
NEC

# SPC BENCHMARK 1™
# FULL DISCLOSURE REPORT

## NEC CORPORATION
## NEC STORAGE M500

**SPC-1 V1.13**

**Submitted for Review: February 20, 2013**
**Submission Identifier: A00126**

**First Edition – February 2013**



**Trademarks**

# Table of Contents

# AUDIT CERTIFICATION



Kentaro Yamamoto
NEC Corporation
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Tokyo, 183-8501, Japan

February 20, 2013

The SPC Benchmark 1™ Reported Data listed below for the NEC Storage M500 was produced in compliance with the SPC Benchmark 1™ v1.13 Remote Audit requirements.

| SPC Benchmark 1™ v1.13 Reported Data | |
|---|---|
| **Tested Storage Product (TSP) Name:** NEC Storage M500 | |
| **Metric** | **Reported Result** |
| SPC-1 IOPS™ | 63,051.60 |
| SPC-1 Price-Performance | $3.98/SPC-1 IOPS™ |
| Total ASU Capacity | 34,923.295 GB |
| Data Protection Level | Protected 1 *(Mirroring)* |
| Total Price (including three-year maintenance) | $251,075.64 |
| Currency Used | U.S. Dollars |
| Target Country for availability, sales and support | USA |

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

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

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643 Bair Island Road, Suite 103
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## AUDIT CERTIFICATION *(CONT.)*

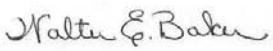


- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by information supplied by NEC Corporation:
  - ✓ The type of each Host System including the number of processors and main memory.
  - ✓ The presence and version number of the SPC-1 Workload Generator on each Host System.
  - ✓ The TSC boundary within each Host System.
- The Test Results Files and resultant Summary Results Files received from NEC Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- There were no differences between the Tested Storage Configuration and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

**Audit Notes:**

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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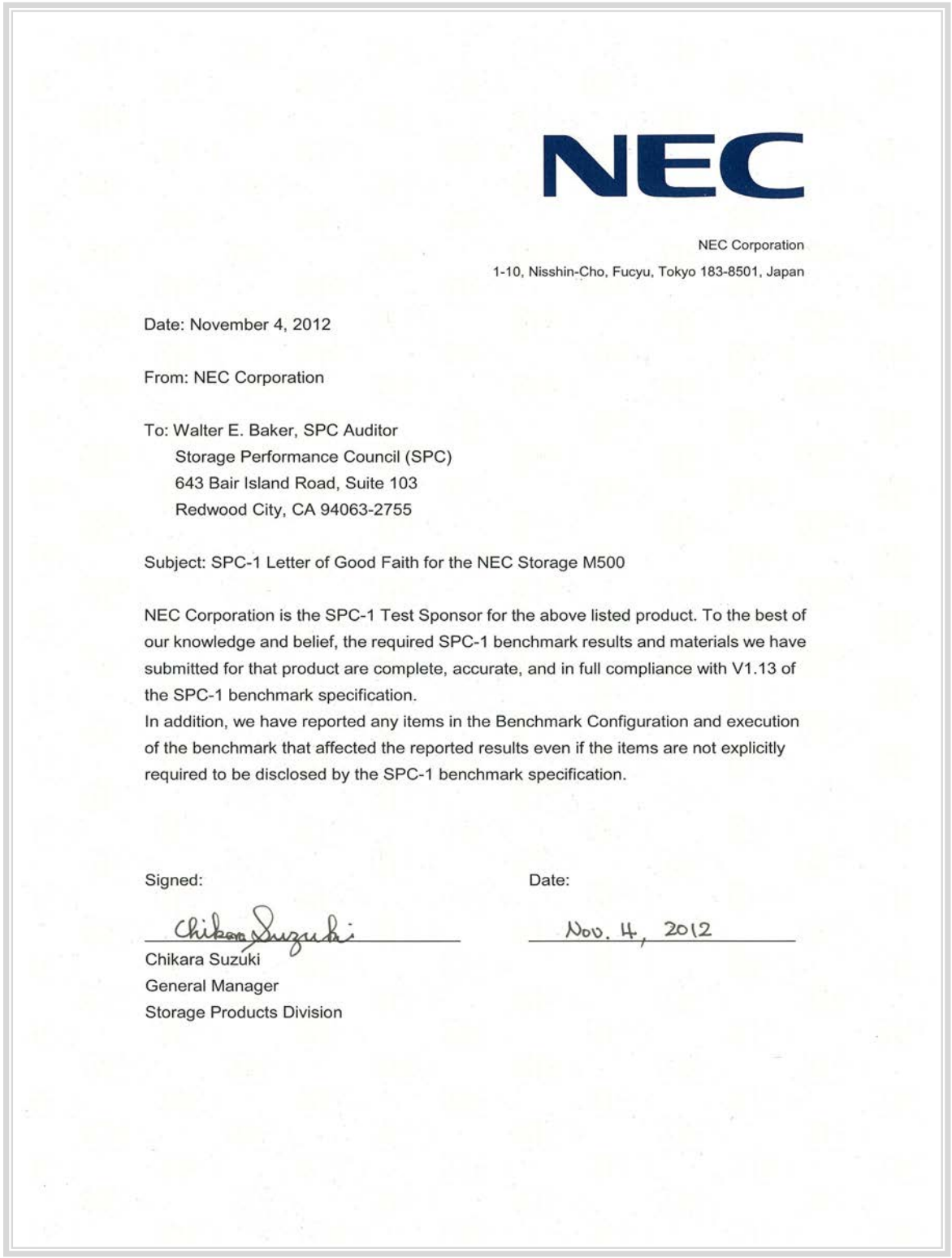
# LETTER OF GOOD FAITH



