



**SPC BENCHMARK 1™
FULL DISCLOSURE REPORT**

**MACROSAN TECHNOLOGIES CO., LTD.
MACROSAN MS5580**

SPC-1 V1.14

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AUDIT CERTIFICATION



Jacky Wang
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9th Floor, Tower B, Sanwei Mansion, No. 581 Huoju Avenue
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November 21, 2014

The SPC Benchmark 1™ Reported Data listed below for the MacroSAN MS5580 was produced in compliance with the SPC Benchmark 1™ v1.14 Remote Audit requirements.

SPC Benchmark 1™ v1.14 Reported Data	
Tested Storage Product (TSP) Name: MacroSAN MS5580	
Metric	Reported Result
SPC-1 IOPS™	271,047.22
SPC-1 Price-Performance	8.78CNY/SPC-1 IOPS™
Total ASU Capacity	5,000,000 GB
Data Protection Level	Protected 2 (Mirroring)
Total Price (including three-year maintenance)	2,381,050.00CNY
Currency Used	CNY
Target Country for availability, sales and support	China

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

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by information supplied by Macro SAN 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.
- The total Application Storage Unit (ASU) Capacity was filled with random data, using an auditor approved tool, prior to execution of the SPC-1 Tests.

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

AUDIT CERTIFICATION (CONT.)

MacroSAN MS5580
SPC-1 Audit Certification

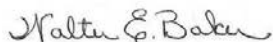
Page 2

- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by information supplied by Macro SAN Technologies Co., Ltd.:
 - ✓ The type of Host Systems 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 execution of each Test, Test Phase, and Test Run was found compliant with all of the requirements and constraints of Clauses 4, 5, and 11 of the SPC-1 Benchmark Specification.
- The Test Results Files and resultant Summary Results Files received from Macro SAN 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) and the Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH



Date: August 1, 2014

From: MacroSAN Technologies Co., Ltd.
581 Huoju Avenue
Hangzhou, China 310052

To: Walter E. Baker
SPC Administrator and Auditor
Storage Performance Council (SPC)
643 Bair Island Road, Suite 103
Redwood City, CA 94063-2755

Subject: SPC-1 Letter of Good Faith for the MacroSAN MS5580

MacroSAN 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 V1.14 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:

LI ZHI

2014-8-01

Li Zhi
President
MacroSAN Technologies Co., Ltd.

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	MacroSAN Technologies Co., Ltd. – http://www.macrosan.com/english/index.aspx Jacky Wang – wangdalong@mcrosan.com 9 th Floor, Tower B, Sanwei Mansion, No. 581 Huoju Avenue Binjiang District, Hangzhou, China Phone: +86 186 6803 0580 FAX: 0571-28182001
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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	V1.14
SPC-1 Workload Generator revision number	V2.3.0
Date Results were first used publicly	November 24, 2014
Date the FDR was submitted to the SPC	November 24, 2014
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	November 21, 2014

Tested Storage Product (TSP) Description

The MS5580 is a new-generation mid-range storage product launched by MacroSAN. It incorporates various advanced design ideas and architecture technologies and provides a secure and reliable storage platform that supports flexible resource deployment for small and medium-sized data centers. MacroSAN MS5580 provides a secure and reliable storage platform with high performance and flexible resource deployment for small and medium-sized data centers.

Regarding resource management, the MS5580 combines the cell-based virtualization technology to support flexible resource deployment through an innovative intelligent cell management technology (ICMT).

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: MacroSAN MS5580	
Metric	Reported Result
SPC-1 IOPS™	271,047.22
SPC-1 Price-Performance™	8.78CNY/SPC-1 IOPS™
Total ASU Capacity	5,000.000 GB
Data Protection Level	Protected 2 (<i>mirroring</i>)
Total Price	2,381,050.00 CNY
Currency Used	CNY
Target Country for availability, sales and support	China

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

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

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

A **Data Protection Level** of **Protected 2** using *Mirroring* configures two or more identical copies of user data.

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

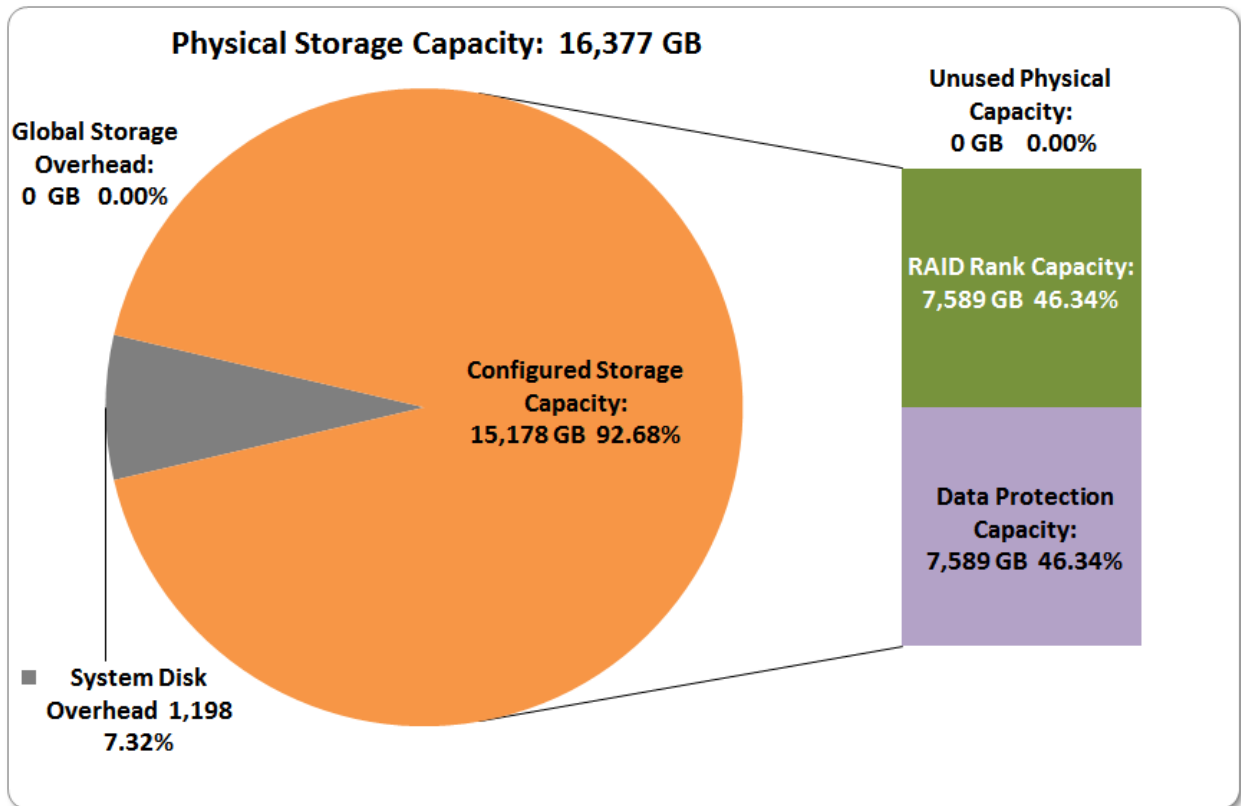
Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 16.

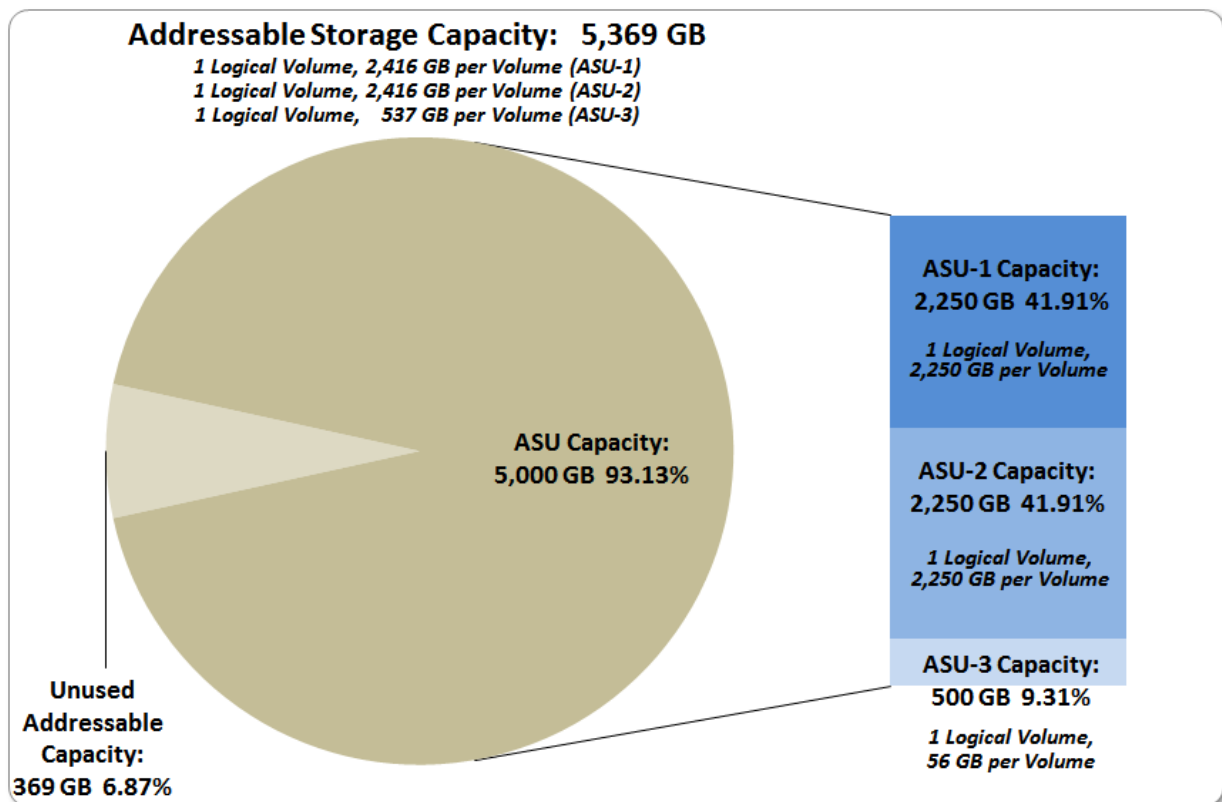
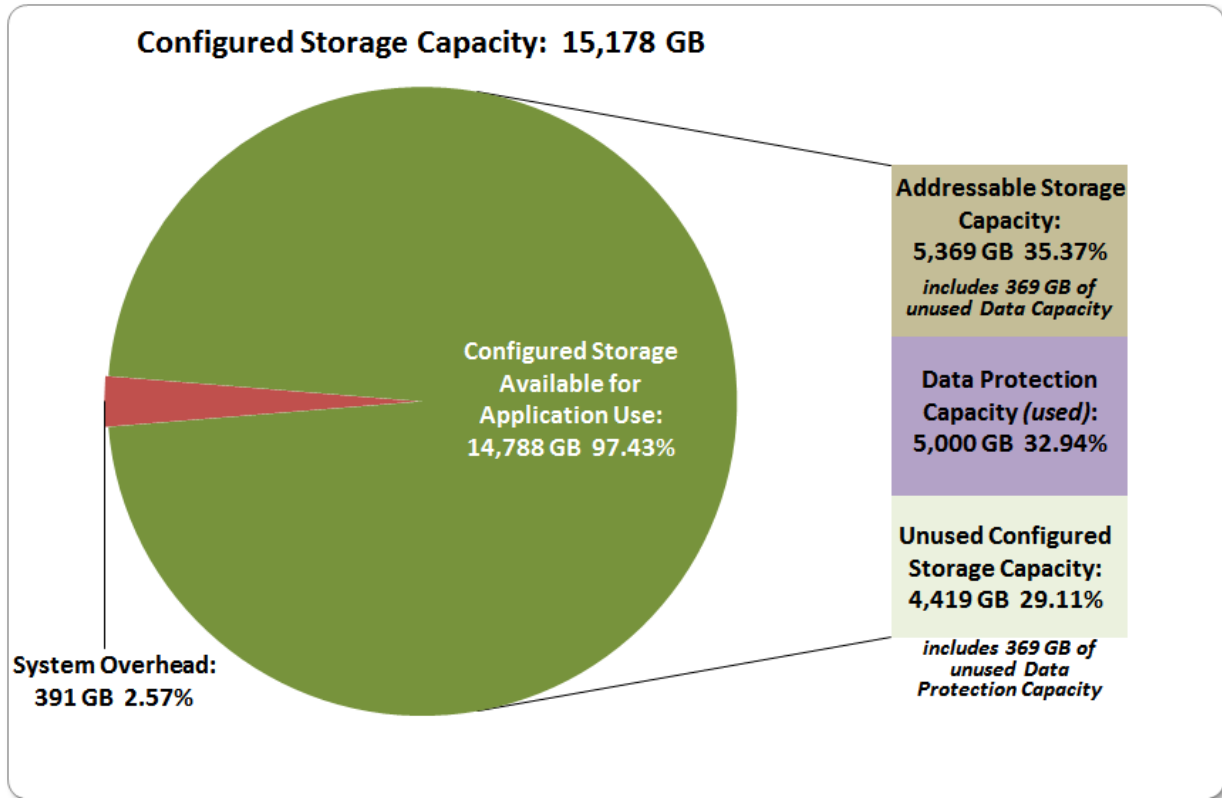
Currency Used is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country (*non-local currency*).

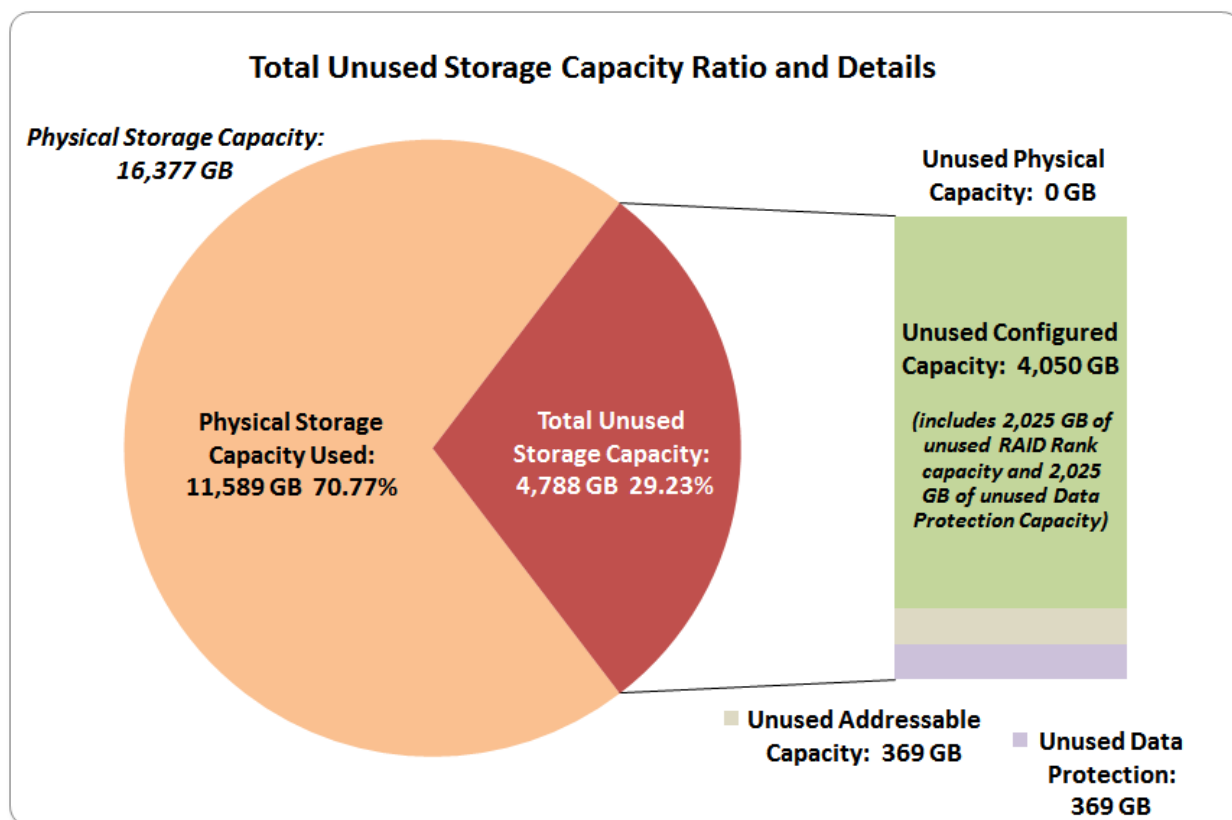
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

Storage Capacities, Relationships, and Utilization

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







SPC-1 Storage Capacity Utilization	
Application Utilization	30.53%
Protected Application Utilization	62.26%
Unused Storage Ratio	29.23%

Application Utilization: Total ASU Capacity (5,000.000 GB) divided by Physical Storage Capacity (16,376.710 GB).

Protected Application Utilization: Total ASU Capacity (5,000.000 GB) plus total Data Protection Capacity (7,589.207 GB) minus unused Data Protection Capacity (2,393.766 GB) divided by Physical Storage Capacity (16,376.710 GB).

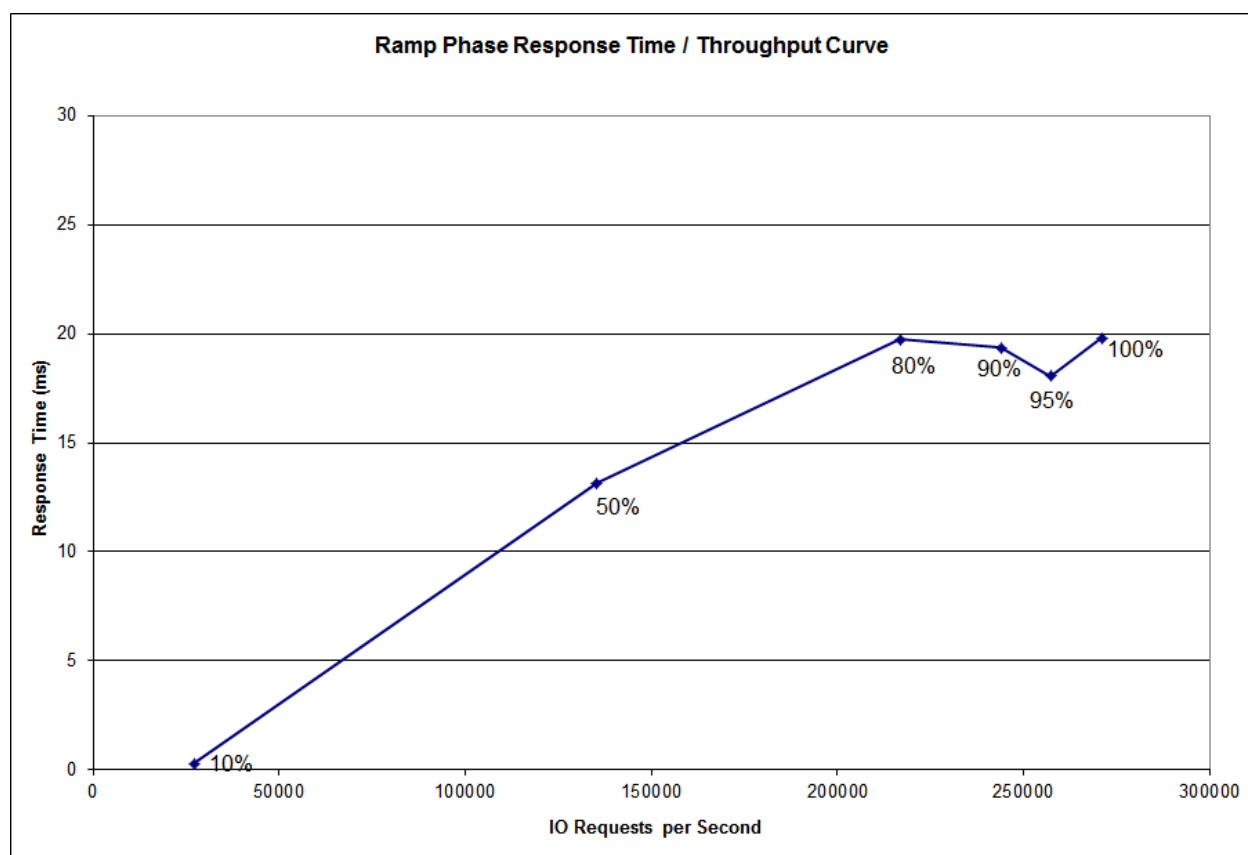
Unused Storage Ratio: Total Unused Capacity (4,787.572 GB) divided by Physical Storage Capacity (16,376.710 GB) and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 28-29.

