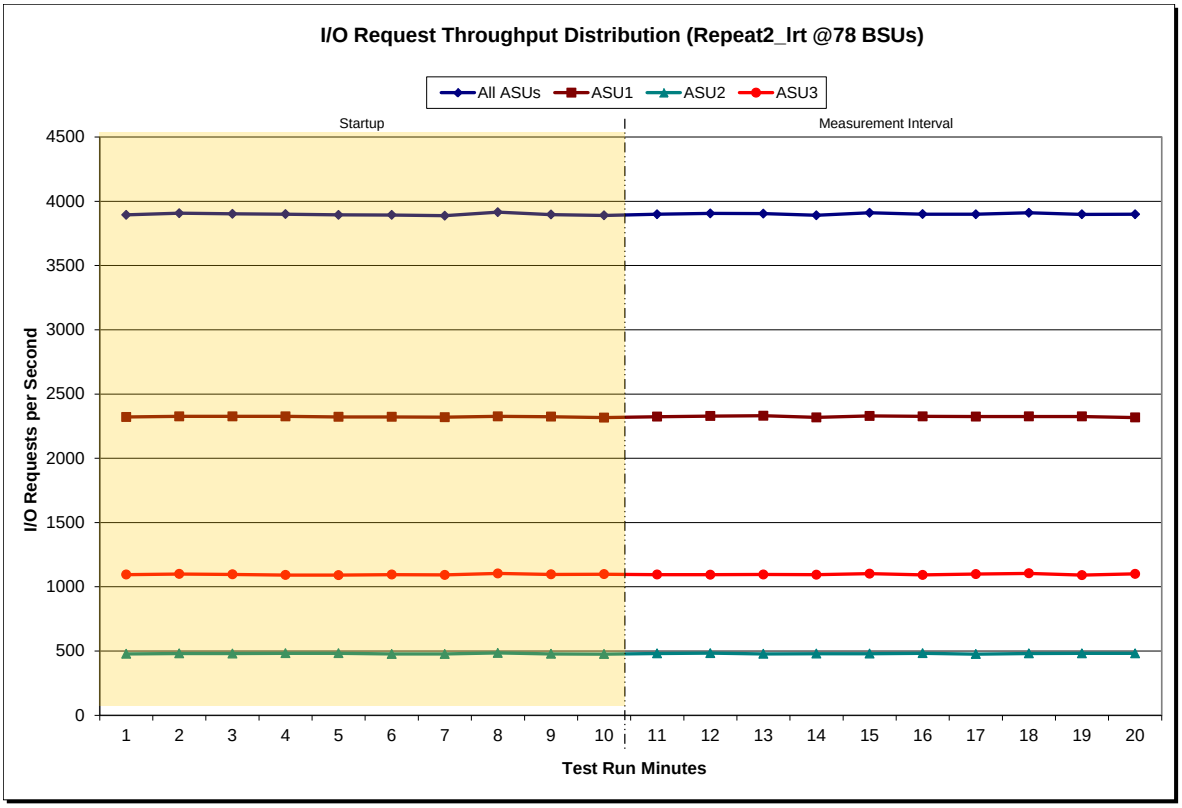


Repeatability 2 LRT – I/O Request Throughput Distribution Data

78 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:42:40	0:52:40	0-9	0:10:00
Measurement Interval	0:52:40	1:02:40	10-19	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	3,893.97	2,321.53	477.87	1,094.57
1	3,906.70	2,325.88	481.23	1,099.58
2	3,902.22	2,325.63	480.37	1,096.22
3	3,899.63	2,325.77	482.30	1,091.57
4	3,894.57	2,321.75	482.13	1,090.68
5	3,893.58	2,322.10	477.17	1,094.32
6	3,888.05	2,319.18	476.65	1,092.22
7	3,915.42	2,326.32	485.28	1,103.82
8	3,896.92	2,323.23	477.60	1,096.08
9	3,889.88	2,315.95	475.78	1,098.15
10	3,899.17	2,323.67	480.58	1,094.92
11	3,905.50	2,328.48	483.38	1,093.63
12	3,903.68	2,330.92	477.50	1,095.27
13	3,890.97	2,317.77	479.53	1,093.67
14	3,910.55	2,329.38	479.55	1,101.62
15	3,900.13	2,325.67	482.27	1,092.20
16	3,899.38	2,324.13	476.32	1,098.93
17	3,910.33	2,325.37	480.82	1,104.15
18	3,897.95	2,325.30	481.75	1,090.90
19	3,899.32	2,317.20	481.47	1,100.65
Average	***3,901.70***	***2,324.79***	***480.32***	***1,096.59***