NEC

NEC Corporation
1-10, Nisshin-Cho, Fucyu, Tokyo 183-8501, Japan

Date: November 4, 2012

From: NEC Corporation

To: Walter E. Baker, SPC 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 NEC Storage M500

NEC Corporation is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V1.13 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: Chikara Suzuki

Date: Nov. 4, 2012

Chikara Suzuki
General Manager
Storage Products Division

# EXECUTIVE SUMMARY

## Test Sponsor and Contact Information

| Test Sponsor and Contact Information | |
|---|---|
| **Test Sponsor Primary Contact** | NEC Corporation – http://www.nec.com<br>Kentaro Yamamoto – k-yamamoto@dh.jp.nec.com<br>1-10, Nisshin-Cho, Fucyu<br>Tokyo, 183-8501, Japan<br>Phone: +81 42 333 5150 |
| **Test Sponsor Alternate Contact** | NEC Corporation – http://www.nec.com<br>Hideaki Fujimori – h-fujimori@ce.jp.nec.com<br>1-10, Nisshin-Cho, Fucyu<br>Tokyo, 183-8501, Japan<br>Phone: +81 42 333 1733<br>FAX: +81 42 333 1818 |
| **Test Sponsor Alternate Contact** | NEC Corporation of America – http://www.necam.com<br>Jim Hawes – jim.hawes@necam.com<br>2880 Scott Blvd.<br>Santa Clara, CA 95050<br>Phone: (602) 237-9830 |
| **Auditor** | Storage Performance Council – http://www.storageperformance.org<br>Walter E. Baker – AuditService@StoragePerformance.org<br>643 Bair Island Road, Suite 103<br>Redwood City, CA 94063<br>Phone: (650) 556-9384<br>FAX: (650) 556-9385 |

## Revision Information and Key Dates

| Revision Information and Key Dates | |
|---|---|
| **SPC-1 Specification revision number** | V1.13 |
| **SPC-1 Workload Generator revision number** | V2.3.0 |
| **Date Results were first used publicly** | February 20, 2013 |
| **Date the FDR was submitted to the SPC** | February 20, 2013 |
| **Date the Priced Storage Configuration is available for shipment to customers** | March 1, 2013 |
| **Date the TSC completed audit certification** | February 19, 2013 |

## Tested Storage Product (TSP) Description

NEC's M500 SAN storage arrays are a great choice for very scalable, mission-critical, high performance, primary or tiered storage. These SAN storage arrays are easy to operate, dependable and efficient. They are also well-suited for use in virtualized environments by virtue of their great scalability, LUN lock stability, support for VMware APIs and flexibility.

NEC M500 SAN arrays feature host interfaces: 8 Gbps Fibre Channel, 10Gbps/1Gbps iSCSI. Both interfaces can be deployed concurrently. M500 offers 3.5" and 2.5" drives. 2.5" drives are attractive due to their lower power and space consumption. 3.5" drives by contract offer the best storage density per spindle. M500 simultaneous supports SAS HDD, NearLine SAS HDD, and SSD in the same enclosures, enabling flexible tiered storage architecture.

## Summary of Results

| SPC-1 Reported Data | |
|---|---|
| **Tested Storage Product (TSP) Name:** NEC Storage M500 | |
| **Metric** | **Reported Result** |
| **SPC-1 IOPS™** | 63,051.60 |
| **SPC-1 Price-Performance™** | $3.98/SPC-1 IOPS™ |
| **Total ASU Capacity** | 34,923.295 GB |
| **Data Protection Level** | Protected 1 *(Mirroring)* |
| **Total Price** | $251,075.64 |
| **Currency Used** | U.S. Dollars |
| **Target Country for availability, sales and support** | USA |

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

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

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

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

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

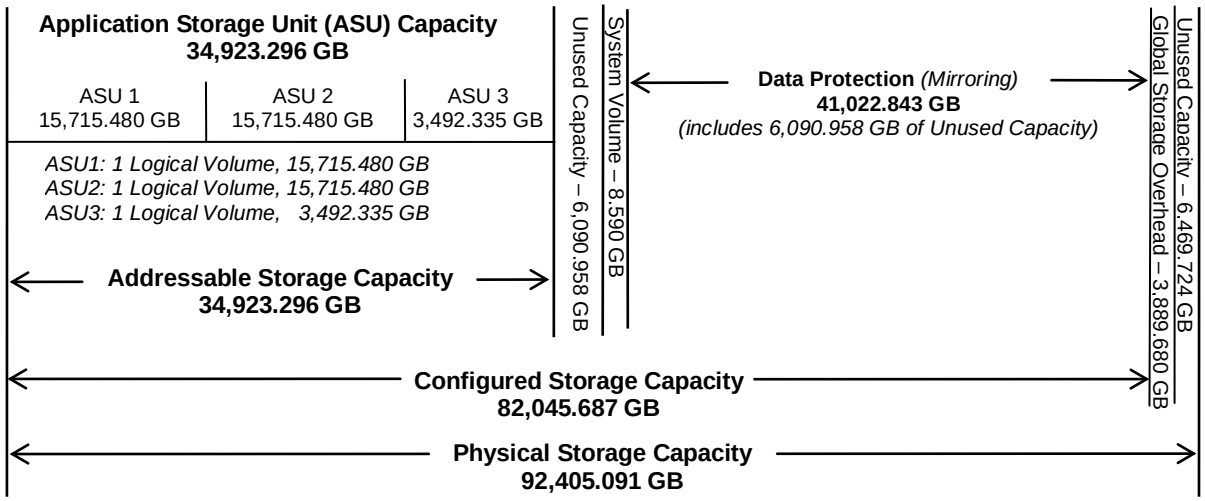
**Total Price** includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 15.