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	27,088.30	135,464.98	216,805.12	243,897.27	257,442.15	271,047.22
Average Response Time (ms):						
All ASUs	0.28	13.15	19.73	19.37	18.07	19.79
ASU-1	0.28	13.36	20.23	19.82	18.48	20.22
ASU-2	0.28	13.35	20.23	19.84	18.44	20.22
ASU-3	0.29	12.62	18.46	18.20	17.04	18.69
Reads	0.29	13.17	20.07	19.64	18.29	19.97
Writes	0.28	13.14	19.51	19.19	17.93	19.67

Priced Storage Configuration Pricing

Part Number	Description	Qty	Unit Price/¥	Extended Price/¥	Discount	Discounted Price/¥
MacroSAN MS5580 Enterprise System						
Controll Module						
1020038	MS5580 Storage Processor Unit (Dual Controllers,AC,128GB Cache, with Battery Cache Protected Module)	1	1,600,000.00	1,600,000.00	85.00%	240,000.00
Disk Enclosure						
1020036	DSU1616(3U,2.5"/3.5",AC)	3	115,000.00	345,000.00	85.00%	51,750.00
Storage Devices						
1020004	Reserved Disk Suite (4*300GB 15K RPM 3.5" SAS Drive)	1	86,000.00	86,000.00	85.00%	12,900.00
2080054	200GB MLC SSD Drive(2.5")	44	150,000.00	6,600,000.00	85.00%	990,000.00
2080085	400GB MLC SSD Drive(2.5")	16	270,000.00	4,320,000.00	85.00%	648,000.00
IO Interface						
2080087	4*8Gbps Fibre Channel I/O modules (Total 4 ports)	4	60,000.00	240,000.00	85.00%	36,000.00
Storage Software						
7050316	MacroSAN Open Data Storage Platform MS5000 Storage System Management Software	1	700,000.00	700,000.00	85.00%	105,000.00
Accessory						
5040001	Patch Cord,DLC/PC-DLC/PC, Multimode,2mm-Parallel,5m	32	50.00	1,600.00	0.00%	1,600.00
FC Switch						
	Brocade300 8Gbps FC Switch with 24 available ports and 16 enabled ports, including 16*8Gbps SFPs, Single-Power Supply,AC	3	33,200.00	99,600.00	0.00%	99,600.00
Third Party						
	Qlogic QLE2562 HBA Card,PCIE,8Gbps DualPort,Fiber Channel Multimode LC Optic Interface	8	3,300.00	26,400.00	0.00%	26,400.00
Total of Product						2,211,250.00
Maintenance Support Service						
53010043	MS5580 Installation Base Service per Set	1	40,000.00	40,000.00	70.00%	12,000.00
53010044	Disk Enclosure Installation Base Service per Set	3	10,000.00	30,000.00	70.00%	9,000.00
53010018	MS5580 SPU Gold-Level 24x7x4H Service (Per Set*3Year)	1	240,000.00	240,000.00	70.00%	72,000.00
53010064	Disk Enclosure Gold-Level 24x7x4H Service (Per Set*3Year)	3	72,000.00	216,000.00	70.00%	64,800.00
	Brocade300 FC Switch 24x7x4H Service (Per Set*3Year), including Installation Base Service(Per Set)	2	6,000.00	12,000.00	0.00%	12,000.00
Total of Service(3 years)						169,800.00
Total Price						2,381,050.00

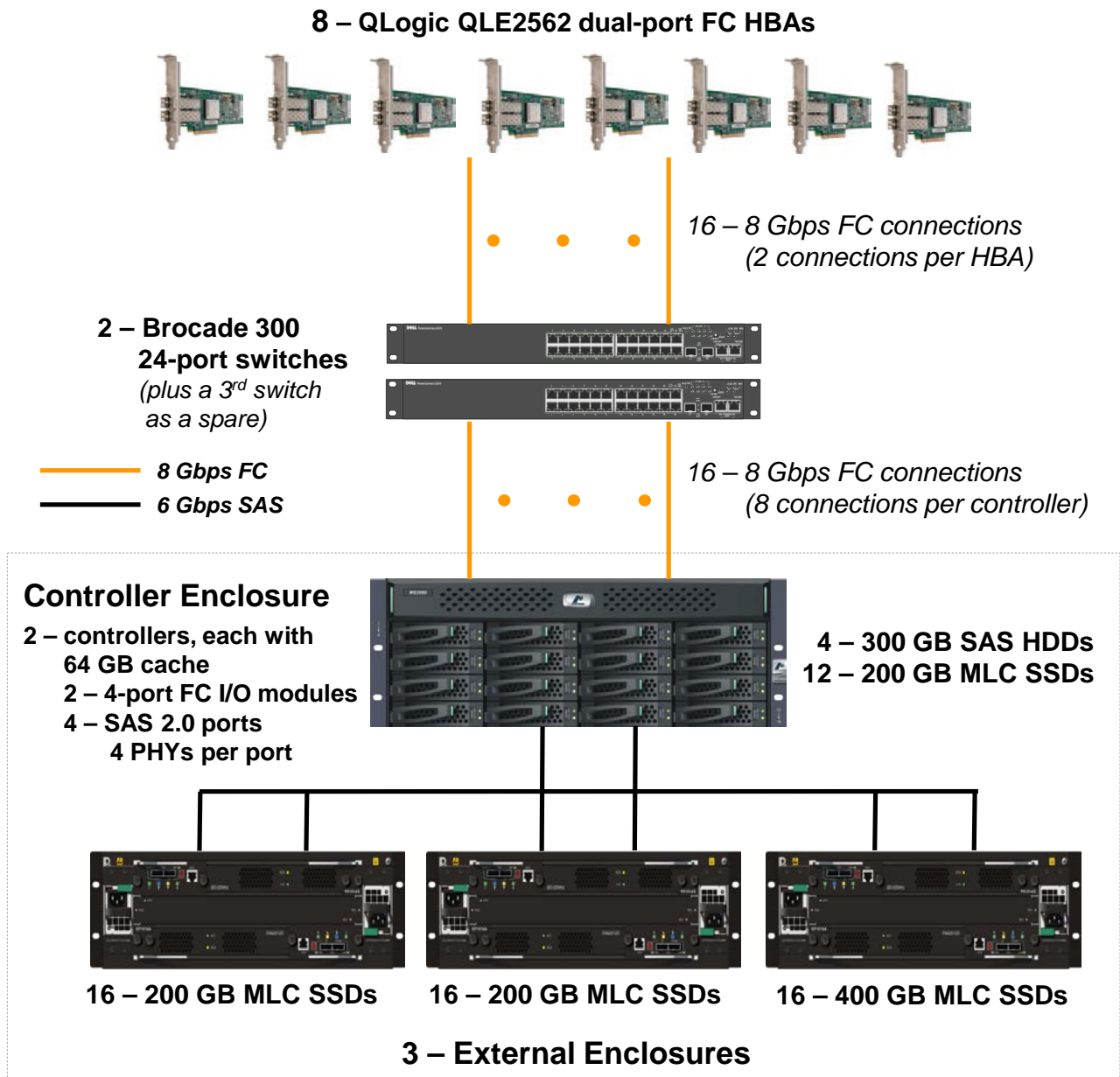
The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

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

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

A third 24-port FC switch was included in the Priced Storage Configuration as a spare to fulfill one of the requirements for a data protection level of [Protected 2](#).

Priced Storage Configuration Diagram



MacroSAN MS5580

Priced Storage Configuration Components

Priced Storage Configuration
8 – QLogic QLE2562 dual-port, 8 Gbps, FC HBAs
3 – Brocade 300 Fibre Channel 24-port switches with 16 ports enabled and SFPs included <i>(3rd switch included as a spare for Protected 2 requirement)</i>
MacroSAN MS5580
1 – Controller Enclosure with 2 – controllers, each controller includes: 64 GB cache <i>(128 GB total)</i> 2 – 4-port Fibre Channel I/O modules <i>(4 modules total, 16 ports total, 16 ports used)</i> 4 – SAS 2.0 ports, 4 6Gbps PHYs per port <i>(16 PHYs total)</i> <i>(8 ports total, 32 PHYs total, 4 ports/16 PHYs used)</i> 4 – 300GB SAS disk drives (HDDs) <i>(system disks)</i> 12 – 200GB MLC SSD drives
3 – External Enclosures <i>(2 enclosures, each with 16 200GB MLC SSDs)</i> <i>(1 enclosures, with 16 400GB MLC SSDs)</i>
4 – 300 GB SAS disk drives (HDDs) 44 – 200 GB MLC SSDs 16 – 400GB MLC SSDs <i>(HDDs and SSDs distributed as documented above)</i>

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

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

Clause 9.4.3.4.3

The FDR will contain a table that lists the major components of each Host System and the Tested Storage Configuration (TSC).

The Host System(s) and TSC table of components may be found on page [24](#) ([Host System\(s\) and Tested Storage Configuration \(TSC\) Table of Components](#)).

Storage Network Configuration

Clause 9.4.3.4.1

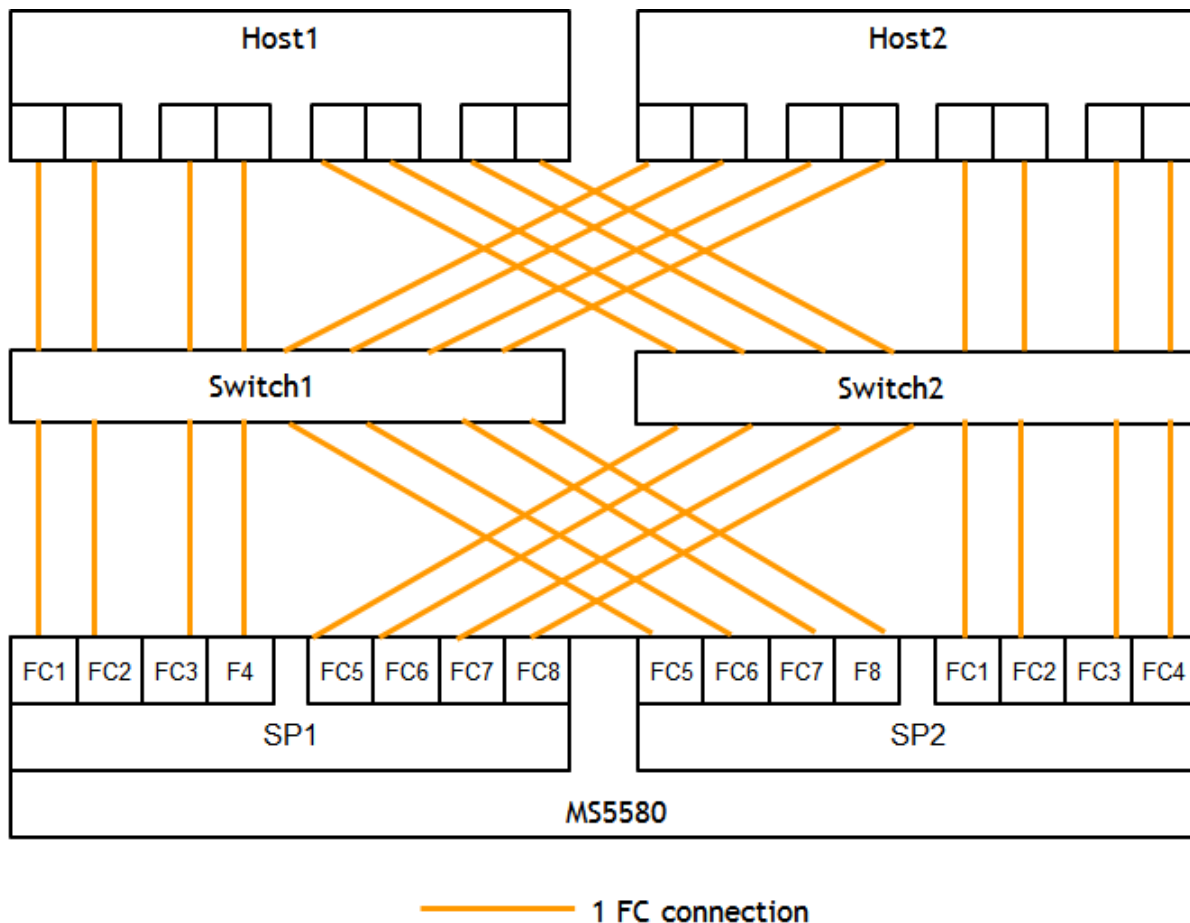
...

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.

Storage Network Diagram



Zone Configuration

Switch 1

Effective configuration:

cfg: spc1_5580_config_1

```
zone: x1      21:00:00:24:ff:2f:89:0d
              21:00:00:24:ff:41:dd:19
              50:0b:34:20:01:27:22:01
```

```
zone: x11     21:00:00:24:ff:2f:89:0d
              21:00:00:24:ff:41:dd:19
              50:0b:34:20:01:25:da:01
```

```
zone: x2      21:00:00:24:ff:2f:89:0c
              21:00:00:24:ff:41:dd:18
              50:0b:34:20:01:27:22:02
```

```
zone: x22     21:00:00:24:ff:2f:89:0c
              21:00:00:24:ff:41:dd:18
              50:0b:34:20:01:25:da:02
```

```
zone: x3      21:00:00:24:ff:2f:88:fd
              21:00:00:24:ff:37:0b:81
              50:0b:34:20:01:27:22:03
```

```
zone: x33     21:00:00:24:ff:2f:88:fd
              21:00:00:24:ff:37:0b:81
              50:0b:34:20:01:25:da:03
```

```
zone: x4      21:00:00:24:ff:2f:88:fc
              21:00:00:24:ff:37:0b:80
              50:0b:34:20:01:27:22:04
```

```
zone: x44     21:00:00:24:ff:2f:88:fc
              21:00:00:24:ff:37:0b:80
              50:0b:34:20:01:25:da:04
```

Switch 2

Effective configuration:

cfg: spc1_5580_config_2

```
zone: x1      21:00:00:24:ff:2f:88:f2
              50:01:43:80:12:06:d2:4a
              50:0b:34:20:01:27:22:05
```

```
zone: x11     21:00:00:24:ff:2f:88:f2
              50:01:43:80:12:06:d2:4a
              50:0b:34:20:01:25:da:05
```

```
zone: x2      21:00:00:24:ff:2f:88:f3
              50:01:43:80:12:06:d2:48
              50:0b:34:20:01:27:22:06
```

```
zone: x22     21:00:00:24:ff:2f:88:f3
              50:01:43:80:12:06:d2:48
              50:0b:34:20:01:25:da:06
```

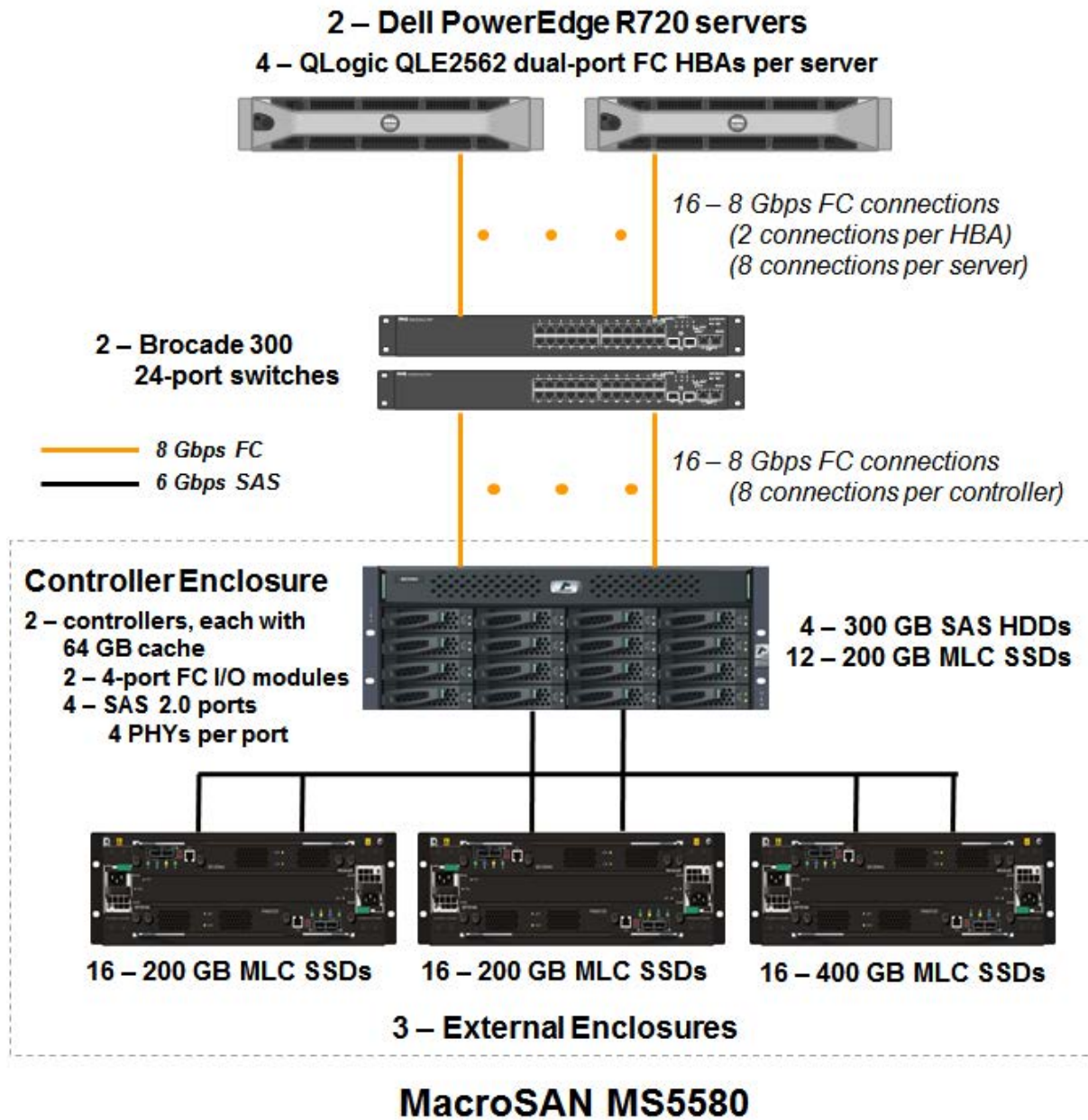
```
zone:  x3      21:00:00:24:ff:41:dd:a3
              50:01:43:80:06:2d:66:30
              50:0b:34:20:01:27:22:07

zone:  x33     21:00:00:24:ff:41:dd:a3
              50:01:43:80:06:2d:66:30
              50:0b:34:20:01:25:da:07

zone:  x4      21:00:00:24:ff:41:dd:a2
              50:01:43:80:06:2d:66:32
              50:0b:34:20:01:27:22:08

zone:  x44     21:00:00:24:ff:41:dd:a2
              50:01:43:80:06:2d:66:32
              50:0b:34:20:01:25:da:08
```

Benchmark Configuration/Tested Storage Configuration Diagram



Host System and Tested Storage Configuration Components

Host Systems
<p>2 – Dell PowerEdge R720 servers, each with:</p> <ul style="list-style-type: none"> 2 – Intel® Xeon® E5-2643-0 processors 3.30 GHz each with 4 cores, 10 MB Intel® Smart Cache 16 GB main memory Red Hat Enterprise Linux Server release 6.2 x86_64 PCIe
Priced Storage Configuration
8 – QLogic QLE2562 dual-port, 8 Gbps, FC HBAs
2 – Brocade 300 Fibre Channel 24-port switches with 16 ports enabled and SFPs included
MacroSAN MS5580
<p>1 – Controller Enclosure with</p> <ul style="list-style-type: none"> 2 – controllers, each controller includes: <ul style="list-style-type: none"> 64 GB cache (<i>128 GB total</i>) 2 – 4-port Fibre Channel I/O modules (<i>4 modules total, 16 ports total, 16 ports used</i>) 4 – SAS 2.0 ports, 4 6Gbps PHYs per port (<i>16 PHYs total, 8 ports total, 32 PHYs total, 4 ports/16 PHYs used</i>) 4 – 300GB SAS disk drives (HDDs) (<i>system disks</i>) 12 – 200GB MLC SSD drives
<p>3 – External Enclosures</p> <ul style="list-style-type: none"> (<i>2 enclosures, each with 16 200GB MLC SSDs</i>) (<i>1 enclosures, with 16 400GB MLC SSDs</i>)
<ul style="list-style-type: none"> 4 – 300 GB SAS disk drives (HDDs) 44 – 200 GB MLC SSDs 16 – 400GB MLC SSDs (<i>HDDs and SSDs distributed as documented above</i>)

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 69 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 70 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 78.

ASU Pre-Fill

Clause 5.3.3

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

The configuration file used to complete the required ASU pre-fill appears in [Appendix D: SPC-1 Workload Generator Storage Commands and Parameters](#) on page 78.

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 [65](#) contains definitions of terms specific to the SPC-1 Data Repository.

