SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

HUAWEI TECHNOLOGIES CO., LTD.
HUAWEI OCEANSTOR™ S8100 *(8-NODE)*

SPC-1 V1.12

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First Edition – November 2010

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AUDIT CERTIFICATION

Michael Ko
Huawei Symantec Technologies Co., Ltd.
20245 Stevens Creek Blvd.
Cupertino, CA 95014

November 10, 2010

The SPC Benchmark 1™ results listed below for the Huawei Symantec Oceanspace™ S8100 *(8-node)* were produced in compliance with the SPC Benchmark 1™ 1.12 Remote Audit requirements.

SPC Benchmark 1™ 1.12 Results	
Tested Storage Configuration (TSC) Name: Huawei Symantec Oceanspace™ S8100 *(8-node)*	
Metric	**Reported Result**
SPC-1 IOPS™	300,062.04
SPC-1 Price-Performance	CNY 48.96/SPC-1 IOPS™
Total ASU Capacity	160,920.000 GB
Data Protection Level	Protected *(Mirroring)*
Total TSC Price (including three-year maintenance)	CNY 14,692,707

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with 1.12 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items, based on information supplied by Huawei Symantec Technologies Co., Ltd.:
  - ✓ Physical Storage Capacity and requirements.
  - ✓ Configured Storage Capacity and requirements.
  - ✓ Addressable Storage Capacity and requirements.
  - ✓ Capacity of each Logical Volume and requirements.
  - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.

Storage Performance Council
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Redwood City, CA 94062
AuditService@storageperformance.org
650.556.9384

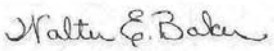
AUDIT CERTIFICATION *(CONT.)*

- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements, based on information supplied by Huawei Symantec Technologies Co., Ltd.:
  - ✓ The type of Host System including the number of processors and main memory.
  - ✓ The presence and version number of the SPC-1 Workload Generator on each Host System.
  - ✓ The TSC boundary within each Host System.
- The Test Results Files and resultant Summary Results Files received from Huawei Symantec Technologies Co., Ltd. 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 (TSC) used for the benchmark and Priced Storage.
- 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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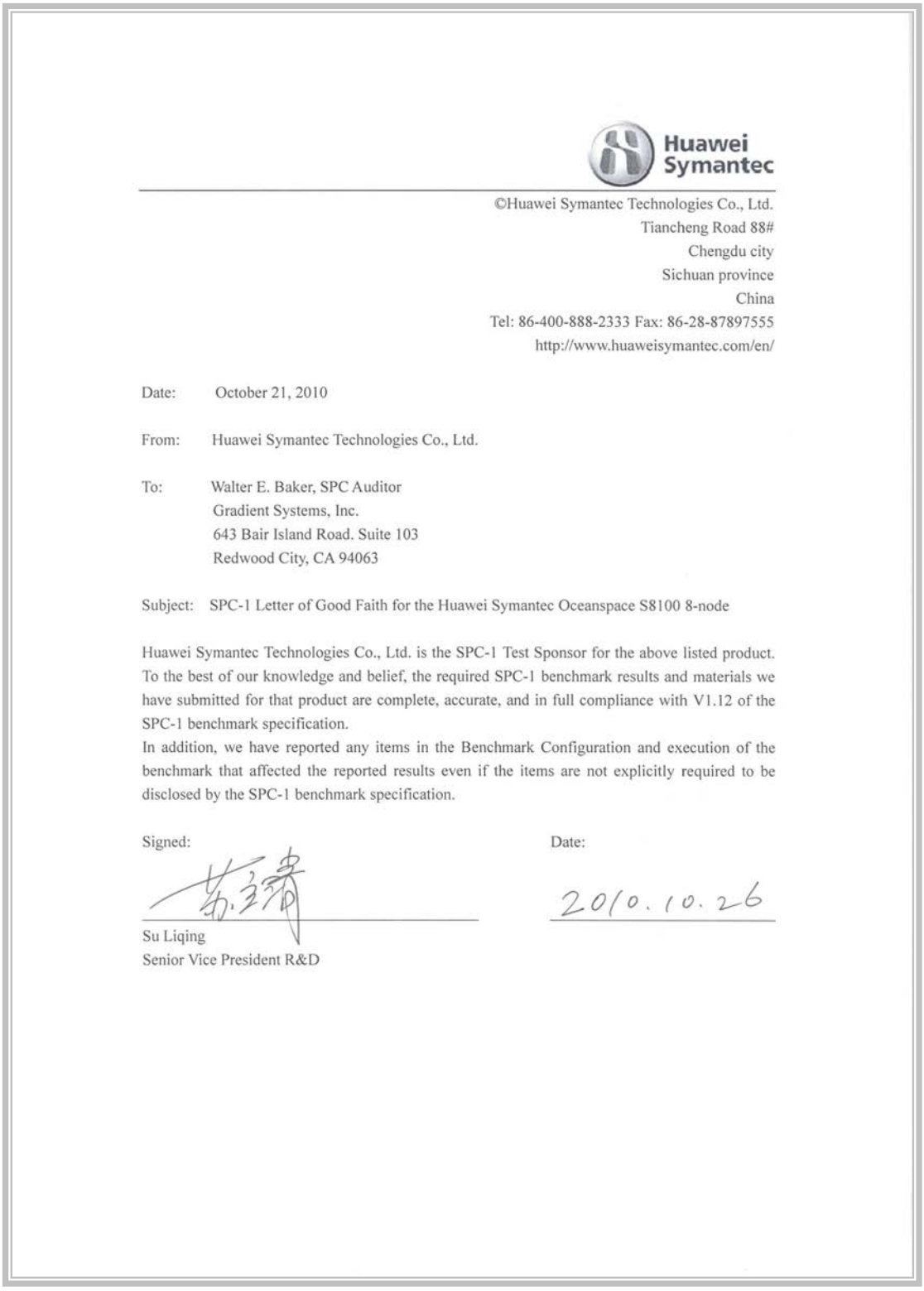
LETTER OF GOOD FAITH



Huawei Symantec

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Date: October 21, 2010

From: Huawei Symantec Technologies Co., Ltd.

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

Subject: SPC-1 Letter of Good Faith for the Huawei Symantec Oceanspace S8100 8-node

Huawei Symantec Technologies Co., Ltd. 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 V1.12 of the SPC-1 benchmark specification.
In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark that affected the reported results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specification.

Signed: Date: 2010.10.26

Su Liqing
Senior Vice President R&D

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
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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	V1.12
SPC-1 Workload Generator revision number	V2.1.0
Date Results were first used publicly	November 11, 2010
Date the FDR was submitted to the SPC	November 11, 2010
Date revised FDR was submitted to the SPC Updated company name, logo and product name to reflect the complete acquisition of Huawei Symantec by Huawei Technologies Co., Ltd.	December 13, 2012
Date the priced storage configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	November 10, 2010

Tested Storage Product (TSP) Description

Huawei OceanStor™ S8100 storage system (hereinafter referred to as the S8100) is a new generation, high-end, storage product that is used by enterprises for mission-critical applications. Boasting high reliability, high performance, high scalability, large capacity, comprehensive data protection, and diversified value-added features, the S8100 is applicable to the scenarios of large-scaled core database, high availability computing, high performance computing, and integrated storage, backup, and retrieving of mass data, and is the best choice for investment saving.

Summary of Results

SPC-1 Results	
Tested Storage Product (TSP) Name: Huawei OceanStor™ S8100 *(8-node)*	
Metric	**Reported Result**
SPC-1 IOPS™	300,062.04
SPC-1 Price-Performance	CNY 48.96/SPC-1 IOPS™
Total ASU Capacity	160,920.000 GB
Data Protection Level	Protected *(Mirroring)*
Total TSP Price (including three-year maintenance)	CNY14,692,707

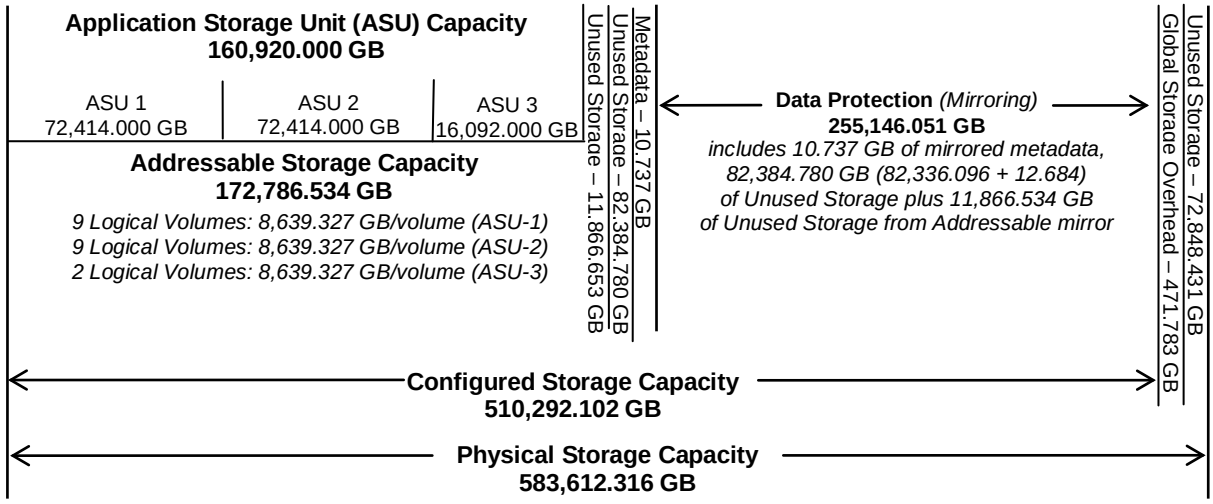
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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

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

Storage Capacities, Relationships, and Utilization

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



SPC-1 Storage Capacity Utilization	
Application Utilization	27.57%
Protected Application Utilization	69.26%
Unused Storage Ratio	44.77%

Application Utilization: Total ASU Capacity *(160,920.000 GB)* divided by Physical Storage Capacity *(583,612.316 GB)*

Protected Application Utilization: (Total ASU Capacity *(160,920.000 GB)* plus total Data Protection Capacity *(255,146.051 GB)* minus unused Data Protection Capacity *(11,866.534 GB)* divided by Physical Storage Capacity *(583,612.316 GB)*

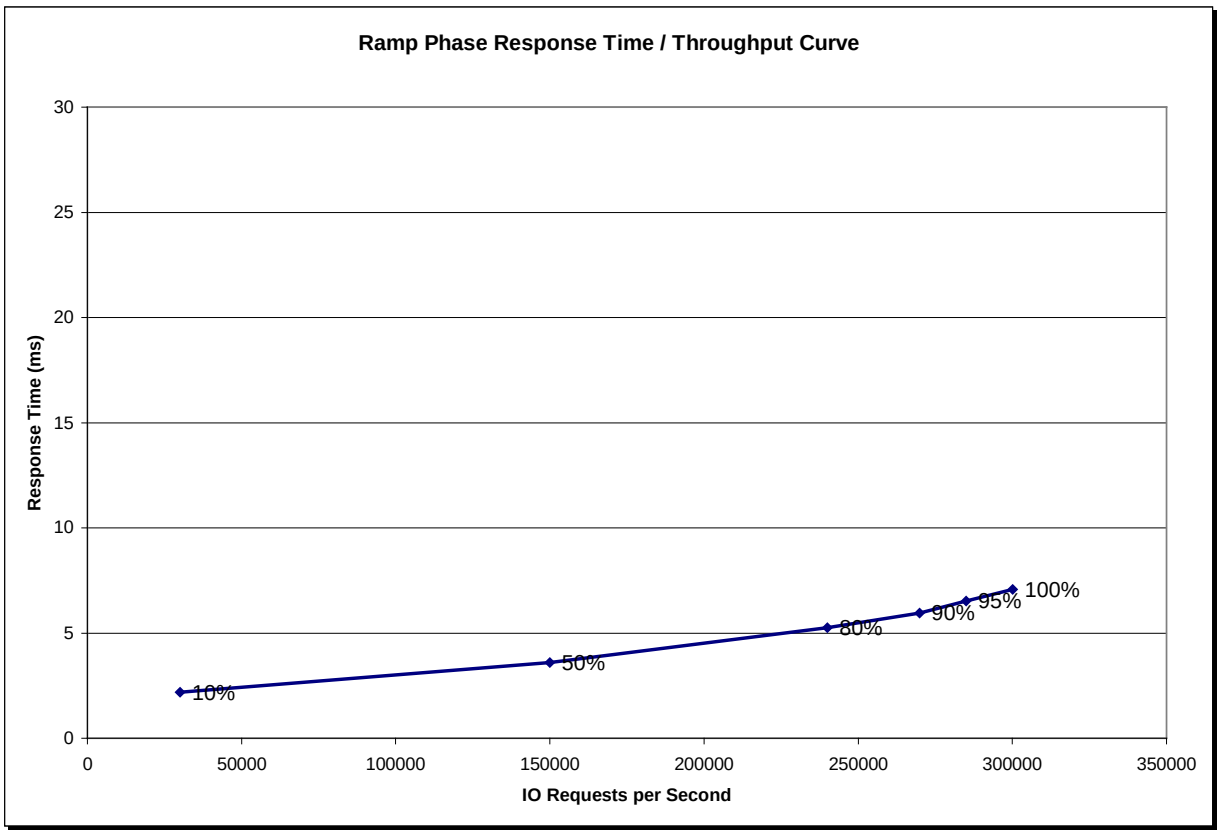
Unused Storage Ratio: Total Unused Capacity *(261,279.058 GB)* divided by Physical Storage Capacity *(583,612.316 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 21-22 in the Full Disclosure Report.

Response Time – Throughput Curve

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

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



Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	29,987.81	150,000.17	239,959.52	269,976.29	285,031.74	300,062.04
Average Response Time (ms):						
All ASUs	2.18	3.60	5.26	5.95	6.53	7.08
ASU-1	2.76	4.54	6.49	7.33	7.97	8.59
ASU-2	2.79	4.83	7.96	9.49	10.63	11.75
ASU-3	0.68	1.09	1.46	1.48	1.67	1.81
Reads	4.58	7.55	11.19	12.92	14.08	15.26
Writes	0.62	1.03	1.39	1.41	1.61	1.74

Priced Storage Configuration Pricing

Product Name	Quantity	Unit Price(CNY)	Total Price(CNY)
S8100 System Rack	1	58,005	58,005
S8100 Service Controller Group *16 GB of memory, 8 GB per controller *8 - 4 Gbps SFPs	4	121,911	487,644
S8100 Management Switch Module	2	8,550	17,100
S8100 Data Switch Module	2	87,113	174,226
Fibre Channel 4-Port Adapter(4Gbps)	16	20,700	331,200
Ethernet 4-Port Adapter(1Gbps)	8	4,500	36,000
S8100 Expansion Rack	8	48,840	390,720
S8100 Data Controller Group（32GB） *32 GB of memory, 16 GB per controller *20 - 4 Gbps SFPs	8	90,504	724,036
S8100 Disk Expansion *4 - 4 Gbps SFPs	56	21,129	1,183,249
300GB/15Krpm (4Gbps) FC disk drive	194	5,400	1,047,600
450GB/15Krpm (4Gbps) FC disk drive	330	7,950	2,623,500
600GB/15Krpm (4Gbps) FC disk drive	628	10,350	6,499,800
Storage Management Base License	1	33,000	33,000
Storage Management 1TB (>251TB)	583	600	349,800
UltraPath Base License	1	7,500	7,500
UltraPath For Windows/Linux License	2	750	1,500
S8000 First Installation Service , per Set per Time	1	541,875	541,875
UltraPath First Installation Service , per Set per Time	2	1,200	2,400
5-Meter Fiber Optic Cable	160	90	14,400
Blank panel	384	70	26,880
Dual-port Qlogic QLE2562 Fiber Channel HBA	8	17,659	141,272
Total *(3-Year Maintenance Included)*			**14,691,707**

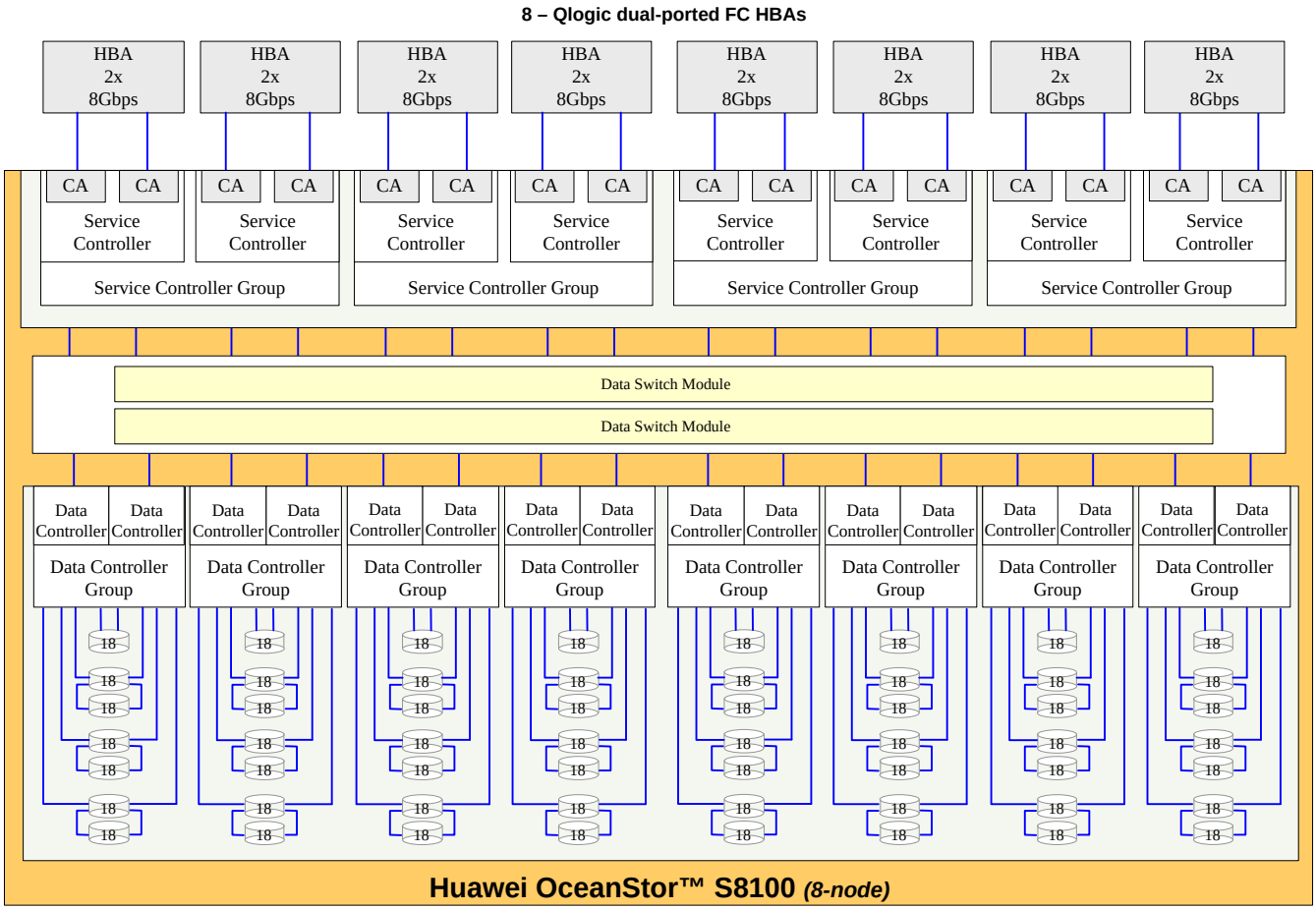
The above pricing includes hardware maintenance and software support for a minimum of three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

- Acknowledgement of new and existing problems with four (4) hours.
- Onsite present 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.