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

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

## Storage Capacities, Relationships, and Utilization

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




| SPC-1 Storage Capacity Utilization | |
|---|---|
| Application Utilization | 37.79% |
| Protected Application Utilization | 75.60% |
| Unused Storage Ratio | 20.18% |

**Application Utilization:** Total ASU Capacity *(34,923.296 GB)* divided by Physical Storage Capacity *(92,405.091 GB)*

**Protected Application Utilization:** Total ASU Capacity *(34,923.296 GB)* plus total Data Protection Capacity *(41,022.843 GB)* minus unused Data Protection Capacity *(6,090.958GB)* divided by Physical Storage Capacity *(92,405.091 GB)*

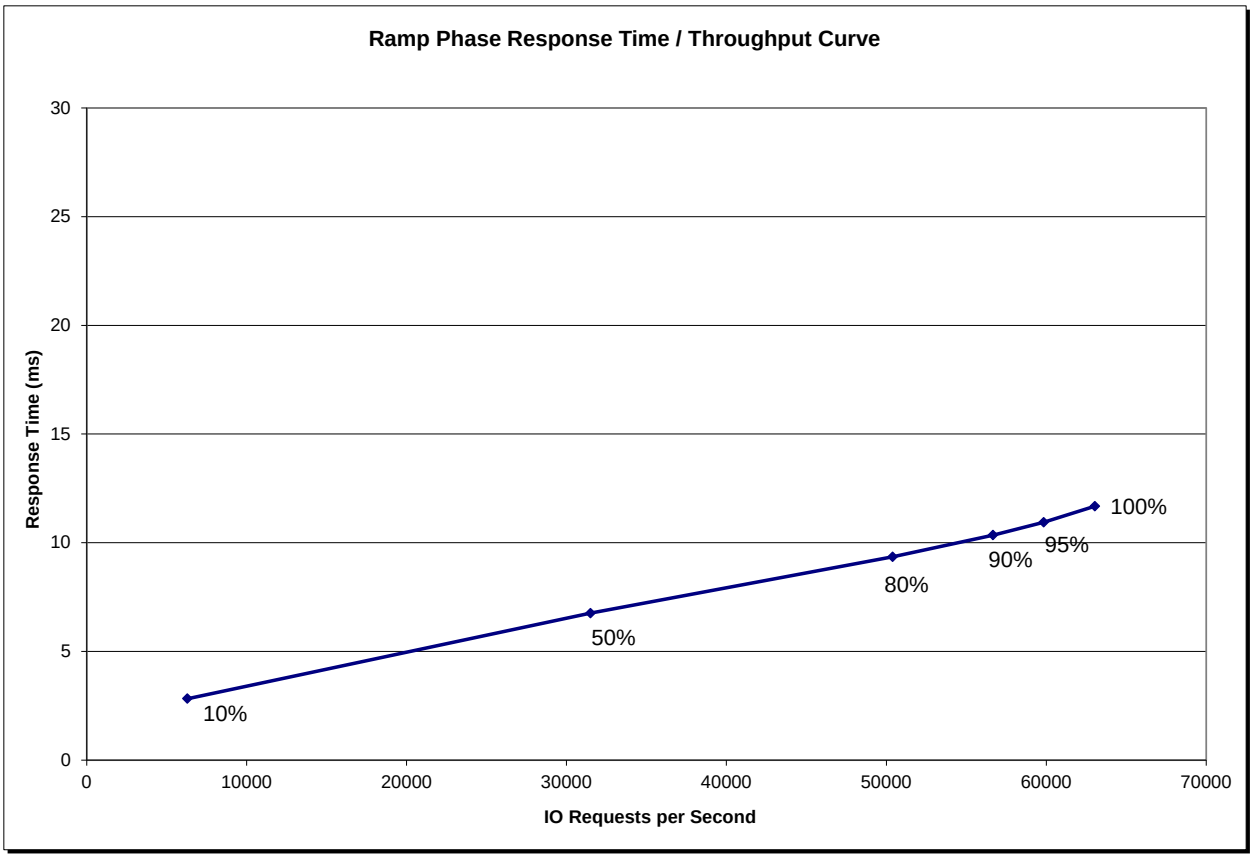
**Unused Storage Ratio:** Total Unused Capacity *(18,651.640 GB)* divided by Physical Storage Capacity *(92,405.091 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 24-25.