Storage Capacities and Relationships

Clause 9.4.3.6.1

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

SPC-1 Storage Capacities

The Physical Storage Capacity consisted of 1,198.296 GB distributed over 4 disk drives (HDDs), each with a formatted capacity of 299.574 GB, 8,787.503 GB distributed over 44 solid state storage devices (SSDs), each with a formatted capacity of 199.716 GB, and 6,390.911 GB distributed over 16 solid state storage devices (SSDs), each with a formatted capacity of 399.432 GB, for a total of 16,376.710 GB. There was 0.00 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0.00 GB (0.00%) of the Physical Storage Capacity. There was 4,050.070 GB (26.68%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 93.13% of the Addressable Storage Capacity resulting in 368.751 GB (6.87%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*mirroring*) capacity was 7,589.207 GB of which 5,000.000 GB was utilized. The total Unused Storage capacity was 4,787.572 GB.

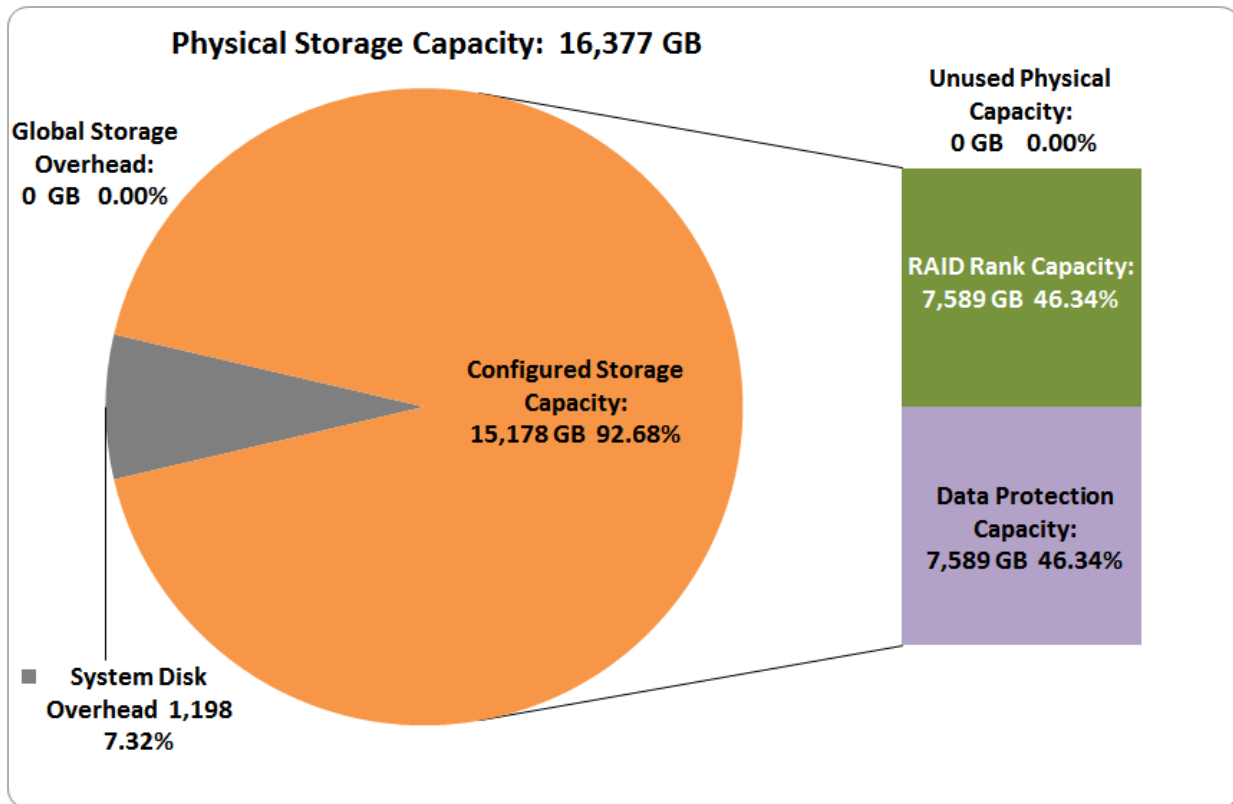
Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.

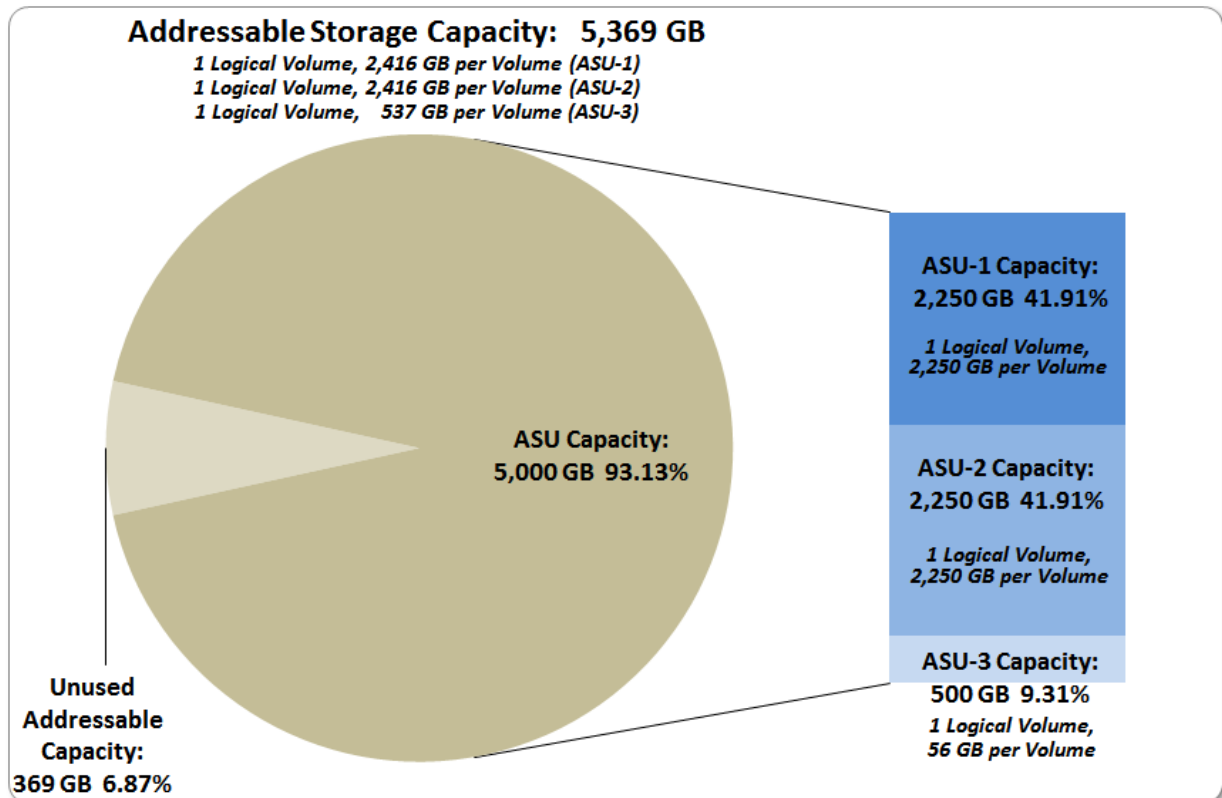
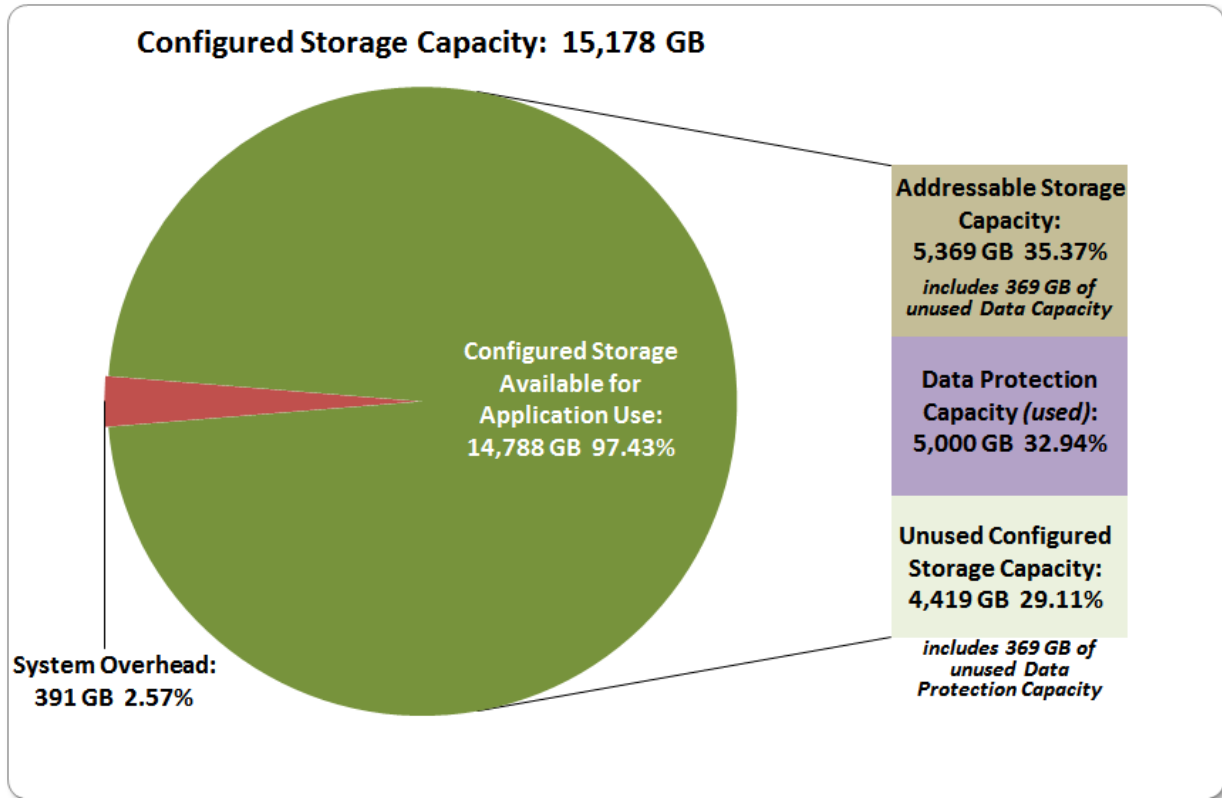
SPC-1 Storage Capacities		
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	5,000.000
Addressable Storage Capacity	Gigabytes (GB)	5,368.751
Configured Storage Capacity	Gigabytes (GB)	15,178.414
Physical Storage Capacity	Gigabytes (GB)	16,376.710
Data Protection (<i>Mirroring</i>)	Gigabytes (GB)	7,589.207
Required Storage (<i>system overhead</i>)	Gigabytes (GB)	1,589.138
Global Storage Overhead	Gigabytes (GB)	0.000
Total Unused Storage	Gigabytes (GB)	4,787.572

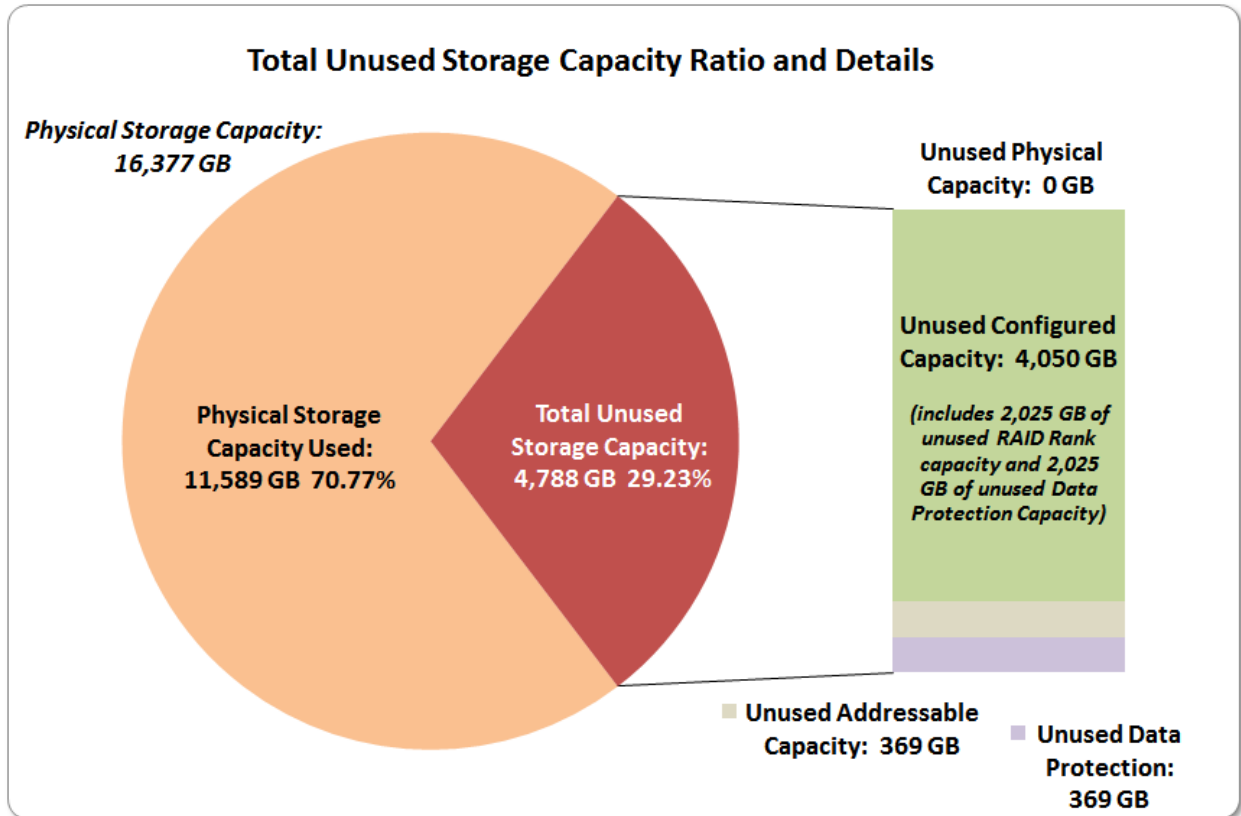
SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	93.13%	32.94%	32.94%
Required for Data Protection (<i>Mirroring</i>)		50.00%	50.00%
Addressable Storage Capacity		35.37%	35.37%
Required Storage (<i>system overhead</i>)		10.47%	9.70%
Configured Storage Capacity			92.68%
Global Storage Overhead			0.00%
Unused Storage:			
Addressable	6.87%		
Configured		26.68%	
Physical			0.00%

SPC-1 Storage Capacity Charts







Storage Capacity Utilization

Clause 9.4.3.6.2

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

Clause 2.8.1

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

Clause 2.8.2

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

Clause 2.8.3

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

SPC-1 Storage Capacity Utilization	
Application Utilization	30.53%
Protected Application Utilization	62.26%
Unused Storage Ratio	29.23%

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 (2,250.000 GB)	ASU-2 (2,250.000 GB)	ASU-3 (500.000 GB)
1 Logical Volume 2,415.919 GB per Logical Volume (2,250.000GB used per Logical Volume)	1 Logical Volume 2,415.919 GB per Logical Volume (2,250.000GB used per Logical Volume)	1 Logical Volume 536.913 GB per Logical Volume (500.000 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was [Protected 2](#) using *Mirroring* as described on page [11](#). See “ASU Configuration” in the [IOPS Test Results File](#) for more detailed configuration information.

SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. An [SPC-1 glossary](#) on page 65 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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

SPC-1 Tests, Test Phases, and Test Runs

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

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

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

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

“Ramp-Up” Test Runs

Clause 5.3.13

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

Clause 5.3.13.3

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

Clause 9.4.3.7.1

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

There were no “Ramp-Up” Test Runs executed in this set of SPC-1 audited measurements.

Primary Metrics Test – Sustainability Test Phase

Clause 5.4.4.1.1

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

Clause 5.4.4.1.2

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

Clause 5.4.4.1.4

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

Clause 9.4.3.7.2

For the Sustainability Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page 80.

Sustainability Test Results File

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

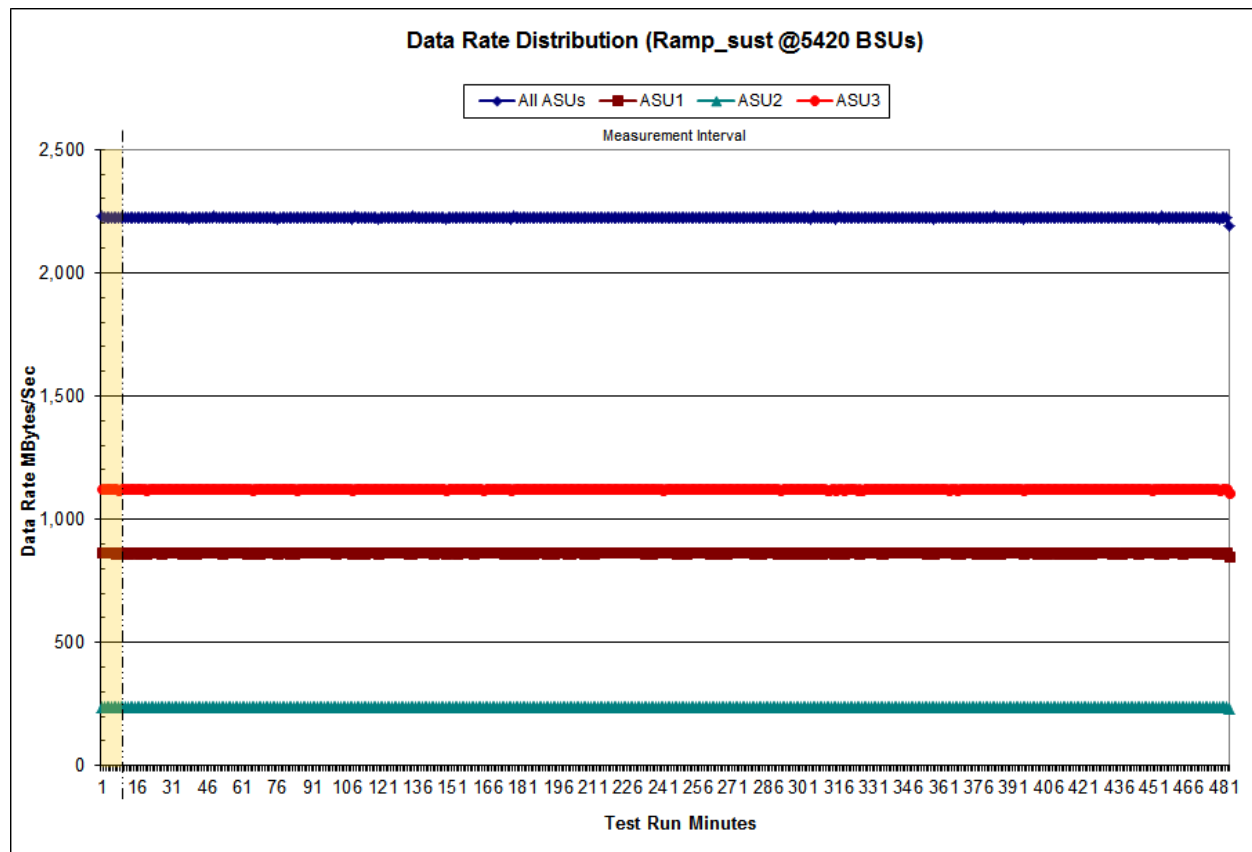
[Sustainability Test Results File](#)

Sustainability – Data Rate Distribution Data (MB/second)

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

[Sustainability Data Rate Table](#)