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 Diagram



16 FC connections *(HBAs – CAs)*

8 – Active-Active service controllers
Two controllers per service controller group
8 GB cache per service controller (*64 GB total)*
2 – **Management Switch Modules
8 – **Ethernet 4-Port Adapters *(1 Gbps*)
16 – ** Fibre Channel 4-port adapters *(4 Gbps)*
32 – 4 Gbps SFPs

2 – Data Switch Modules

16 – Active-Active data controllers
Two controllers per data controller group
16 GB cache/controller *(256 GB total)*
160 – 4 Gbps SFPs
18 – disk drives included in each data controller group

56 – S8100 Disk Expansions
18 – disk drives per S8100 Disk Expansion
224 – 4 Gbps SFPs *(4 SFPs/disk expansion)*

1,152 – 15K RPM FC disk drives
628 – 600 GB 15K RPM disk drives
330 – 450 GB 15K RPM disk drives
194 – 300 GB 15K RPM disk drives

********The 2 Management Switch Modules and 8 Ethernet 4-Port Adapters are used by the service controller controllers (nodes) to communicate and synchronize with each other. The 16 Fibre Channel 4-Port Adapters, labeled as "CA" in the above diagram, are used by the service controllers for connectivity with the data controllers and Host Systems.*

Priced Storage Configuration Components

Priced Storage Configuration:
Huawei UltraPath For Windows/Linux
8 – Qlogic dual-port QLE2562 FC HBAs
Huawei OceanStor™ S8100 *(8-node)*
8 - Active-Active service controllers in 4 service controller groups:
2 service controllers per service controller group
8 GB cache per service controller *(64 GB total)*
16 – Fibre Channel 4-port adapters (4 Gbps)
4 – 4 Gbps front-end connections per service controller (*32 total, 16 used)*
32 – 4 Gbps SFPs
16 - Active-Active data controllers in 8 data controller groups:
2 data controllers per data controller group
16 GB cache per data controller *(256 GB total)*
4 – 4 Gbps backend connections per data controller *(64 total, 64 used)*
160 – 4 Gbps SFPs
18 – 15K RPM FC disk drives included in each data controller group *(144 disk drives total)*
2 – Data Switch Modules
2 – Management Switch Modules
8 – Ethernet 4-Port Adapters *(1 Gbps)*
56– S8100 Disk Expansion each with four 4 Gbps SFPs *(224 SFPs total)* and 18 15K RPM FC disk drives *(1,008 disk drives total)*
1,152 –15K RPM FC disk drives 628 – 600 GB 15K RPM disk drives 330 – 450 GB 15K RPM disk drives 194 – 300 GB 15K RPM disk drives

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 18 *(*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 TSC did not utilize network storage.

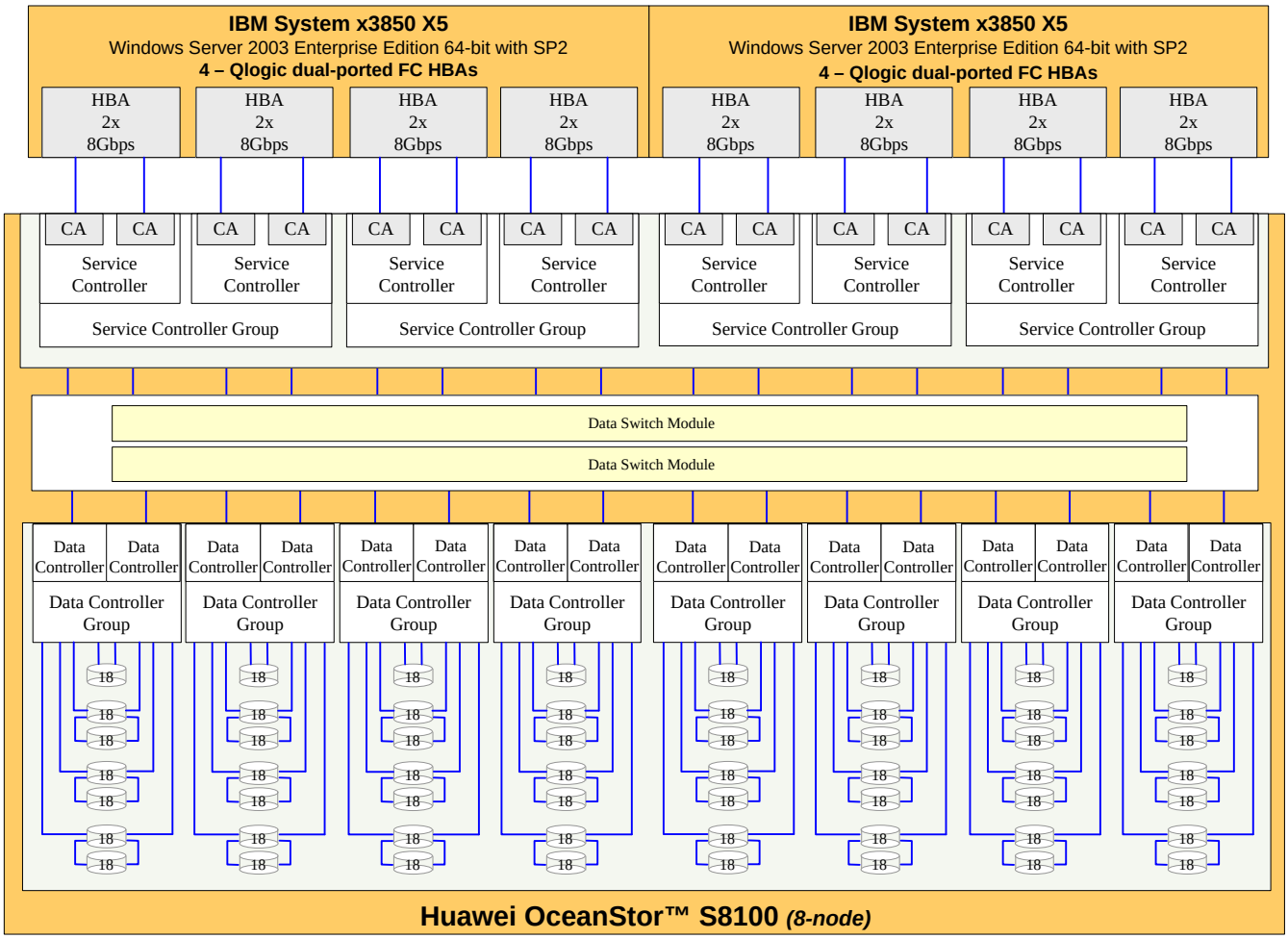
Host System and Tested Storage Configuration (TSC) Table of Components

Clause 9.4.3.4.3

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

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

Benchmark Configuration/Tested Storage Configuration Diagram



16 FC connections *(HBAs – CAs)*

8 – Active-Active service controllers
Two controllers per service controller group
8 GB cache per service controller (*64 GB total)*
2 – **Management Switch Modules
8 – **Ethernet 4-Port Adapters *(1 Gbps*)
16 – ** Fibre Channel 4-port adapters *(4 Gbps)*
32 – 4 Gbps SFPs

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18 – disk drives per S8100 Disk Expansion
224 – 4 Gbps SFPs *(4 SFPs/disk expansion)*

1,152 – 15K RPM FC disk drives
628 – 600 GB 15K RPM disk drives
330 – 450 GB 15K RPM disk drives
194 – 300 GB 15K RPM disk drives

********The 2 Management Switch Modules and 8 Ethernet 4-Port Adapters are used by the service controller controllers (nodes) to communicate and synchronize with each other. The 16 Fibre Channel 4-Port Adapters, labeled as "CA" in the above diagram, are used by the service controllers for connectivity with the data controllers and Host Systems.*

Host System(s) and Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):
2 – IBM System x3850 X5 Server each with:	Huawei UltraPath For Windows/Linux
4 – Intel Xeon E7530 1.86 GHz 6 Core Processors with 12 MB L2 cache per processor	8 – Qlogic dual-port QLE2562 FC HBAs
64 GB main memory	**Huawei OceanStor™ S8100 *(8-node)***
Windows Server 2003 Enterprise Edition 64-bit with SP2	**8 – Active-Active service controllers in 4 service controller groups** 2 service controllers per service controller group 8 GB cache per service controller *(64 GB total)* 16 – Fibre Channel 4-port adapters (4 Gbps) 4 – 4 Gbps front-end connections per service controller (*32 total, 16 used))* 32 – 4 Gbps SFPs **16 – Active-Active data controllers in 8 service controller groups** 2 data controllers per data controller group 16 GB cache per data controller *(256 GB total)* 4 – 4 Gbps backend connections per data controller *(64 total, 64 used)* 160 – 4 Gbps SFPs 18 – 15K RPM FC disk drives included in each data controller group *(144 disk drives total)*
PCIe	2 – Data Switch Modules
	2 – Management Switch Modules
	8 – Ethernet 4-Port Adapters *(1 Gbps)*
	56– S8100 Disk Expansion each with four 4 Gbps SFPs *(224 SFPs total)* and 18 15K RPM FC disk drives *(1,008 disk drives total)*
	1,152 –15K RPM FC disk drives 628 – 600 GB 15K RPM disk drives 330 – 450 GB 15K RPM disk drives 194 – 300 GB 15K RPM disk drives

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 71.

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

SPC-1 Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	160,920.000
Addressable Storage Capacity	Gigabytes (GB)	172,786.534
Configured Storage Capacity	Gigabytes (GB)	510,292.102
Physical Storage Capacity	Gigabytes (GB)	583,612.316
Data Protection *(Mirroring)*	Gigabytes (GB)	255,146.051
Required Storage *(metadata)*	Gigabytes (GB)	21.475
Global Storage Overhead	Gigabytes (GB)	471.783
Total Unused Storage	Gigabytes (GB)	261,279.058

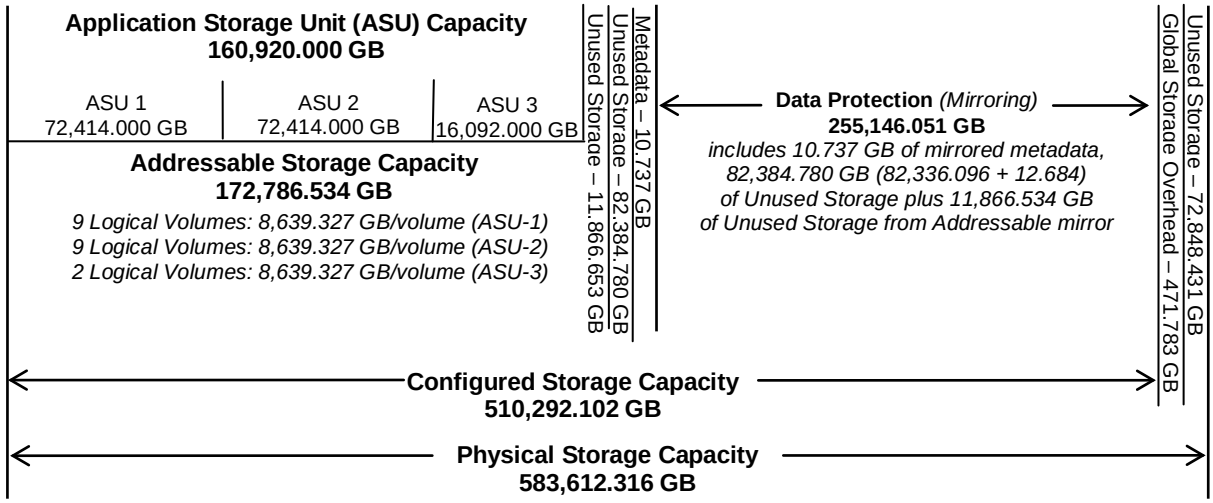
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	**Configured Storage Capacity**	**Physical Storage Capacity**
Total ASU Capacity	93.13%	31.53%	27.57%
Required for Data Protection *(Mirrored)*		50.00%	43.72%
Addressable Storage Capacity		33.86%	29.61%
Required Storage *(metadata)*		0.004%	0.004%
Configured Storage Capacity			87.44%
Global Storage Overhead			0.08%
Unused Storage:			
Addressable	6.87%		
Configured		32.28%	
Physical			12.48%

The Physical Storage Capacity consisted of 583,612.316 GB distributed over 628 disk drives each with a formatted capacity of 600.127GB, 330 disk drives each with a formatted capacity 450.098 GB and 194 disk drives each with a formatted capacity of 300.000 GB *(1,152 disk drives total)*. There was 72,848.431 GB (12.48%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 471.783 GB (0.08%) of Physical Storage Capacity. There was 164,697.559 GB (32.28%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 93.13% of the Addressable Storage Capacity resulting in 11,866.534 GB (6.87%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(mirroring)* capacity was 255,146.051 GB of which 243.279.517 GB was utilized. The total Unused Storage was 261,279.058 GB.

SPC-1 Storage Capacities and Relationships Illustration

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



Logical Volume Capacity and ASU Mapping

Clause 9.4.3.6.3

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

Logical Volume Capacity and Mapping		
ASU-1 (72,414.00 GB)	**ASU-2 (72,414.00 GB)**	**ASU-3 (16.092.000 GB)**
9 Logical Volumes 8,639.327 GB per Logical Volume (8,046.000 GB used per Logical Volume)	9 Logical Volumes 8,639.327 GB per Logical Volume (8,046.000 GB used per Logical Volume)	2 Logical Volumes 8,639.327 GB per Logical Volume (8,046.000 GB used per Logical Volume)

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

Storage Capacity Utilization

Clause 9.4.3.6.2

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

Clause 2,8.1

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

Clause 2,8.2

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

Clause 2,8.3

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

SPC-1 Storage Capacity Utilization	
Application Utilization	27.57%
Protected Application Utilization	69.26%
Unused Storage Ratio	44.77%

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 60 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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

SPC-1 Tests, Test Phases, and Test Runs

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

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

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

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

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

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

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.4.3.7.1

For the Sustainability Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 73.

Sustainability Test Results File

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

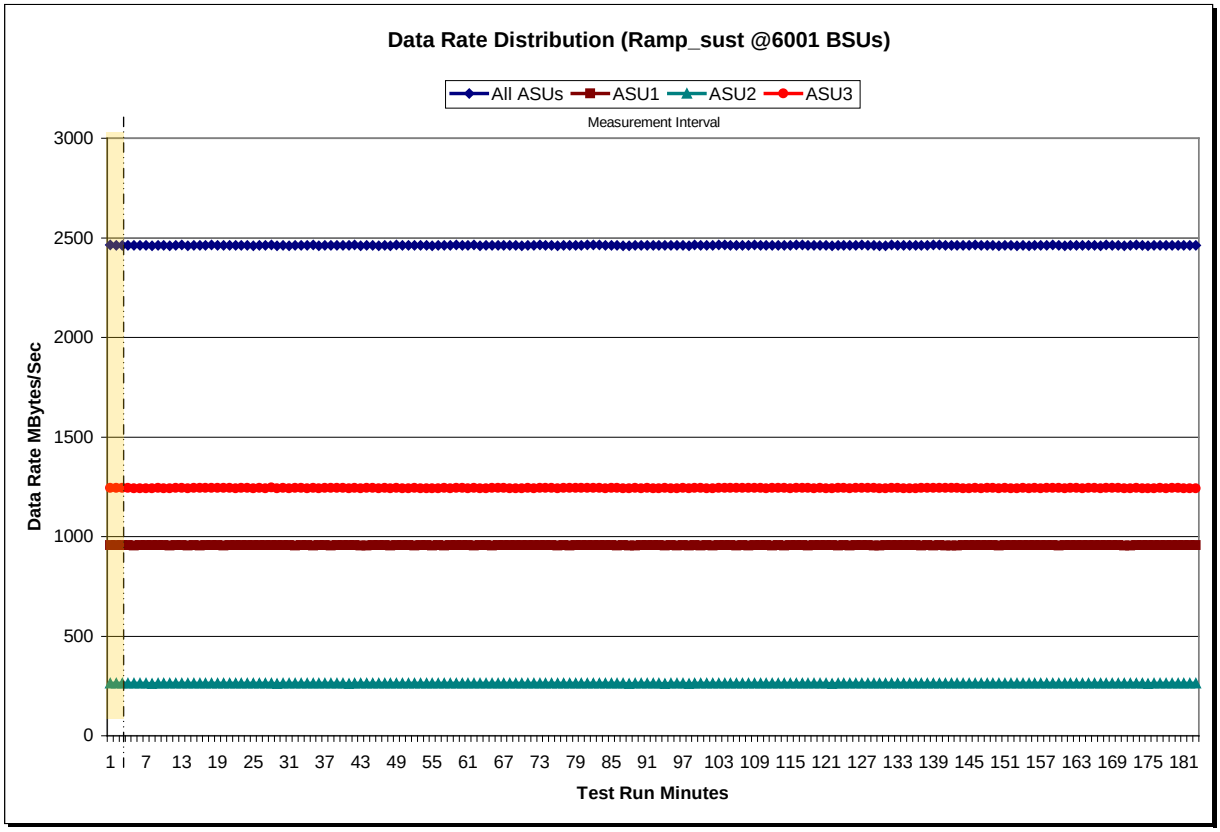
Sustainability Test Results File

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

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	22:37:05	22:40:05	0-2	0:03:00
Measurement Interval	22:40:05	1:40:05	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	2,464.95	957.67	263.65	1,243.63	63	2,462.53	957.05	263.17	1,242.31	126	2,464.08	956.41	263.42	1,244.25
1	2,463.08	956.08	262.75	1,244.24	64	2,462.38	955.40	262.56	1,244.42	127	2,463.20	956.79	263.19	1,243.23
2	2,463.26	956.65	263.27	1,243.34	65	2,463.22	957.04	262.95	1,243.23	128	2,462.88	955.70	263.39	1,243.79
3	2,463.16	956.59	263.02	1,243.55	66	2,461.84	955.97	262.73	1,243.15	129	2,460.49	955.32	262.81	1,242.35
4	2,461.47	955.28	263.23	1,242.96	67	2,462.93	956.92	263.13	1,242.89	130	2,460.71	956.09	262.54	1,242.08
5	2,462.14	956.33	263.56	1,242.25	68	2,462.27	956.35	263.32	1,242.60	131	2,463.68	956.25	263.21	1,244.22
6	2,461.58	955.92	263.16	1,242.50	69	2,460.62	955.99	263.06	1,241.57	132	2,462.66	955.81	263.50	1,243.35
7	2,460.20	955.79	262.29	1,242.11	70	2,462.49	956.24	262.79	1,243.46	133	2,462.16	956.03	263.24	1,242.89
8	2,462.70	956.37	262.58	1,243.74	71	2,461.56	956.47	262.68	1,242.41	134	2,461.15	955.76	262.81	1,242.58
9	2,461.55	956.67	263.39	1,241.49	72	2,463.45	955.91	263.12	1,244.42	135	2,461.65	956.22	263.02	1,242.41
10	2,460.46	955.60	262.73	1,242.14	73	2,462.77	956.50	263.02	1,243.25	136	2,462.52	955.67	262.96	1,243.89
11	2,461.94	956.23	262.70	1,243.01	74	2,462.38	956.09	262.61	1,243.69	137	2,462.72	956.23	263.44	1,243.05
12	2,464.07	956.81	263.36	1,243.91	75	2,459.68	955.48	262.75	1,241.45	138	2,463.54	955.67	263.08	1,244.79
13	2,460.92	955.62	262.49	1,242.81	76	2,462.04	955.88	262.78	1,243.38	139	2,463.88	955.80	263.32	1,244.76
14	2,462.06	955.88	262.72	1,243.45	77	2,462.20	955.52	262.91	1,243.76	140	2,462.02	954.84	263.34	1,243.84
15	2,462.59	955.49	263.20	1,243.90	78	2,462.82	956.07	263.68	1,243.06	141	2,462.24	955.66	263.50	1,243.09
16	2,463.09	956.90	262.90	1,243.29	79	2,462.70	955.90	263.19	1,243.60	142	2,461.66	955.56	262.83	1,243.27
17	2,463.69	956.27	263.33	1,244.09	80	2,463.31	956.37	263.23	1,243.71	143	2,462.43	957.18	262.59	1,242.66
18	2,461.75	956.02	262.60	1,243.13	81	2,463.76	957.23	262.59	1,243.94	144	2,462.38	956.29	263.27	1,242.82
19	2,462.14	955.57	263.21	1,243.36	82	2,463.56	955.82	263.28	1,244.45	145	2,463.60	956.15	263.01	1,244.44
20	2,463.15	956.50	263.06	1,243.58	83	2,462.49	956.76	262.77	1,242.97	146	2,461.61	956.05	262.60	1,242.96
21	2,462.58	956.54	263.46	1,242.57	84	2,463.14	955.79	263.19	1,244.15	147	2,462.65	955.80	262.69	1,244.16
22	2,462.56	956.16	263.22	1,243.18	85	2,461.48	955.70	262.63	1,243.14	148	2,462.31	956.30	262.77	1,243.25
23	2,462.59	956.01	262.56	1,244.02	86	2,460.31	956.34	262.70	1,241.27	149	2,460.64	955.32	262.75	1,242.58
24	2,460.66	956.02	262.74	1,241.90	87	2,460.14	955.55	262.30	1,242.28	150	2,462.67	955.83	262.93	1,243.91
25	2,462.20	956.26	262.73	1,243.21	88	2,462.20	955.10	263.50	1,243.60	151	2,461.86	956.45	263.13	1,242.27
26	2,461.44	955.83	263.58	1,242.02	89	2,462.92	957.10	263.64	1,242.18	152	2,460.58	955.80	262.89	1,241.89
27	2,465.00	956.00	263.34	1,245.66	90	2,462.82	956.89	262.85	1,243.08	153	2,462.18	956.13	262.88	1,243.17
28	2,459.94	955.90	262.41	1,241.63	91	2,462.41	956.47	263.05	1,242.90	154	2,460.17	955.83	263.18	1,241.16
29	2,463.26	956.32	263.66	1,243.28	92	2,461.33	956.15	263.11	1,242.07	155	2,462.61	955.90	262.80	1,243.91
30	2,460.39	955.94	262.97	1,241.47	93	2,461.64	955.63	262.32	1,243.70	156	2,461.43	956.08	262.90	1,242.46
31	2,462.29	955.62	262.84	1,243.83	94	2,461.85	956.41	262.87	1,242.58	157	2,462.69	956.00	262.83	1,243.86
32	2,462.74	956.46	262.93	1,243.35	95	2,461.15	955.64	262.78	1,242.73	158	2,464.49	956.34	263.18	1,244.97
33	2,462.02	956.35	263.16	1,242.51	96	2,462.68	956.35	262.95	1,243.38	159	2,461.94	955.71	262.91	1,243.32
34	2,463.46	955.42	262.96	1,245.08	97	2,460.55	955.50	262.34	1,242.71	160	2,460.95	955.96	263.05	1,241.93
35	2,460.57	955.79	263.02	1,241.75	98	2,464.43	956.95	263.09	1,244.39	161	2,462.94	956.24	263.56	1,243.14
36	2,463.25	956.76	262.86	1,243.62	99	2,462.37	955.50	262.64	1,244.23	162	2,462.69	955.85	263.32	1,243.52
37	2,461.68	955.32	262.69	1,243.66	100	2,461.89	955.95	263.06	1,242.89	163	2,461.55	956.11	262.87	1,242.57
38	2,463.09	956.07	263.36	1,243.67	101	2,461.47	955.57	263.00	1,242.90	164	2,462.51	956.23	263.25	1,243.03
39	2,462.46	956.04	263.19	1,243.23	102	2,463.51	956.89	263.10	1,243.52	165	2,461.65	955.93	262.70	1,243.02
40	2,462.21	956.94	262.31	1,242.96	103	2,463.38	955.83	263.60	1,243.96	166	2,460.91	955.77	262.72	1,242.42
41	2,463.47	956.28	263.21	1,243.98	104	2,462.27	955.84	263.32	1,243.11	167	2,463.90	956.72	263.01	1,244.18
42	2,461.08	955.42	262.82	1,242.84	105	2,462.17	955.58	263.39	1,243.20	168	2,462.68	956.27	262.86	1,243.54
43	2,461.58	955.16	262.89	1,243.53	106	2,462.97	956.04	262.90	1,244.02	169	2,462.15	956.47	262.66	1,243.02
44	2,463.22	956.63	262.46	1,244.13	107	2,461.52	955.33	262.75	1,243.43	170	2,460.86	955.70	263.12	1,242.04
45	2,460.41	955.77	262.78	1,241.86	108	2,463.53	956.67	263.12	1,243.74	171	2,461.53	955.57	263.05	1,242.91
46	2,462.40	955.90	263.34	1,243.16	109	2,462.66	956.57	262.53	1,243.56	172	2,463.35	956.09	262.97	1,244.29
47	2,460.31	955.43	262.68	1,242.19	110	2,461.70	955.91	263.04	1,242.76	173	2,462.15	956.18	262.99	1,242.98
48	2,463.65	956.65	263.08	1,243.92	111	2,461.55	954.90	262.79	1,243.85	174	2,460.90	955.83	262.40	1,242.66
49	2,462.30	956.57	262.97	1,242.76	112	2,461.99	956.24	262.43	1,243.32	175	2,462.14	956.51	262.86	1,242.77
50	2,462.98	956.53	263.75	1,242.70	113	2,461.27	955.14	262.67	1,243.46	176	2,462.40	956.07	262.83	1,243.50
51	2,462.76	955.62	263.19	1,243.94	114	2,461.55	956.23	263.10	1,242.22	177	2,462.08	956.57	262.99	1,242.52
52	2,461.99	956.20	262.97	1,242.82	115	2,463.33	956.09	263.28	1,243.96	178	2,462.49	956.07	263.41	1,243.00
53	2,462.34	955.90	263.46	1,242.98	116	2,464.07	956.84	263.80	1,243.42	179	2,462.51	956.16	262.79	1,243.55
54	2,460.96	955.68	263.12	1,242.16	117	2,461.52	955.56	262.76	1,243.20	180	2,461.75	956.63	263.07	1,242.04
55	2,461.60	955.99	263.38	1,242.23	118	2,462.23	956.33	263.14	1,242.75	181	2,462.36	956.81	262.69	1,242.86
56	2,461.37	955.11	262.91	1,243.35	119	2,463.18	956.08	263.18	1,243.92	182	2,462.12	956.41	262.87	1,242.84
57	2,462.16	956.48	263.14	1,242.54	120	2,461.98	955.95	263.24	1,242.79					
58	2,463.69	956.85	262.70	1,244.14	121	2,460.51	955.80	262.37	1,242.34					
59	2,462.66	956.45	263.07	1,243.13	122	2,461.20	955.53	262.43	1,243.23					
60	2,462.12	956.47	262.79	1,242.87	123	2,462.82	956.42	263.28	1,243.12					
61	2,463.87	955.56	263.28	1,245.03	124	2,461.65	955.56	263.42	1,242.67					
62	2,461.08	956.40	263.01	1,241.67	125	2,462.92	956.56	263.04	1,243.32					