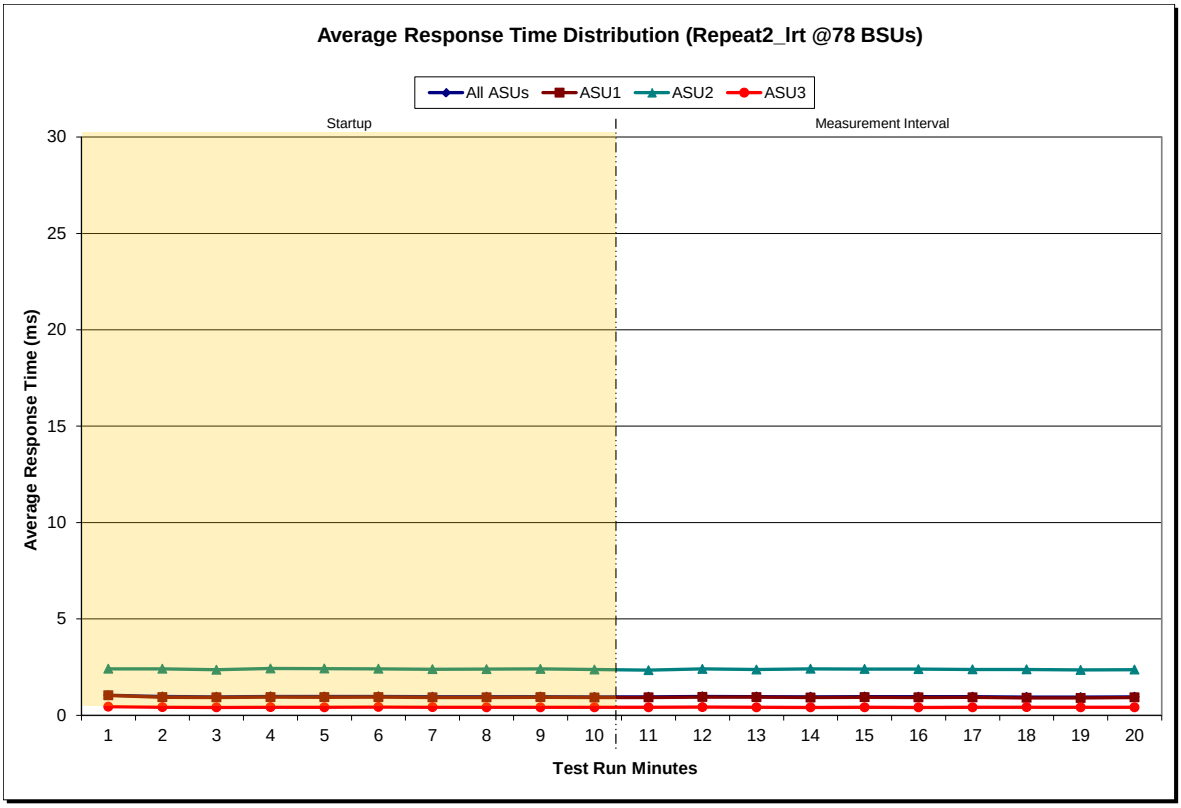
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

78 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	0:42:40	0:52:40	0-9	0:10:00
Measurement Interval	0:52:40	1:02:40	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.04	1.03	2.41	0.44
1	0.97	0.93	2.41	0.42
2	0.96	0.92	2.36	0.41
3	0.98	0.94	2.43	0.42
4	0.97	0.94	2.42	0.41
5	0.98	0.94	2.41	0.43
6	0.96	0.93	2.39	0.42
7	0.96	0.93	2.39	0.41
8	0.97	0.93	2.40	0.41
9	0.95	0.92	2.37	0.41
10	0.96	0.92	2.34	0.41
11	0.98	0.95	2.41	0.42
12	0.97	0.94	2.37	0.41
13	0.96	0.92	2.41	0.41
14	0.97	0.93	2.40	0.41
15	0.96	0.93	2.40	0.41
16	0.96	0.93	2.38	0.41
17	0.94	0.90	2.38	0.42
18	0.94	0.90	2.35	0.41
19	0.96	0.92	2.36	0.41
Average	***0.96***	***0.92***	***2.38***	***0.41***