## 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** | 6,299.46 | 31,501.83 | 50,404.57 | 56,674.18 | 59,848.47 | 63,051.60 |
| ***Average Response Time (ms):*** | | | | | | |
| **All ASUs** | 2.82 | 6.76 | 9.35 | 10.35 | 10.94 | 11.68 |
| **ASU-1** | 3.88 | 9.26 | 12.73 | 14.01 | 14.77 | 15.64 |
| **ASU-2** | 3.32 | 8.71 | 12.33 | 13.68 | 14.48 | 15.40 |
| **ASU-3** | 0.37 | 0.60 | 0.89 | 1.12 | 1.26 | 1.66 |
| **Reads** | 6.00 | 15.25 | 21.04 | 23.14 | 24.34 | 25.59 |
| **Writes** | 0.75 | 1.23 | 1.74 | 2.02 | 2.21 | 2.62 |

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

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

## Priced Storage Configuration Pricing

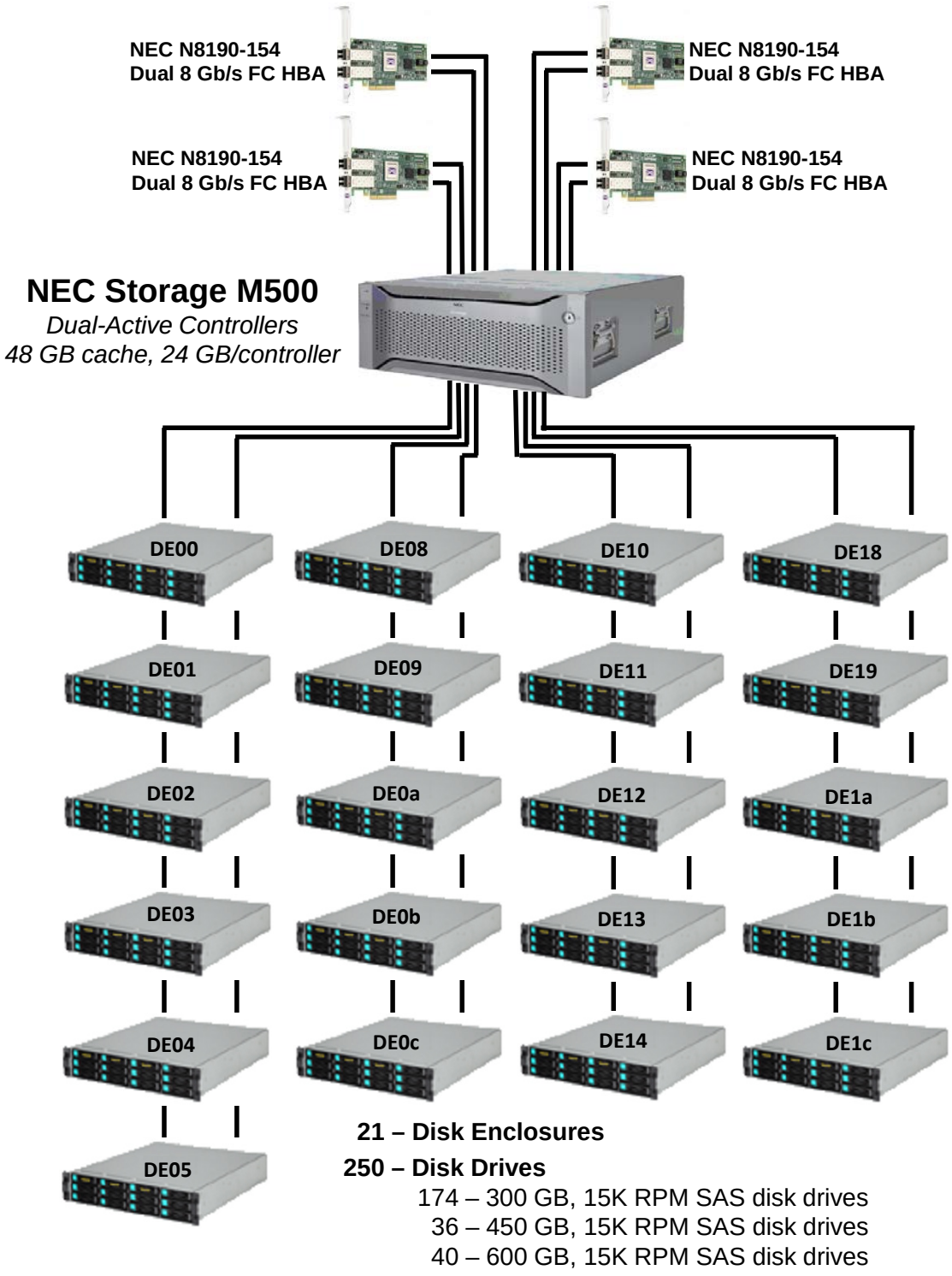
| PART# | Product Name | Qty | Unit List Price | Extended LP | Discount | Discounted Price |
|---|---|---|---|---|---|---|
| NF5341-SB00E | M500 Disk Array Unit | 1 | $53,500.00 | $53,500.00 | 20.0% | $42,800.00 |
| NF5341-SF02WE | Controller Card(8Gb FC 8Port) | 2 | $4,995.00 | $9,990.00 | 20.0% | $7,992.00 |
| NF5341-SC03E | Standard Cache Memory(48GB) | 1 | $3,695.00 | $3,695.00 | 20.0% | $2,956.00 |
| NF5321-SE70E | Disk Enclosure(3.5", 6Gbps) | 21 | $3,288.00 | $69,048.00 | 20.0% | $55,238.40 |
| NF5321-SM725E | SAS Disk Drive(3.5", 15krpm/300GB, 6Gbps) | 174 | $395.00 | $68,730.00 | 20.0% | $54,984.00 |
| NF5321-SM727E | SAS Disk Drive(3.5", 15krpm/450GB, 6Gbps) | 36 | $440.00 | $15,840.00 | 20.0% | $12,672.00 |
| NF5321-SM728E | SAS Disk Drive(3.5", 15krpm/600GB, 6Gbps) | 40 | $540.00 | $21,600.00 | 20.0% | $17,280.00 |
| N8190-154 | 8Gbps Dual Port Fibre Channel HBA | 4 | $1,355.00 | $5,420.00 | 10.0% | $4,878.00 |
| FC cable | FC cable | 16 | $100.00 | $1,600.00 | 10.0% | $1,440.00 |