Sustainability – Data Rate Distribution Graph

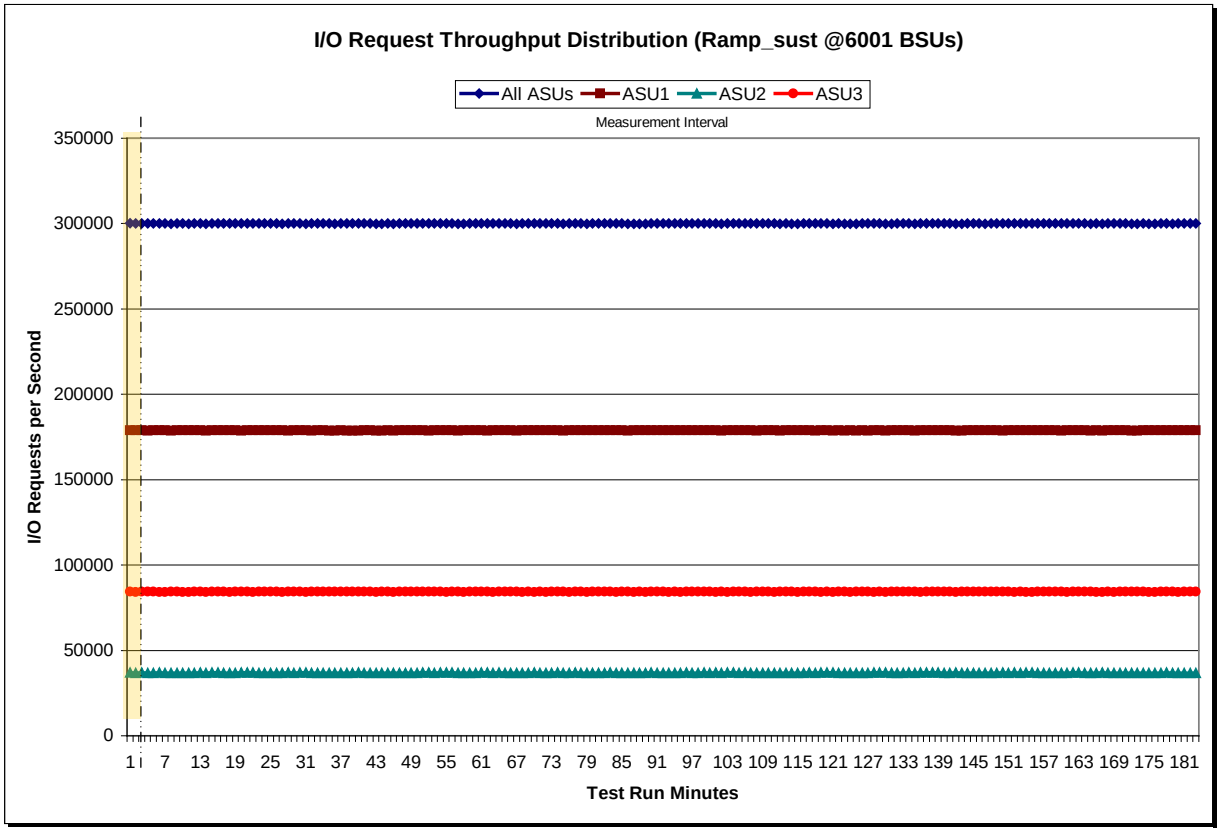


Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	22:37:05	22:40:05	0-2	0:03:00
Measurement Interval	22:40:05	1:40:05	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	300,335.48	178,987.28	36,965.62	84,382.58	63	300,145.80	178,875.75	36,927.82	84,342.23	126	300,046.13	178,769.50	36,908.53	84,368.10
1	299,986.47	178,837.27	36,888.53	84,260.67	64	300,093.98	178,803.38	36,877.00	84,413.60	127	300,070.27	178,851.17	36,960.57	84,258.53
2	300,095.55	178,864.77	36,922.50	84,308.28	65	300,120.52	178,908.13	36,882.78	84,329.60	128	300,053.07	178,797.92	36,945.82	84,309.33
3	299,997.63	178,756.77	36,891.50	84,349.37	66	299,947.38	178,764.58	36,890.53	84,292.27	129	299,976.85	178,776.15	36,925.28	84,275.42
4	300,008.47	178,849.17	36,868.93	84,290.37	67	300,066.28	178,880.20	36,909.10	84,276.98	130	299,968.45	178,783.85	36,880.45	84,304.15
5	299,983.68	178,817.67	36,939.67	84,226.35	68	300,130.40	178,899.80	36,898.38	84,332.22	131	300,225.57	178,976.97	36,902.70	84,345.90
6	300,078.60	178,887.57	36,909.17	84,281.87	69	300,017.43	178,807.75	36,929.73	84,279.95	132	299,990.97	178,799.55	36,898.48	84,292.93
7	299,912.28	178,758.50	36,856.02	84,297.77	70	300,088.57	178,821.37	36,888.08	84,379.12	133	300,075.50	178,839.78	36,943.98	84,291.73
8	300,031.57	178,836.10	36,898.27	84,297.20	71	300,008.38	178,866.77	36,867.12	84,274.50	134	299,960.07	178,766.55	36,893.87	84,299.65
9	300,049.20	178,870.93	36,909.62	84,268.65	72	300,021.10	178,791.98	36,906.48	84,322.63	135	299,997.72	178,813.23	36,947.30	84,237.18
10	299,973.35	178,818.93	36,901.25	84,253.17	73	300,065.03	178,817.75	36,926.33	84,320.95	136	300,198.33	178,894.17	36,971.33	84,332.83
11	300,020.37	178,823.37	36,908.55	84,288.45	74	299,956.05	178,769.37	36,864.72	84,321.97	137	300,160.37	178,848.08	36,968.28	84,344.00
12	300,162.08	178,894.13	36,926.38	84,341.57	75	300,039.82	178,883.95	36,892.13	84,263.73	138	300,067.88	178,782.28	36,921.53	84,364.07
13	299,903.28	178,762.80	36,881.90	84,258.58	76	300,093.60	178,817.93	36,918.08	84,357.58	139	300,117.93	178,875.97	36,901.77	84,340.20
14	300,062.40	178,798.83	36,940.37	84,323.20	77	300,017.18	178,784.42	36,905.98	84,326.78	140	299,996.72	178,781.22	36,895.80	84,319.70
15	300,045.35	178,821.53	36,917.13	84,306.68	78	299,975.80	178,792.83	36,914.87	84,268.10	141	299,909.65	178,705.62	36,926.52	84,277.52
16	300,102.07	178,884.80	36,892.05	84,325.22	79	300,076.68	178,837.00	36,913.13	84,326.55	142	299,897.50	178,702.05	36,859.62	84,335.83
17	300,086.83	178,904.32	36,908.88	84,273.63	80	300,074.95	178,827.25	36,914.25	84,333.45	143	300,097.60	178,887.33	36,900.35	84,309.92
18	300,016.80	178,799.30	36,902.50	84,315.00	81	300,068.30	178,925.43	36,836.77	84,306.10	144	300,077.82	178,830.82	36,905.53	84,341.47
19	300,010.35	178,751.07	36,927.80	84,331.48	82	300,150.50	178,900.17	36,926.48	84,323.85	145	300,130.72	178,850.20	36,903.07	84,377.45
20	300,139.53	178,850.35	36,949.93	84,339.25	83	300,038.47	178,889.27	36,877.48	84,271.72	146	299,950.10	178,790.33	36,869.97	84,289.80
21	300,035.23	178,837.03	36,920.63	84,277.57	84	300,134.53	178,872.68	36,892.02	84,369.83	147	300,046.02	178,840.35	36,880.45	84,325.22
22	300,163.62	178,920.48	36,908.60	84,334.53	85	299,963.35	178,760.53	36,905.98	84,296.83	148	300,008.47	178,811.73	36,852.42	84,344.32
23	300,025.62	178,783.43	36,888.98	84,353.20	86	299,973.07	178,816.88	36,888.10	84,268.08	149	299,999.92	178,766.98	36,916.98	84,315.95
24	300,000.45	178,791.17	36,913.18	84,296.10	87	299,931.40	178,791.82	36,850.12	84,289.47	150	299,986.95	178,790.18	36,891.63	84,305.13
25	300,040.57	178,833.93	36,894.27	84,312.37	88	299,981.22	178,790.47	36,913.37	84,277.38	151	300,053.05	178,869.58	36,921.87	84,261.60
26	299,962.57	178,799.78	36,895.40	84,267.38	89	300,121.92	178,898.83	36,920.55	84,302.53	152	299,983.97	178,790.07	36,886.48	84,307.42
27	300,060.13	178,754.50	36,915.33	84,390.30	90	300,126.78	178,910.43	36,890.55	84,325.80	153	300,010.85	178,825.55	36,918.53	84,266.77
28	300,051.28	178,873.68	36,880.53	84,297.07	91	300,057.03	178,859.20	36,899.98	84,297.85	154	300,073.48	178,892.32	36,937.05	84,244.12
29	300,172.07	178,879.22	36,978.18	84,314.67	92	300,000.07	178,825.05	36,903.57	84,271.45	155	300,057.58	178,878.92	36,874.62	84,304.05
30	299,944.02	178,810.48	36,929.02	84,204.52	93	300,018.77	178,805.43	36,843.82	84,369.52	156	300,119.33	178,897.67	36,858.33	84,363.33
31	299,990.93	178,778.82	36,876.95	84,335.17	94	300,013.35	178,848.77	36,882.23	84,282.35	157	300,013.57	178,799.20	36,870.88	84,343.48
32	300,142.13	178,916.37	36,909.63	84,316.13	95	300,042.28	178,793.85	36,915.72	84,332.72	158	300,118.62	178,857.95	36,898.92	84,361.75
33	300,079.35	178,864.85	36,911.85	84,302.65	96	300,073.63	178,871.25	36,888.45	84,313.93	159	300,000.80	178,769.47	36,896.48	84,334.85
34	300,018.37	178,759.08	36,892.88	84,366.40	97	300,030.97	178,834.37	36,868.83	84,327.77	160	300,108.37	178,920.58	36,913.30	84,274.48
35	299,910.55	178,722.12	36,890.72	84,297.72	98	300,195.07	178,929.50	36,939.72	84,325.85	161	300,073.98	178,823.73	36,939.25	84,311.00
36	300,117.78	178,911.80	36,848.03	84,357.95	99	300,056.68	178,802.65	36,908.80	84,345.23	162	300,042.18	178,791.03	36,916.52	84,334.63
37	299,997.48	178,766.13	36,910.08	84,321.27	100	300,052.28	178,846.70	36,920.43	84,285.15	163	300,170.37	178,928.57	36,899.90	84,341.90
38	300,021.18	178,768.15	36,909.55	84,343.48	101	299,959.30	178,762.72	36,896.98	84,299.60	164	299,981.15	178,776.12	36,903.42	84,301.62
39	300,001.22	178,766.52	36,918.95	84,315.75	102	300,087.97	178,895.95	36,919.80	84,272.22	165	299,988.13	178,806.17	36,908.67	84,273.30
40	300,093.43	178,845.42	36,889.17	84,358.85	103	300,096.40	178,807.00	36,920.72	84,368.68	166	299,932.70	178,755.70	36,919.42	84,257.58
41	300,100.02	178,835.48	36,909.08	84,355.45	104	300,047.25	178,809.62	36,902.18	84,335.45	167	300,085.48	178,906.22	36,888.37	84,290.90
42	299,902.10	178,743.68	36,880.72	84,277.70	105	300,110.17	178,881.48	36,924.27	84,304.42	168	300,026.65	178,845.63	36,906.65	84,274.37
43	299,916.43	178,744.60	36,874.03	84,297.80	106	300,042.95	178,854.45	36,913.45	84,275.05	169	300,082.02	178,808.65	36,894.67	84,378.70
44	300,098.17	178,858.37	36,907.48	84,332.32	107	299,987.65	178,771.10	36,892.90	84,323.65	170	299,997.72	178,808.03	36,895.22	84,294.47
45	299,914.80	178,738.40	36,911.57	84,264.83	108	300,079.78	178,830.88	36,902.18	84,346.72	171	299,966.70	178,732.47	36,914.13	84,320.10
46	300,054.97	178,787.22	36,908.70	84,359.05	109	300,028.20	178,819.78	36,862.95	84,345.47	172	299,930.57	178,694.58	36,889.32	84,346.67
47	300,057.93	178,828.37	36,883.17	84,346.40	110	300,033.60	178,841.23	36,911.68	84,280.68	173	300,090.43	178,871.33	36,909.27	84,309.83
48	300,074.93	178,842.45	36,884.82	84,347.67	111	299,921.85	178,750.07	36,874.97	84,296.82	174	299,977.78	178,853.77	36,855.35	84,268.67
49	300,077.37	178,872.35	36,912.97	84,292.05	112	300,160.03	178,922.87	36,883.42	84,353.75	175	299,979.87	178,802.73	36,904.25	84,272.88
50	300,073.05	178,850.27	36,928.72	84,294.07	113	299,957.20	178,804.78	36,862.95	84,289.47	176	300,066.05	178,849.75	36,867.87	84,348.43
51	300,016.38	178,767.78	36,918.75	84,329.85	114	299,933.05	178,792.65	36,878.72	84,261.68	177	300,085.82	178,836.22	36,919.13	84,330.47
52	300,068.48	178,842.45	36,910.32	84,315.72	115	300,108.60	178,832.35	36,909.77	84,366.48	178	299,952.07	178,781.60	36,874.13	84,296.33
53	300,016.38	178,786.03	36,928.07	84,302.28	116	300,165.45	178,872.95	36,977.07	84,315.43	179	300,020.52	178,850.02	36,900.65	84,269.85
54	299,998.62	178,790.43	36,926.88	84,281.30	117	300,038.30	178,778.77	36,908.07	84,351.47	180	300,090.38	178,908.18	36,878.58	84,303.62
55	300,028.77	178,792.88	36,928.75	84,307.13	118	299,997.58	178,802.33	36,926.50	84,268.75	181	300,190.72	178,908.22	36,899.35	84,383.15
56	299,899.37	178,694.17	36,898.90	84,306.30	119	300,124.50	178,812.45	36,951.85	84,360.20	182	299,998.42	178,800.42	36,891.83	84,306.17
57	299,968.00	178,830.07	36,885.05	84,252.88	120	299,935.43	178,774.90	36,915.32	84,245.22	***Average***	***300,039.06***	***178,823.97***	***36,902.98***	***84,312.12***
58	300,219.17	178,959.23	36,888.82	84,371.12	121	300,002.92	178,843.73	36,863.57	84,295.62					
59	300,017.05	178,807.23	36,896.12	84,313.70	122	299,923.48	178,721.03	36,841.72	84,360.73					
60	300,081.20	178,816.68	36,931.37	84,333.15	123	299,979.85	178,814.72	36,908.98	84,256.15					
61	300,033.13	178,718.73	36,950.67	84,363.73	124	299,957.50	178,726.28	36,906.55	84,324.67					
62	300,036.52	178,871.53	36,886.62	84,278.37	125	300,038.43	178,846.42	36,891.72	84,300.30					