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

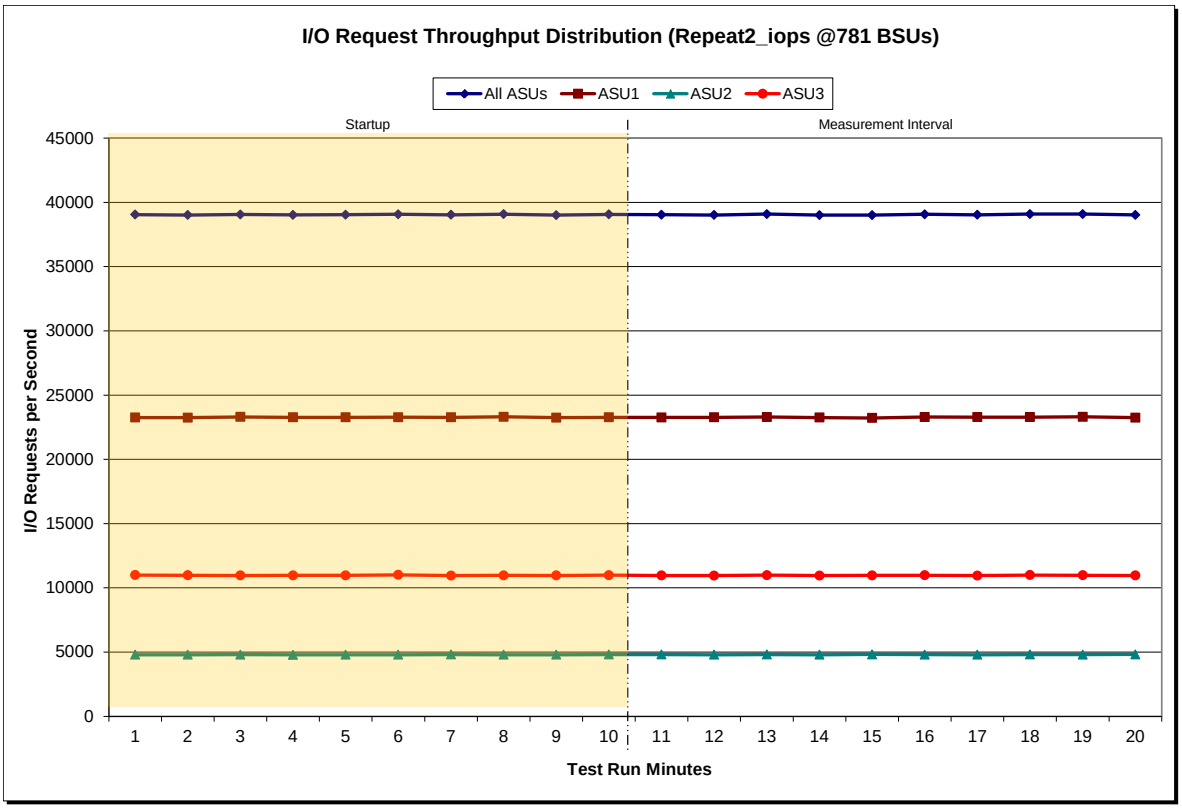


Repeatability 2 IOPS – I/O Request Throughput Distribution Data

781 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:02:48	1:12:49	0-9	0:10:01
Measurement Interval	1:12:49	1:22:49	10-19	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	39,045.50	23,255.10	4,796.75	10,993.65
1	39,017.78	23,245.47	4,793.10	10,979.22
2	39,058.13	23,297.43	4,798.27	10,962.43
3	39,025.12	23,271.45	4,785.65	10,968.02
4	39,034.98	23,269.28	4,794.05	10,971.65
5	39,069.98	23,272.83	4,789.12	11,008.03
6	39,027.95	23,264.62	4,809.77	10,953.57
7	39,076.70	23,307.85	4,796.97	10,971.88
8	39,004.40	23,244.02	4,795.92	10,964.47
9	39,061.30	23,269.33	4,806.82	10,985.15
10	39,034.67	23,263.35	4,807.53	10,963.78
11	39,011.60	23,266.07	4,790.58	10,954.95
12	39,084.17	23,292.78	4,807.00	10,984.38
13	39,006.87	23,252.52	4,796.57	10,957.78
14	39,007.65	23,216.13	4,818.10	10,973.42
15	39,070.85	23,290.55	4,803.75	10,976.55
16	39,034.60	23,286.52	4,790.57	10,957.52
17	39,087.48	23,281.62	4,808.97	10,996.90
18	39,083.78	23,308.30	4,799.03	10,976.45
19	39,018.93	23,244.45	4,814.28	10,960.20
Average	***39,044.06***	***23,270.23***	***4,803.64***	***10,970.19***