Sustainability – Data Rate Distribution Graph

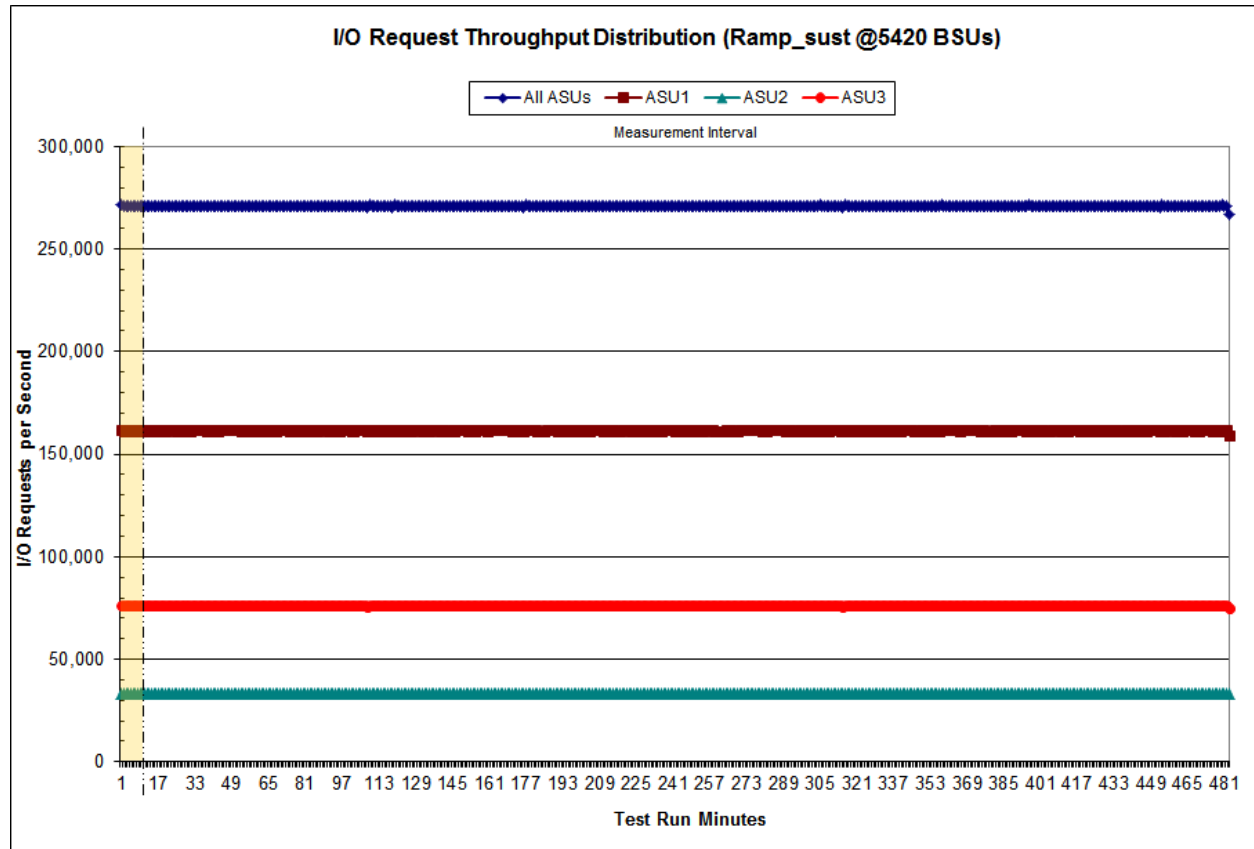


Sustainability – I/O Request Throughput Distribution Data

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

[Sustainability I/O Request Throughput Table](#)

Sustainability – I/O Request Throughput Distribution Graph

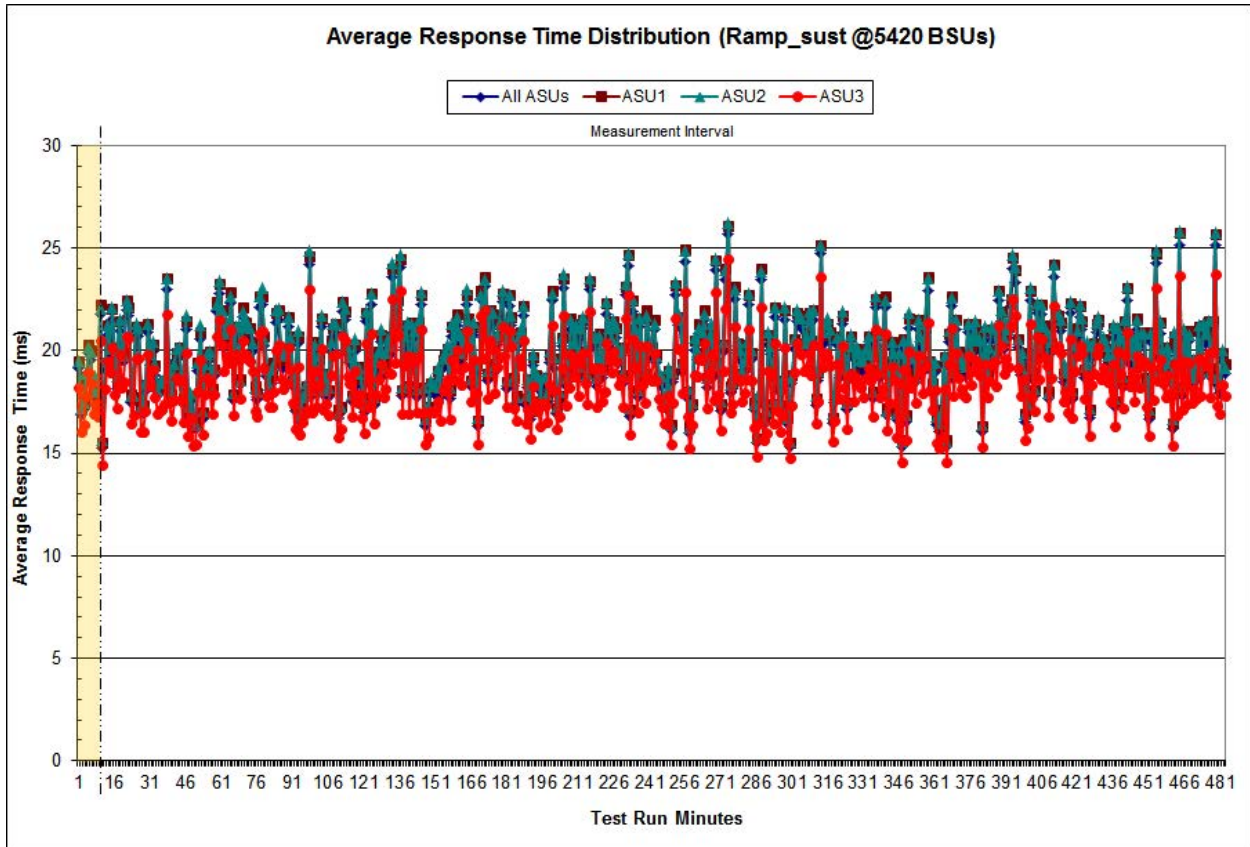


Sustainability – Average Response Time (ms) Distribution Data

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

[Sustainability Average Response Time Table](#)

Sustainability – Average Response Time (ms) Distribution Graph



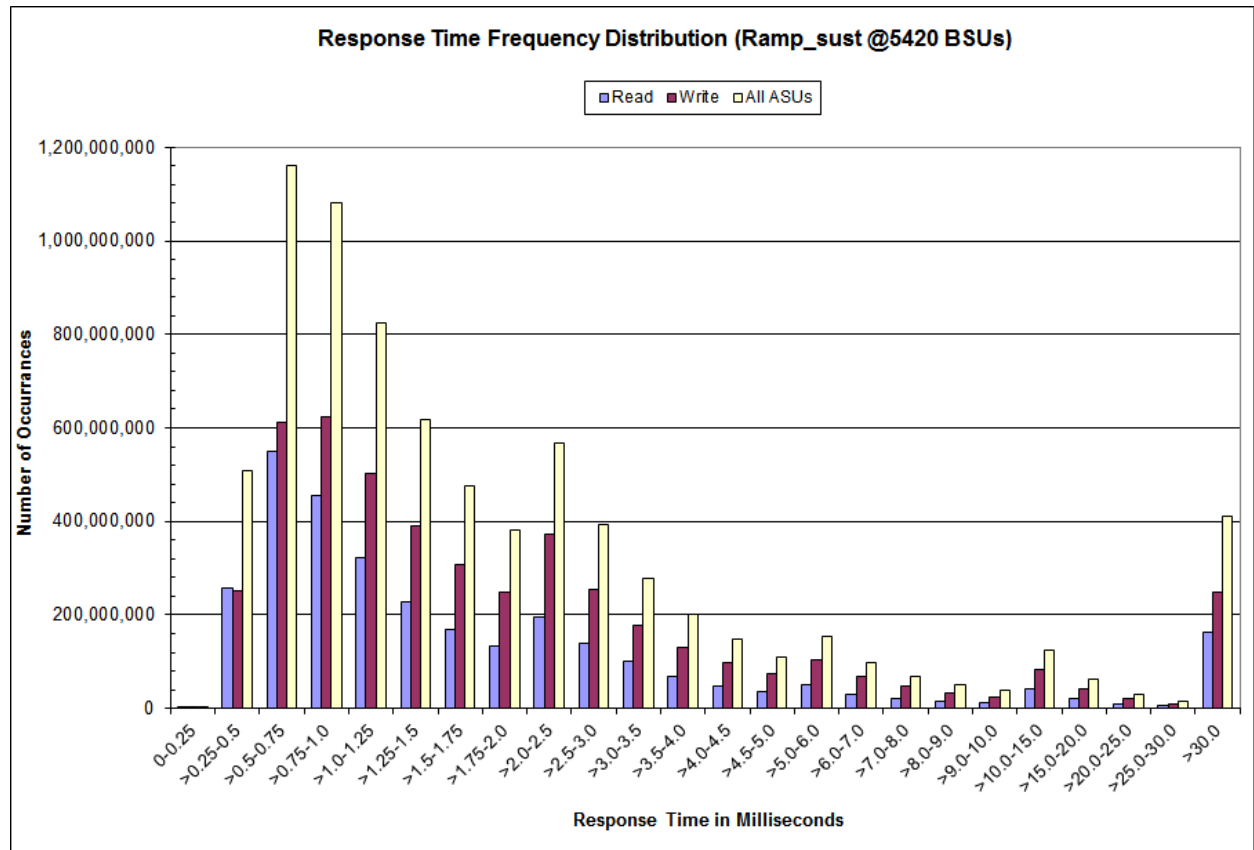
Sustainability – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	995,815	258,408,329	550,191,144	456,347,881	321,442,057	228,702,229	169,810,165	132,234,128
Write	1,324,055	250,327,671	612,402,076	625,082,749	502,859,862	389,123,205	306,588,361	248,553,974
All ASUs	2,319,870	508,736,000	1,162,593,220	1,081,430,630	824,301,919	617,825,434	476,398,526	380,788,102
ASU1	1,570,190	345,228,342	747,079,630	656,589,645	483,834,917	356,103,311	271,571,626	215,404,200
ASU2	365,466	65,803,330	148,166,812	135,159,803	101,337,457	75,041,351	57,430,816	45,648,659
ASU3	384,214	97,704,328	267,346,778	289,681,182	239,129,545	186,680,772	147,396,084	119,735,243

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	195,425,119	138,718,937	99,838,489	69,045,041	48,798,418	36,078,774	49,465,332	31,079,418
Write	372,301,654	253,612,399	178,821,596	131,449,223	98,241,305	74,994,285	104,682,888	67,916,352
All ASUs	567,726,773	392,331,336	278,660,085	200,494,264	147,039,723	111,073,059	154,148,220	98,995,770
ASU1	319,586,808	222,041,343	158,401,729	112,998,112	82,311,707	62,065,451	86,319,759	55,583,847
ASU2	67,791,748	47,140,400	33,932,814	24,329,582	17,695,235	13,270,774	18,348,351	11,722,415
ASU3	180,348,217	123,149,593	86,325,542	63,166,570	47,032,781	35,736,834	49,480,110	31,689,508

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	21,112,452	15,908,670	12,940,801	41,575,696	22,119,368	10,130,293	5,087,025	162,611,194
Write	46,674,111	33,725,485	25,601,447	81,851,070	41,547,156	19,835,547	9,326,791	249,621,947
All ASUs	67,786,563	49,634,155	38,542,248	123,426,766	63,666,524	29,965,840	14,413,816	412,233,141
ASU1	38,382,195	28,659,767	22,822,169	75,047,971	37,315,695	17,360,790	8,414,038	246,797,552
ASU2	7,987,518	5,827,220	4,532,420	14,459,899	7,588,437	3,590,612	1,744,638	51,072,661
ASU3	21,416,850	15,147,168	11,187,659	33,918,896	18,762,392	9,014,438	4,255,140	114,362,928

Sustainability – Response Time Frequency Distribution Graph



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

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

Primary Metrics Test – IOPS Test Phase

Clause 5.4.4.2

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

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

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

Clause 9.4.3.7.3

For the IOPS Test Phase the FDR shall contain:

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [80](#).

IOPS Test Results File

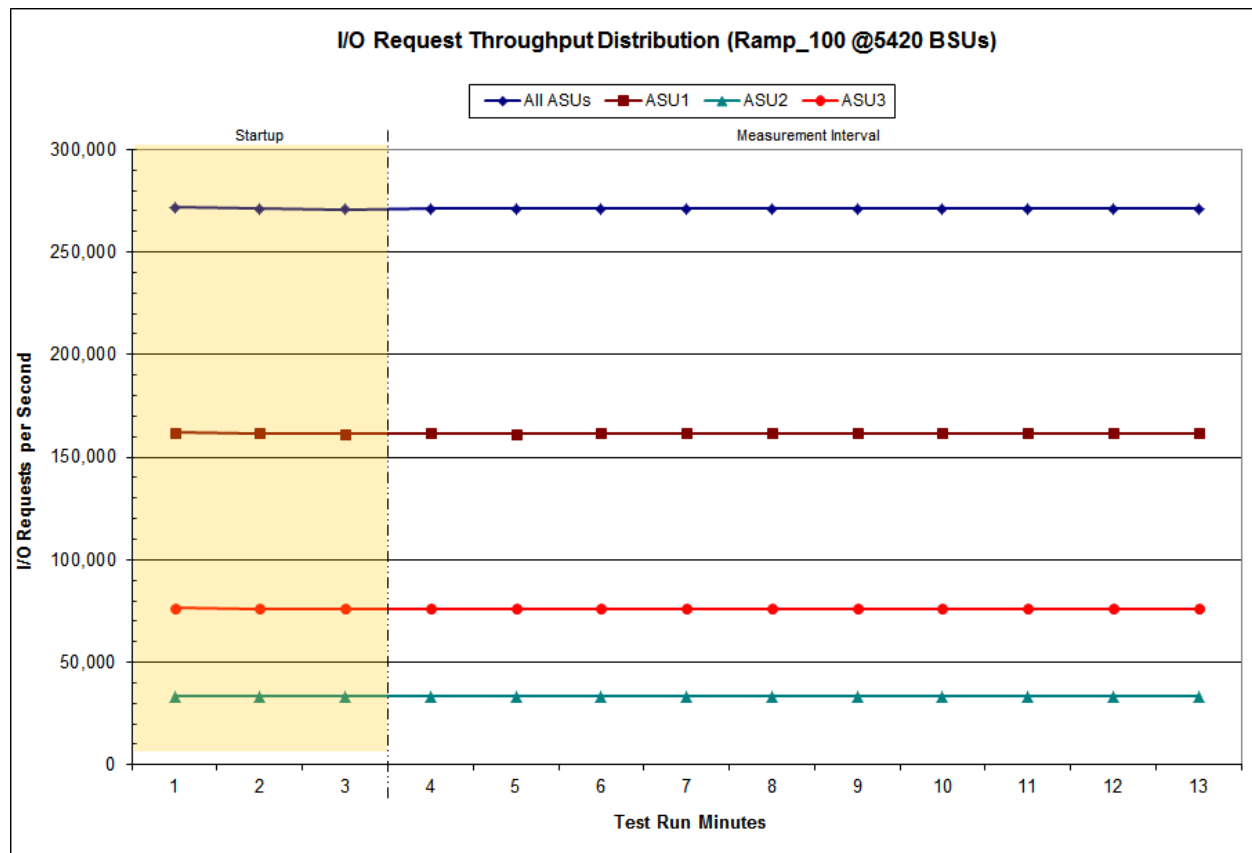
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

IOPS Test Run – I/O Request Throughput Distribution Data

5,240 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	16:16:14	16:19:15	0-2	0:03:01
<i>Measurement Interval</i>	16:19:15	16:29:15	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	271,656.50	161,893.15	33,415.18	76,348.17
1	271,113.13	161,614.65	33,358.78	76,139.70
2	270,907.22	161,457.07	33,307.37	76,142.78
3	270,998.43	161,516.67	33,334.85	76,146.92
4	270,971.05	161,491.13	33,311.35	76,168.57
5	271,078.97	161,558.03	33,338.32	76,182.62
6	270,997.35	161,564.27	33,329.27	76,103.82
7	271,061.28	161,559.15	33,316.00	76,186.13
8	271,131.97	161,562.70	33,383.12	76,186.15
9	271,023.93	161,561.23	33,291.08	76,171.62
10	271,074.42	161,577.07	33,361.05	76,136.30
11	271,055.17	161,544.80	33,343.23	76,167.13
12	271,079.63	161,553.18	33,341.73	76,184.72
Average	271,047.22	161,548.82	33,335.00	76,163.40

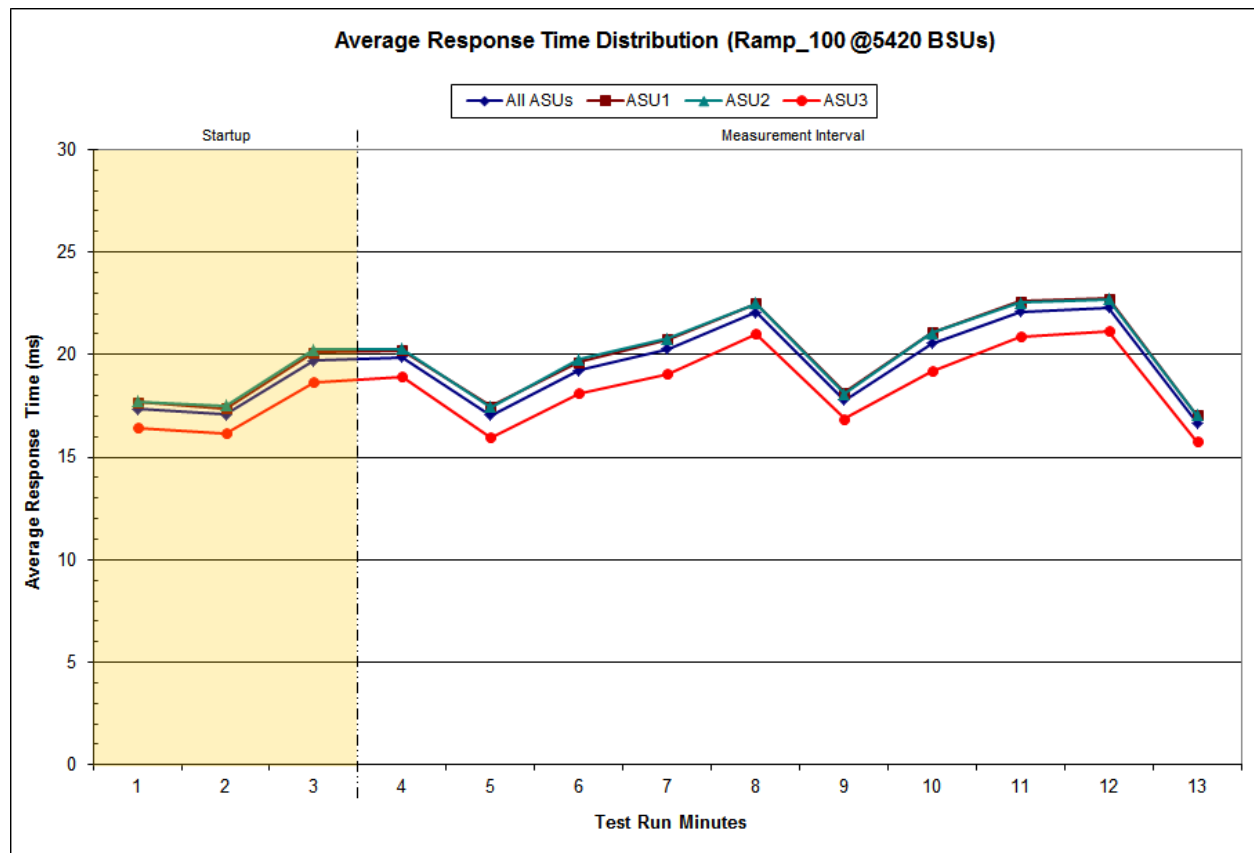
IOPS Test Run – I/O Request Throughput Distribution Graph



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

5,240 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	16:16:14	16:19:15	0-2	0:03:01
<i>Measurement Interval</i>	16:19:15	16:29:15	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	17.34	17.68	17.70	16.45
1	17.06	17.38	17.51	16.18
2	19.71	20.10	20.25	18.65
3	19.86	20.21	20.27	18.93
4	17.05	17.48	17.44	15.96
5	19.23	19.65	19.76	18.13
6	20.28	20.74	20.79	19.07
7	22.07	22.48	22.50	21.02
8	17.79	18.16	18.08	16.86
9	20.54	21.08	21.05	19.18
10	22.11	22.60	22.54	20.87
11	22.28	22.73	22.69	21.16
12	16.68	17.04	17.04	15.75
Average	19.79	20.22	20.22	18.69