Sustainability – I/O Request Throughput Distribution Graph

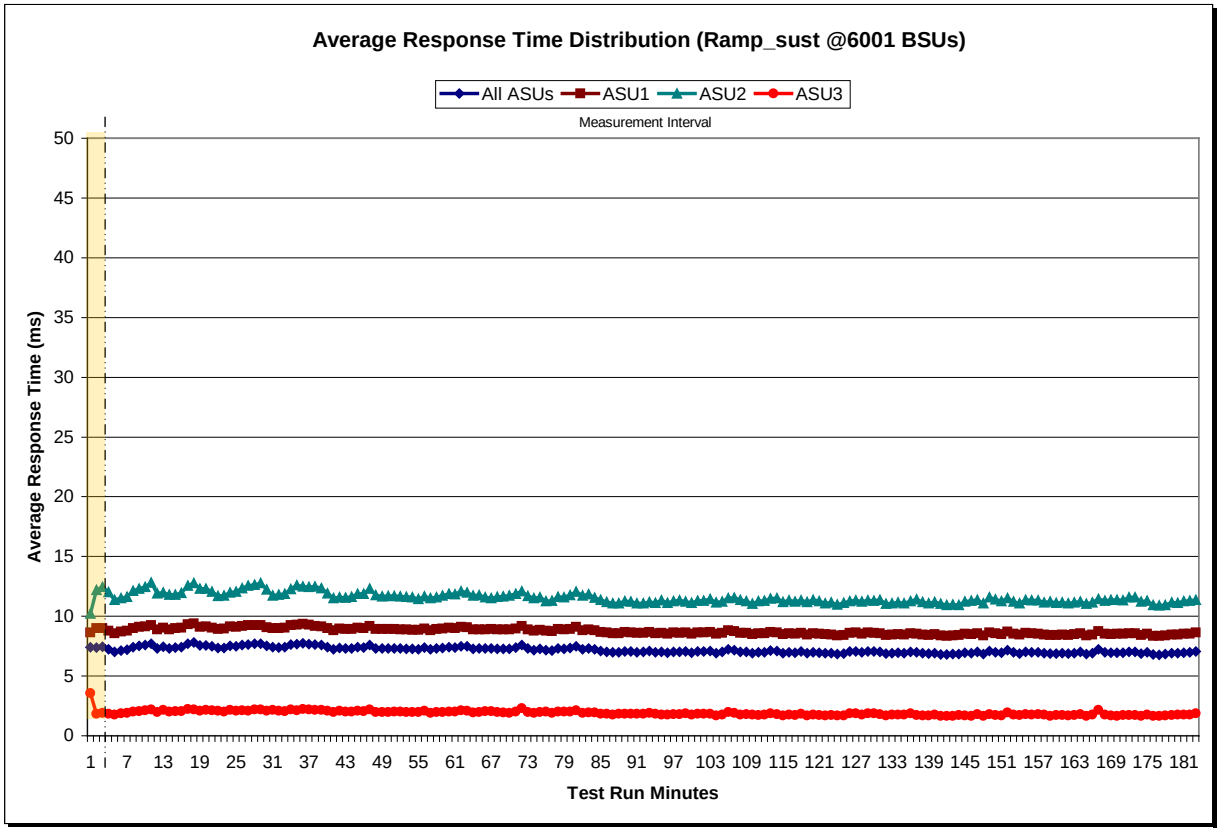


Sustainability – Average Response Time (ms) Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	22:37:05	22:40:05	0-2	0:03:00
Measurement Interval	22:40:05	1:40:05	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	7.41	8.63	10.23	3.58	63	7.29	8.89	11.74	1.94	126	7.06	8.63	11.33	1.86
1	7.38	8.99	12.20	1.84	64	7.30	8.90	11.77	1.97	127	6.97	8.54	11.24	1.78
2	7.44	9.01	12.47	1.90	65	7.31	8.91	11.58	2.05	128	7.06	8.62	11.36	1.87
3	7.22	8.78	12.01	1.84	66	7.31	8.91	11.53	2.06	129	7.05	8.61	11.31	1.87
4	7.01	8.58	11.37	1.77	67	7.28	8.89	11.62	1.97	130	7.01	8.58	11.37	1.78
5	7.13	8.70	11.50	1.86	68	7.27	8.88	11.66	1.93	131	6.86	8.43	11.05	1.71
6	7.20	8.79	11.63	1.90	69	7.28	8.88	11.72	1.92	132	6.90	8.47	11.08	1.77
7	7.42	9.00	12.12	2.01	70	7.37	8.97	11.89	2.03	133	6.93	8.50	11.16	1.75
8	7.53	9.13	12.32	2.04	71	7.61	9.19	12.08	2.30	134	6.91	8.48	11.08	1.77
9	7.59	9.16	12.46	2.14	72	7.30	8.90	11.69	1.99	135	7.02	8.58	11.25	1.86
10	7.71	9.25	12.81	2.19	73	7.18	8.77	11.53	1.90	136	6.99	8.54	11.40	1.74
11	7.32	8.90	11.91	1.98	74	7.26	8.85	11.60	1.99	137	6.89	8.45	11.19	1.71
12	7.47	9.04	11.99	2.15	75	7.18	8.77	11.28	2.00	138	6.86	8.42	11.10	1.70
13	7.32	8.90	11.80	2.01	76	7.14	8.75	11.29	1.92	139	6.92	8.48	11.20	1.75
14	7.38	8.99	11.80	2.05	77	7.31	8.92	11.61	2.03	140	6.82	8.38	11.05	1.66
15	7.42	9.02	11.96	2.04	78	7.28	8.88	11.59	2.00	141	6.80	8.36	10.96	1.67
16	7.71	9.31	12.56	2.21	79	7.33	8.92	11.75	2.01	142	6.82	8.40	10.98	1.67
17	7.80	9.40	12.79	2.20	80	7.50	9.09	12.06	2.13	143	6.84	8.41	10.94	1.72
18	7.54	9.12	12.32	2.10	81	7.24	8.82	11.73	1.90	144	6.94	8.52	11.24	1.70
19	7.56	9.13	12.31	2.15	82	7.29	8.88	11.84	1.93	145	6.91	8.48	11.31	1.67
20	7.47	9.04	12.05	2.13	83	7.22	8.81	11.55	1.95	146	7.01	8.56	11.37	1.81
21	7.34	8.92	11.68	2.09	84	7.08	8.66	11.38	1.85	147	6.83	8.40	11.08	1.66
22	7.36	8.96	11.73	2.03	85	7.03	8.62	11.21	1.84	148	7.08	8.63	11.57	1.81
23	7.52	9.13	11.99	2.15	86	6.97	8.57	11.08	1.76	149	6.99	8.56	11.41	1.72
24	7.50	9.10	12.05	2.10	87	6.98	8.57	11.08	1.82	150	6.93	8.50	11.28	1.71
25	7.60	9.20	12.36	2.13	88	7.06	8.66	11.25	1.84	151	7.17	8.73	11.54	1.95
26	7.64	9.24	12.56	2.08	89	7.05	8.64	11.25	1.82	152	6.97	8.53	11.23	1.78
27	7.69	9.26	12.65	2.19	90	7.00	8.59	11.08	1.83	153	6.89	8.47	11.07	1.72
28	7.71	9.27	12.77	2.18	91	7.01	8.61	11.08	1.85	154	7.03	8.59	11.39	1.79
29	7.51	9.07	12.26	2.10	92	7.08	8.68	11.18	1.90	155	6.99	8.55	11.34	1.76
30	7.42	9.00	11.73	2.16	93	6.98	8.56	11.11	1.83	156	6.99	8.54	11.33	1.80
31	7.40	8.99	11.79	2.09	94	7.02	8.60	11.35	1.77	157	6.90	8.45	11.16	1.75
32	7.43	9.05	11.88	2.04	95	6.95	8.53	11.11	1.76	158	6.87	8.43	11.22	1.65
33	7.65	9.26	12.28	2.19	96	7.04	8.63	11.28	1.80	159	6.88	8.44	11.14	1.72
34	7.68	9.30	12.59	2.13	97	7.03	8.61	11.35	1.79	160	6.90	8.45	11.17	1.73
35	7.73	9.35	12.51	2.22	98	7.06	8.63	11.25	1.88	161	6.86	8.42	11.09	1.69
36	7.68	9.28	12.47	2.20	99	6.94	8.52	11.11	1.76	162	6.91	8.48	11.15	1.72
37	7.62	9.19	12.50	2.16	100	7.06	8.65	11.30	1.83	163	7.00	8.57	11.25	1.81
38	7.58	9.15	12.33	2.16	101	7.07	8.66	11.31	1.84	164	6.83	8.40	11.07	1.67
39	7.42	9.01	11.93	2.09	102	7.10	8.69	11.45	1.83	165	6.92	8.47	11.15	1.77
40	7.24	8.83	11.52	1.99	103	6.92	8.52	11.16	1.70	166	7.22	8.74	11.46	2.15
41	7.35	8.96	11.60	2.08	104	7.00	8.59	11.24	1.78	167	6.97	8.54	11.29	1.77
42	7.30	8.91	11.57	2.00	105	7.22	8.80	11.53	1.99	168	6.94	8.49	11.38	1.69
43	7.31	8.92	11.64	2.00	106	7.17	8.75	11.55	1.91	169	6.95	8.53	11.39	1.65
44	7.43	9.03	11.88	2.08	107	7.02	8.61	11.39	1.75	170	6.96	8.53	11.36	1.72
45	7.39	8.98	11.87	2.04	108	7.02	8.60	11.26	1.80	171	7.02	8.57	11.60	1.74
46	7.60	9.18	12.32	2.18	109	6.92	8.51	11.07	1.75	172	7.02	8.58	11.58	1.74
47	7.32	8.93	11.79	1.98	110	6.97	8.56	11.26	1.72	173	6.87	8.43	11.23	1.65
48	7.30	8.91	11.66	1.99	111	6.99	8.57	11.29	1.75	174	6.98	8.54	11.32	1.75
49	7.31	8.91	11.71	1.99	112	7.12	8.69	11.50	1.87	175	6.80	8.37	10.93	1.67
50	7.32	8.92	11.70	2.01	113	7.08	8.66	11.53	1.80	176	6.77	8.34	10.91	1.64
51	7.31	8.90	11.68	2.02	114	6.91	8.49	11.20	1.69	177	6.83	8.39	10.95	1.70
52	7.28	8.87	11.63	1.98	115	7.00	8.57	11.33	1.76	178	6.91	8.48	11.18	1.73
53	7.27	8.86	11.58	1.99	116	6.94	8.52	11.24	1.72	179	6.91	8.48	11.13	1.75
54	7.25	8.86	11.43	1.99	117	7.04	8.61	11.34	1.84	180	6.96	8.52	11.26	1.77
55	7.37	8.97	11.65	2.09	118	6.89	8.46	11.18	1.68	181	6.97	8.54	11.32	1.76
56	7.22	8.83	11.52	1.91	119	7.00	8.57	11.36	1.77	182	7.07	8.63	11.39	1.87
57	7.30	8.91	11.60	1.98	120	6.95	8.53	11.27	1.72	***Average***	***7.16***	***8.74***	***11.54***	***1.89***
58	7.35	8.97	11.75	2.00	121	6.89	8.48	11.10	1.70					
59	7.42	9.04	11.88	2.02	122	6.90	8.47	11.15	1.72					
60	7.38	8.99	11.83	2.03	123	6.82	8.39	10.99	1.68					
61	7.50	9.10	12.09	2.11	124	6.86	8.43	11.13	1.68					
62	7.47	9.06	12.00	2.11	125	7.05	8.62	11.28	1.87					

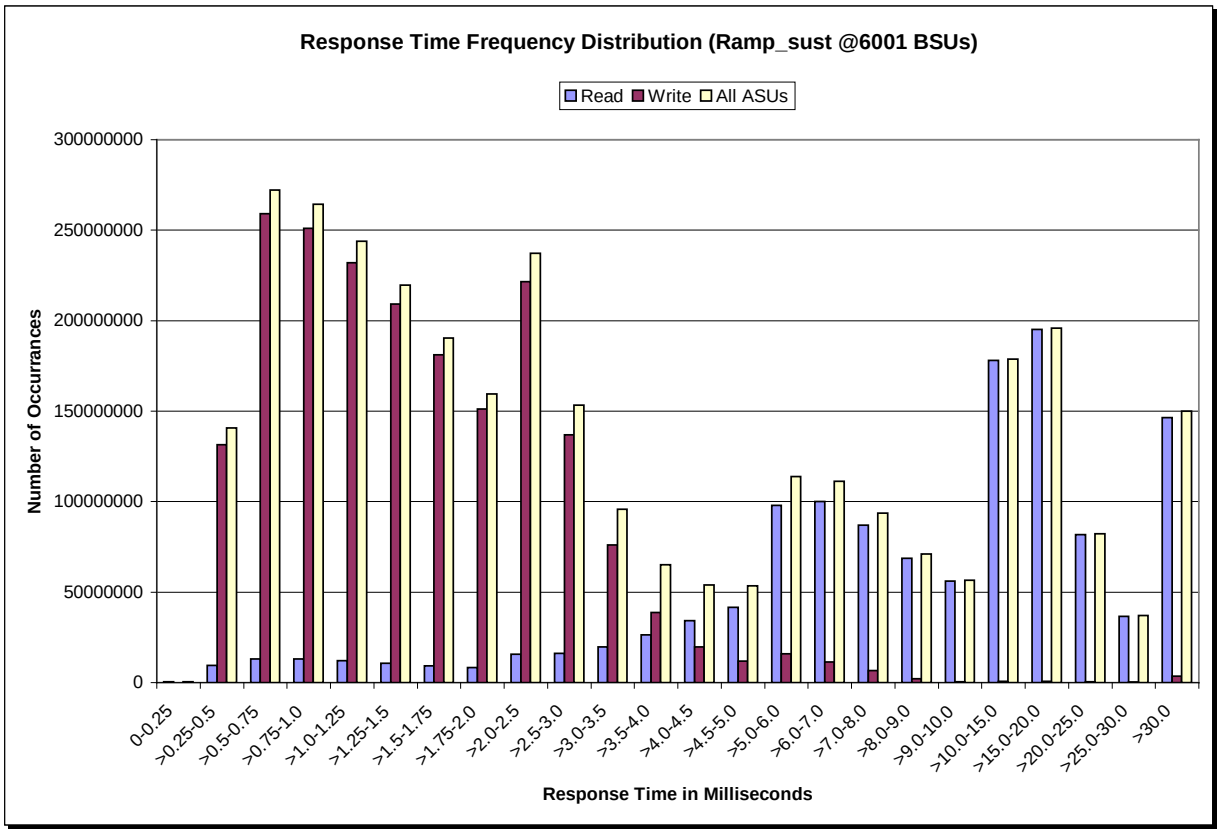
Sustainability – Average Response Time (ms) Distribution Graph



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	392,686	9,398,290	13,008,344	13,186,716	12,046,798	10,593,310	9,300,754	8,398,799
Write	88,889	131,369,293	259,133,074	251,106,044	231,935,182	209,150,671	181,080,783	151,129,410
All ASUs	481,575	140,767,583	272,141,418	264,292,760	243,981,980	219,743,981	190,381,537	159,528,209
ASU1	436,422	75,638,832	129,063,272	121,590,843	111,398,049	99,228,666	85,170,096	71,150,033
ASU2	27,281	16,002,628	28,272,470	26,853,280	24,744,852	22,153,722	19,043,240	15,818,585
ASU3	17,872	49,126,123	114,805,676	115,848,637	107,839,079	98,361,593	86,168,201	72,559,591
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	15,676,674	16,263,454	19,750,240	26,359,266	34,192,480	41,599,923	97,915,641	99,996,645
Write	221,477,742	136,978,490	76,102,391	38,714,305	19,835,482	11,808,043	15,959,839	11,367,551
All ASUs	237,154,416	153,241,944	95,852,631	65,073,571	54,027,962	53,407,966	113,875,480	111,364,196
ASU1	106,942,937	72,184,798	49,929,478	40,240,288	39,190,646	42,177,234	93,410,713	91,770,603
ASU2	23,253,501	14,722,243	8,807,630	5,747,250	5,003,048	5,426,693	12,772,027	14,178,309
ASU3	106,957,978	66,334,903	37,115,523	19,086,033	9,834,268	5,804,039	7,692,740	5,415,284
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	86,947,004	68,813,018	56,073,500	178,068,108	195,164,899	81,832,905	36,716,733	146,320,643
Write	6,743,069	2,228,904	501,716	595,302	644,461	507,256	266,430	3,678,591
All ASUs	93,690,073	71,041,922	56,575,216	178,663,410	195,809,360	82,340,161	36,983,163	149,999,234
ASU1	76,991,401	59,244,930	47,771,613	149,768,054	161,834,222	66,944,276	29,592,737	109,627,158
ASU2	13,453,086	10,695,157	8,546,950	28,582,063	33,638,651	15,134,176	7,254,095	38,420,812
ASU3	3,245,586	1,101,835	256,653	313,293	336,487	261,709	136,331	1,951,264

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

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

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

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

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

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

Clause 9.4.3.7.2

For the IOPS Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 73.

IOPS Test Results File

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

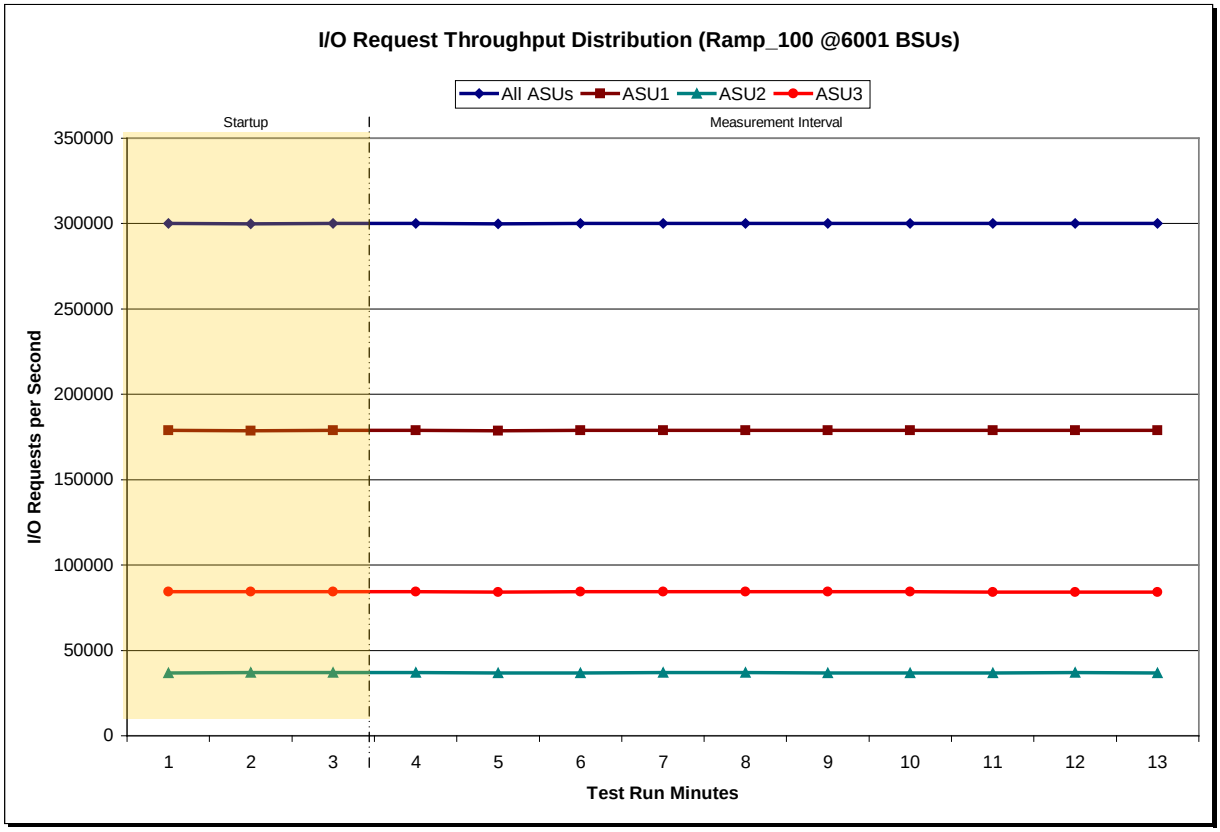
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

6001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:46:39	1:49:40	0-2	0:03:01
Measurement Interval	1:49:40	1:59:40	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	300,079.07	178,834.97	36,894.07	84,350.03
1	299,975.15	178,742.60	36,926.95	84,305.60
2	300,171.95	178,939.58	36,926.83	84,305.53
3	300,175.03	178,942.47	36,916.32	84,316.25
4	299,929.22	178,766.93	36,894.25	84,268.03
5	300,012.17	178,826.87	36,878.35	84,306.95
6	300,201.03	178,903.58	36,962.03	84,335.42
7	299,999.35	178,786.22	36,916.53	84,296.60
8	300,115.87	178,827.52	36,909.23	84,379.12
9	300,113.07	178,841.58	36,905.95	84,365.53
10	299,989.60	178,833.15	36,875.13	84,281.32
11	300,037.27	178,834.92	36,926.97	84,275.38
12	300,047.78	178,890.67	36,899.42	84,257.70
Average	***300,062.04***	***178,845.39***	***36,908.42***	***84,308.23***