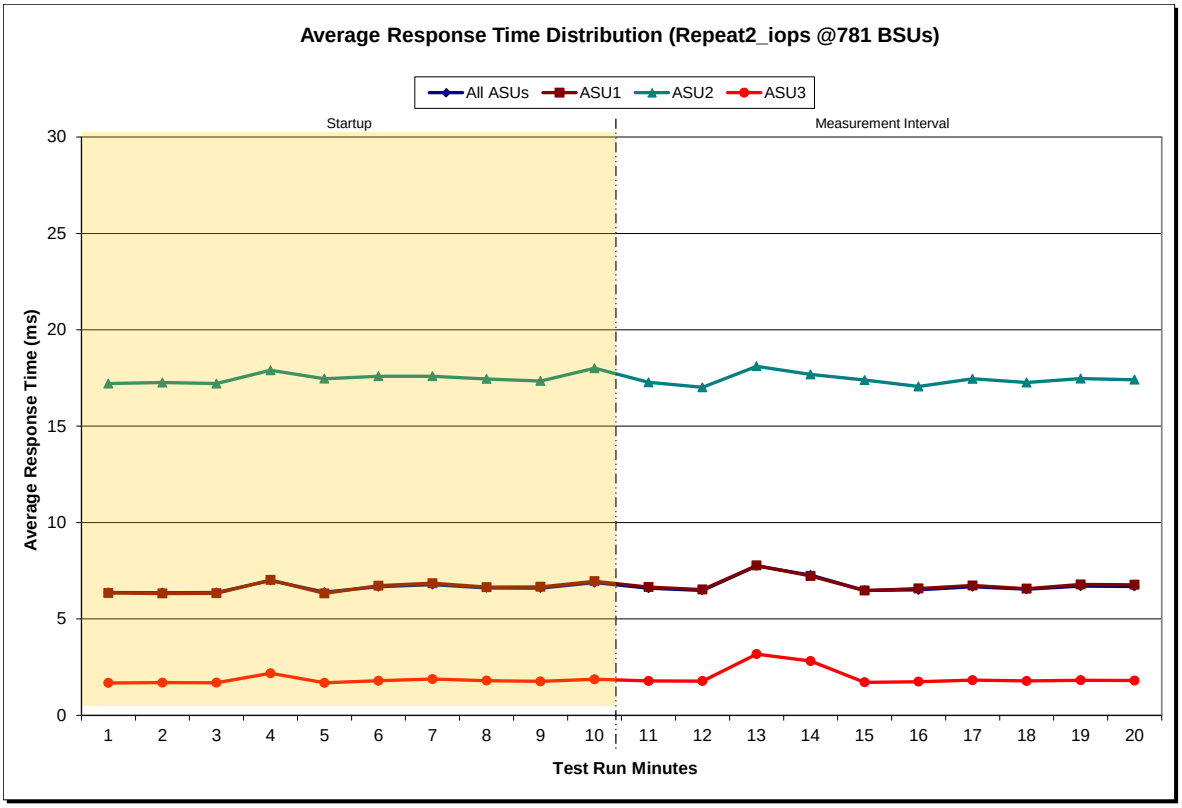
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

781 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:02:48	1:12:49	0-9	0:10:01
Measurement Interval	1:12:49	1:22:49	10-19	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	6.37	6.35	17.21	1.68
1	6.36	6.32	17.26	1.69
2	6.36	6.33	17.21	1.69
3	6.99	7.02	17.90	2.18
4	6.39	6.32	17.46	1.68
5	6.67	6.72	17.59	1.79
6	6.78	6.85	17.59	1.88
7	6.61	6.65	17.45	1.79
8	6.60	6.66	17.34	1.76
9	6.88	6.95	18.00	1.86
10	6.59	6.65	17.27	1.78
11	6.48	6.52	17.02	1.77
12	7.75	7.77	18.10	3.17
13	7.27	7.23	17.68	2.81
14	6.48	6.47	17.39	1.71
15	6.51	6.58	17.06	1.74
16	6.67	6.73	17.46	1.82
17	6.54	6.57	17.26	1.78
18	6.70	6.79	17.47	1.82
19	6.68	6.77	17.41	1.80
Average	***6.77***	***6.81***	***17.41***	***2.02***

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0351	0.2810	0.0697	0.2100	0.0181	0.0699	0.0349	0.2812
COV	0.005	0.002	0.005	0.004	0.022	0.008	0.011	0.003

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

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

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2806	0.0702	0.2100	0.0180	0.0699	0.0352	0.2811
COV	0.009	0.003	0.009	0.004	0.012	0.007	0.010	0.003

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0349	0.2809	0.0700	0.2101	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.002	0.001	0.005	0.003	0.004	0.001

Data Persistence Test

Clause 6

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

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

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

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

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

Clause 9.4.3.8

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 68.

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	78,015,584
Total Number of Logical Blocks Verified	67,641,392
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 9.4.3.9

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

The Dot Hill AssuredSAN™ Pro 5000 as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

PRICING INFORMATION

Clause 9.4.3.3.6

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

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

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.8

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

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration may be found in the Executive Summary portion of this document on page 15.

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Onsite Audit of the Dot Hill AssuredSAN™ Pro 5000.