| Power Cord | Power Cord (10 ft.) | 44 | $18.20 | $800.80 | 10.0% | $720.72 |
| Power Strips | Power Strips (8 outlets) | 6 | $78.00 | $468.00 | 10.0% | $421.20 |
| RACK | Rack 42U | 4 | $1,799.00 | $7,196.00 | 10.0% | $6,476.40 |
| UFSM01-500300AM | M500 Base Product Storage Manager Software including Storage Manager Express, Access Control, Storage Power Conserver and Thin Provisioning. | 1 | $0.00 | $0.00 | 20.0% | $0.00 |
| UFS206-0050W0AM | Path Manager for Windows | 1 | $0.00 | $0.00 | 20.0% | $0.00 |
| Q24-DN000000011294 | 3 Years Upgraded Platinum Warranty M500 M500 Disk Array Unit | 1 | $14,745.00 | $14,745.00 | 15.0% | $12,533.25 |
| Q24-DN000000011295 | 3 Years Upgraded Platinum Warranty for Host Port Kit(2x 8Gb FC 4Port) | 2 | $896.00 | $1,792.00 | 15.0% | $1,523.20 |
| Q24-DN000000011300 | 3 Years Upgraded Platinum Warranty for Standard Cache Memory(48GB[6x8GB]) | 1 | $800.15 | $800.15 | 15.0% | $680.13 |
| Q24-DN000000006694 | 3YR Upgraded to Platinum Warranty M100 DiskExp3.5"6Gbps | 21 | $822.00 | $17,262.00 | 15.0% | $14,672.70 |
| Q24-DN000000006752 | 3YR Upgraded to Platinum Warranty M100 HDD 3.5" 15K 300GB 6Gbps(per 12Disks) | 15 | $300.00 | $4,500.00 | 15.0% | $3,825.00 |
| Q24-DN000000006753 | 3YR Upgraded to Platinum Warranty M100 HDD 3.5" 15K 450GB 6Gbps(per 12Disks) | 3 | $300.00 | $900.00 | 15.0% | $765.00 |
| Q24-DN000000006754 | 3YR Upgraded to Platinum Warranty M100 HDD 3.5" 15K 600GB 6Gbps(per 12Disks) | 4 | $300.00 | $1,200.00 | 15.0% | $1,020.00 |
| Q24-DN000000011346 | 3 Years Upgraded Platinum SW Maintenance for M500 Base Product | 1 | $9,293.28 | $9,293.28 | 15.0% | $7,899.29 |
| Q24-DN000000010953 | 3 Year Platinum PathMgr5.0Win Software Maintenance | 1 | $351.00 | $351.00 | 15.0% | $298.35 |
| **Totals** | | | | *$308,731.23* | | **$251,075.64** |