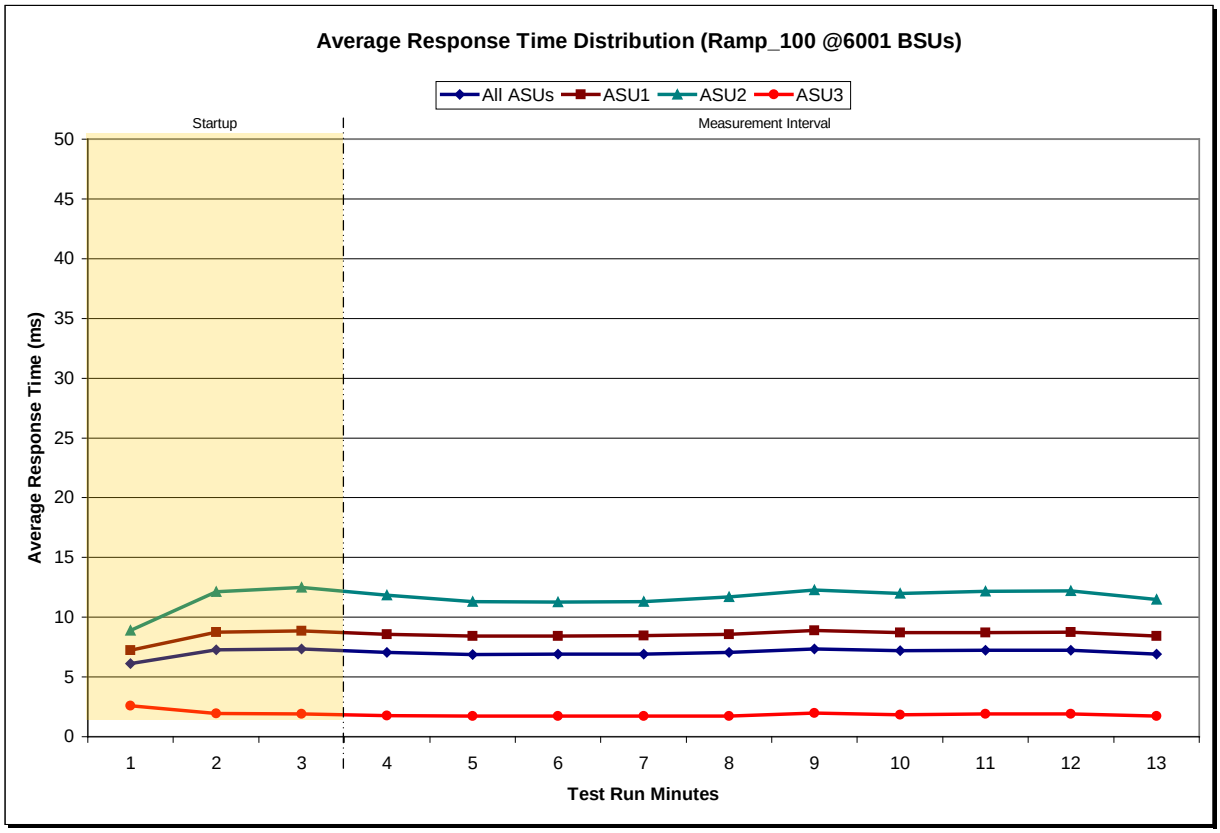
IOPS Test Run – I/O Request Throughput Distribution Graph



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

6001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:46:39	1:49:40	0-2	0:03:01
Measurement Interval	1:49:40	1:59:40	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	6.13	7.24	8.89	2.58
1	7.26	8.76	12.13	1.93
2	7.35	8.85	12.48	1.92
3	7.06	8.56	11.84	1.78
4	6.89	8.42	11.31	1.72
5	6.90	8.44	11.28	1.74
6	6.91	8.46	11.30	1.72
7	7.04	8.57	11.71	1.74
8	7.36	8.88	12.27	1.99
9	7.19	8.71	12.00	1.85
10	7.23	8.72	12.16	1.90
11	7.25	8.74	12.20	1.92
12	6.93	8.44	11.49	1.72
Average	***7.08***	***8.59***	***11.75***	***1.81***

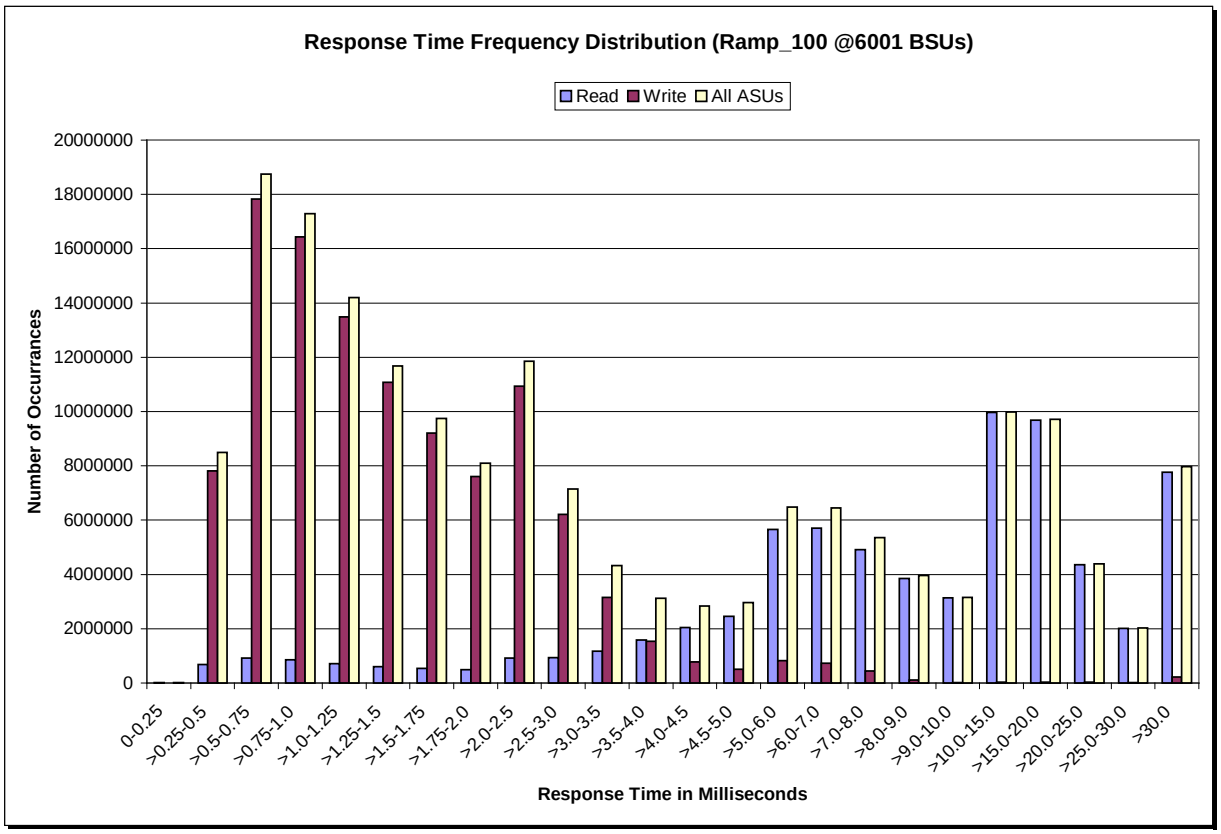
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	13,510	684,413	917,968	854,125	717,885	606,308	532,325	490,282
Write	943	7,805,634	17,834,027	16,431,946	13,479,974	11,079,904	9,215,222	7,614,463
All ASUs	14,453	8,490,047	18,751,995	17,286,071	14,197,859	11,686,212	9,747,547	8,104,745
ASU1	13,662	4,673,061	8,946,127	7,840,080	6,373,582	5,226,761	4,362,597	3,644,938
ASU2	620	966,987	1,951,553	1,736,782	1,416,785	1,163,393	967,791	797,938
ASU3	171	2,849,999	7,854,315	7,709,209	6,407,492	5,296,058	4,417,159	3,661,869
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	920,980	941,049	1,171,247	1,586,583	2,049,052	2,460,074	5,665,175	5,712,783
Write	10,932,387	6,207,730	3,156,351	1,533,633	782,741	499,879	818,632	730,256
All ASUs	11,853,367	7,148,779	4,327,598	3,120,216	2,831,793	2,959,953	6,483,807	6,443,039
ASU1	5,420,827	3,464,723	2,401,279	2,097,147	2,179,556	2,406,988	5,347,481	5,258,057
ASU2	1,155,712	675,991	386,953	271,794	269,297	311,304	747,369	840,009
ASU3	5,276,828	3,008,065	1,539,366	751,275	382,940	241,661	388,957	344,973
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	4,910,446	3,845,714	3,133,273	9,961,075	9,681,091	4,366,034	2,014,041	7,762,594
Write	447,910	118,621	22,160	30,681	35,608	26,410	16,894	214,933
All ASUs	5,358,356	3,964,335	3,155,433	9,991,756	9,716,699	4,392,444	2,030,935	7,977,527
ASU1	4,355,536	3,297,167	2,654,530	8,335,040	8,026,984	3,564,827	1,614,523	5,800,064
ASU2	789,133	609,016	489,762	1,640,762	1,671,452	814,093	407,660	2,062,488
ASU3	213,687	58,152	11,141	15,954	18,263	13,524	8,752	114,975

IOPS Test Run –Response Time Frequency Distribution Graph



IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
180,034,966	172,057,439	7,977,527

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0700	0.2101	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.000

Primary Metrics Test – Response Time Ramp Test Phase

Clause 5.4.4.3

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

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

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

Clause 9.4.3.7.3

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 73.

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 - 6001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	1:46:39	1:49:40	0-2	0:03:01
Measurement Interval	1:49:40	1:59:40	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	300,079.07	178,834.97	36,894.07	84,350.03
1	299,975.15	178,742.60	36,926.95	84,305.60
2	300,171.95	178,939.58	36,926.83	84,305.53
3	300,175.03	178,942.47	36,916.32	84,316.25
4	299,929.22	178,766.93	36,894.25	84,268.03
5	300,012.17	178,826.87	36,878.35	84,306.95
6	300,201.03	178,903.58	36,962.03	84,335.42
7	299,999.35	178,786.22	36,916.53	84,296.60
8	300,115.87	178,827.52	36,909.23	84,379.12
9	300,113.07	178,841.58	36,905.95	84,365.53
10	299,989.60	178,833.15	36,875.13	84,281.32
11	300,037.27	178,834.92	36,926.97	84,275.38
12	300,047.78	178,890.67	36,899.42	84,257.70
Average	*300,062.04*	*178,845.39*	*36,908.42*	*84,308.23*

95% Load Level - 5700 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:05:49	2:08:50	0-2	0:03:01
Measurement Interval	2:08:50	2:18:50	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	285,096.45	169,901.05	35,071.27	80,124.13
1	285,001.57	169,831.50	35,054.10	80,115.97
2	285,003.60	169,885.12	35,060.25	80,058.23
3	284,956.92	169,792.88	35,050.35	80,113.68
4	285,135.48	169,988.35	35,036.18	80,110.95
5	285,037.27	169,824.20	35,058.08	80,154.98
6	285,117.65	169,925.42	35,100.42	80,091.82
7	284,910.15	169,822.95	35,021.45	80,065.75
8	285,085.92	169,893.08	35,049.68	80,143.15
9	285,115.85	169,890.67	35,066.10	80,159.08
10	284,996.30	169,803.40	35,062.43	80,130.47
11	284,951.47	169,833.83	35,086.40	80,031.23
12	285,010.43	169,924.03	35,059.93	80,026.47
Average	*285,031.74*	*169,869.88*	*35,059.10*	*80,102.76*

90% Load Level - 5400 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:25:00	2:28:01	0-2	0:03:01
Measurement Interval	2:28:01	2:38:01	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	270,092.97	160,991.22	33,210.05	75,891.70
1	270,028.13	160,912.60	33,232.55	75,882.98
2	270,048.38	160,957.22	33,204.55	75,886.62
3	270,068.48	161,003.12	33,207.47	75,857.90
4	269,797.02	160,742.30	33,206.73	75,847.98
5	270,028.82	160,915.45	33,244.18	75,869.18
6	269,944.95	160,892.02	33,207.08	75,845.85
7	270,035.92	160,948.05	33,236.65	75,851.22
8	269,991.72	160,872.15	33,223.15	75,896.42
9	269,881.17	160,853.37	33,176.15	75,851.65
10	269,917.32	160,823.42	33,221.07	75,872.83
11	270,018.38	160,914.10	33,216.42	75,887.87
12	270,079.15	160,974.30	33,199.52	75,905.33
Average	*269,976.29*	*160,893.83*	*33,213.84*	*75,868.62*

80% Load Level - 4800 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	2:44:03	2:47:04	0-2	0:03:01
Measurement Interval	2:47:04	2:57:04	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	240,062.73	143,095.45	29,494.92	67,472.37
1	240,005.42	143,033.73	29,479.78	67,491.90
2	240,027.37	143,082.10	29,537.75	67,407.52
3	239,970.15	143,050.43	29,491.02	67,428.70
4	239,989.52	143,061.73	29,503.47	67,424.32
5	239,971.42	143,036.90	29,507.90	67,426.62
6	239,912.73	142,958.67	29,515.40	67,438.67
7	239,988.03	142,992.33	29,553.25	67,442.45
8	239,932.48	143,018.85	29,502.47	67,411.17
9	239,925.72	143,054.50	29,473.23	67,397.98
10	240,009.28	143,031.72	29,511.42	67,466.15
11	239,961.63	143,005.10	29,521.55	67,434.98
12	239,934.18	143,011.05	29,543.07	67,380.07
Average	*239,959.52*	*143,022.13*	*29,512.28*	*67,425.11*

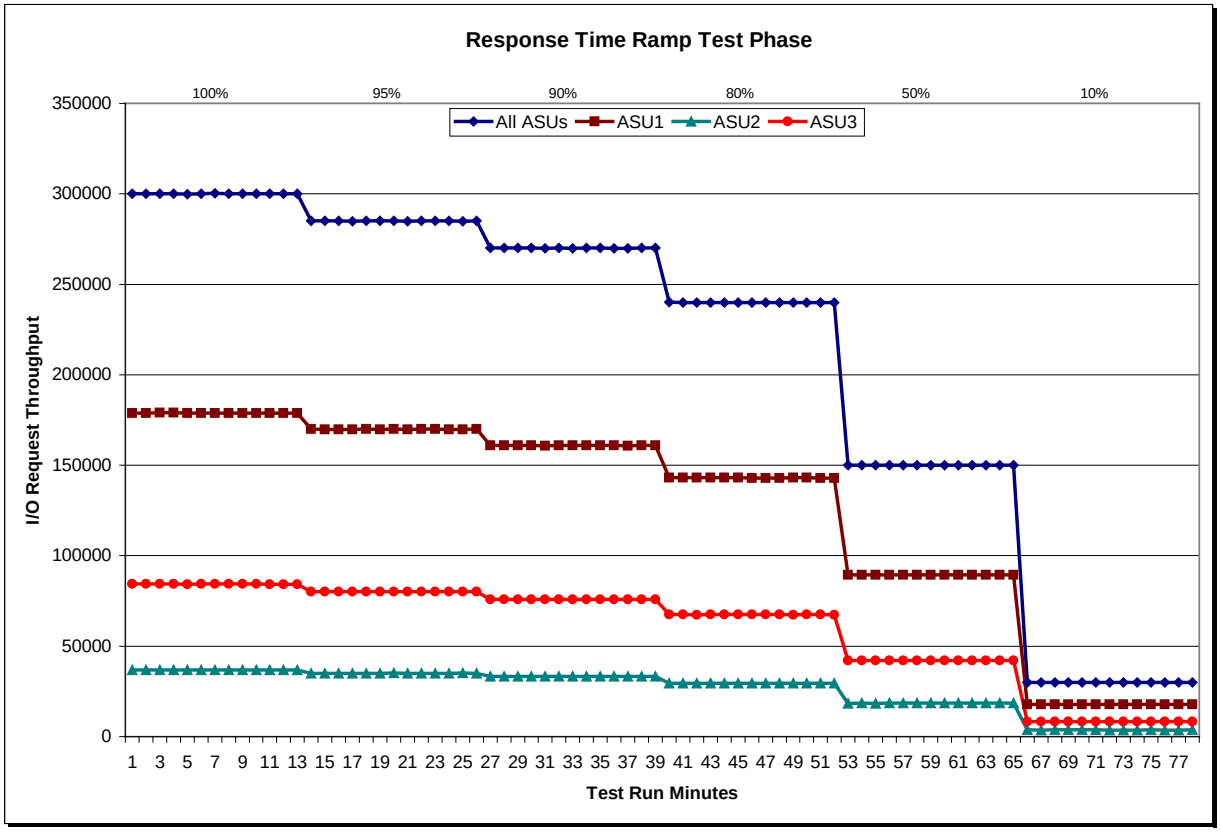
50% Load Level - 3000 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:02:49	3:05:50	0-2	0:03:01
Measurement Interval	3:05:50	3:15:50	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	149,986.27	89,414.22	18,424.92	42,147.13
1	149,994.15	89,447.55	18,434.42	42,112.18
2	150,015.53	89,434.20	18,425.10	42,156.23
3	149,961.27	89,387.60	18,433.12	42,140.55
4	149,924.53	89,364.33	18,471.70	42,088.50
5	149,975.43	89,372.58	18,442.20	42,160.65
6	150,015.67	89,415.18	18,465.72	42,134.77
7	150,088.47	89,429.53	18,496.55	42,162.38
8	150,092.27	89,434.25	18,461.45	42,196.57
9	150,018.68	89,349.20	18,470.70	42,198.78
10	149,971.32	89,364.18	18,436.13	42,171.00
11	149,967.92	89,396.52	18,459.73	42,111.67
12	149,986.10	89,372.65	18,453.48	42,159.97
Average	*150,000.17*	*89,388.60*	*18,459.08*	*42,152.48*

10% Load Level - 600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:21:20	3:24:21	0-2	0:03:01
Measurement Interval	3:24:21	3:34:21	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	29,990.20	17,887.48	3,694.47	8,408.25
1	30,000.53	17,900.45	3,672.02	8,428.07
2	29,999.65	17,887.15	3,690.53	8,421.97
3	29,986.37	17,874.15	3,694.07	8,418.15
4	30,014.68	17,894.03	3,702.20	8,418.45
5	29,997.72	17,880.43	3,693.10	8,424.18
6	29,990.82	17,879.32	3,681.57	8,429.93
7	29,965.43	17,861.20	3,683.35	8,420.88
8	29,958.08	17,873.22	3,668.98	8,415.88
9	30,001.70	17,886.33	3,695.75	8,419.62
10	29,998.85	17,888.65	3,680.77	8,429.43
11	29,960.45	17,857.80	3,671.53	8,431.12
12	30,004.02	17,866.53	3,702.75	8,434.73
Average	*29,987.81*	*17,876.17*	*3,687.41*	*8,424.24*

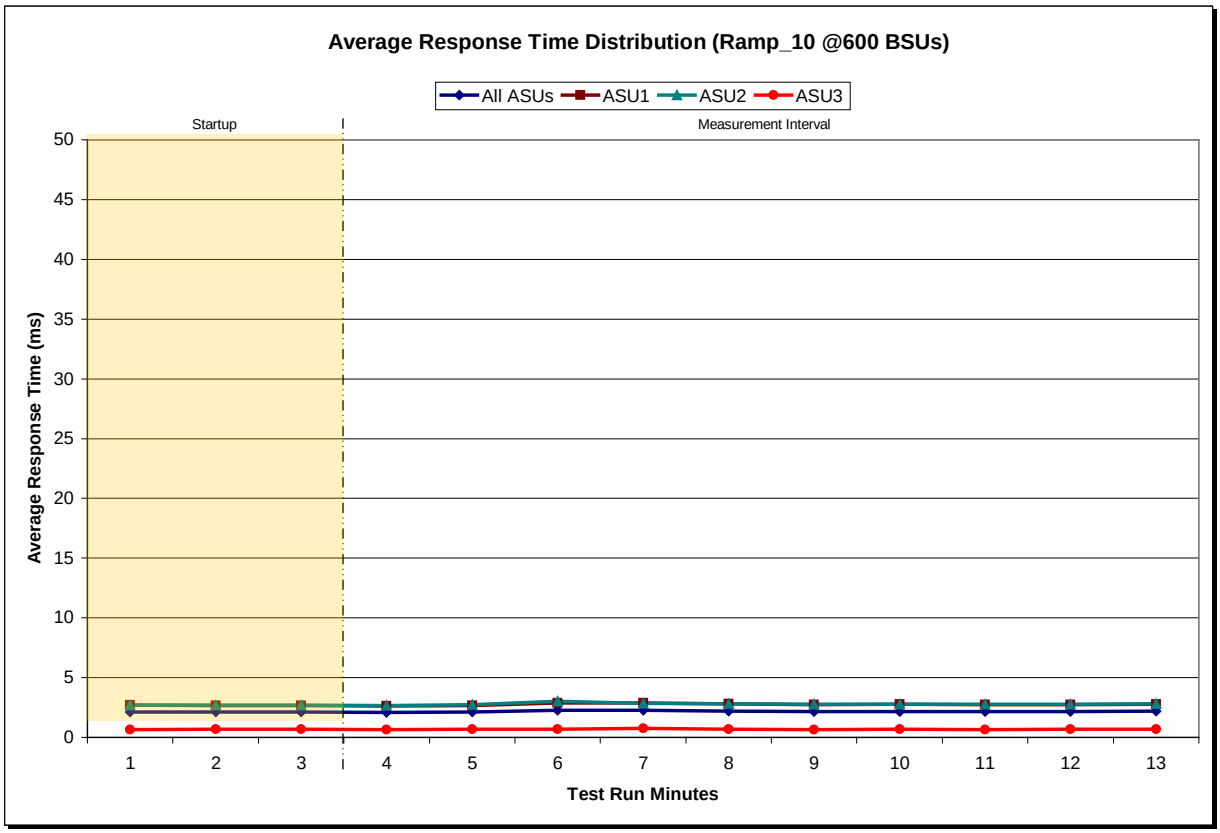
Response Time Ramp Distribution (IOPS) Graph



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

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:21:20	3:24:21	0-2	0:03:01
Measurement Interval	3:24:21	3:34:21	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.12	2.70	2.72	0.65
1	2.11	2.67	2.70	0.68
2	2.12	2.67	2.71	0.69
3	2.08	2.63	2.67	0.66
4	2.12	2.68	2.72	0.68
5	2.28	2.88	3.04	0.69
6	2.27	2.88	2.84	0.75
7	2.20	2.80	2.82	0.68
8	2.16	2.75	2.76	0.65
9	2.18	2.76	2.77	0.67
10	2.15	2.73	2.76	0.65
11	2.17	2.75	2.77	0.69
12	2.19	2.77	2.80	0.68
Average	***2.18***	***2.76***	***2.79***	***0.68***

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2810	0.0701	0.2100	0.0180	0.0700	0.0350	0.2809
COV	0.004	0.001	0.002	0.002	0.008	0.003	0.004	0.001

Repeatability Test

Clause 5.4.5

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

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

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

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

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

Clause 9.4.3.7.4

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in "Appendix E: SPC-1 Workload Generator Input Parameters" on Page 73.