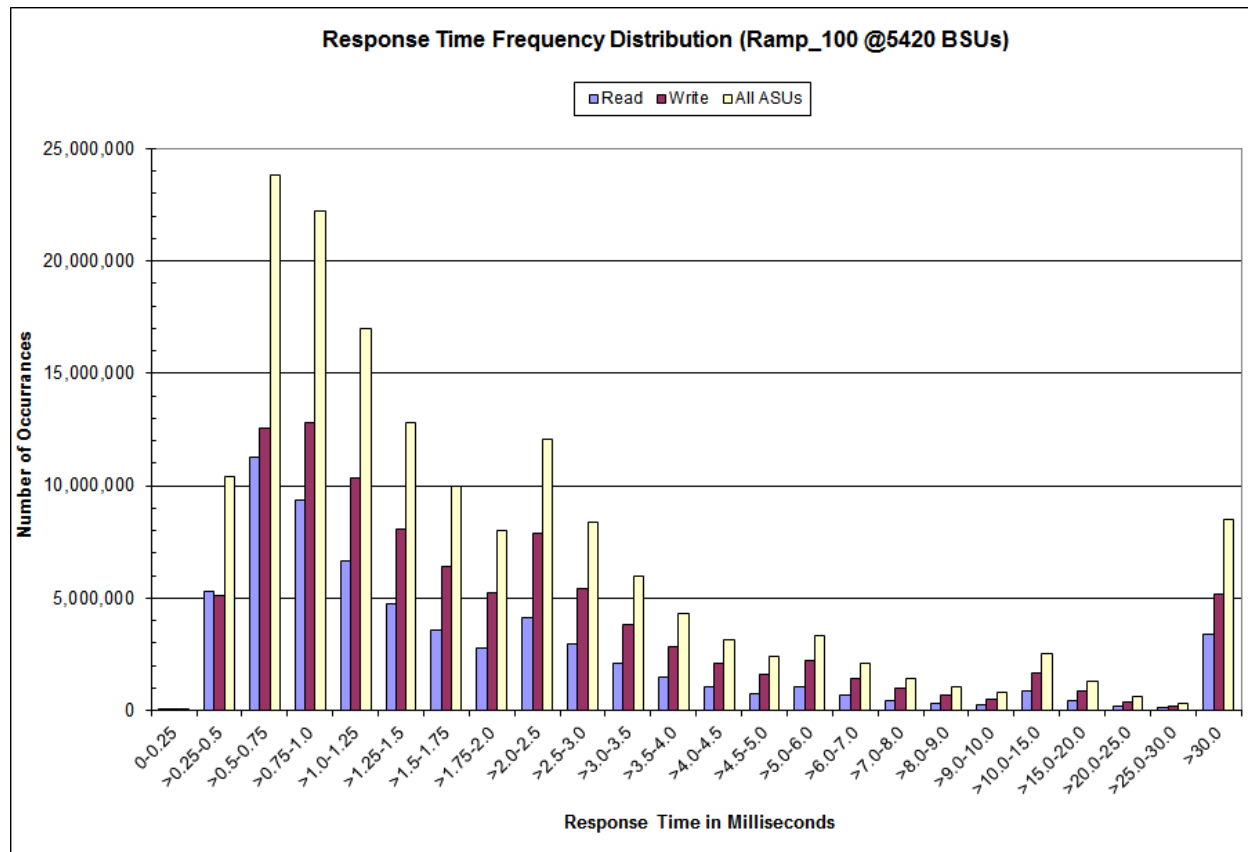
IOPS Test Run – Average Response Time (ms) Distribution Graph



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	22,616	5,312,631	11,285,318	9,389,286	6,654,270	4,771,603	3,572,012	2,790,910
Write	26,768	5,118,485	12,531,667	12,809,042	10,342,938	8,060,580	6,406,307	5,237,964
All ASUs	49,384	10,431,116	23,816,985	22,198,328	16,997,208	12,832,183	9,978,319	8,028,874
ASU1	34,110	7,090,805	15,314,428	13,487,216	9,989,123	7,407,512	5,697,127	4,546,027
ASU2	7,584	1,345,910	3,033,235	2,775,403	2,088,835	1,562,163	1,202,743	962,954
ASU3	7,690	1,994,401	5,469,322	5,935,709	4,919,250	3,862,508	3,078,449	2,519,893
Response Time (ms)	>2.0-2.5	>2.5-3.0	>3.0-3.5	>3.5-4.0	>4.0-4.5	>4.5-5.0	>5.0-6.0	>6.0-7.0
Read	4,144,848	2,950,700	2,132,147	1,478,525	1,046,650	773,360	1,063,051	664,934
Write	7,894,992	5,429,301	3,855,133	2,847,194	2,123,691	1,615,723	2,245,109	1,439,690
All ASUs	12,039,840	8,380,001	5,987,280	4,325,719	3,170,341	2,389,083	3,308,160	2,104,624
ASU1	6,778,794	4,737,595	3,399,647	2,431,178	1,772,260	1,333,781	1,851,437	1,182,939
ASU2	1,438,794	1,008,242	728,841	525,307	381,616	285,576	394,211	250,081
ASU3	3,822,252	2,634,164	1,858,792	1,369,234	1,016,465	769,726	1,062,512	671,604
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	449,378	339,246	278,529	878,340	456,867	212,393	104,470	3,364,874
Write	977,162	701,183	528,082	1,678,536	857,262	407,305	191,642	5,159,842
All ASUs	1,426,540	1,040,429	806,611	2,556,876	1,314,129	619,698	296,112	8,524,716
ASU1	808,768	603,370	480,969	1,564,608	773,207	360,902	173,041	5,106,917
ASU2	169,628	122,099	95,236	300,629	156,259	74,443	35,624	1,054,848
ASU3	448,144	314,960	230,406	691,639	384,663	184,353	87,447	2,362,951

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
162,622,556	154,097,840	8,524,716

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2811	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.001	0.002	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 15.

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

Clause 9.4.3.7.4

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [80](#).

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

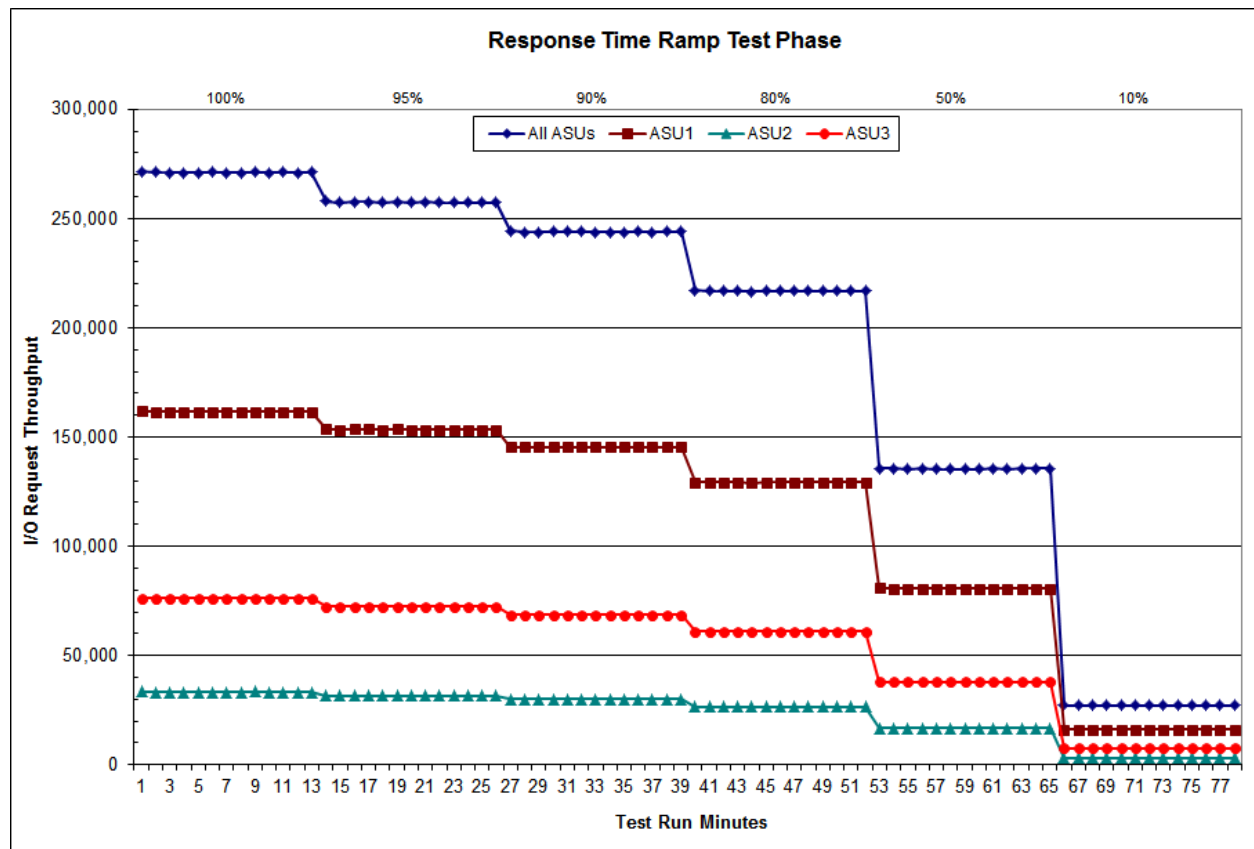
The five Test Runs that comprise the Response Time Ramp Phase are executed at 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit (BSU) load level used to produce the SPC-1 IOPS™ primary metric. The 100% BSU load level is included in the following Response Time Ramp data table and graph for completeness.

100% Load Level: 5,420 BSUs					95% Load Level: 5,149 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:16:14	16:19:15	0-3	0:03:01	Start-Up/Ramp-Up	16:29:30	16:32:31	0-3	0:03:01
Measurement Interval	16:19:15	16:29:15	3-12	0:10:00	Measurement Interval	16:32:31	16:42:31	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	271,656.50	161,893.15	33,415.18	76,348.17	0	257,833.87	153,612.98	31,717.15	72,503.73
1	271,113.13	161,614.65	33,358.78	76,139.70	1	257,436.18	153,386.47	31,657.38	72,392.33
2	270,907.22	161,457.07	33,307.37	76,142.78	2	257,528.42	153,558.87	31,685.82	72,283.73
3	270,998.43	161,516.67	33,334.85	76,146.92	3	257,488.83	153,509.18	31,677.23	72,302.42
4	270,971.05	161,491.13	33,311.35	76,168.57	4	257,377.03	153,419.00	31,683.95	72,274.08
5	271,078.97	161,558.03	33,338.32	76,182.62	5	257,537.02	153,515.57	31,697.67	72,323.78
6	270,997.35	161,564.27	33,329.27	76,103.82	6	257,457.98	153,413.60	31,662.13	72,382.25
7	271,061.28	161,559.15	33,316.00	76,186.13	7	257,544.03	153,461.47	31,655.40	72,427.17
8	271,131.97	161,562.70	33,383.12	76,186.15	8	257,428.27	153,434.73	31,694.50	72,299.03
9	271,023.93	161,561.23	33,291.08	76,171.62	9	257,457.02	153,474.23	31,651.48	72,331.30
10	271,074.42	161,577.07	33,361.05	76,136.30	10	257,422.30	153,396.15	31,691.50	72,334.65
11	271,055.17	161,544.80	33,343.23	76,167.13	11	257,376.30	153,357.87	31,664.00	72,354.43
12	271,079.63	161,553.18	33,341.73	76,184.72	12	257,332.70	153,357.88	31,636.95	72,337.87
Average	271,047.22	161,548.82	33,335.00	76,163.40	Average	257,442.15	153,433.97	31,671.48	72,336.70
90% Load Level: 4,878 BSUs					80% Load Level: 4,376 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:42:45	16:45:46	0-3	0:03:01	Start-Up/Ramp-Up	16:55:58	16:58:59	0-3	0:03:01
Measurement Interval	16:45:46	16:55:46	3-12	0:10:00	Measurement Interval	16:58:59	17:08:59	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	244,316.30	145,562.68	30,050.25	68,703.37	0	217,276.62	129,468.37	26,734.83	61,073.42
1	243,863.73	145,405.60	29,985.58	68,472.55	1	216,717.12	129,160.12	26,660.90	60,896.10
2	243,802.75	145,281.85	30,001.22	68,519.68	2	216,837.20	129,261.32	26,651.60	60,924.28
3	243,907.88	145,428.57	29,955.62	68,523.70	3	216,939.87	129,319.12	26,696.75	60,924.00
4	244,018.60	145,420.28	30,039.52	68,558.80	4	216,705.90	129,059.80	26,680.05	60,966.05
5	243,932.32	145,388.22	30,004.57	68,539.53	5	216,770.77	129,165.88	26,702.48	60,902.40
6	243,849.97	145,344.15	29,970.77	68,535.05	6	216,827.85	129,231.18	26,676.30	60,920.37
7	243,800.13	145,309.28	30,000.82	68,490.03	7	216,896.00	129,263.50	26,707.33	60,925.17
8	243,840.47	145,370.18	29,984.52	68,485.77	8	216,762.95	129,225.00	26,637.58	60,900.37
9	243,942.17	145,449.17	29,968.58	68,524.42	9	216,814.05	129,240.62	26,660.78	60,912.65
10	243,877.22	145,302.30	30,028.28	68,546.63	10	216,819.98	129,231.12	26,645.88	60,942.98
11	243,902.22	145,403.75	30,004.00	68,494.47	11	216,758.87	129,207.30	26,651.92	60,899.65
12	243,901.68	145,342.65	29,983.12	68,575.92	12	216,754.98	129,196.05	26,673.45	60,885.48
Average	243,897.27	145,375.86	29,993.98	68,527.43	Average	216,805.12	129,213.96	26,673.25	60,917.91

Response Time Ramp Distribution (IOPS) Data (continued)

50% Load Level: 2,710 BSUs					10% Load Level: 542 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:09:08	17:12:09	0-3	0:03:01	Start-Up/Ramp-Up	17:22:15	17:25:16	0-3	0:03:01
Measurement Interval	17:12:09	17:22:09	3-12	0:10:00	Measurement Interval	17:25:16	17:35:16	3-12	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	135,645.70	80,888.88	16,688.65	38,068.17	0	27,158.28	16,194.25	3,339.08	7,624.95
1	135,507.33	80,784.47	16,684.07	38,038.80	1	27,091.87	16,154.10	3,332.18	7,605.58
2	135,433.00	80,714.63	16,670.53	38,047.83	2	27,068.42	16,131.83	3,330.80	7,605.78
3	135,482.12	80,779.83	16,658.00	38,044.28	3	27,086.15	16,164.75	3,322.78	7,598.62
4	135,436.30	80,695.45	16,666.27	38,074.58	4	27,093.15	16,158.62	3,319.75	7,614.78
5	135,469.27	80,777.02	16,643.55	38,048.70	5	27,085.77	16,152.32	3,327.75	7,605.70
6	135,458.40	80,763.55	16,656.55	38,038.30	6	27,132.82	16,164.42	3,335.60	7,632.80
7	135,420.98	80,716.15	16,672.32	38,032.52	7	27,078.13	16,133.60	3,330.20	7,614.33
8	135,491.78	80,780.00	16,643.13	38,068.65	8	27,068.22	16,134.60	3,330.68	7,602.93
9	135,423.22	80,723.65	16,648.97	38,050.60	9	27,105.87	16,162.52	3,334.48	7,608.87
10	135,479.60	80,755.08	16,631.65	38,092.87	10	27,088.28	16,140.08	3,322.75	7,625.45
11	135,512.53	80,792.22	16,655.92	38,064.40	11	27,081.30	16,139.87	3,343.42	7,598.02
12	135,475.60	80,747.48	16,675.13	38,052.98	12	27,063.28	16,134.22	3,322.27	7,606.80
Average	135,464.98	80,753.04	16,655.15	38,056.79	Average	27,088.30	16,148.50	3,328.97	7,610.83

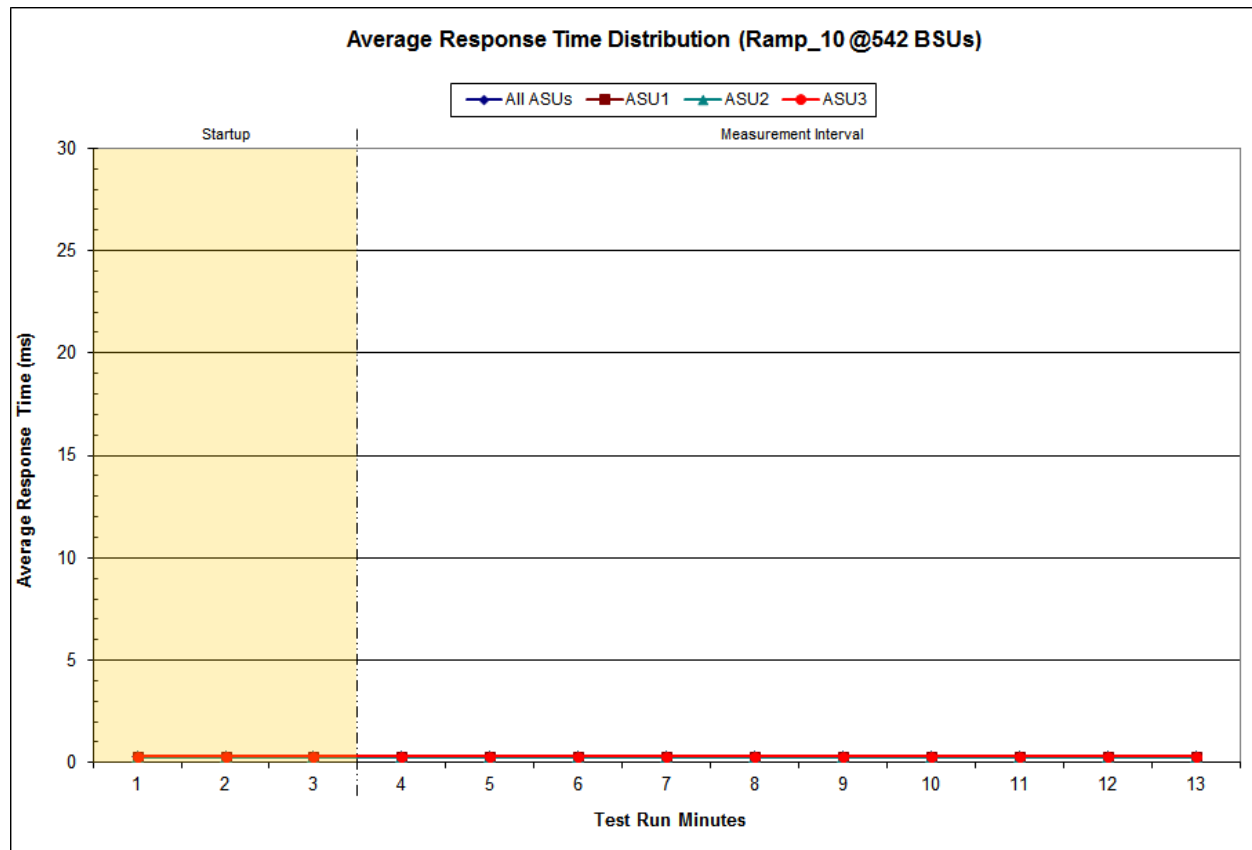
Response Time Ramp Distribution (IOPS) Graph



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

524 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:22:15	17:25:16	0-2	0:03:01
<i>Measurement Interval</i>	17:25:16	17:35:16	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.28	0.28	0.28	0.29
1	0.28	0.28	0.28	0.29
2	0.28	0.28	0.28	0.29
3	0.28	0.28	0.28	0.29
4	0.28	0.28	0.28	0.29
5	0.28	0.28	0.28	0.29
6	0.28	0.28	0.28	0.29
7	0.28	0.28	0.28	0.29
8	0.28	0.28	0.28	0.29
9	0.28	0.28	0.28	0.29
10	0.28	0.28	0.28	0.29
11	0.28	0.28	0.28	0.29
12	0.28	0.28	0.28	0.29
Average	0.28	0.28	0.28	0.29

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0351	0.2809	0.0700	0.2101	0.0180	0.0700	0.0349	0.2810
COV	0.005	0.001	0.002	0.002	0.006	0.003	0.003	0.001

Repeatability Test

Clause 5.4.5

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

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

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

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

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

Clause 9.4.3.7.5

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [80](#).