* M500 Disk Array Unit includes SAS ports for disk enclosure.
* SFP is included in each component.
* Price of M500 Disk Array Unit includes price of Software products (UFSM01-500300AM and UFS206-0050W0AM).

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

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

## Priced Storage Configuration Diagram




The distribution of disk drives to disk enclosures is documented on page 21.

## Priced Storage Configuration Components

| Priced Storage Configuration: |
|---|
| 4 – N8190-154 dual 8 Gb/s FC HBAs |
| **NEC Storage M500**<br>**dual controllers – Active-Active**<br>24 GB cache per controller *(48 GB total)*<br>1 – FC 8-port Controller Card per controller *(8 Gbps, 2 Controller Cards total)*<br>8 – 8 Gbps front-end connections per controller *(16 total, 8 used)*<br>4 –6 Gbps SAS backend connections per controller *(8 total, 8 used)* |
| 21 – Disk Enclosures (3.5”, 6 Gbps) |
| 250 – 15K RPM SAS disk drives<br>164 – 300 GB disk drives<br>36 – 450 GB disk drives<br>40 – 600 GB disk drives |

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

# CONFIGURATION INFORMATION

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

*Clause 9.4.3.4.1*

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

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

## Storage Network Configuration

*Clause 9.4.3.4.1*

…

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

*Clause 9.4.3.4.2*

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

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

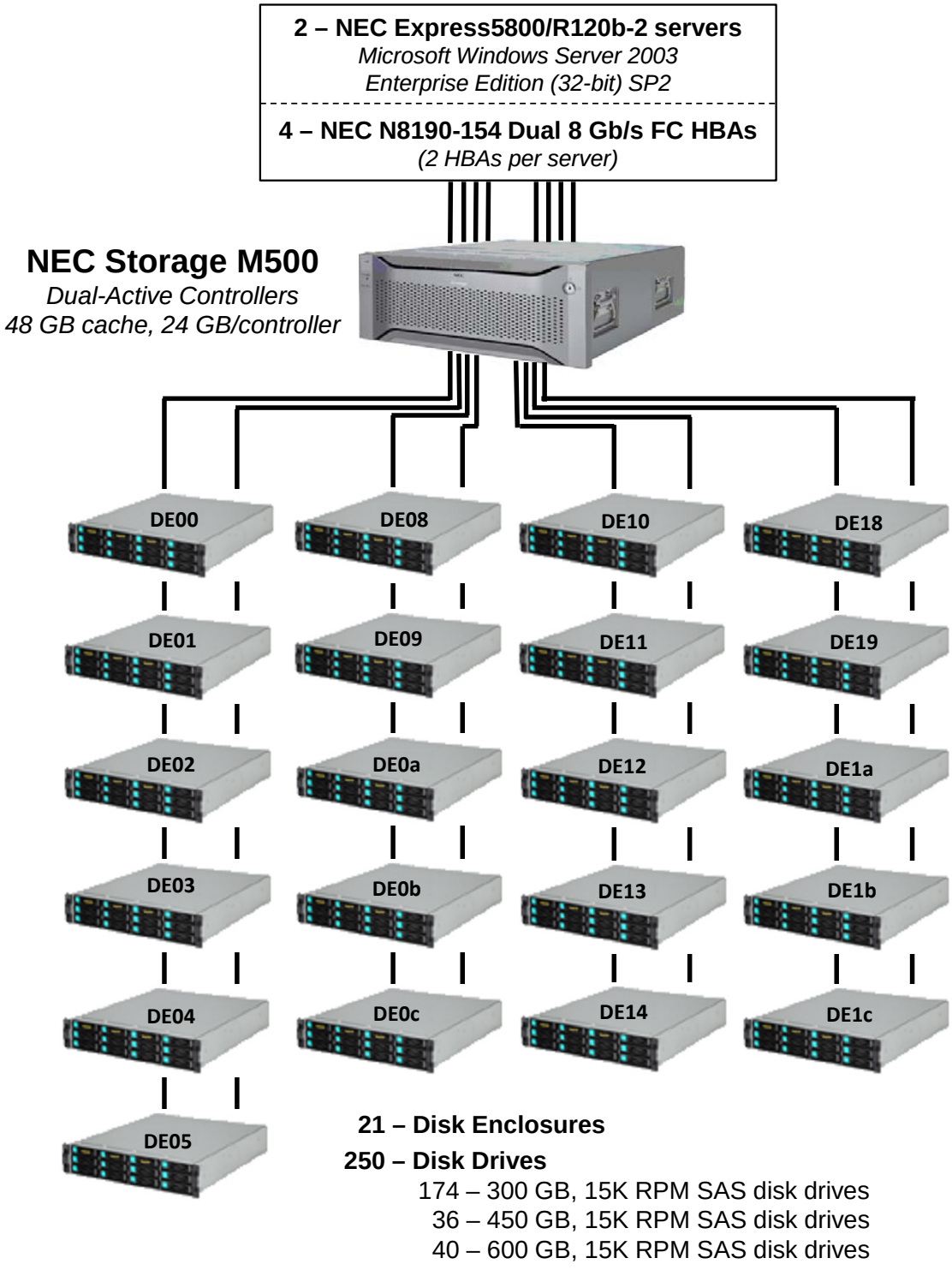
## Host System(s) and Tested Storage Configuration (TSC) Table of Components