Repeatability Test Results File

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

	SPC-1 IOPS™
Primary Metrics	***300,062.04***
Repeatability Test Phase 1	300,055.21
Repeatability Test Phase 2	300,076.08

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

	SPC-1 LRT™
Primary Metrics	***2.18 ms***
Repeatability Test Phase 1	2.20 ms
Repeatability Test Phase 2	2.20 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)..

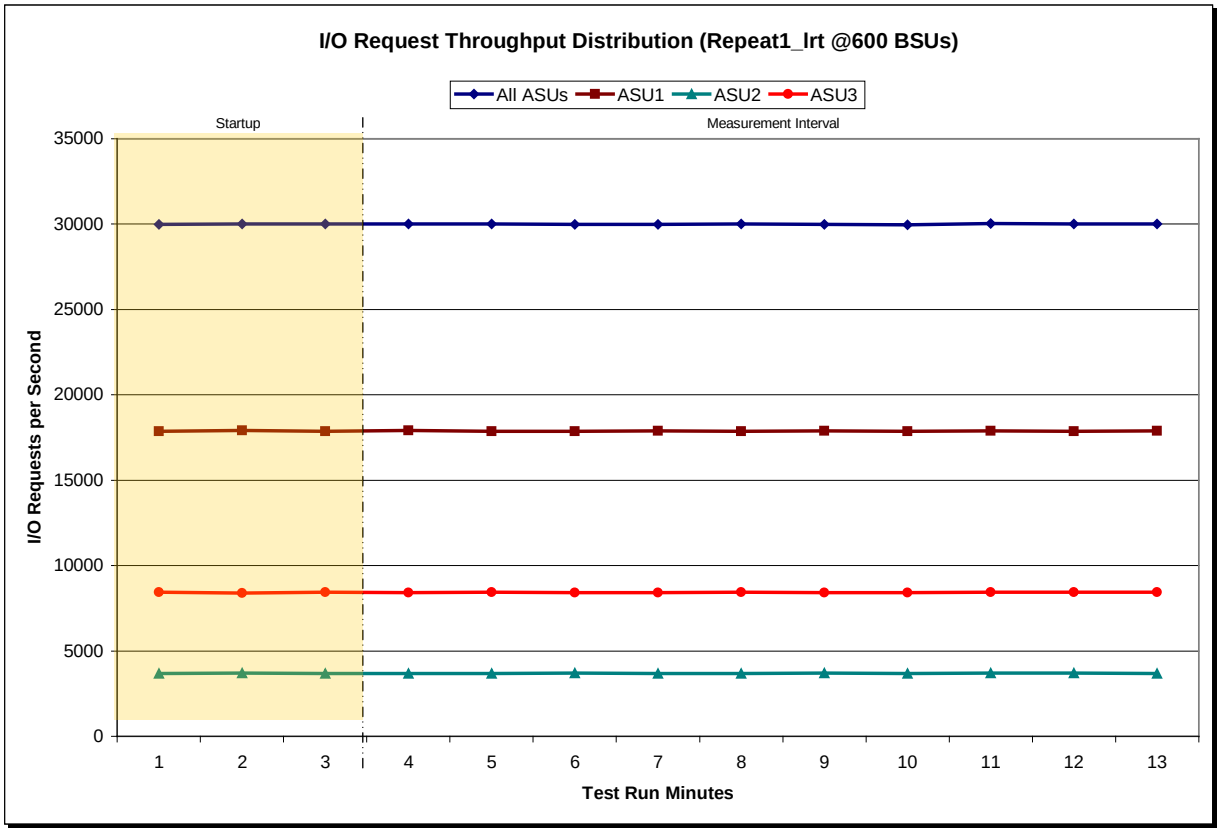
A link to the test result file generated from each Repeatability Test Run is listed below.

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

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:40:10	3:43:10	0-2	0:03:00
Measurement Interval	3:43:10	3:53:10	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	29,975.70	17,860.92	3,679.02	8,435.77
1	30,021.60	17,925.43	3,692.65	8,403.52
2	30,002.02	17,875.22	3,686.73	8,440.07
3	30,016.47	17,911.10	3,688.40	8,416.97
4	30,000.98	17,869.73	3,686.80	8,444.45
5	29,995.52	17,875.08	3,696.17	8,424.27
6	29,987.92	17,890.83	3,683.65	8,413.43
7	30,001.35	17,877.35	3,688.87	8,435.13
8	29,997.10	17,880.23	3,696.30	8,420.57
9	29,968.17	17,871.82	3,686.60	8,409.75
10	30,028.90	17,895.15	3,696.52	8,437.23
11	30,005.87	17,875.75	3,695.60	8,434.52
12	30,005.12	17,881.55	3,688.45	8,435.12
Average	***30,000.74***	***17,882.86***	***3,690.74***	***8,427.14***

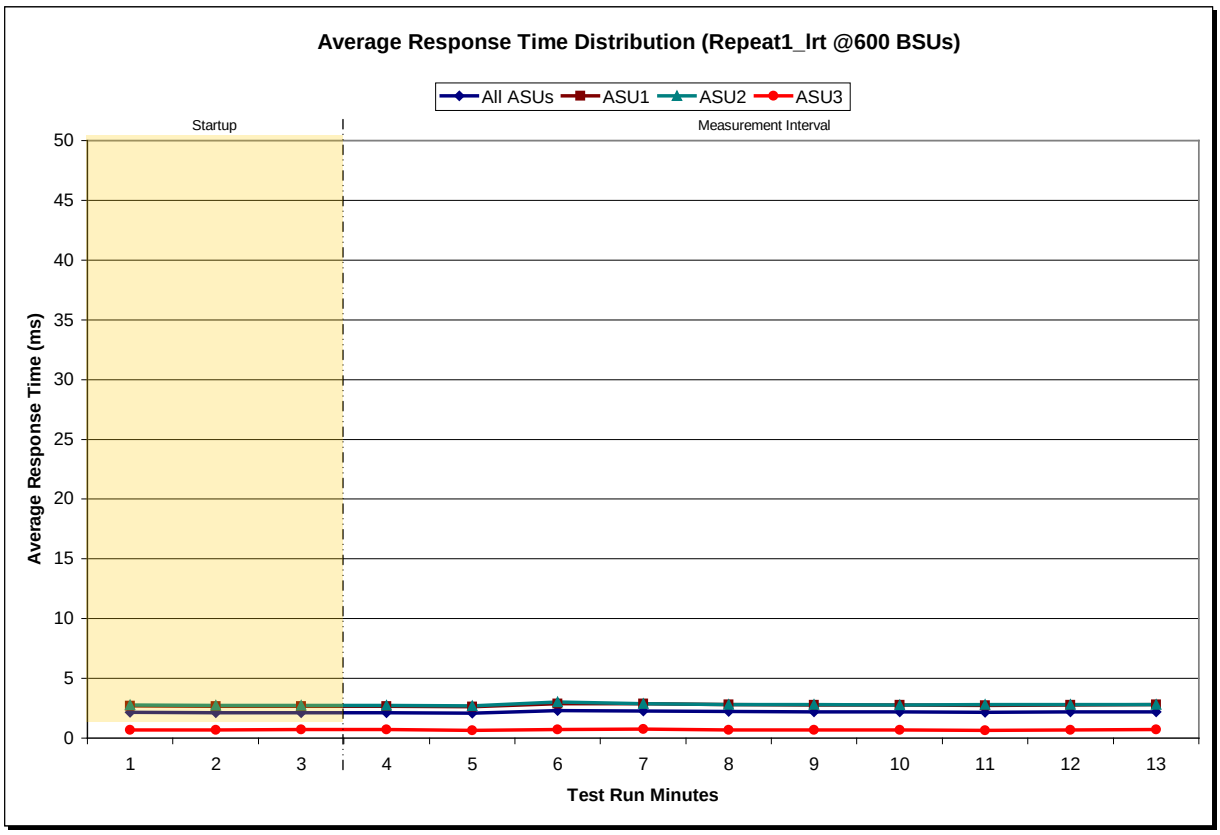
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:40:10	3:43:10	0-2	0:03:00
Measurement Interval	3:43:10	3:53:10	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.15	2.71	2.78	0.68
1	2.12	2.67	2.73	0.68
2	2.13	2.67	2.74	0.73
3	2.13	2.66	2.74	0.71
4	2.09	2.64	2.71	0.66
5	2.29	2.88	3.01	0.73
6	2.28	2.88	2.88	0.74
7	2.22	2.81	2.82	0.70
8	2.19	2.77	2.80	0.67
9	2.20	2.78	2.79	0.70
10	2.17	2.75	2.79	0.67
11	2.18	2.76	2.81	0.68
12	2.21	2.80	2.81	0.71
Average	***2.20***	***2.77***	***2.81***	***0.70***

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

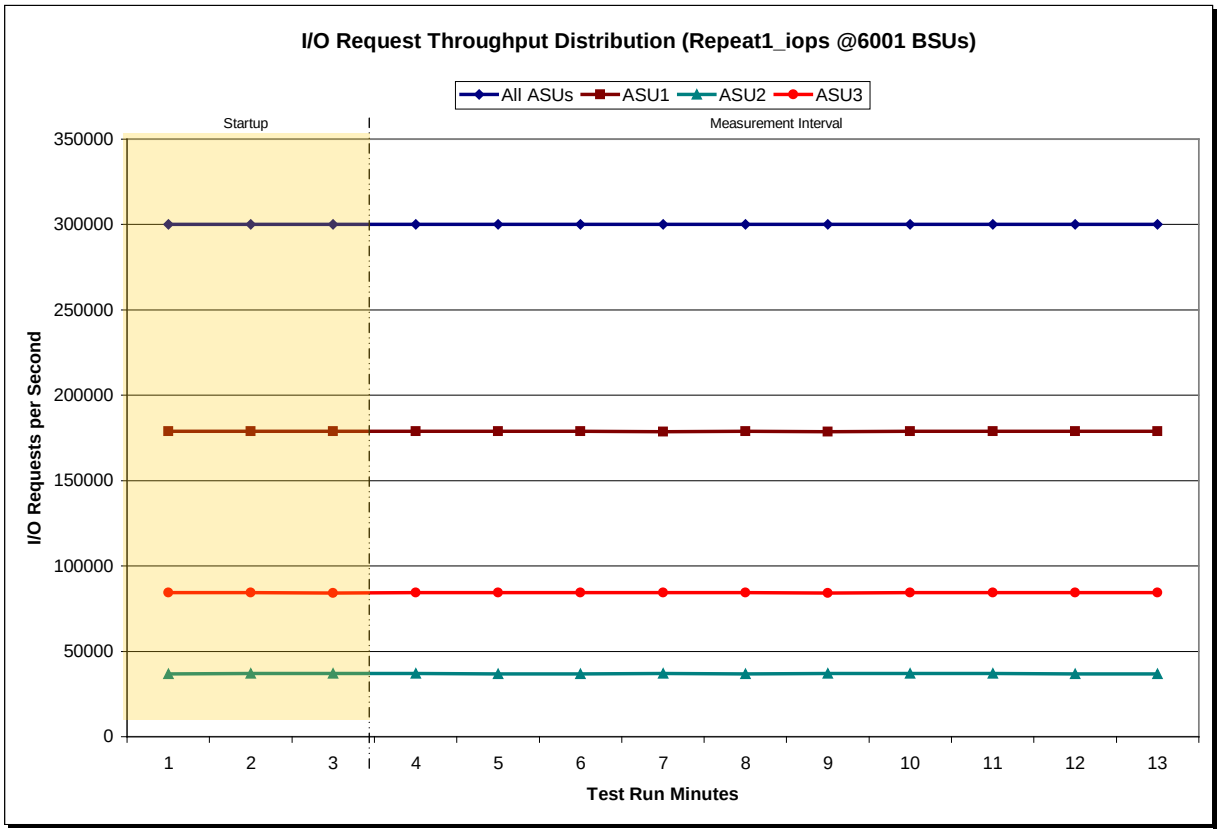


Repeatability 1 IOPS – I/O Request Throughput Distribution Data

6001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:59:25	4:02:26	0-2	0:03:01
Measurement Interval	4:02:26	4:12:26	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	300,143.47	178,865.98	36,904.42	84,373.07
1	300,143.78	178,906.30	36,929.55	84,307.93
2	300,035.63	178,840.58	36,926.05	84,269.00
3	300,054.67	178,821.37	36,918.20	84,315.10
4	300,067.18	178,840.03	36,903.43	84,323.72
5	300,023.00	178,802.70	36,890.23	84,330.07
6	300,030.10	178,775.72	36,920.65	84,333.73
7	300,157.98	178,883.77	36,897.18	84,377.03
8	300,012.68	178,777.40	36,948.60	84,286.68
9	300,075.63	178,814.90	36,936.88	84,323.85
10	300,071.80	178,788.72	36,965.12	84,317.97
11	300,060.78	178,809.18	36,897.48	84,354.12
12	299,998.22	178,821.58	36,871.07	84,305.57
Average	***300,055.21***	***178,813.54***	***36,914.89***	***84,326.78***

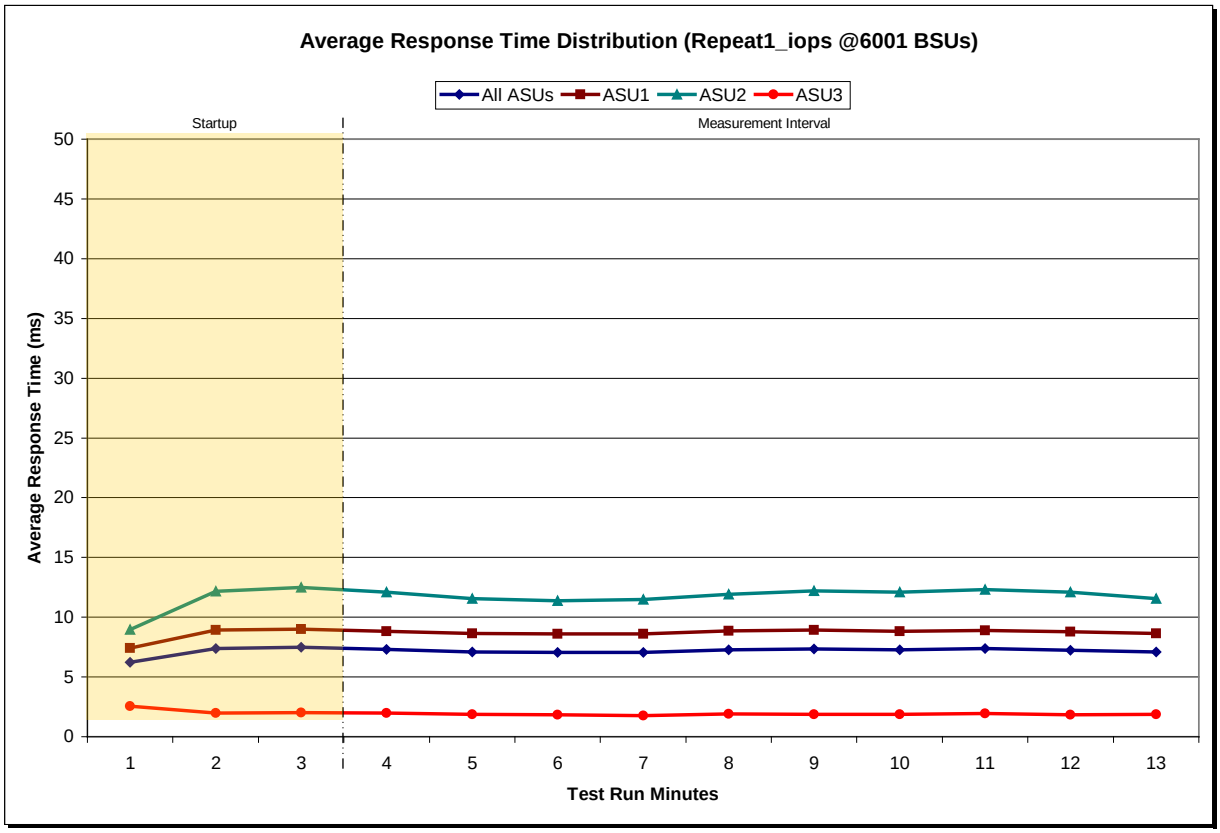
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

6001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:59:25	4:02:26	0-2	0:03:01
Measurement Interval	4:02:26	4:12:26	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	6.24	7.42	8.95	2.55
1	7.38	8.93	12.18	1.97
2	7.47	9.01	12.47	2.03
3	7.31	8.84	12.09	1.98
4	7.10	8.66	11.55	1.86
5	7.05	8.61	11.37	1.84
6	7.05	8.62	11.47	1.78
7	7.28	8.85	11.93	1.92
8	7.34	8.91	12.20	1.86
9	7.28	8.84	12.10	1.87
10	7.37	8.90	12.30	1.94
11	7.23	8.78	12.09	1.84
12	7.10	8.65	11.54	1.87
Average	***7.21***	***8.77***	***11.86***	***1.88***

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

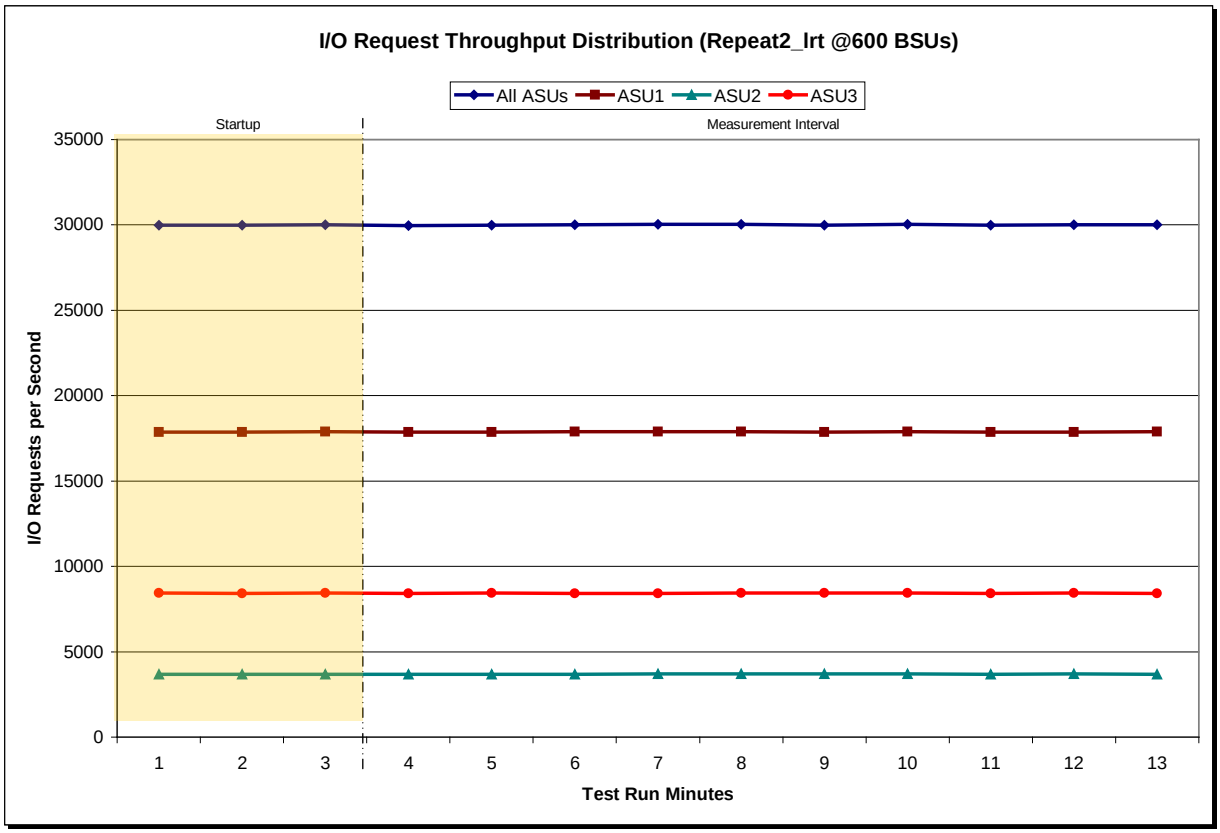


Repeatability 2 LRT – I/O Request Throughput Distribution Data

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:17:58	4:20:58	0-2	0:03:00
Measurement Interval	4:20:58	4:30:58	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	29,991.72	17,876.95	3,678.10	8,436.67
1	29,980.72	17,871.42	3,691.20	8,418.10
2	30,004.53	17,886.80	3,680.63	8,437.10
3	29,964.97	17,864.50	3,687.10	8,413.37
4	29,990.92	17,866.85	3,688.70	8,435.37
5	30,000.98	17,886.85	3,686.93	8,427.20
6	30,024.80	17,898.78	3,706.80	8,419.22
7	30,026.37	17,891.92	3,696.12	8,438.33
8	29,997.90	17,875.53	3,693.18	8,429.18
9	30,023.40	17,892.88	3,696.12	8,434.40
10	29,975.15	17,868.77	3,678.18	8,428.20
11	29,998.98	17,871.12	3,696.70	8,431.17
12	30,001.38	17,894.28	3,685.43	8,421.67
Average	***30,000.49***	***17,881.15***	***3,691.53***	***8,427.81***