APPENDIX A: SPC-1 GLOSSARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

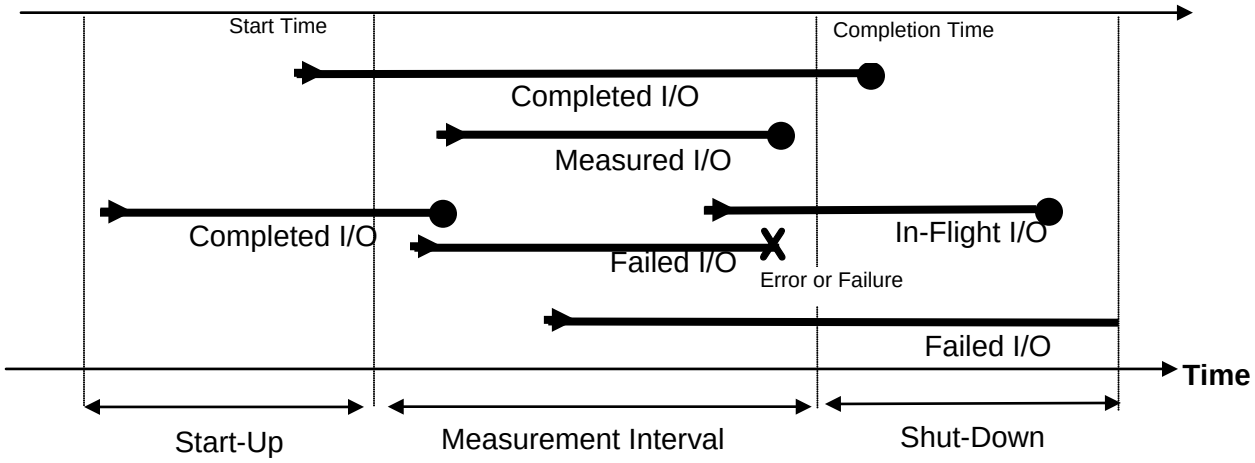
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

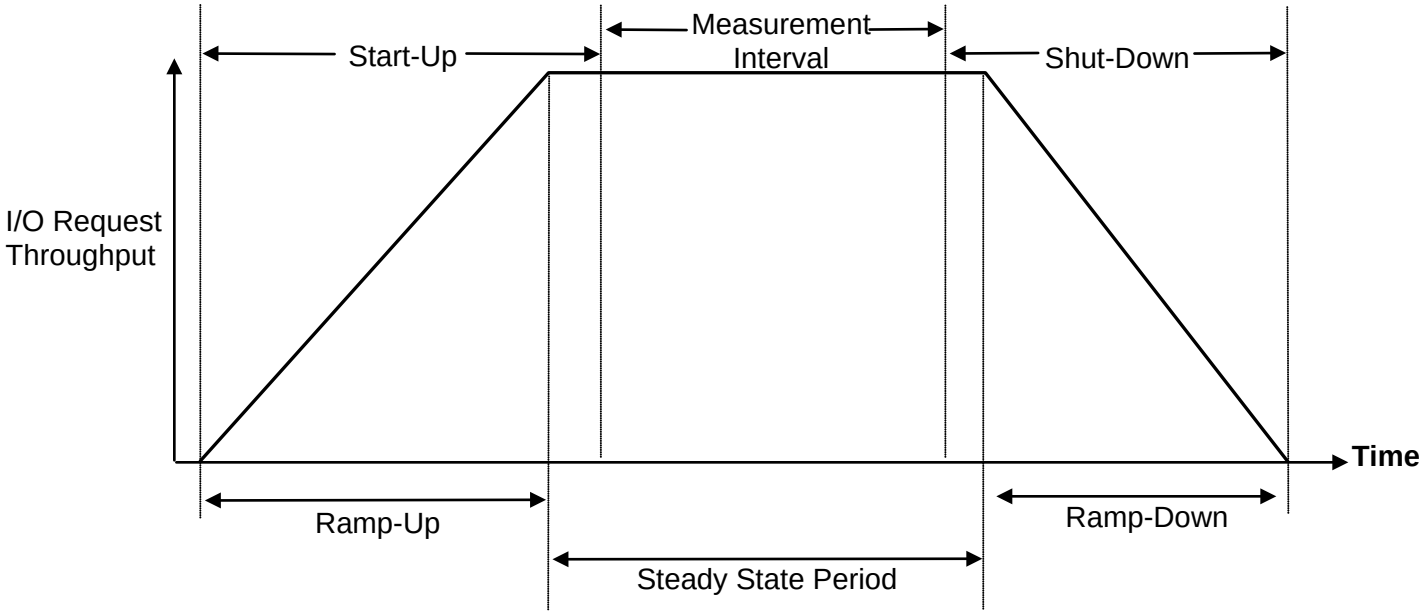
Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have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

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

I/O Completion Types



SPC-1 Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

The **chunk-size** parameter was set to 512 KB for each RAID 10 HDD vdisk as part of the vdisk creation process documented in the **Create HDD vdisks** section of *Appendix C: Tested Storage Configuration (TSC) Creation* on page 64.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

A CLI session is started with the Dot Hill AssuredSAN™ Pro 5000, via the Host System, using either telnet or Hyperterm to enter the commands described below.