*Clause 9.4.3.4.3*

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

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

## Benchmark Configuration/Tested Storage Configuration Diagram



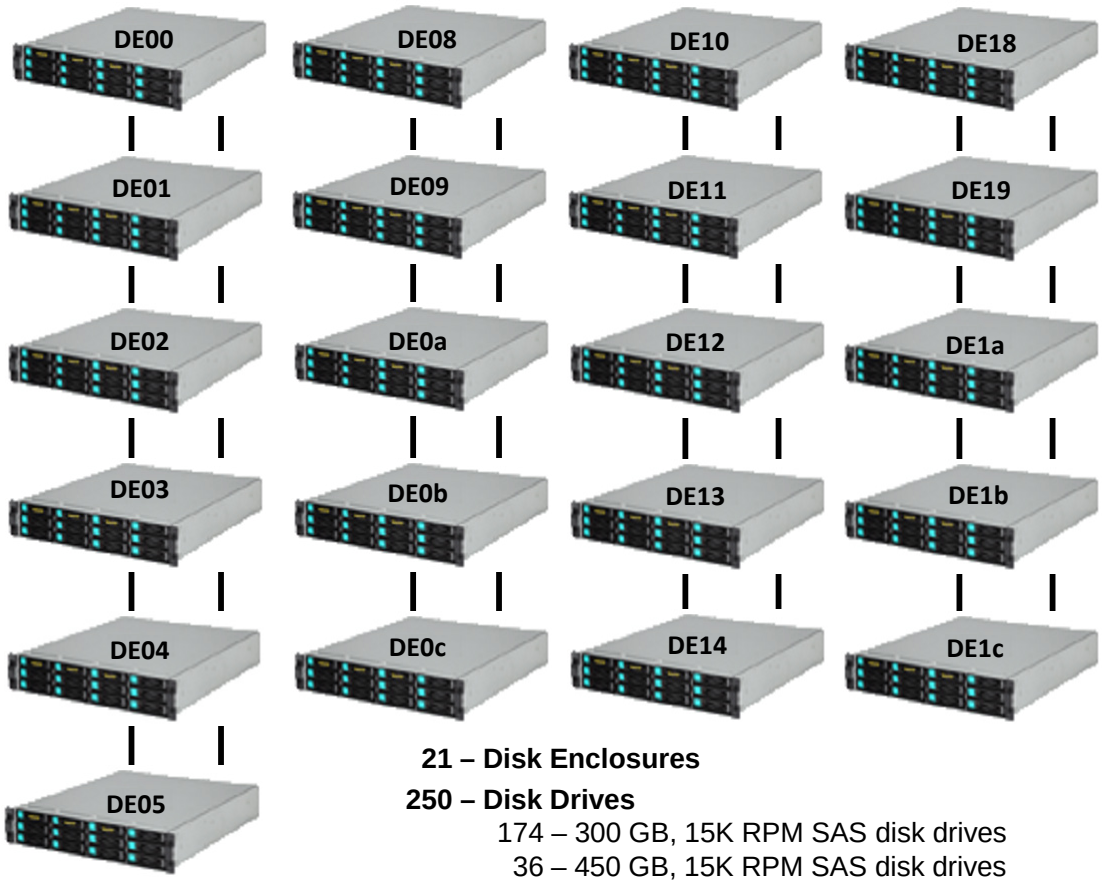

The distribution of disk drives to disk enclosures is documented on page 21.

## Host Systems and Tested Storage Configuration Components

| Host Systems: | Tested Storage Configuration (TSC): |
|---|---|
| **2 – NEC Express5800/R120b-2 servers**<br>each server with:<br>1 – Intel Xeon X5650 6 core processor 2.66 GHz, 12 MB Intel Smart Cache<br>8 GB main memory<br>Microsoft Windows 2003 Enterprise Edition (32-bit) with SP2<br>PCIe | 4 – N8190-154 dual 8 Gb/s FC HBAs |
| | **NEC Storage M500**<br>**dual controllers – Active-Active**<br>24 GB cache per controller *(48 GB total)*<br>1 – FC 8-port Controller Card per controller *(8 Gbps, 2 Controller Cards total)*<br>8 – 8Gbps front-end connections per controller *(16 total, 8 used)*<br>4 –6 Gbps SAS backend connections per controller *(8 total and 8 used)* |
| | 21 – Disk Enclosures (3.5”, 6 Gbps) |
| | 250 – 15K RPM SAS disk drives<br>164 – 300 GB disk drives<br>36 – 450 GB disk drives<br>40 – 600 GB disk drives |

## Distribution of Disk Drives to Disk Enclosures

| | | | |
|---|---|---|---|
| **DE00:**<br>*12 – 300 GB disk drives* | **DE08:**<br>*12 – 300 GB disk drives* | **DE10:**<br>*12 – 600 GB disk drives* | **DE18:**<br>*12 – 300 GB disk drives* |
| **DE01:**<br>*12 – 300 GB disk drives* | **DE09:**<br>*12 – 300 GB disk drives* | **DE11:**<br>*12 – 300 GB disk drives* | **DE19:**<br>*8 – 300 GB disk drives*<br>*4 – 450 GB disk drives* |
| **DE02:**<br>*12 – 300 GB disk drives* | **DE0a:**<br>*12 – 450 GB disk drives* | **DE12:**<br>*12 – 300 GB disk drives* | **DE1a:**<br>*8 – 450 GB disk drives*<br>*4 – 300 GB disk drives* |
| **DE03:**<br>*12 – 300 GB disk drives* | **DE0b**:<br>*12 – 450 GB disk drives* | **DE13:**<br>*12 – 600 GB disk drives* | **DE1b:**<br>*6 – 300 GB disk drives*<br>*4 – 600 GB disk drives*<br>*2 – 300 GB disk drives* |
| **DE04:**<br>*12 – 300 GB disk drives* | **DE0c:**<br>*12 – 300 GB disk drives* | **DE14:**<br>*12 – 600 GB disk drives* | **DE1c:**:<br>*12 – 300 GB disk drives* |
| **DE05:**<br>*10 – 300 GB disk drives* | | | |




**21 – Disk Enclosures**

**250 – Disk Drives**

174 – 300 GB, 15K RPM SAS disk drives
36 – 450 GB, 15K RPM SAS disk drives
40 – 600 GB, 15K RPM SAS disk drives

## Customer Tunable Parameters and Options

*Clause 9.4.3.5.1*

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

*Appendix B: Customer Tunable Parameters and Options* on page 63 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

## Tested Storage Configuration (TSC) Description

*Clause 9.4.3.5.2*

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

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

*Appendix C: Tested Storage Configuration (TSC) Creation* on page 64 contains the detailed information that describes how to create and configure the logical TSC.

## SPC-1 Workload Generator Storage Configuration

*Clause 9.4.3.5.3*

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

The SPC-1 Workload Generator storage configuration commands and parameters for this measurement appear in *Appendix D: SPC-1 Workload Generator Storage Commands and Parameters* on page 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 59 contains definitions of terms specific to the SPC-1 Data Repository.

## Storage Capacities and Relationships

*Clause 9.4.3.6.1*

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

### SPC-1 Storage Capacities

The Physical Storage Capacity consisted of 92,405.091 GB distributed over 250 disk drives. That capacity was distributed between 174 disk drives with a formatted capacity of 300.00 GB per disk drive, 36 disk drives with a formatted capacity of 450.00 GB per disk drive and 40 disk drives with a formatted capacity of 600.127 GB per disk drive. There was 6,469.724 GB (7.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 3,889.680 GB (4.21%) of the Physical Storage Capacity. There was 12,181.916 GB (14.85%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity resulting in 0.00 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection *(Mirroring)* capacity was 41,022.843 GB of which 34,931.885 GB was utilized. The total Unused Storage capacity was 18,651.640 GB.