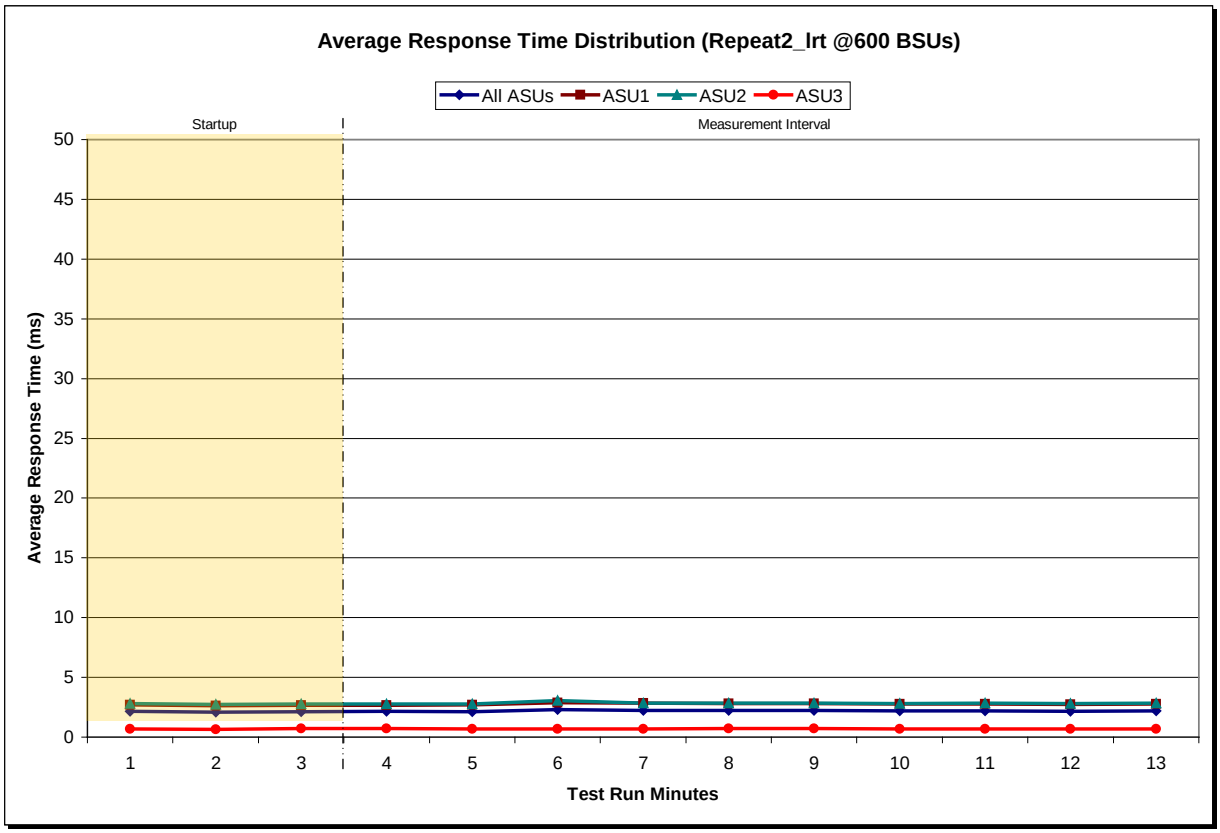
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:17:58	4:20:58	0-2	0:03:00
Measurement Interval	4:20:58	4:30:58	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.15	2.70	2.80	0.70
1	2.09	2.64	2.74	0.65
2	2.13	2.68	2.78	0.70
3	2.14	2.68	2.77	0.72
4	2.13	2.68	2.78	0.68
5	2.29	2.87	3.07	0.70
6	2.23	2.84	2.85	0.68
7	2.22	2.80	2.84	0.71
8	2.23	2.82	2.85	0.72
9	2.20	2.78	2.82	0.70
10	2.20	2.78	2.84	0.69
11	2.17	2.74	2.81	0.67
12	2.21	2.78	2.85	0.70
Average	***2.20***	***2.78***	***2.85***	***0.70***

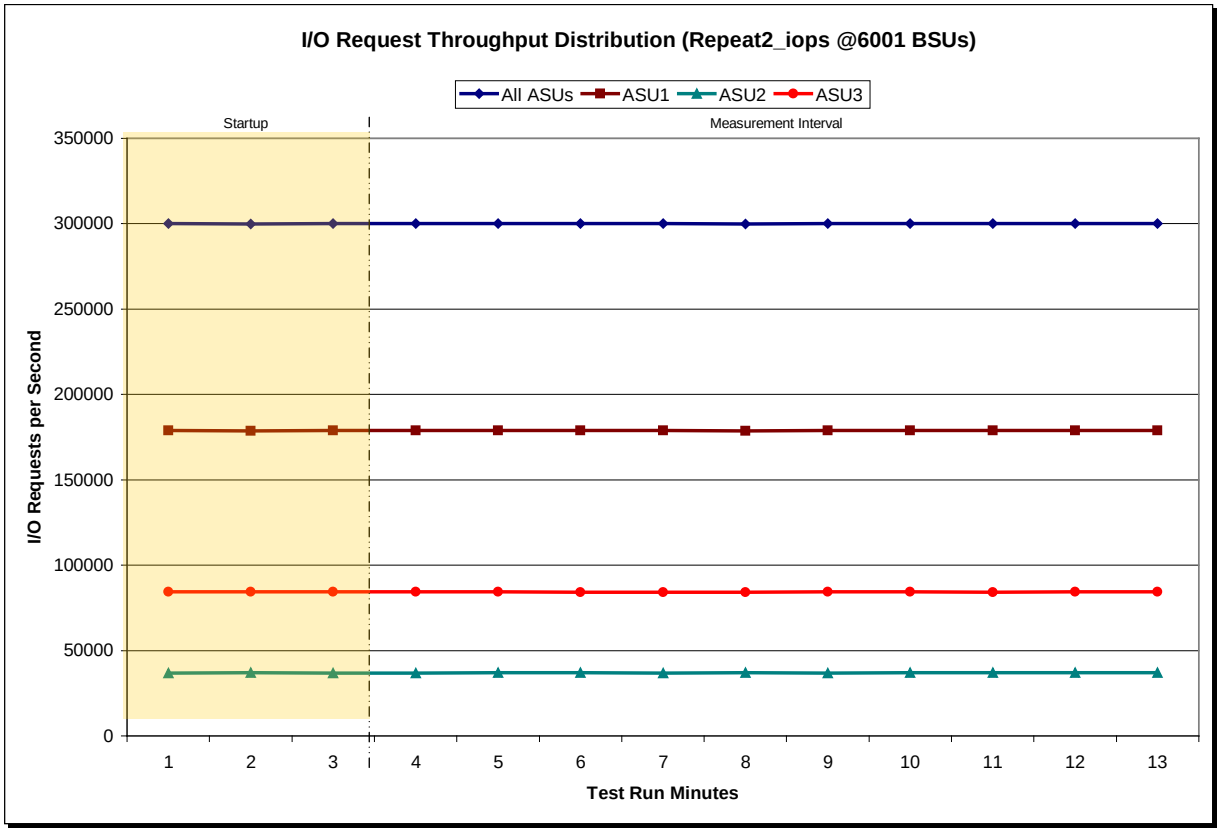
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

6001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:36:46	4:39:47	0-2	0:03:01
Measurement Interval	4:39:47	4:49:47	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	300,047.52	178,808.52	36,908.73	84,330.27
1	299,970.75	178,752.30	36,925.30	84,293.15
2	300,046.03	178,807.17	36,894.52	84,344.35
3	300,144.37	178,940.50	36,897.98	84,305.88
4	300,186.90	178,872.58	36,916.77	84,397.55
5	300,043.12	178,807.38	36,952.65	84,283.08
6	300,031.88	178,867.33	36,896.95	84,267.60
7	299,910.55	178,728.33	36,942.63	84,239.58
8	300,100.40	178,844.23	36,892.73	84,363.43
9	300,112.70	178,843.12	36,918.15	84,351.43
10	299,992.52	178,808.50	36,916.85	84,267.17
11	300,062.22	178,849.28	36,922.13	84,290.80
12	300,176.15	178,953.05	36,915.62	84,307.48
Average	***300,076.08***	***178,851.43***	***36,917.25***	***84,307.40***

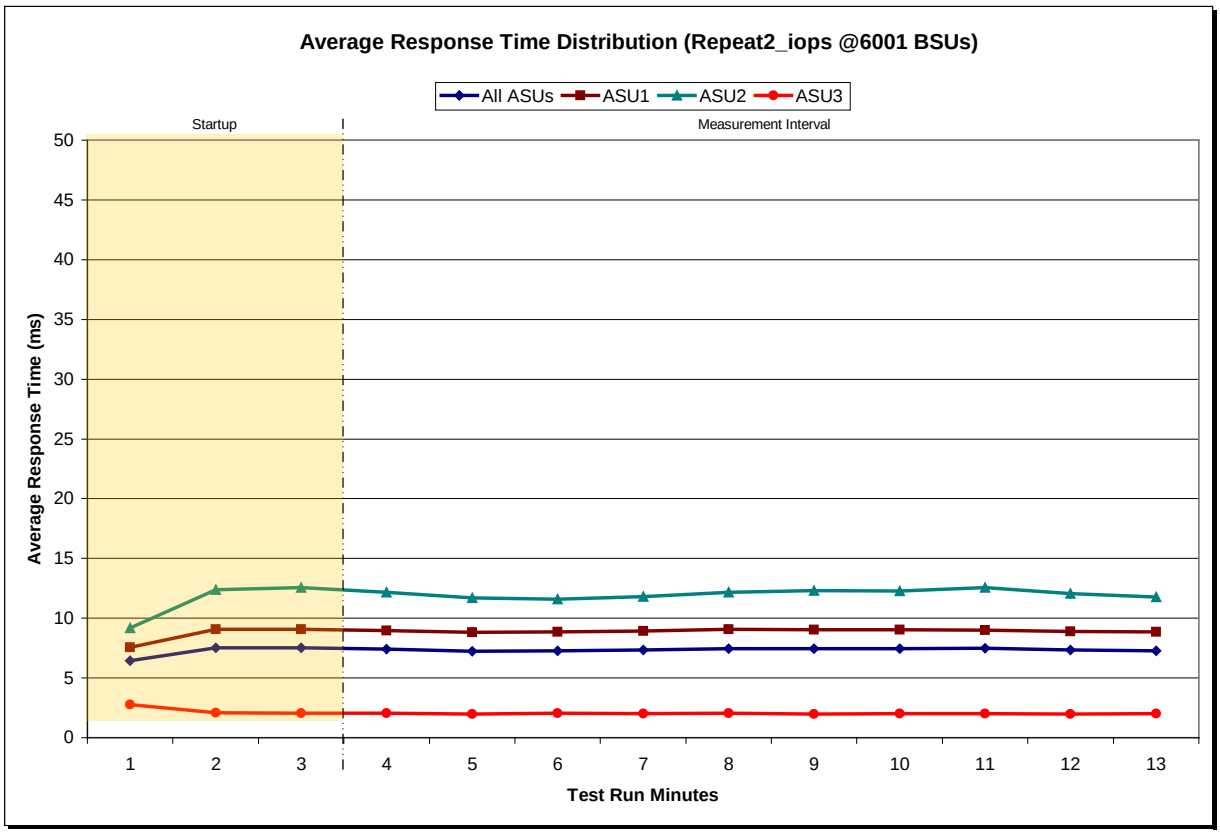
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

6001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:36:46	4:39:47	0-2	0:03:01
Measurement Interval	4:39:47	4:49:47	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	6.43	7.57	9.19	2.79
1	7.52	9.07	12.40	2.10
2	7.53	9.08	12.56	2.06
3	7.41	8.95	12.16	2.06
4	7.25	8.82	11.70	1.96
5	7.27	8.85	11.58	2.03
6	7.33	8.92	11.82	2.01
7	7.47	9.05	12.17	2.04
8	7.46	9.05	12.32	1.98
9	7.46	9.03	12.28	2.03
10	7.48	9.02	12.58	2.00
11	7.33	8.87	12.06	1.99
12	7.29	8.85	11.75	2.02
Average	***7.38***	***8.94***	***12.04***	***2.01***

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0350	0.2811	0.0699	0.2100	0.0180	0.0700	0.0351	0.2809
COV	0.003	0.001	0.003	0.002	0.006	0.003	0.004	0.001

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

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

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	***0.0350***	***0.2810***	***0.0700***	***0.2100***	***0.0180***	***0.0700***	***0.0350***	***0.2810***
MIM	0.0351	0.2810	0.0700	0.2100	0.0180	0.0700	0.0351	0.2809
COV	0.002	0.001	0.003	0.001	0.006	0.002	0.003	0.001

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

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

Data Persistence Test

Clause 6

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

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

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

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

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

Clause 9.4.3.8

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

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

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 73.

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	
Total Number of Logical Blocks Verified	
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	1024
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 9.2.4.9

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

The Huawei OceanStor™ S8100 *(8-node)* as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

PRICING INFORMATION

Clause 9.4.3.3.6

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

Pricing information may found in the Priced Storage Configuration Pricing section on page 14.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.7

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

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

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the Huawei OceanStor™ S8100 *(8-node)*.

APPENDIX A: SPC-1 GLOSSARY

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

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

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

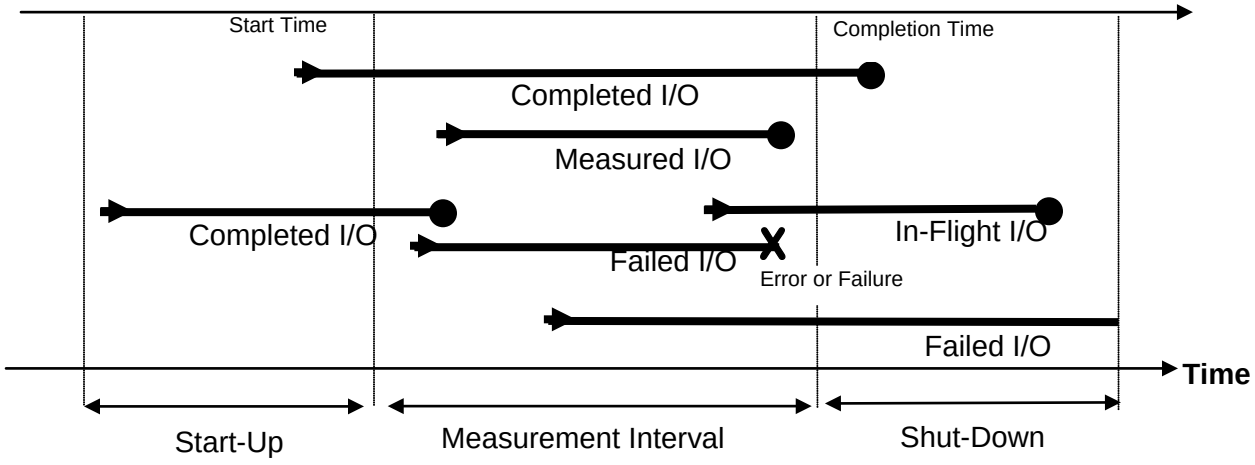
Test: A collection of Test Phases and or Test Runs sharing a common objective.

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

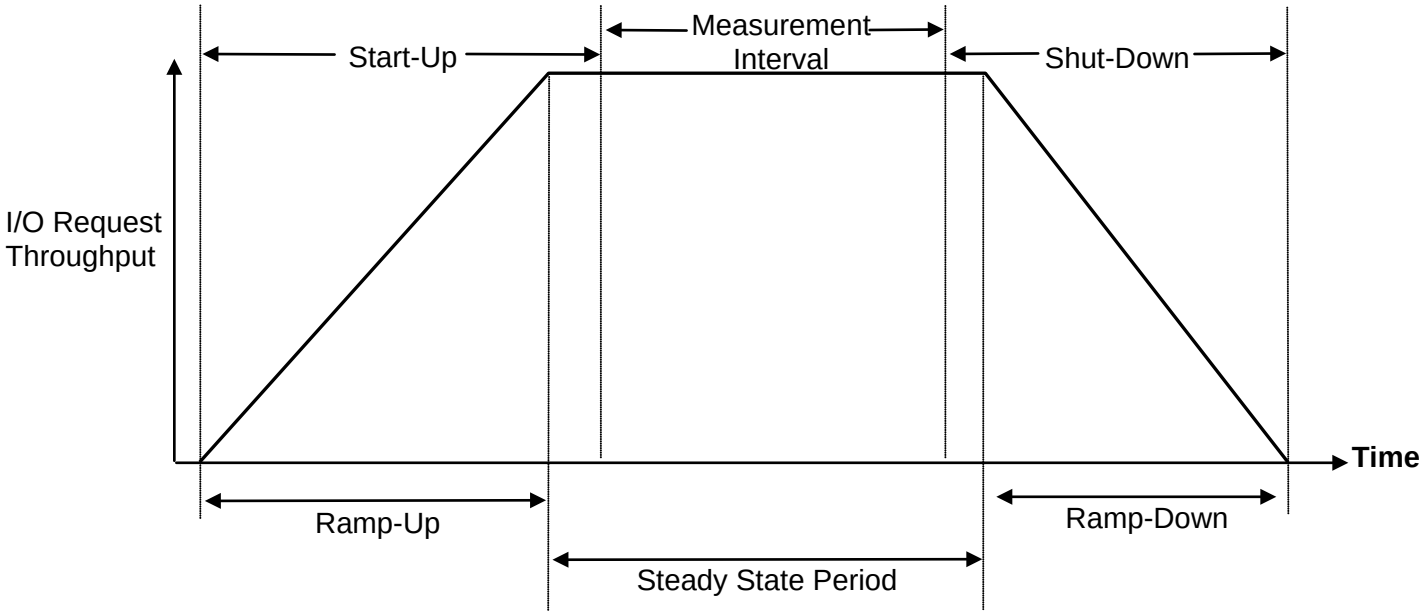
period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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

I/O Completion Types



SPC-1 Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

Windows 2003 Server

The execution throttle, **queue depth**, was changed from a default value of 65535 to 1024 for each HBA in the configuration.

S8100

Enable **write cache with no mirroring**.

Set the cache high-low watermarks: **low watermark** is 80% and **high watermark** is 90%.

Set the read cache policy to **no prefetch**.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

1. Configure the HBAs

Using **regedit.exe**, change the execution throttle, **queue depth**, in the Windows registry from a default value of 65535 to 1024 for each HBA in the configuration.

2. Create RAID groups and LUNs in the data controller groups

2.1 Login to the S8100 CLI console of each of the eight data controller groups using SSH, and execute the **raid_lun.script** with the **autobat** S8100 command-line tool. The script will create 12 RAID groups and 12 LUNs *(1 LUNs per RAID group)* in each data controller group. The following is an example to create the RAID groups and LUNs on one data controller group:

OceanStor: admin> autobat -i 129.22.240.65 -u admin -f raid_lun.script

The **createrg** command creates a RAID group. The **creatlun** command creates a LUN with a capacity 1,716,606 MiB. The ***-p 0*** parameter, in the **creatlun** command sets the read cache policy as **no prefetch** and the ***-m 0*** parameter sets the write cache policy as **write cache with no mirroring**.