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	271,047.22
Repeatability Test Phase 1	270,985.48
Repeatability Test Phase 2	270,989.94

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

	SPC-1 LRT™
Primary Metrics	0.28 ms
Repeatability Test Phase 1	0.28 ms
Repeatability Test Phase 2	0.28 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 plus 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 \(IOPS\)](#)

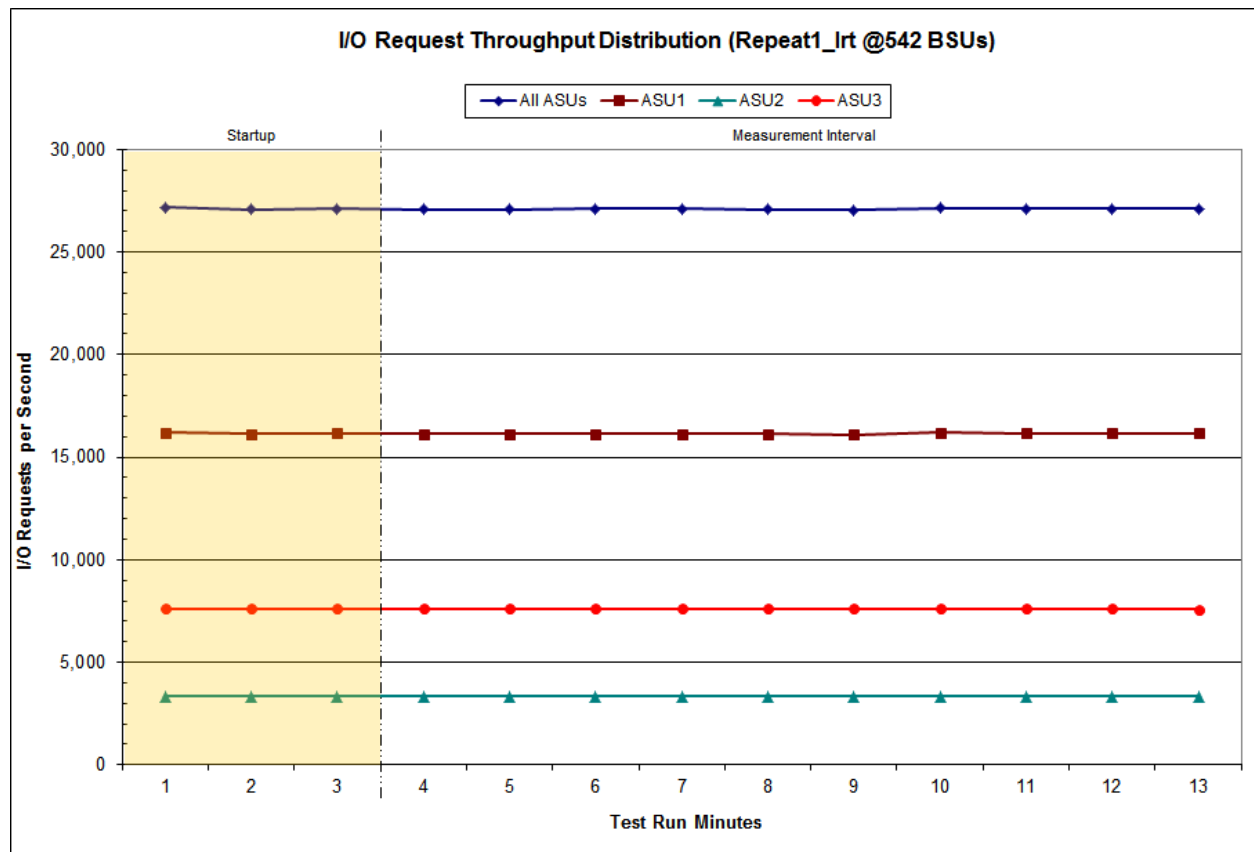
[Repeatability Test Phase 2, Test Run 1 \(LRT\)](#)

[Repeatability Test Phase 2, Test Run 2 \(IOPS\)](#)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

524 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:35:27	17:38:27	0-2	0:03:00
<i>Measurement Interval</i>	17:38:27	17:48:27	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	27,163.10	16,209.13	3,335.27	7,618.70
1	27,090.03	16,128.02	3,343.98	7,618.03
2	27,100.27	16,162.65	3,334.15	7,603.47
3	27,092.17	16,138.87	3,332.17	7,621.13
4	27,080.50	16,145.20	3,329.02	7,606.28
5	27,096.83	16,148.52	3,325.90	7,622.42
6	27,096.30	16,143.97	3,328.88	7,623.45
7	27,076.58	16,130.77	3,326.67	7,619.15
8	27,047.08	16,099.32	3,337.88	7,609.88
9	27,144.32	16,183.28	3,334.87	7,626.17
10	27,108.42	16,162.05	3,320.50	7,625.87
11	27,111.18	16,165.28	3,332.93	7,612.97
12	27,096.17	16,163.10	3,343.48	7,589.58
Average	27,094.96	16,148.04	3,331.23	7,615.69

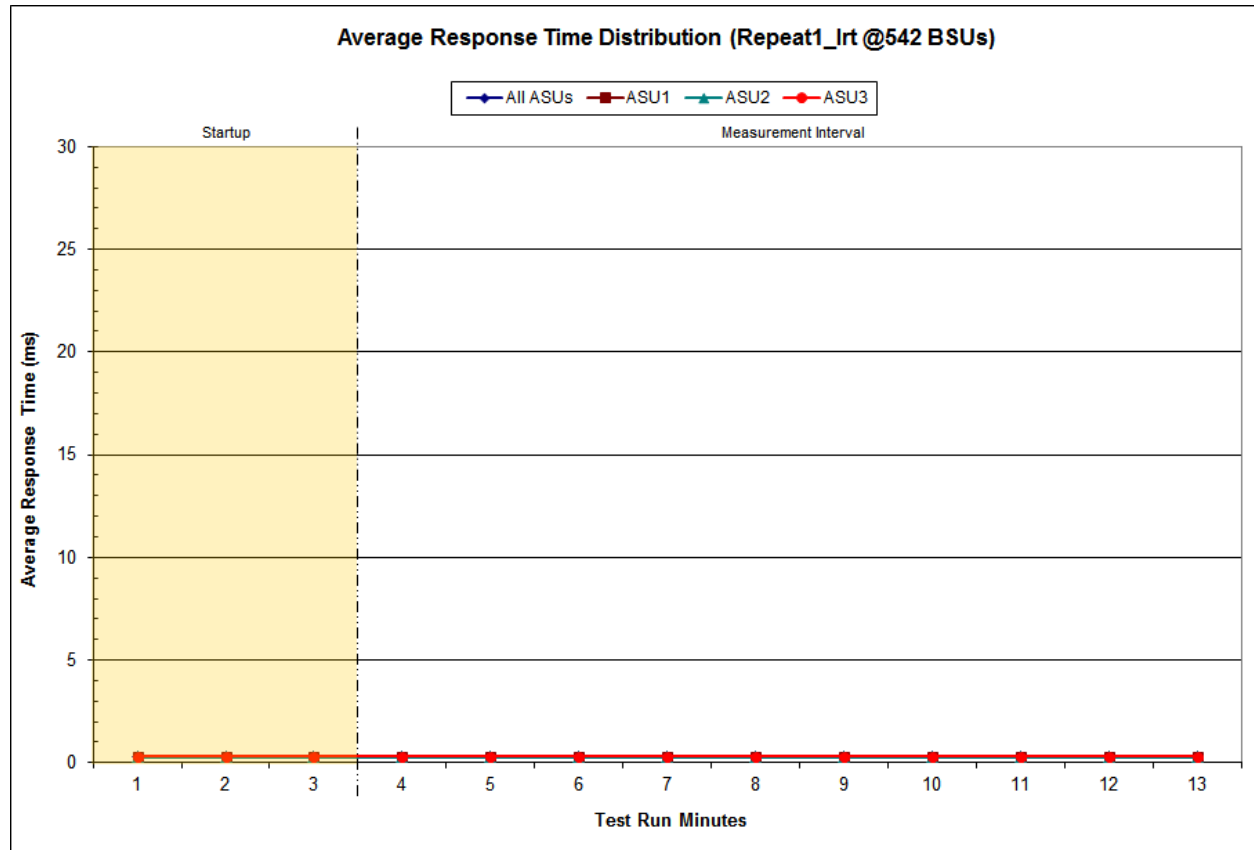
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

524 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:35:27	17:38:27	0-2	0:03:00
<i>Measurement Interval</i>	17:38:27	17:48:27	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.28	0.28	0.28	0.29
1	0.28	0.28	0.28	0.29
2	0.28	0.28	0.28	0.29
3	0.28	0.28	0.28	0.29
4	0.28	0.28	0.28	0.29
5	0.28	0.28	0.28	0.29
6	0.28	0.28	0.28	0.29
7	0.28	0.28	0.28	0.29
8	0.28	0.28	0.28	0.29
9	0.28	0.28	0.28	0.29
10	0.28	0.28	0.28	0.29
11	0.28	0.28	0.28	0.29
12	0.28	0.28	0.28	0.29
Average	0.28	0.28	0.28	0.29

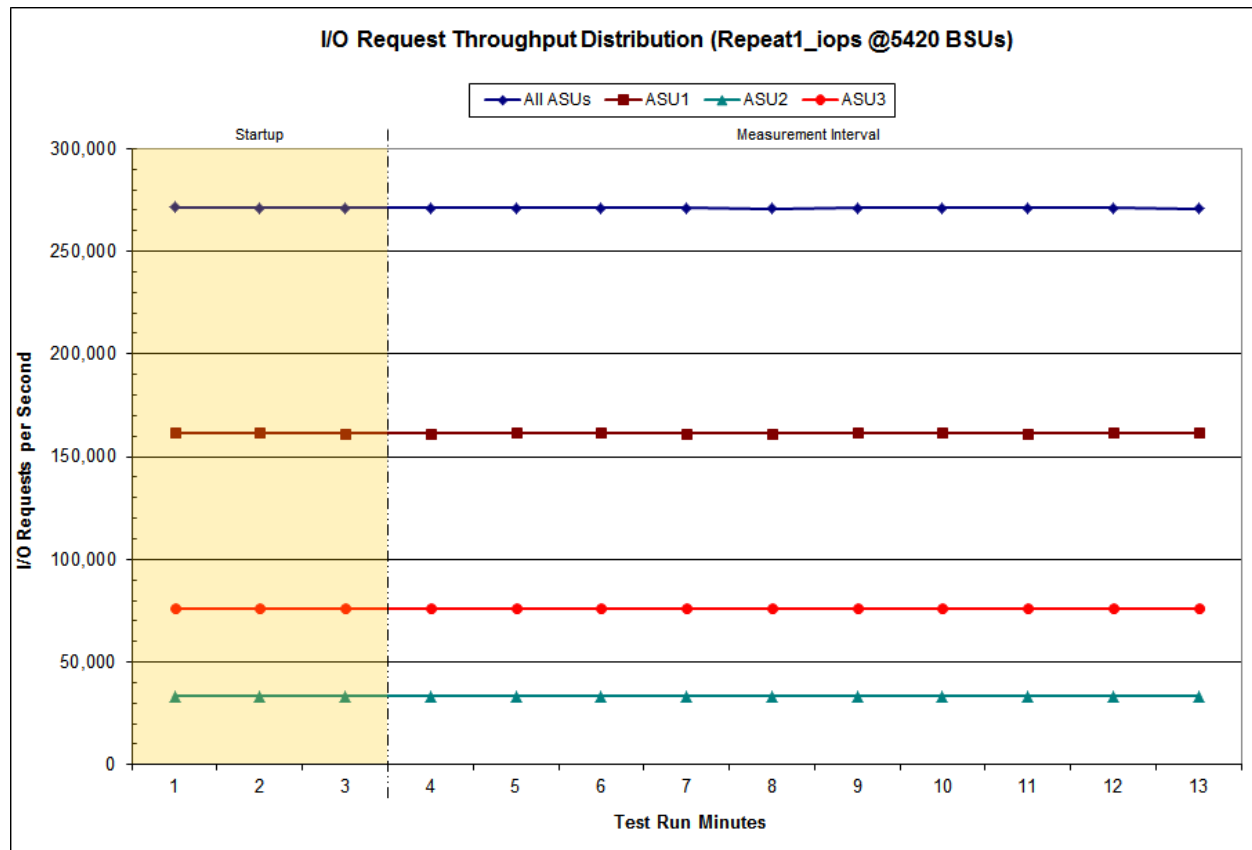
Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



Repeatability 1 IOPS – I/O Request Throughput Distribution Data

5,240 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:48:43	17:51:44	0-2	0:03:01
<i>Measurement Interval</i>	17:51:44	18:01:44	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	271,414.77	161,757.10	33,373.63	76,284.03
1	271,128.67	161,565.32	33,364.20	76,199.15
2	270,954.27	161,487.78	33,333.15	76,133.33
3	270,936.65	161,480.70	33,314.22	76,141.73
4	271,049.88	161,554.62	33,293.17	76,202.10
5	270,941.78	161,530.45	33,327.05	76,084.28
6	271,008.42	161,487.03	33,329.27	76,192.12
7	270,916.08	161,417.55	33,347.80	76,150.73
8	270,991.68	161,522.25	33,346.00	76,123.43
9	271,067.13	161,564.97	33,364.12	76,138.05
10	270,959.08	161,449.38	33,319.10	76,190.60
11	271,054.30	161,556.72	33,324.67	76,172.92
12	270,929.73	161,534.80	33,313.38	76,081.55
Average	270,985.48	161,509.85	33,327.88	76,147.75

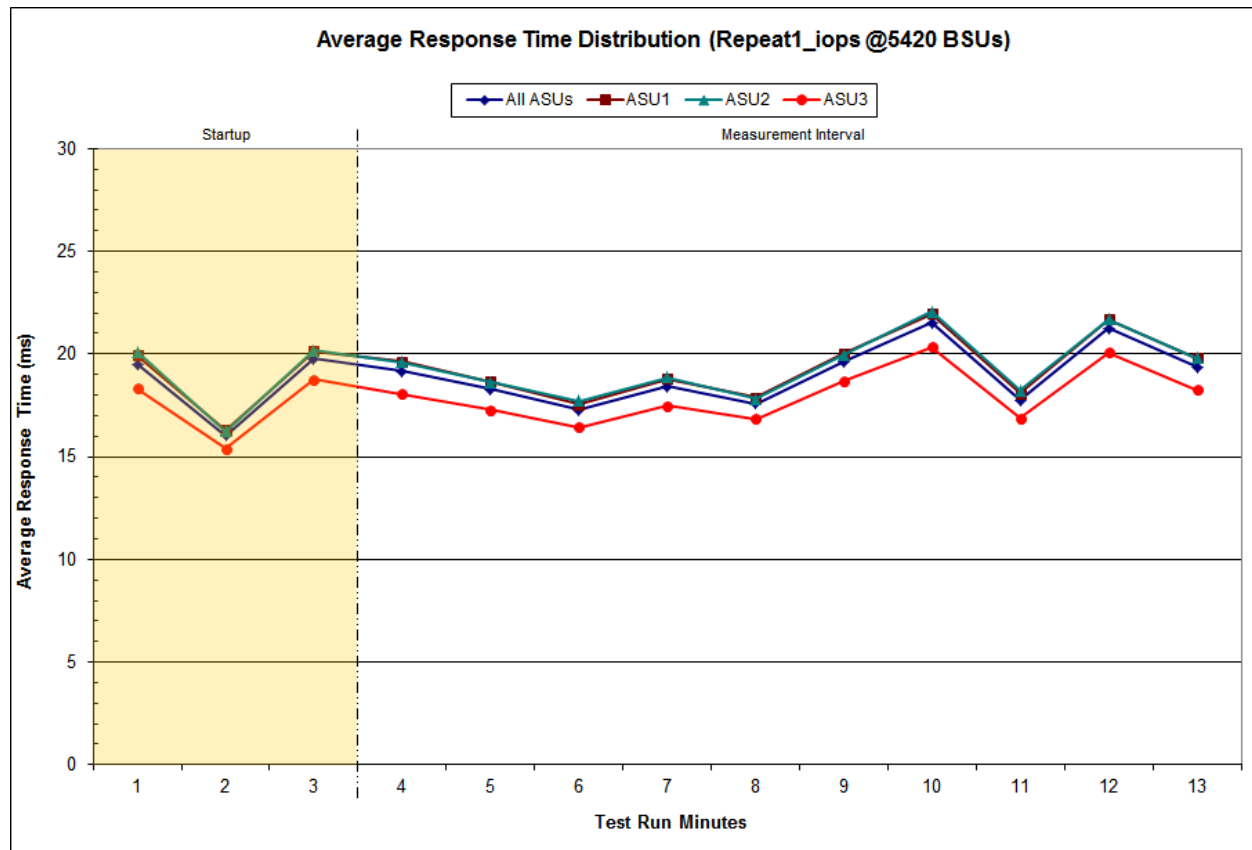
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

5,240 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	17:48:43	17:51:44	0-2	0:03:01
<i>Measurement Interval</i>	17:51:44	18:01:44	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	19.51	19.94	20.10	18.32
1	16.04	16.31	16.24	15.39
2	19.76	20.15	20.18	18.75
3	19.18	19.62	19.59	18.05
4	18.27	18.66	18.64	17.28
5	17.26	17.56	17.70	16.45
6	18.43	18.79	18.87	17.49
7	17.58	17.88	17.80	16.83
8	19.65	20.04	19.97	18.68
9	21.51	21.95	22.05	20.35
10	17.76	18.09	18.21	16.86
11	21.24	21.69	21.70	20.08
12	19.36	19.80	19.79	18.24
Average	19.02	19.41	19.43	18.03

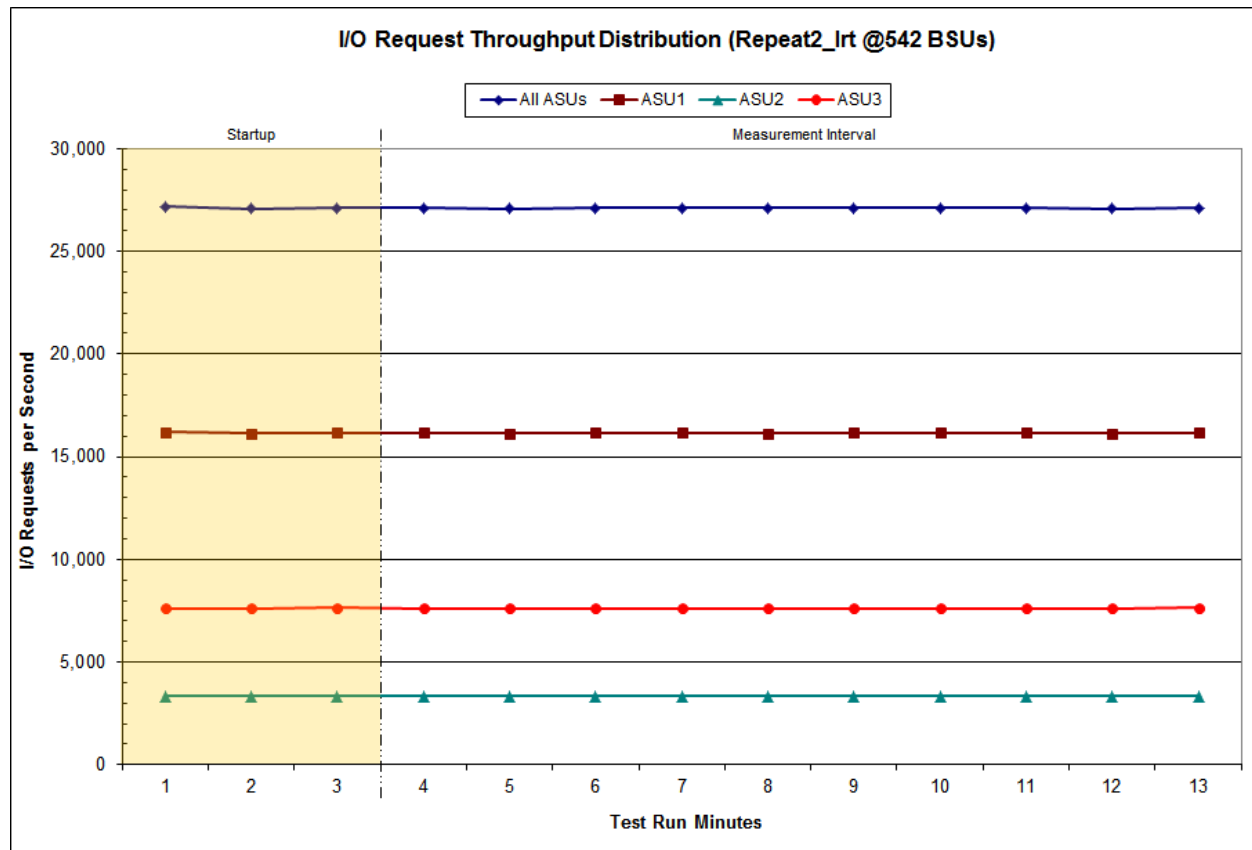
Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



Repeatability 2 LRT – I/O Request Throughput Distribution Data

524 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:01:55	18:04:55	0-2	0:03:00
<i>Measurement Interval</i>	18:04:55	18:14:55	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	27,167.72	16,199.98	3,344.42	7,623.32
1	27,077.77	16,143.43	3,329.67	7,604.67
2	27,119.78	16,162.63	3,324.08	7,633.07
3	27,109.50	16,171.18	3,334.67	7,603.65
4	27,089.03	16,140.12	3,340.85	7,608.07
5	27,100.60	16,160.82	3,333.92	7,605.87
6	27,113.30	16,164.08	3,330.03	7,619.18
7	27,101.48	16,148.60	3,329.17	7,623.72
8	27,106.10	16,156.38	3,336.52	7,613.20
9	27,093.90	16,167.22	3,320.53	7,606.15
10	27,113.05	16,177.85	3,338.23	7,596.97
11	27,084.37	16,129.05	3,335.57	7,619.75
12	27,109.78	16,149.85	3,326.52	7,633.42
Average	27,102.11	16,156.52	3,332.60	7,613.00