Create HDD vdisks

The following CLI commands will create six RAID10 HDD vdisks, using ten disk drives for each HDD vdisk.

```
create vdisk level r10 chunk-size 512K assigned-to a disks
0.0,0.1:0.2,0.3:0.4,0.5:0.6,0.7:0.8,0.9 SAS-R10-A1
create vdisk level r10 chunk-size 512K assigned-to a disks
1.0,1.1:1.2,1.3:1.4,1.5:1.6,1.7:1.8,1.9 SAS-R10-A2
create vdisk level r10 chunk-size 512K assigned-to a disks
2.0,2.1:2.2,2.3:2.4,2.5:2.6,2.7:2.8,2.9 SAS-R10-A3

create vdisk level r10 chunk-size 512K assigned-to b disks
0.10,0.11:0.12,0.13:0.14,0.15:0.16,0.17:0.18,0.19 SAS-R10-B1
create vdisk level r10 chunk-size 512K assigned-to b disks
1.10,1.11:1.12,1.13:1.14,1.15:1.16,1.17:1.18,1.19 SAS-R10-B2
create vdisk level r10 chunk-size 512K assigned-to b disks
2.10,2.11:2.12,2.13:2.14,2.15:2.16,2.17:2.18,2.19 SAS-R10-B3
```

Create SSD vdisks

The following CLI commands will create four RAID-1 SSD vdisks, using two SSDs for each SSD vdisk.

```
create vdisk level r1 assigned-to a disks 1.20,1.21 SSD-R10-A1
create vdisk level r1 assigned-to a disks 2.20,2.21 SSD-R10-A2
#
create vdisk level r1 assigned-to b disks 0.22,0.23 SSD-R10-B1
create vdisk level r1 assigned-to b disks 2.22,2.23 SSD-R10-B2
```

Create Storage Pools

Two storage pools, A and B, are created by the following CLI commands. Each storage pool will contain three HDD vdisks and two SSD vdisks.

```
#
# Create storage pools for controller A & controller B
#
#create storage-pool assigned-to a components SAS-R10-A1,SAS-R10-A2,SAS-R10-A3,SSD-
R10-B1,SSD-R10-B2 component-names psc-1,psc-2,psc-3,psc-4,psc-5 A

create storage-pool assigned-to b components SAS-R10-B1,SAS-R10-B2,SAS-R10-B3,SSD-
R10-A1,SSD-R10-A2 component-names psc-11,psc-12,psc-13,psc-14,psc-15 B
```

Create Volumes

The following CLI commands will create a total of fourteen volumes, seven volumes for each storage pool. Six of the volumes for each storage pool will be created with a capacity of 1,335 GB. The remaining volume for each storage pool will be created with a capacity of 891 GB.

```
#
# Create Volumes from Pool
#
# Volumes for A Controller
#
create volume storage-pool A size 1335GB ASU1-A1
create volume storage-pool A size 1335GB ASU1-A2
create volume storage-pool A size 1335GB ASU1-A3

create volume storage-pool A size 1335GB ASU2-A1
create volume storage-pool A size 1335GB ASU2-A2
create volume storage-pool A size 1335GB ASU2-A3

create volume storage-pool A size 891GB ASU3-A1
#
# Volumes for B Controller
#
create volume storage-pool B size 1335GB ASU1-B1
create volume storage-pool B size 1335GB ASU1-B2
create volume storage-pool B size 1335GB ASU1-B3
#
create volume storage-pool B size 1335GB ASU2-B1
create volume storage-pool B size 1335GB ASU2-B2
create volume storage-pool B size 1335GB ASU2-B3
#
create volume storage-pool B size 891GB ASU3-B1
```

Map Volumes to Host Ports

Each of the fourteen volumes is mapped to a specific host port with the following CLI commands.

```
#
# Map Volumes to Host Ports
#
map volume lun 10 ports a0 ASU1-A1
map volume lun 12 ports a2 ASU1-A2
map volume lun 14 ports a0 ASU1-A3
#
map volume lun 16 ports a2 ASU2-A1
map volume lun 18 ports a0 ASU2-A2
map volume lun 20 ports a2 ASU2-A3
#
map volume lun 22 ports a0 ASU3-A1
#
map volume lun 11 ports b0 ASU1-B1
map volume lun 13 ports b2 ASU1-B2
map volume lun 15 ports b0 ASU1-B3
#
map volume lun 17 ports b2 ASU2-B1
map volume lun 19 ports b0 ASU2-B2
map volume lun 21 ports b2 ASU2-B3
#
map volume lun 23 ports b0 ASU3-B1
```

Create SPC-1 Logical Volumes

The steps that follow are executed on the Host System to define the Windows partititons, volumes and stripe sets that comprise the SPC-1 Logical Volumes. Those volumes are used to configure the SPC-1 Application Storage Units (ASUs).