Each of the LUNs is mapped to a service controller and assigned a unique name, which uses a **sd** prefix. For example, **sdan, sdb, sdbn, sdcl, sddj, sddv sdfr**, and **sdn**.

A listing of **raid_lun.script** appears at the end of this section.

2.2 Create two "share" LUNs, each with a capacity of 5,120 MiB, using the S8100 CLI console of one data controller group. Those two LUNs are used for metadata maintenance in the service controller groups. The commands to create the two LUNs are listed below.

OceanStor: admin> createlun -i 0 -n share1 -s 5120 -u 64 -c A -w 1 -m 0

OceanStor: admin> createlun -i 1 -n share2 -s 5120 -u 64 -c A -w 1 -m 0

2.3 Login to the S8100 CLI console of each of the eight data controller groups using SSH, and change the **high water mark** to **90%** and **low water mark** to **80%** using the following CLI command:

OceanStor: admin> chgcache -h 90 -l 80

raid_lun.script

```
createrg -n RAID10_1 -l 10 -m 2 -d 0,0:0,1:0,2:2,0:2,1:2,2:4,0:4,1:4,2:6,0:6,1:6,2:
createrg -n RAID10_2 -l 10 -m 2 -d 0,3:0,4:0,5:2,3:2,4:2,5:4,3:4,4:4,5:6,3:6,4:6,5:
createrg -n RAID10_3 -l 10 -m 2 -d 0,6:0,7:0,8:2,6:2,7:2,8:4,6:4,7:4,8:6,6:6,7:6,8:
createrg -n RAID10_4 -l 10 -m 2 -d
0,9:0,10:0,11:2,9:2,10:2,11:4,9:4,10:4,11:6,9:6,10:6,11:
createrg -n RAID10_5 -l 10 -m 2 -d
0,12:0,13:0,14:2,12:2,13:2,14:4,12:4,13:4,14:6,12:6,13:6,14:
createrg -n RAID10_6 -l 10 -m 2 -d
0,15:0,16:0,17:2,15:2,16:2,17:4,15:4,16:4,17:6,15:6,16:6,17:
createrg -n RAID10_7 -l 10 -m 2 -d 1,0:1,1:1,2:3,0:3,1:3,2:5,0:5,1:5,2:7,0:7,1:7,2:
```

```
createrg -n RAID10_8 -l 10 -m 2 -d 1,3:1,4:1,5:3,3:3,4:3,5:5,3:5,4:5,5:7,3:7,4:7,5:
createrg -n RAID10_9 -l 10 -m 2 -d 1,6:1,7:1,8:3,6:3,7:3,8:5,6:5,7:5,8:7,6:7,7:7,8:
createrg -n RAID10_10 -l 10 -m 2 -d
1,9:1,10:1,11:3,9:3,10:3,11:5,9:5,10:5,11:7,9:7,10:7,11:
createrg -n RAID10_11 -l 10 -m 2 -d
1,12:1,13:1,14:3,12:3,13:3,14:5,12:5,13:5,14:7,12:7,13:7,14:
createrg -n RAID10_12 -l 10 -m 2 -d
1,15:1,16:1,17:3,15:3,16:3,17:5,15:5,16:5,17:7,15:7,16:7,17:
createlun -i 0 -n LUN_1 -s 1716606 -u 512 -c A -w 1 -m 0 -p 0
createlun -i 1 -n LUN_2 -s 1716606 -u 512 -c B -w 1 -m 0 -p 0
createlun -i 2 -n LUN_3 -s 1716606 -u 512 -c A -w 1 -m 0 -p 0
createlun -i 3 -n LUN_4 -s 1716606 -u 512 -c B -w 1 -m 0 -p 0
createlun -i 4 -n LUN_5 -s 1716606 -u 512 -c A -w 1 -m 0 -p 0
createlun -i 5 -n LUN_6 -s 1716606 -u 512 -c B -w 1 -m 0 -p 0
createlun -i 6 -n LUN_7 -s 1716606 -u 512 -c A -w 1 -m 0 -p 0
createlun -i 7 -n LUN_8 -s 1716606 -u 512 -c B -w 1 -m 0 -p 0
createlun -i 8 -n LUN_9 -s 1716606 -u 512 -c A -w 1 -m 0 -p 0
createlun -i 9 -n LUN_10 -s 1716606 -u 512 -c B -w 1 -m 0 -p 0
createlun -i 10 -n LUN_11 -s 1716606 -u 512 -c A -w 1 -m 0 -p 0
createlun -i 11 -n LUN_12 -s 1716606 -u 512 -c B -w 1 -m 0 -p 0
```

3. Create disk groups and volumes

3.1 Login to the S8100 CLI console of each of the eight data controller groups and execute the **www_luns.script** to create a listing of WWN information for each LUN created by **raid_lun.script**. The following is an example to create the listing on one data controller group:

OceanStor: admin> autobat -i 129.22.240.65 -u admin -f www_luns.script

3.2 Login to the S8100 CLI console of one of the service controllers and execute the **www_elements.script**, using the command listed below, to create a listing that contains the unique **sd** name and corresponding WWN for each LUN created by **raid_lun.script**.

OceanStor: admin> autobat -i 129.22.240.75 -u admin -f www_elements.script

The information created from **www_luns.script** and **www_elements.script** document the relationship between the LUN names associated with the data controllers and the **sd** names associated with service controllers via the common WWN. This information is used in **disk_volume.script** to create disk groups, each consisting of four LUNs with the same LUN name from the four data controller groups. For example:

- **dg1** *(disk group 1)* contains LUNs **sdan, sdb, sdbn, sdcl, sddj, sddv sdfr**, and **sdn** each identified as **LUN_1** in all eight data controller groups.
- **dg2** *(disk group 2)* contains LUNs **sdao, sdbo, sdc, sdcm, sddk, sddw**, **sdfs**, and **sdn** each identified as **LUN_2** in all eight data controller groups.

3.3 Login to the S8100 CLI console of one of the service controllers and execute the **disk_volume.script** using the command listed below. The script will create 12 disk groups, 12 volumes, and map the 12 volumes to Windows.

OceanStor: admin> autobat -i 129.22.240.75 -u admin -f disk_volume.script

The **vxdg** command creates each disk group in the appropriate service controller group. The **vxassist** command creates each volume in the appropriate service controller group. The entire capacity of each disk group is allocated to each volume, resulting in 12 volumes, each with a capacity of 13,410.984 GiB *(28,124,872,704 sectors, 512 bytes/sector)*. The **addmap** command maps the 12 volumes to the Host System.

Listings for **www_luns.script**, **www_elements.script**, and **disk_volume.script** appear below.

www_luns.script

```
showlun -i 0
showlun -i 1
showlun -i 2
showlun -i 3
showlun -i 4
showlun -i 5
showlun -i 6
showlun -i 7
showlun -i 8
showlun -i 9
showlun -i 10
showlun -i 11
```

www_elements.script

```
#!/bin/bash
for i in `vxdisklist |grep 1799.99 |awk '{print $1}'`
do
echo $i `vxdisk list $i |grep udid |awk '{print $2}' | awk -F '%5F' '//{print $4}'`
#vxdisk list $i |grep udid |awk '{print $2}' | awk -F '%5F' '//{print $4}'
Done
```

diskgroup_volume.script

```
vxdg -s init dg1 sdan sdb sdbn sdcl sddj sddv sdfr sdn
vxdg -s init dg2 sdao sdbo sdc sdcm sddk sddw sdfs sdo
vxdg -s init dg3 sdap sdbp sdcn sdd sddl sddx sdft sdp
vxdg -s init dg4 sdaq sdbq sdco sddm sddy sde sdfu sdq
vxdg -s init dg5 sdar sdbr sdcp sddn sddz sdf sdfv sdr
vxdg -s init dg6 sdas sdbs sdcq sddo sdea sdfw sdg sds
vxdg -s init dg7 sdat sdbt sdcr sddp sdeb sdfx sdh sdt
vxdg -s init dg8 sdau sdbu sdcs sddq sdec sdfy sdi sdu
vxdg -s init dg9 sdav sdbv sdct sddr sded sdfz sdj sdv
vxdg -s init dg10 sdaw sdbw sdcu sdds sdee sdga sdk sdw
vxdg -s init dg11 sdax sdbx sdcv sddt sdef sdgb sdl sdx
vxdg -s init dg12 sday sdby sdcw sddu sdeg sdgc sdm sdy
vxassist -g dg1 make v1 28124872704 layout=stripe sdan sdb sdbn sdcl sddj sddv sdfr
sdn
vxassist -g dg2 make v2 28124872704 layout=stripe sdao sdbo sdc sdcm sddk sddw sdfs
sdo
vxassist -g dg3 make v3 28124872704 layout=stripe sdap sdbp sdcn sdd sddl sddx sdft
sdp
vxassist -g dg4 make v4 28124872704 layout=stripe sdaq sdbq sdco sddm sddy sde sdfu
sdq
vxassist -g dg5 make v5 28124872704 layout=stripe sdar sdbr sdcp sddn sddz sdf sdfv
sdr
vxassist -g dg6 make v6 28124872704 layout=stripe sdas sdbs sdcq sddo sdea sdfw sdg
sds
```

```
vxassist -g dg7 make v7 28124872704 layout=stripe sdat sdbt sdcr sddp sdeb sdfx sdh
sdt
vxassist -g dg8 make v8 28124872704 layout=stripe sdau sdbu sdcs sddq sdec sdfy sdi
sdu
vxassist -g dg9 make v9 28124872704 layout=stripe sdav sdbv sdct sddr sded sdfz sdj
sdv
vxassist -g dg10 make v10 28124872704 layout=stripe sdaw sdbw sdcu sdds sdee sdga sdk
sdw
vxassist -g dg11 make v11 28124872704 layout=stripe sdax sdbx sdcv sddt sdef sdgb sdl
sdx
vxassist -g dg12 make v12 28124872704 layout=stripe sday sdby sdcw sddu sdeg sdgc sdm
sdy
addmap -gi 1 -hl 0 -dg dg1 -v v1
addmap -gi 1 -hl 1 -dg dg2 -v v2
addmap -gi 1 -hl 2 -dg dg3 -v v3
addmap -gi 1 -hl 3 -dg dg4 -v v4
addmap -gi 1 -hl 4 -dg dg5 -v v5
addmap -gi 1 -hl 5 -dg dg6 -v v6
addmap -gi 1 -hl 6 -dg dg7 -v v7
addmap -gi 1 -hl 7 -dg dg8 -v v8
addmap -gi 1 -hl 8 -dg dg9 -v v9
addmap -gi 1 -hl 9 -dg dg10 -v v10
addmap -gi 1 -hl 10 -dg dg11 -v v11
addmap -gi 1 -hl 11 -dg dg12 -v v12
```

4. Create Windows stripe volumes

The **doSPC.bat** script is executed from a command line window on the Host System and invokes the Windows Diskpart utility to perform the following:

- Convert disk type for MBR to GPT using **convertGPT.script**.
- Convert all Basic disks to Dynamic disks using **convertDynamic.script**.
- Create an aligned primary partition on each Dynamic disk using **align.script**.. Each primary partition will begin on the closest alignment boundary that is 32,768 MiB from the beginning of the Dynamic disk.
- Using **createVolumes.script**, create twenty unformatted, striped (RAID 0) volumes. Using 686,592 MiB of each of the twelve Dynamic disks and assign drive letters "F" to "Y" to the volumes. The twenty volumes comprise the SPC-1 Logical Volumes.

doSPC.bat

```
@echo ********************************************************
@echo * Warning make sure your boot device is PhysicalDrive 0 *
@echo ********************************************************
timeout /t 1 /NOBREAK
diskpart /s convertGPT.script
timeout /t 1 /NOBREAK
diskpart /s align.script
timeout /t 1 /NOBREAK
diskpart /s convertDynamic.script
timeout /t 1 /NOBREAK
diskpart /s createVolumes.script
```

convertGPT.script

```
select disk 1
convert gpt noerr
select disk 2
convert gpt noerr
select disk 3
convert gpt noerr
select disk 4
convert gpt noerr
select disk 5
convert gpt noerr
select disk 6
convert gpt noerr
select disk 7
convert gpt noerr
select disk 8
convert gpt noerr
select disk 9
convert gpt noerr
select disk 10
convert gpt noerr
select disk 11
convert gpt noerr
select disk 12
convert gpt noerr
```

align.script

```
select disk 1
create partition primary align=32768
select disk 2
create partition primary align=32768
select disk 3
create partition primary align=32768
select disk 4
create partition primary align=32768
select disk 5
create partition primary align=32768
select disk 6
create partition primary align=32768
select disk 7
create partition primary align=32768
select disk 8
create partition primary align=32768
select disk 9
create partition primary align=32768
select disk 10
create partition primary align=32768
select disk 11
create partition primary align=32768
select disk 12
create partition primary align=32768
```

convertDynamic.script

```
select disk 1
convert dynamic noerr
select disk 2
convert dynamic noerr
select disk 3
convert dynamic noerr
select disk 4
```

```
convert dynamic noerr
select disk 5
convert dynamic noerr
select disk 6
convert dynamic noerr
select disk 7
convert dynamic noerr
select disk 8
convert dynamic noerr
select disk 9
convert dynamic noerr
select disk 10
convert dynamic noerr
select disk 11
convert dynamic noerr
select disk 12
convert dynamic noerr
```

createVolumes.script

```
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=F
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=G
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=H
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=I
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=J
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=K
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=L
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=M
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=N
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=O
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=P
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=Q
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=R
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=S
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=T
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=U
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=V
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=W
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=X
create volume stripe size=686592 disk=1,2,3,4,5,6,7,8,9,10,11,12
assign letter=Y
```

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

Primary Metrics and Repeatability Tests

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

```
javaparms="-Xmx3000m -Xms1200m -Xss256k"
host=master
slaves=(slave1,slave2,slave3,slave4,slave5,slave6,slave7,slave8,slave9,slave10,slave
11,slave12,slave13,slave14,slave15,slave16,slave17,slave18,slave19,slave20,slave21,s
lave22,slave23,slave24,slave25,slave26,slave27,slave28,slave29,slave30,slave31,slave
32,slave33,slave34,slave35,slave36,slave37,slave38,slave39,slave40,slave41,slave42,s
lave43,slave44,slave45,slave46,slave47,slave48,slave49,slave50,slave51,slave52,slave
53,slave54,slave55,slave56,slave57,slave58,slave59,slave60,slave61)
sd=asu1_1,lun=\\.\F:,size=8046g
sd=asu1_2,lun=\\.\G:,size=8046g
sd=asu1_3,lun=\\.\H:,size=8046g
sd=asu1_4,lun=\\.\I:,size=8046g
sd=asu1_5,lun=\\.\J:,size=8046g
sd=asu1_6,lun=\\.\K:,size=8046g
sd=asu1_7,lun=\\.\L:,size=8046g
sd=asu1_8,lun=\\.\M:,size=8046g
sd=asu1_9,lun=\\.\N:,size=8046g
sd=asu2_1,lun=\\.\O:,size=8046g
sd=asu2_2,lun=\\.\P:,size=8046g
sd=asu2_3,lun=\\.\Q:,size=8046g
sd=asu2_4,lun=\\.\R:,size=8046g
sd=asu2_5,lun=\\.\S:,size=8046g
sd=asu2_6,lun=\\.\T:,size=8046g
sd=asu2_7,lun=\\.\U:,size=8046g
sd=asu2_8,lun=\\.\V:,size=8046g
sd=asu2_9,lun=\\.\W:,size=8046g
sd=asu3_1,lun=\\.\X:,size=8046g
sd=asu3_2,lun=\\.\Y:,size=8046g
```

Persistence Test

The content of SPC-2 Workload Generator command and parameter file, used in this benchmark to execute the Persistence Test, is listed below.

Persistence Test Run 1 (write phase)

```
host=localhost,jvms=8,maxstreams=300
sd=sd1,lun=\\.\F:,size=8046000000000
sd=sd2,lun=\\.\G:,size=8046000000000
sd=sd3,lun=\\.\H:,size=8046000000000
sd=sd4,lun=\\.\I:,size=8046000000000
sd=sd5,lun=\\.\J:,size=8046000000000
sd=sd6,lun=\\.\K:,size=8046000000000
sd=sd7,lun=\\.\L:,size=8046000000000
sd=sd8,lun=\\.\M:,size=8046000000000
sd=sd9,lun=\\.\N:,size=8046000000000
sd=sd10,lun=\\.\O:,size=8046000000000
sd=sd11,lun=\\.\P:,size=8046000000000
sd=sd12,lun=\\.\Q:,size=8046000000000
sd=sd13,lun=\\.\R:,size=8046000000000
sd=sd14,lun=\\.\S:,size=8046000000000
```

```
sd=sd15,lun=\\.\T:,size=8046000000000
sd=sd16,lun=\\.\U:,size=8046000000000
sd=sd17,lun=\\.\V:,size=8046000000000
sd=sd18,lun=\\.\W:,size=8046000000000
sd=sd19,lun=\\.\X:,size=8046000000000
sd=sd20,lun=\\.\Y:,size=8046000000000
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=TR1-248s_SPC-2-persist-w,streams=248
```

Persistence Test Run 2 (read phase)

```
host=localhost,jvms=8,maxstreams=300
sd=sd1,lun=\\.\F:,size=8046000000000
sd=sd2,lun=\\.\G:,size=8046000000000
sd=sd3,lun=\\.\H:,size=8046000000000
sd=sd4,lun=\\.\I:,size=8046000000000
sd=sd5,lun=\\.\J:,size=8046000000000
sd=sd6,lun=\\.\K:,size=8046000000000
sd=sd7,lun=\\.\L:,size=8046000000000
sd=sd8,lun=\\.\M:,size=8046000000000
sd=sd9,lun=\\.\N:,size=8046000000000
sd=sd10,lun=\\.\O:,size=8046000000000
sd=sd11,lun=\\.\P:,size=8046000000000
sd=sd12,lun=\\.\Q:,size=8046000000000
sd=sd13,lun=\\.\R:,size=8046000000000
sd=sd14,lun=\\.\S:,size=8046000000000
sd=sd15,lun=\\.\T:,size=8046000000000
sd=sd16,lun=\\.\U:,size=8046000000000
sd=sd17,lun=\\.\V:,size=8046000000000
sd=sd18,lun=\\.\W:,size=8046000000000
sd=sd19,lun=\\.\X:,size=8046000000000
sd=sd20,lun=\\.\Y:,size=8046000000000
maxlatestart=1
reportinginterval=5
segmentlength=512m
maxpersistenceerrors=10
rd=default,buffers=1,rdpct=100,xfersize=1024k
rd=TR1-248s_SPC-2-persist-r
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

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

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

```
@echo off
echo list volume >> volume.script
for /l %%i in (1 1 20) do (
 echo select volume %%i >> volume.script
 echo detail volume >>volume.script
)
diskpart /s volume.script >>partitionedhostsystem.txt
start host1.bat
cd "c:\spc\spc1"
java -Xmx3000m -Xms2048m metrics -b 6001
java -Xmx3000m -Xms2048m repeat1 -b 6001
java -Xmx3000m -Xms2048m repeat2 -b 6001
cd "c:\spc\spc2"
call spc2.bat -f persist1.cfg -o init -init
call spc2.bat -f persist1.cfg -o persist1
```

Persistence Test Run 2

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

```
@echo off
echo list volume >> volume_persist2.script
for /l %%i in (1 1 20) do (
 echo select volume %%i >> volume_persist2.script
 echo detail volume >>volume_persist2.script
)
diskpart /s volume_persist2.script >>partitionedhostsystemofpersist2.txt
cd "c:\spc\spc2"
call spc2.bat -f persist2.cfg -o persist2
```

Slave JVMs

The following scripts were used to start the Slave JVMs on each of the two Host Systems.

host1.bat

```
cd "C:\spc\spc1"
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave1.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave2.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave3.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave4.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave5.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave6.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave7.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave8.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave9.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave10.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave11.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave12.txt
```

```
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave13.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave14.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave15.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave16.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave17.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave18.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave19.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave20.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave21.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave22.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave23.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave24.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave25.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave26.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave27.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave28.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave29.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave30.txt
```

host2.bat

```
cd "c:\spc\spc1"
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave31.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave32.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave33.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave34.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave35.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave36.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave37.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave38.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave39.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave40.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave41.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave42.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave43.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave44.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave45.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave46.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave47.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave48.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave49.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave50.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave51.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave52.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave53.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave54.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave55.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave56.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave57.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave58.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave59.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave60.txt
start java -Xmx3000m -Xms1200m -Xss256k spc1 -f c:\spc\spc1\slave61.txt
```