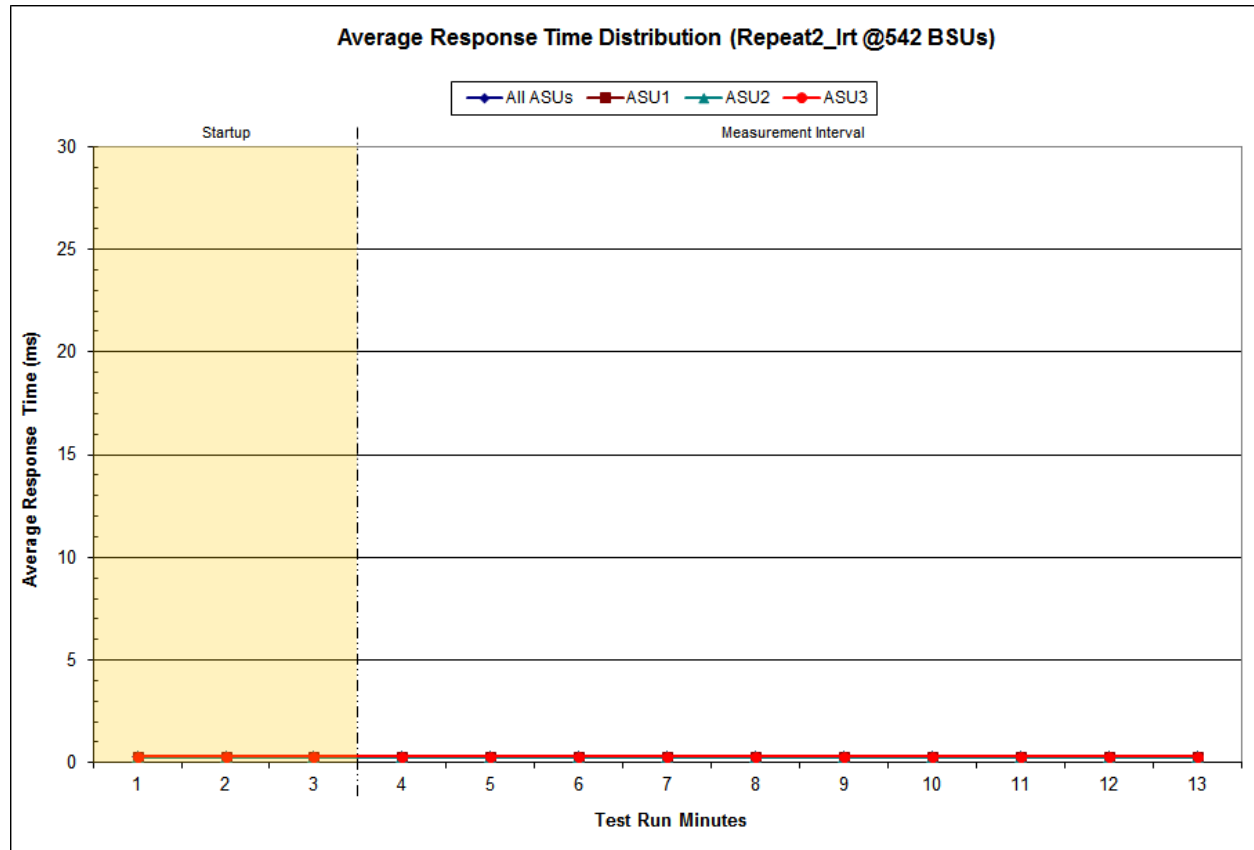
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

524 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:01:55	18:04:55	0-2	0:03:00
<i>Measurement Interval</i>	18:04:55	18:14:55	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.28	0.28	0.28	0.29
1	0.28	0.28	0.28	0.29
2	0.28	0.28	0.28	0.29
3	0.28	0.28	0.28	0.29
4	0.28	0.28	0.28	0.29
5	0.28	0.28	0.28	0.29
6	0.28	0.28	0.28	0.29
7	0.28	0.28	0.28	0.29
8	0.28	0.28	0.28	0.29
9	0.28	0.28	0.28	0.29
10	0.28	0.28	0.28	0.29
11	0.28	0.28	0.28	0.29
12	0.28	0.28	0.28	0.29
Average	0.28	0.28	0.28	0.29

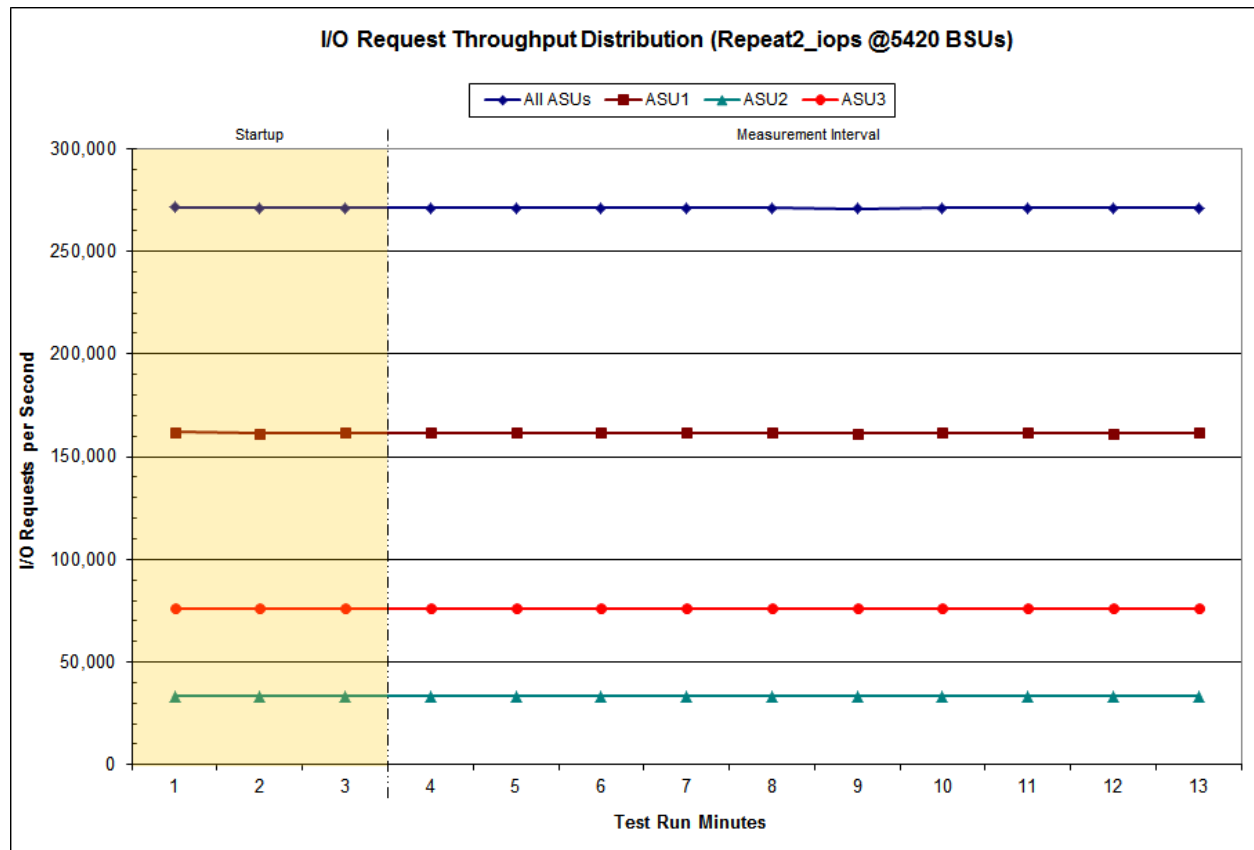
Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



Repeatability 2 IOPS – I/O Request Throughput Distribution Data

5,240 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:15:10	18:18:11	0-2	0:03:01
<i>Measurement Interval</i>	18:18:11	18:28:11	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	271,517.60	161,866.97	33,390.17	76,260.47
1	271,009.15	161,477.43	33,333.13	76,198.58
2	271,053.23	161,524.82	33,326.62	76,201.80
3	270,982.92	161,559.97	33,313.70	76,109.25
4	271,091.65	161,561.17	33,351.22	76,179.27
5	271,013.18	161,548.90	33,304.72	76,159.57
6	271,034.35	161,552.77	33,315.27	76,166.32
7	270,951.10	161,514.62	33,318.48	76,118.00
8	270,893.00	161,436.42	33,308.48	76,148.10
9	270,938.20	161,527.53	33,314.33	76,096.33
10	270,990.53	161,502.45	33,349.77	76,138.32
11	270,953.42	161,457.08	33,323.83	76,172.50
12	271,051.00	161,545.65	33,347.03	76,158.32
Average	270,989.94	161,520.66	33,324.68	76,144.60

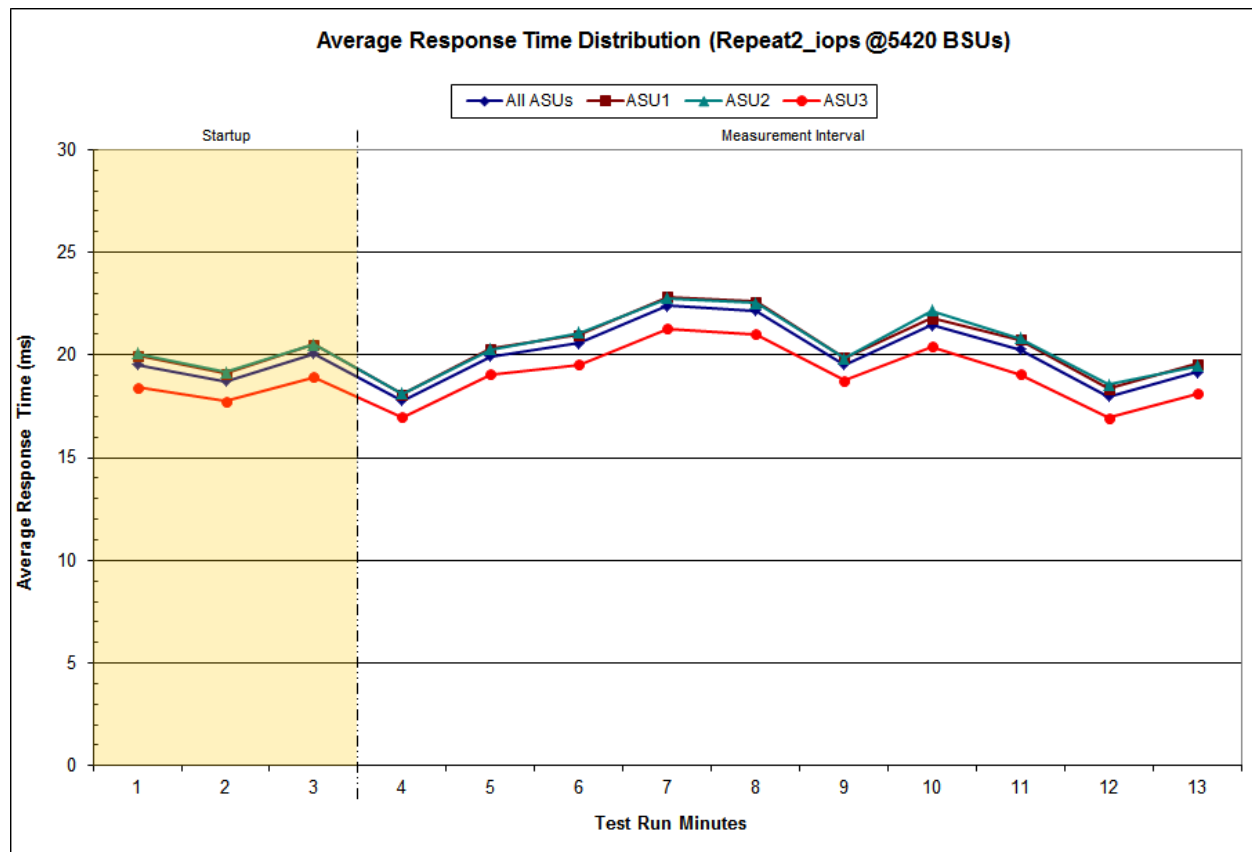
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

5,240 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	18:15:10	18:18:11	0-2	0:03:01
<i>Measurement Interval</i>	18:18:11	18:28:11	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	19.55	19.96	20.07	18.44
1	18.73	19.10	19.17	17.75
2	20.07	20.51	20.51	18.94
3	17.77	18.08	18.12	16.98
4	19.95	20.30	20.27	19.06
5	20.59	20.98	21.07	19.55
6	22.38	22.82	22.77	21.28
7	22.15	22.60	22.53	21.02
8	19.55	19.86	19.84	18.75
9	21.45	21.80	22.17	20.41
10	20.28	20.74	20.83	19.08
11	17.99	18.36	18.55	16.95
12	19.15	19.56	19.48	18.12
Average	20.13	20.51	20.56	19.12

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



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

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.15.2

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

Clause 5.3.15.3

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2811	0.0699	0.2099	0.0181	0.0699	0.0350	0.2811
COV	0.003	0.001	0.003	0.001	0.006	0.003	0.002	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.001	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	0.2811	0.0700	0.2100	0.0180	0.0700	0.0350	0.2809
COV	0.004	0.002	0.002	0.002	0.006	0.003	0.005	0.001

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<i>IM</i>	<i>0.0350</i>	<i>0.2810</i>	<i>0.0700</i>	<i>0.2100</i>	<i>0.0180</i>	<i>0.0700</i>	<i>0.0350</i>	<i>0.2810</i>
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.001	0.003	0.001	0.001	0.000

Data Persistence Test

Clause 6

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

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

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

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

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

Clause 9.4.3.8

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page 80.

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	650,374,512
Total Number of Logical Blocks Verified	233,051,552
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 9.4.3.9

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

The MacroSAN MS5580 as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

PRICING INFORMATION

Clause 9.4.3.3.6

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

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

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.8

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

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

ANOMALIES OR IRREGULARITIES

Clause 9.4.3.10

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the MacroSAN MS5580.

APPENDIX A: SPC-1 GLOSSARY

“Decimal” (*powers of ten*) Measurement Units

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

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

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

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

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

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

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

“Binary” (*powers of two*) Measurement Units

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

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

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

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

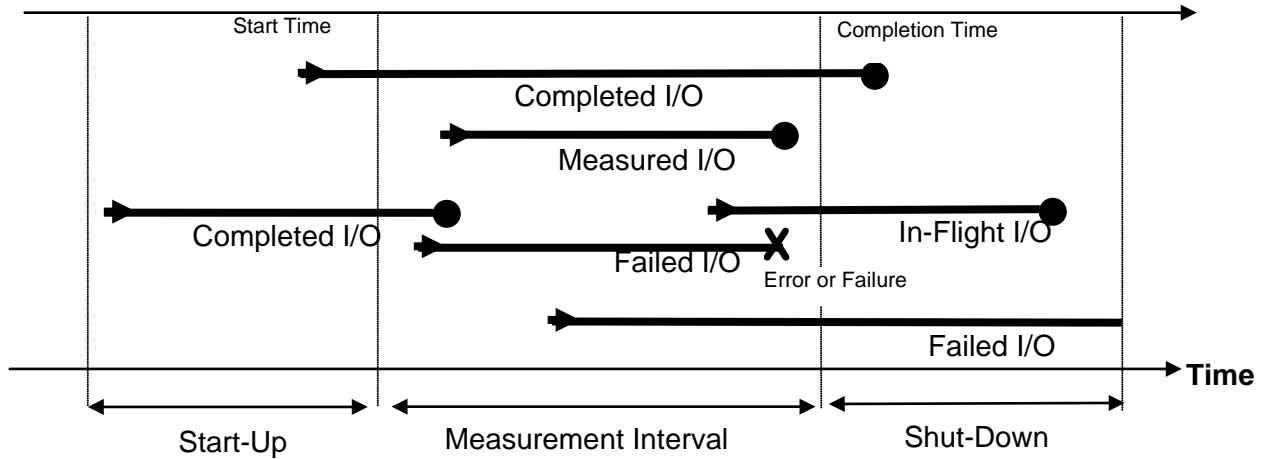
Steady State: The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

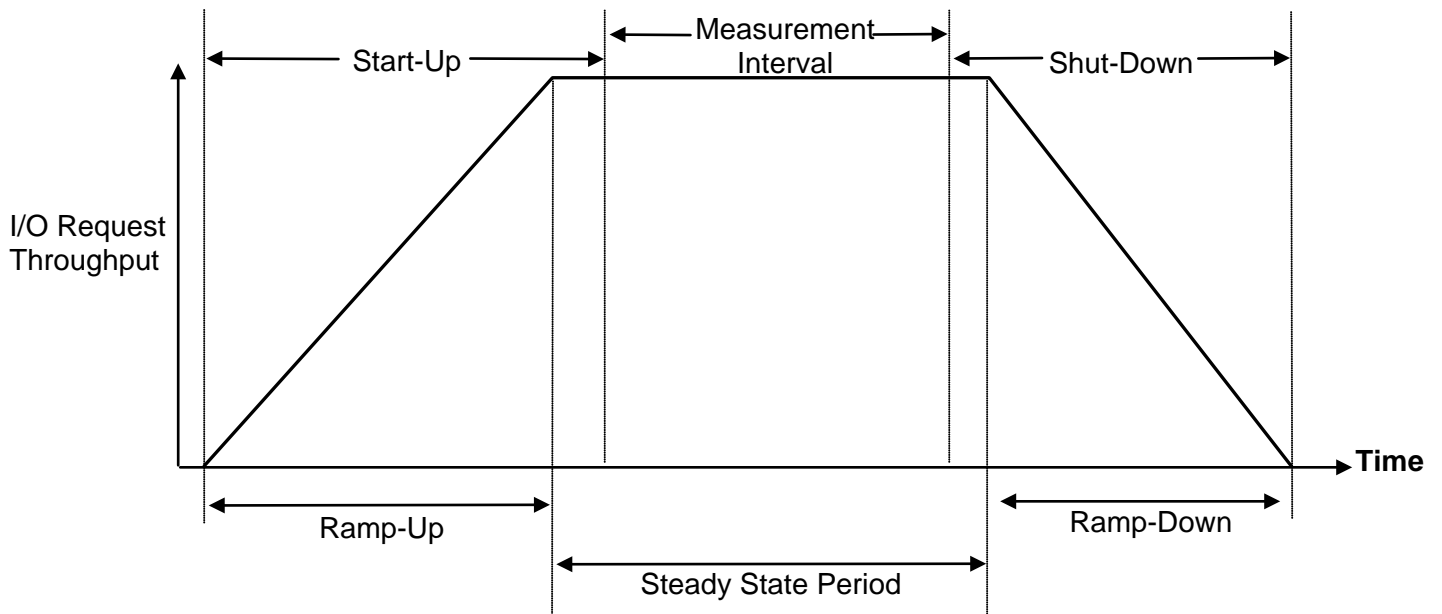
Test Run: The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall have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

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

I/O Completion Types



SPC-1 Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

Red Hat Enterprise Linux 6.2 (64-bit)

Change the I/O scheduler from **cfq** to **noop** on each Host System, which will result in all incoming I/O requests inserted into a simple, unordered FIFO queue. This change was done by the execution of the [scheduler.sh](#) script as documented in [Appendix C: Tested Storage Configuration \(TSC\) Creation](#).

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The scripts referenced in Steps 1–3 appear in the section, [Referenced Scripts](#).

Step 1: Create Storage Pool, RAID1 Groups, LUNs, Clients, Mapping and Deploy LUNs

Execute the [init_environment_ms5580.sh](#) script, via a Host System CLI session, on either of the Storage Controllers to complete the following:

1. Create 1 storage pool: **Pool-1**
2. Create 30 RAID1 Groups in **Pool-1**
3. Create 30 LUNs (*1 LUN per RAID1 Group, 181 GiB per LUN*)
4. Create 16 Clients
5. Add Host System FC Initiators to Clients
(*2 Initiators per Client and each Initiator from one Host System*)
6. Create Storage Targets to Clients
(*1 Target per Client and each Target is associated with 1 FC port*)
7. Add LUNs to Targets
(*2 LUNs per Target for 14 Targets, 1 LUN per Target for 2 Targets*)

Step 2: Create Volumes on the Master Host System

Execute the [mkvolumes_ms5580.sh](#) script on the Master Host System to create 3 logical volumes as follows:

1. **Create Physical Volumes:** Create 30 physical volumes using the **pvcreate** command.
2. **Create Volume Groups:** Create 1 volume group (**vg1**) using the **vgcreate** command using the following 30 physical volumes: /dev/sdb, /dev/sdc, /dev/sdd, /dev/sde, /dev/sdf, /dev/sdg, /dev/sdh, /dev/sdi, /dev/sdj, /dev/sdk, /dev/sdl, /dev/sdm, /dev/sdn, /dev/sdo, /dev/sdp, /dev/sdq, /dev/sdr, /dev/sds, /dev/sdt, /dev/sdu, /dev/sdv, /dev/sdw, /dev/sdx, /dev/sdy, /dev/sdz, /dev/sdaa, /dev/sdab, /dev/sdac, /dev/sdad, /dev/sdae.
3. **Create Logical Volumes:**
 - a. Create 1 logical volume with a capacity of 2,250 GiB on **vg1** for ASU-1.
 - b. Create 1 logical volume with a capacity of 2,250 GiB on **vg1** for ASU-2.
 - c. Create 1 logical volume with a capacity of 500 GiB on **vg1** for ASU-3.
4. **Scan Physical Volumes, Volume Group, Logical Volumes and Activate each Logical Volume:**

Execute the [lv_scan.sh](#) script on the Slave Host Systems to scan the physical volumes, volume group and logical volumes. In addition, the script will make each logical volume available (activate).