1. Start the Windows Disk Administrator...
2. Examine the Windows Physical Disk Properties and locate disks with LUN# - 10,11,12,13,14,15,16,17,18,19,20,21,22,23
3. Put each of these disks in Online State from Offline
4. Create Striped Volumes, RAW (do not format) as below, using all of the available capacity in each LUN.
    a. Volume K – using disks with LUN # 22 and 23 for ASU-3.
    b. Volume I – using disks with LUN # 10,11,12,13,14,15 for ASU-1.
    c. Volume J – using disks with LUN # 16,17,18,19,20,21 for ASU-2.
5. Volumes I, J , K are now ready for use

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.

ASU-PreFill-script.cfg

```
compratio=1

sd=default,threads=8
sd=sd1,lun=\\.\i:,threads=4
sd=sd2,lun=\\.\j:,threads=4
sd=sd3,lun=\\.\k:,threads=4

wd=default,rdpct=0,seek=-1,xfersize=512k
wd=wd1,sd=sd1
wd=wd2,sd=sd2
wd=wd3,sd=sd3

rd=asuprefill,wd=wd*,iorate=max,elapsed=24h,interval=60
```

Primary Metrics, Repeatability and Persistence Tests

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

spc1.cfg

```
sd=asu1_1,lun=\\.\i:
sd=asu2_1,lun=\\.\j:
sd=asu3_1,lun=\\.\k:
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

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

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

The **vdbench-32-64.bat script**, invoked to execute the required ASU pre-fill, is a revised version of the default execution script, **vdbench.bat**, included with the VDbench distribution. The default script was revised to explicitly use a 32-bit JVM, which is required for Windows. The remaining benchmark execution used a 64-bit JVM.

```
rem
rem PreFill ASU space with vdbench
rem
cd C:\spc1-test-results\5000\W2008R2-spc-v2-3-5\SPC-Command-Files\Java-Pre-Fill
rem
call  C:\vdbench503rc11\vdbench-32-64.bat -f C:\spc1-test-results\5000\W2008R2-spc-
v2-3-5\SPC-Command-Files\Java-Pre-Fill\ASU-PreFill-script.cfg -o prefill.out
rem
java -version
rem
rem SPC-1 Test Suite command file
rem
cd C:\spc1-test-results\5000\W2008R2-spc-v2-3-5
cd 2013-02-09-1200-Pool-A+B-6xR10-10d-600GB-10K+4xR1-400GB-SSD-FW-C100R07-01-14-
VOLs-IJK
rem
cd 2013-02-09-1200-BSU-781
rem
rem Rangetest run - single load point
rem
java range -b 781 -s 72000 -t 300
rem
rem Metrics sustainability -
rem
java metrics -b 781 -s 7200:600 -t 28800
rem
rem Repeatability Runs
rem
java -Xmx512m -Xms512m repeat1 -b 781 -s 600
java -Xmx512m -Xms512m repeat2 -b 781 -s 600
rem
rem copy spc1_persist.cfg spc1.cfg
rem
rem Persist runs
rem
java -Xmx512m -Xms512m persist1 -b 781
rem
rem Insert commands to power off & on ports on Ethernet switched PDU
rem
rem
rem  Run second Persist command to validate contents of storage
rem
rem Run persist2 after power cycle
rem
```