Step 3: Change the Scheduler on each Host System

Execute the [scheduler.sh](#) script on each Host System to change the scheduler of each block device from *cfq* to *noop*.

Referenced Scripts

init_environment_ms5580.sh

```
#!/bin/bash

#Create Pool-1
echo pool mgt create -n Pool-1 -t t | /odsp/bin/odsp-cli

#Create RAID: 30 * RAID1
echo raid mgt create -n RAID-1 -p Pool-1 -l RAID1 -d 1:1:1:5,1:1:1:6 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-2 -p Pool-1 -l RAID1 -d 1:1:1:7,1:1:1:8 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-3 -p Pool-1 -l RAID1 -d 1:2:1:1,1:2:1:2 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-4 -p Pool-1 -l RAID1 -d 1:2:1:3,1:2:1:4 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-5 -p Pool-1 -l RAID1 -d 1:3:1:1,1:3:1:2 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-6 -p Pool-1 -l RAID1 -d 1:3:1:3,1:3:1:4 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-7 -p Pool-1 -l RAID1 -d 1:4:1:1,1:4:1:2 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-8 -p Pool-1 -l RAID1 -d 1:4:1:3,1:4:1:4 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-9 -p Pool-1 -l RAID1 -d 1:1:1:9,1:1:1:10 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-10 -p Pool-1 -l RAID1 -d 1:1:1:11,1:1:1:12 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-11 -p Pool-1 -l RAID1 -d 1:2:1:5,1:2:1:6 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-12 -p Pool-1 -l RAID1 -d 1:2:1:7,1:2:1:8 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-13 -p Pool-1 -l RAID1 -d 1:3:1:5,1:3:1:6 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-14 -p Pool-1 -l RAID1 -d 1:3:1:7,1:3:1:8 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-15 -p Pool-1 -l RAID1 -d 1:4:1:5,1:4:1:6 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-16 -p Pool-1 -l RAID1 -d 1:4:1:7,1:4:1:8 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-17 -p Pool-1 -l RAID1 -d 1:1:1:13,1:1:1:14 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-18 -p Pool-1 -l RAID1 -d 1:1:1:15,1:1:1:16 |
/odsp/bin/odsp-cli
```

```
echo raid mgt create -n RAID-19 -p Pool-1 -l RAID1 -d 1:2:1:9,1:2:1:10 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-20 -p Pool-1 -l RAID1 -d 1:2:1:11,1:2:1:12 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-21 -p Pool-1 -l RAID1 -d 1:3:1:9,1:3:1:10 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-22 -p Pool-1 -l RAID1 -d 1:3:1:11,1:3:1:12 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-23 -p Pool-1 -l RAID1 -d 1:4:1:9,1:4:1:10 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-24 -p Pool-1 -l RAID1 -d 1:4:1:11,1:4:1:12 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-25 -p Pool-1 -l RAID1 -d 1:2:1:13,1:2:1:14 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-26 -p Pool-1 -l RAID1 -d 1:2:1:15,1:2:1:16 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-27 -p Pool-1 -l RAID1 -d 1:3:1:13,1:3:1:14 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-28 -p Pool-1 -l RAID1 -d 1:3:1:15,1:3:1:16 |
/odsp/bin/odsp-cli

echo raid mgt create -n RAID-29 -p Pool-1 -l RAID1 -d 1:4:1:13,1:4:1:14 |
/odsp/bin/odsp-cli
echo raid mgt create -n RAID-30 -p Pool-1 -l RAID1 -d 1:4:1:15,1:4:1:16 |
/odsp/bin/odsp-cli

#Create LUN: 30
echo lun mgt create -n LUN-1 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-1 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-2 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-2 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-3 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-3 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-4 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-4 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-5 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-5 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-6 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-6 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-7 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-7 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-8 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-8 | /odsp/bin/odsp-cli

echo lun mgt create -n LUN-9 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-9 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-10 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-10 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-11 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-11 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-12 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-12 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-13 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-13 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-14 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-14 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-15 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-15 | /odsp/bin/odsp-cli
```



```
echo lun mgt create -n LUN-16 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-16 | /odsp/bin/odsp-cli

echo lun mgt create -n LUN-17 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-17 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-18 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-18 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-19 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-19 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-20 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-20 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-21 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-21 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-22 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-22 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-23 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-23 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-24 -o SP1 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-24 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-25 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-25 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-26 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-26 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-27 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-27 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-28 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-28 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-29 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-29 | /odsp/bin/odsp-cli
echo lun mgt create -n LUN-30 -o SP2 -p Pool-1 -r disable -w disable -m no-sync -s
181 -R RAID-30 | /odsp/bin/odsp-cli

#Create Client: 16
echo client mgt create -n Client-SP1-1 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP1-2 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP1-3 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP1-4 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP1-5 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP1-6 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP1-7 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP1-8 -m N | /odsp/bin/odsp-cli

echo client mgt create -n Client-SP2-1 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-2 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-3 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-4 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-5 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-6 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-7 -m N | /odsp/bin/odsp-cli
echo client mgt create -n Client-SP2-8 -m N | /odsp/bin/odsp-cli

#Add Initiator with Client: 16
echo client mgt addinitiator -c Client-SP1-1 -t FC -i 21-00-00-24-ff-2f-89-0d -f |
/odsp/bin/odsp-cli
echo client mgt addinitiator -c Client-SP1-1 -t FC -i 21-00-00-24-ff-41-dd-19 -f |
/odsp/bin/odsp-cli

echo client mgt addinitiator -c Client-SP1-2 -t FC -i 21-00-00-24-ff-2f-89-0c -f |
/odsp/bin/odsp-cli
echo client mgt addinitiator -c Client-SP1-2 -t FC -i 21-00-00-24-ff-41-dd-18 -f |
/odsp/bin/odsp-cli
```

```
echo client mgt addinitiator -c Client-SP1-3 -t FC -i 21-00-00-24-ff-2f-88-fd -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP1-3 -t FC -i 21-00-00-24-ff-37-0b-81 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP1-4 -t FC -i 21-00-00-24-ff-2f-88-fc -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP1-4 -t FC -i 21-00-00-24-ff-37-0b-80 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP1-5 -t FC -i 21-00-00-24-ff-2f-88-f2 -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP1-5 -t FC -i 50-01-43-80-12-06-d2-4a -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP1-6 -t FC -i 21-00-00-24-ff-2f-88-f3 -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP1-6 -t FC -i 50-01-43-80-12-06-d2-48 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP1-7 -t FC -i 21-00-00-24-ff-41-dd-a3 -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP1-7 -t FC -i 50-01-43-80-06-2d-66-30 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP1-8 -t FC -i 21-00-00-24-ff-41-dd-a2 -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP1-8 -t FC -i 50-01-43-80-06-2d-66-32 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP2-1 -t FC -i 21-00-00-24-ff-2f-89-0d -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP2-1 -t FC -i 21-00-00-24-ff-41-dd-19 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP2-2 -t FC -i 21-00-00-24-ff-2f-89-0c -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP2-2 -t FC -i 21-00-00-24-ff-41-dd-18 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP2-3 -t FC -i 21-00-00-24-ff-2f-88-fd -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP2-3 -t FC -i 21-00-00-24-ff-37-0b-81 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP2-4 -t FC -i 21-00-00-24-ff-2f-88-fc -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP2-4 -t FC -i 21-00-00-24-ff-37-0b-80 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP2-5 -t FC -i 21-00-00-24-ff-2f-88-f2 -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP2-5 -t FC -i 50-01-43-80-12-06-d2-4a -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP2-6 -t FC -i 21-00-00-24-ff-2f-88-f3 -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP2-6 -t FC -i 50-01-43-80-12-06-d2-48 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP2-7 -t FC -i 21-00-00-24-ff-41-dd-a3 -f |  
/odsp/bin/odsp-cli
```

```
echo client mgt addinitiator -c Client-SP2-7 -t FC -i 50-01-43-80-06-2d-66-30 -f |  
/odsp/bin/odsp-cli  
  
echo client mgt addinitiator -c Client-SP2-8 -t FC -i 21-00-00-24-ff-41-dd-a2 -f |  
/odsp/bin/odsp-cli  
echo client mgt addinitiator -c Client-SP2-8 -t FC -i 50-01-43-80-06-2d-66-32 -f |  
/odsp/bin/odsp-cli  
  
#Create Target: 16  
echo client target create -c Client-SP1-1 -t FC -n Target-SP1-1 -f 50-0b-34-20-01-  
27-22-01 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP1-2 -t FC -n Target-SP1-2 -f 50-0b-34-20-01-  
27-22-02 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP1-3 -t FC -n Target-SP1-3 -f 50-0b-34-20-01-  
27-22-03 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP1-4 -t FC -n Target-SP1-4 -f 50-0b-34-20-01-  
27-22-04 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP1-5 -t FC -n Target-SP1-5 -f 50-0b-34-20-01-  
27-22-05 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP1-6 -t FC -n Target-SP1-6 -f 50-0b-34-20-01-  
27-22-06 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP1-7 -t FC -n Target-SP1-7 -f 50-0b-34-20-01-  
27-22-07 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP1-8 -t FC -n Target-SP1-8 -f 50-0b-34-20-01-  
27-22-08 | /odsp/bin/odsp-cli  
  
echo client target create -c Client-SP2-1 -t FC -n Target-SP2-1 -s 50-0b-34-20-01-  
25-da-01 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP2-2 -t FC -n Target-SP2-2 -s 50-0b-34-20-01-  
25-da-02 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP2-3 -t FC -n Target-SP2-3 -s 50-0b-34-20-01-  
25-da-03 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP2-4 -t FC -n Target-SP2-4 -s 50-0b-34-20-01-  
25-da-04 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP2-5 -t FC -n Target-SP2-5 -s 50-0b-34-20-01-  
25-da-05 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP2-6 -t FC -n Target-SP2-6 -s 50-0b-34-20-01-  
25-da-06 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP2-7 -t FC -n Target-SP2-7 -s 50-0b-34-20-01-  
25-da-07 | /odsp/bin/odsp-cli  
echo client target create -c Client-SP2-8 -t FC -n Target-SP2-8 -s 50-0b-34-20-01-  
25-da-08 | /odsp/bin/odsp-cli  
  
#Add LUN  
echo client target addlun -t FC -n Target-SP1-1 -l LUN-1 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-1 -l LUN-2 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-2 -l LUN-3 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-2 -l LUN-4 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-3 -l LUN-5 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-3 -l LUN-6 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-4 -l LUN-7 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-4 -l LUN-8 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-5 -l LUN-17 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-6 -l LUN-19 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-6 -l LUN-20 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-7 -l LUN-21 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-7 -l LUN-22 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-8 -l LUN-23 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP1-8 -l LUN-24 | /odsp/bin/odsp-cli  
  
echo client target addlun -t FC -n Target-SP2-1 -l LUN-9 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP2-1 -l LUN-10 | /odsp/bin/odsp-cli  
echo client target addlun -t FC -n Target-SP2-2 -l LUN-11 | /odsp/bin/odsp-cli
```

```
echo client target addlun -t FC -n Target-SP2-2 -l LUN-12 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-3 -l LUN-13 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-3 -l LUN-14 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-4 -l LUN-15 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-4 -l LUN-16 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-5 -l LUN-18 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-6 -l LUN-25 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-6 -l LUN-26 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-7 -l LUN-27 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-7 -l LUN-28 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-8 -l LUN-29 | /odsp/bin/odsp-cli
echo client target addlun -t FC -n Target-SP2-8 -l LUN-30 | /odsp/bin/odsp-cli
```

```
exit 0
```

mkvolumes_ms5580.sh

```
#!/bin/bash

#pv
pvcreate /dev/sdb
pvcreate /dev/sdc
pvcreate /dev/sdd
pvcreate /dev/sde
pvcreate /dev/sdf
pvcreate /dev/sdg
pvcreate /dev/sdh
pvcreate /dev/sdi
pvcreate /dev/sdj
pvcreate /dev/sdk
pvcreate /dev/sdl
pvcreate /dev/sdm
pvcreate /dev/sdn
pvcreate /dev/sdo
pvcreate /dev/sdp
pvcreate /dev/sdq
pvcreate /dev/sdr
pvcreate /dev/sds
pvcreate /dev/sdt
pvcreate /dev/sdu
pvcreate /dev/sdv
pvcreate /dev/sdw
pvcreate /dev/sdx
pvcreate /dev/sdy
pvcreate /dev/sdz
pvcreate /dev/sdaa
pvcreate /dev/sdab
pvcreate /dev/sdac
pvcreate /dev/sdad
pvcreate /dev/sdae

#vg
vgcreate vg1 /dev/sdb /dev/sdc /dev/sdd /dev/sde /dev/sdf /dev/sdg /dev/sdh /dev/sdi
/dev/sdj /dev/sdk /dev/sdl /dev/sdm /dev/sdn /dev/sdo /dev/sdp /dev/sdq /dev/sdr
/dev/sds /dev/sdt /dev/sdu /dev/sdv /dev/sdw /dev/sdx /dev/sdy /dev/sdz /dev/sdaa
/dev/sdab /dev/sdac /dev/sdad /dev/sdae

#lv
lvcreate -n asu11 -i 30 -I 512 -C y -L 2250g vg1

lvcreate -n asu21 -i 30 -I 512 -C y -L 2250g vg1
```

```
lvcreate -n asu31 -i 30 -I 512 -C y -L 500g vg1  
  
exit 0
```

lv_scan.sh

```
#!/bin/bash  
  
echo '-----pvscan-----'  
pvscan  
echo '-----vgscan-----'  
vgscan  
echo '-----lvscan-----'  
lvscan  
  
lvchange -ay /dev/vg1/asu11  
  
lvchange -ay /dev/vg1/asu21  
  
lvchange -ay /dev/vg1/asu31
```

scheduler.sh

```
#!/bin/bash  
  
#default: noop anticipatory deadline [cfq]  
for i in sdb sdc sdd sde sdf sdg sdh sdi sdj sdk sdl sdm sdn sdo sdp sdq sdr sds sdt  
sdu sdv sdw sdx sdy sdz sdaa sdab sdac sdad sdae  
do  
    echo noop > /sys/block/$i/queue/scheduler  
done  
  
#show  
cat -n /sys/block/sd[b-z]/queue/scheduler /sys/block/sd[a][a-z]/queue/scheduler
```

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

ASU Pre-Fill

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

```
compratio=1

sd=sd1,lun=/dev/vg1/asu11,size=2250g,openflags=o_direct,threads=32

sd=sd2,lun=/dev/vg1/asu21,size=2250g,openflags=o_direct,threads=32

sd=sd3,lun=/dev/vg1/asu31,size=500g,openflags=o_direct,threads=32

wd=wd1,sd=sd*,rdpct=0,seekpct=-1,xfersize=128K

rd=asu_prefill,wd=wd1,iorate=max,elapsed=36000,interval=10
```

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 (*Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase*) and Repeatability (*Repeatability Test Phase 1 and Repeatability Test Phase 2*) Tests is listed below.

```
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)
sd=asu1_1,lun=/dev/vg1/asu11,size=2250g
sd=asu2_1,lun=/dev/vg1/asu21,size=2250g
sd=asu3_1,lun=/dev/vg1/asu31,size=500g
```

SPC-1 Persistence Test

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

```
sd=asu1_1,lun=/dev/vg1/asu11,size=2250g
sd=asu2_1,lun=/dev/vg1/asu21,size=2250g
sd=asu3_1,lun=/dev/vg1/asu31,size=500g
```

Slave JVMs

Each Slave JVM was invoked with a command and parameter file similar to the example listed below. The only difference in each file was **host** parameter value, which was unique to each Slave JVM, e.g. **slave1...slave55**.

```
master=10.77.77.23
host=slave1
sd=asu1_1,lun=/dev/vg1/asu11,size=2250g
sd=asu2_1,lun=/dev/vg1/asu21,size=2250g
sd=asu3_1,lun=/dev/vg1/asu31,size=500g
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

The first script, [master_execution_script1_ms5580.sh](#), was invoked to execute the required ASU pre-fill, 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 (*write phase*) in an uninterrupted sequence. This script also invoked a separate script, [slave_multi_run.sh](#), to manually start the Slave JVMs.

The second script, [master_execution_script2_ms5580.sh](#), was invoked to execute SPC-1 Persistence Test Run 2 (read phase).

Both scripts also invoked additional scripts to capture the detailed TSC profile listings required for a Remote Audit.

master_execution_script1_ms5580.sh

```
#!/bin/bash

# Create the first storage profile at the start of run...
echo "Create the first storage profile at the start of run..."
ssh root@172.0.0.51 >/dev/null 2>&1 << eeoff
/root/profile_ms5580.sh start
exit
eeoff

# Create the first volume listing at the start of run...
echo "Create the first volume listing at the start of run..."
/root/volume_listing.sh start

# ASU prefill
echo "ASU prefill started....."
/root/vdbench503/vdbench -f /root/spc/spc1_prefill_ms5580.parm -o
/root/spc/prefill_out_ms5580
echo "ASU prefill complete....."

# Start Slave JVMs
cd /root/spc/

\cp spc1_iops_ms5580.cfg spc1.cfg

/root/slave_multi_run.sh 1 27

ssh root@172.0.10.22 >/dev/null 2>&1 << eeoff
/root/slave_multi_run.sh 28 55
exit
eeoff

# SPC-1 Primary Metrics Test 28800
java -Xmx640m -Xms640m metrics -b 5420 -t 28800

# SPC-1 Repeatability Test
java -Xmx640m -Xms640m repeat1 -b 5420

java -Xmx640m -Xms640m repeat2 -b 5420

killall java
ssh root@172.0.10.22 killall java
```



```
# SPC-1 Persistence Test Run 1
\cp spc1_persist_ms5580.cfg spc1.cfg

java -Xmx8192m -Xms8192m persist1 -b 5420

exit 0
```

slave_multi_run.sh

```
#!/bin/bash

start_index=$1
end_index=$2
for ((i=$start_index;i<=$end_index;i++))do
    java spc1 -f /root/spc/slave/slave$i.txt > /root/spc/slaveOut/slave$i.out &
done
```

master_execution_script2_ms5580.sh

```
#!/bin/bash

# SPC-1 Persistence Test Run 2
cd /root/spc
\cp spc1_persist_ms5580.cfg spc1.cfg

java -Xmx8192m -Xms8192m persist2

cd /root/
# Create the second storage profile at the end of run...
echo "Create the second storage profile at the end of run..."
ssh root@172.0.0.51 >/dev/null 2>&1 << eeofff
/root/profile_ms5580.sh end
exit
eeofff

# Create the second volume listing at the start of run...
echo "Create the second volume listing at the second of run..."
/root/volume_listing.sh end

exit 0
```

APPENDIX F: THIRD-PARTY QUOTATION

Host Bus Adapter (HBA)



The screenshot displays a Taobao.com product listing for a Qlogic QLE2562 FC8 HBA. The product is described as a Gen2 x4 full original product. The price is listed as ¥3300.00. Shipping is from Guangdong Shenzhen to Zhejiang Hangzhou Binjiang District, with a shipping fee of ¥22.00. The quantity is set to 1, with 20 items in stock. The page includes buttons for '立即购买' (Buy Now) and '加入购物车' (Add to Cart). The seller is '陌然盛科数码商城' (Moran Shengke Digital Mall) with a 4.9 rating for description, service, and logistics. The page also features a '皇冠卖家' (Crown Seller) badge and a '2014 11月1日 嘉年华会场' (2014 November 1st Carnival Event) banner.

Qlogic QLE2562 FC8 双通道 HBA, PCI-E Gen2 x4 全新 原装正品

价格 **¥3300.00**

配送 广东深圳 至 浙江杭州滨江区
快递 ¥22.00

数量 件(库存20件)

[立即购买](#) [加入购物车](#)

承诺 **7**天无理由

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皇冠卖家
陌然盛科数码商城
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掌柜: 陌然盛科数码商城
联系: [和我联系](#)
资质:

描述	服务	物流
4.9	4.9	4.9

进入店铺 收藏店铺

看了又看