```
rem java                    persist2
```

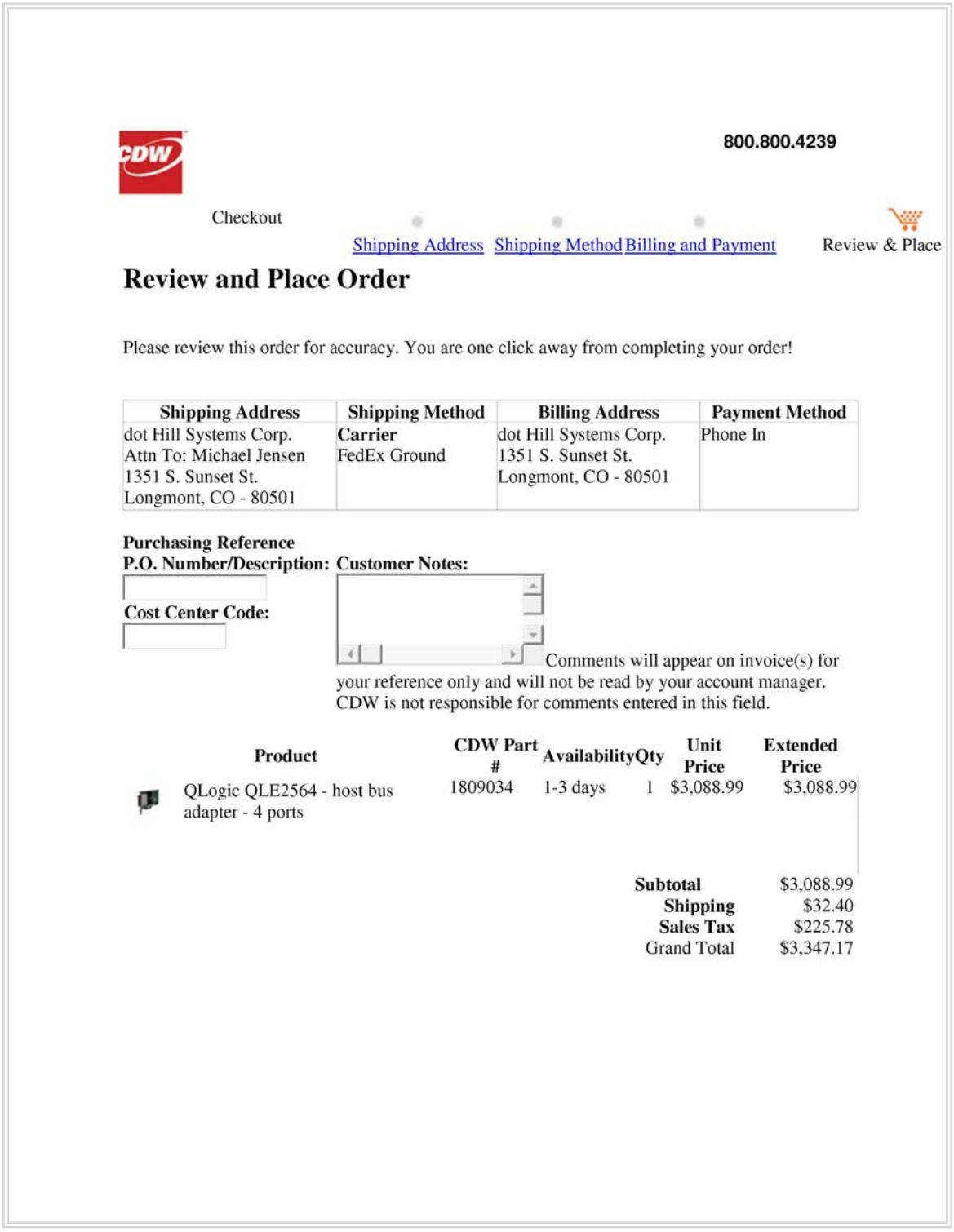
Persistence Test Run 2

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

```
cd C:\spc1-test-results\5000\W2008R2-spc-v2-3-5
cd 2013-02-09-1200-Pool-A+B-6xR10-10d-600GB-10K+4xR1-400GB-SSD-FW-C100R07-01-14-
VOLs-IJK

cd 2013-02-09-1200-BSU-781

rem  Run second Persist command to validate contents of storage

rem Run persist2 after power cycle

java -Xmx512m -Xms512m persist2
```

APPENDIX F: THIRD-PARTY QUOTATION

Qlogic QLE2564 HBA



800.800.4239

Checkout

Shipping Address | Shipping Method | Billing and Payment | Review & Place

Review and Place Order

Please review this order for accuracy. You are one click away from completing your order!

Shipping Address	Shipping Method	Billing Address	Payment Method
dot Hill Systems Corp. Attn To: Michael Jensen 1351 S. Sunset St. Longmont, CO - 80501	**Carrier** FedEx Ground	dot Hill Systems Corp. 1351 S. Sunset St. Longmont, CO - 80501	Phone In

Purchasing Reference
P.O. Number/Description:

Cost Center Code:

Customer Notes:

Comments will appear on invoice(s) for your reference only and will not be read by your account manager. CDW is not responsible for comments entered in this field.

Product	CDW Part #	Availability	Qty	Unit Price	Extended Price
QLogic QLE2564 - host bus adapter - 4 ports	1809034	1-3 days	1	$3,088.99	$3,088.99

Subtotal	$3,088.99
Shipping	$32.40
Sales Tax	$225.78
Grand Total	$3,347.17