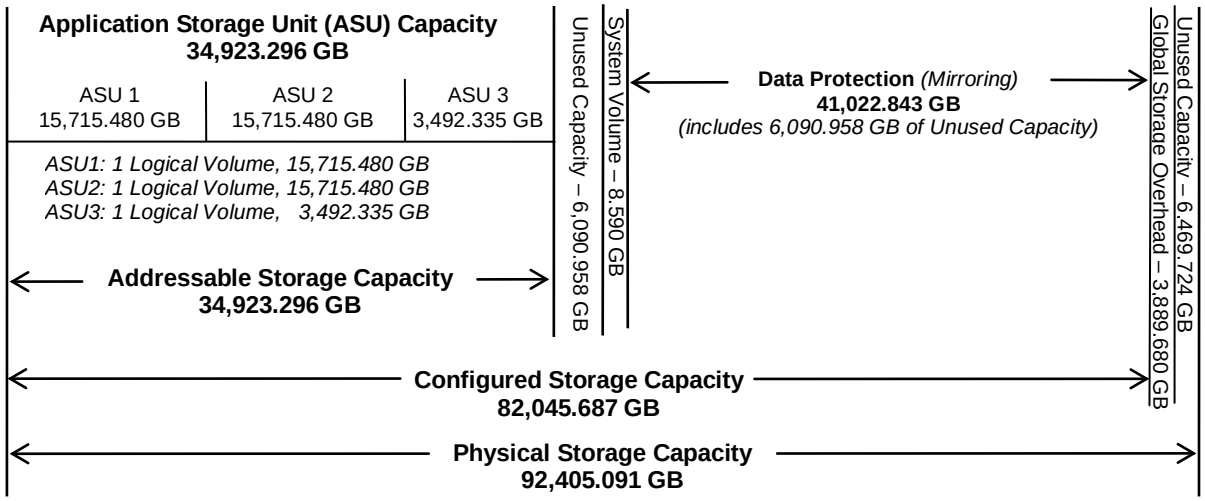
*Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.*

**SPC-1 Storage Capacities**

| Storage Hierarchy Component | Units | Capacity |
|---|---|---|
| Total ASU Capacity | Gigabytes (GB) | 34,923.296 |
| Addressable Storage Capacity | Gigabytes (GB) | 34,923.296 |
| Configured Storage Capacity | Gigabytes (GB) | 82,045.687 |
| Physical Storage Capacity | Gigabytes (GB) | 92,405.091 |
| Data Protection *(Mirroring)* | Gigabytes (GB) | 41,022.843 |
| Required Storage *(system volume)* | Gigabytes (GB) | 8.590 |
| Global Storage Overhead | Gigabytes (GB) | 3,889.680 |
| Total Unused Storage | Gigabytes (GB) | 18,651.640 |

## SPC-1 Storage Capacities and Relationships Illustration

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




## SPC-1 Storage Hierarchy Ratios

| | Addressable Storage Capacity | Configured Storage Capacity | Physical Storage Capacity |
|---|---|---|---|
| **Total ASU Capacity** | 100.00% | 42.57% | 37.79% |
| **Required for Data Protection *(Mirroring)*** | | 50.00% | 44.39% |
| **Addressable Storage Capacity** | | 42.57% | 37.79% |
| **Required Storage *(system volume)*** | | 0.01% | 0.01% |
| **Configured Storage Capacity** | | | 88.79% |
| **Global Storage Overhead** | | | 4.21% |
| **Unused Storage:** | | | |
| **Addressable** | 0.00% | | |
| **Configured** | | 14.85% | |
| **Physical** | | | 7.00% |

## Storage Capacity Utilization

*Clause 9.4.3.6.2*

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

*Clause 2.8.1*

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

*Clause 2.8.2*

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

*Clause 2.8.3*

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

| SPC-1 Storage Capacity Utilization | |
|---|---|
| Application Utilization | 37.79% |
| Protected Application Utilization | 75.60% |
| Unused Storage Ratio | 20.18% |

## 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 (15,715.480 GB)** | **ASU-2 (15,715.480 GB)** | **ASU-3 (3,492.335 GB)** |
| 1 Logical Volume<br>15,715.480 GB per Logical Volume<br>(15,715.480 GB used per Logical Volume) | 1 Logical Volume<br>15,715.480 GB per Logical Volume<br>(15,715.480 GB used per Logical | 1 Logical Volume<br>3,492.335 GB per Logical Volume<br>(3,492.335 GB used per Logical Volume) |

The Data Protection Level used for all Logical Volumes was **Protected 1** using ***Mirroring*** as described on page 12. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

# SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. *"Appendix A: SPC-1 Glossary"* on page 60 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

*Clause 5.4.3*

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

## SPC-1 Tests, Test Phases, and Test Runs

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

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

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

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

## Primary Metrics Test – Sustainability Test Phase

*Clause 5.4.4.1.1*

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

*Clause 5.4.4.1.2*

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

*Clause 5.4.4.1.4*

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

*Clause 9.4.3.7.1*

*For the Sustainability Test Phase the FDR shall contain:*

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

### SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 79.

### Sustainability Test Results File

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

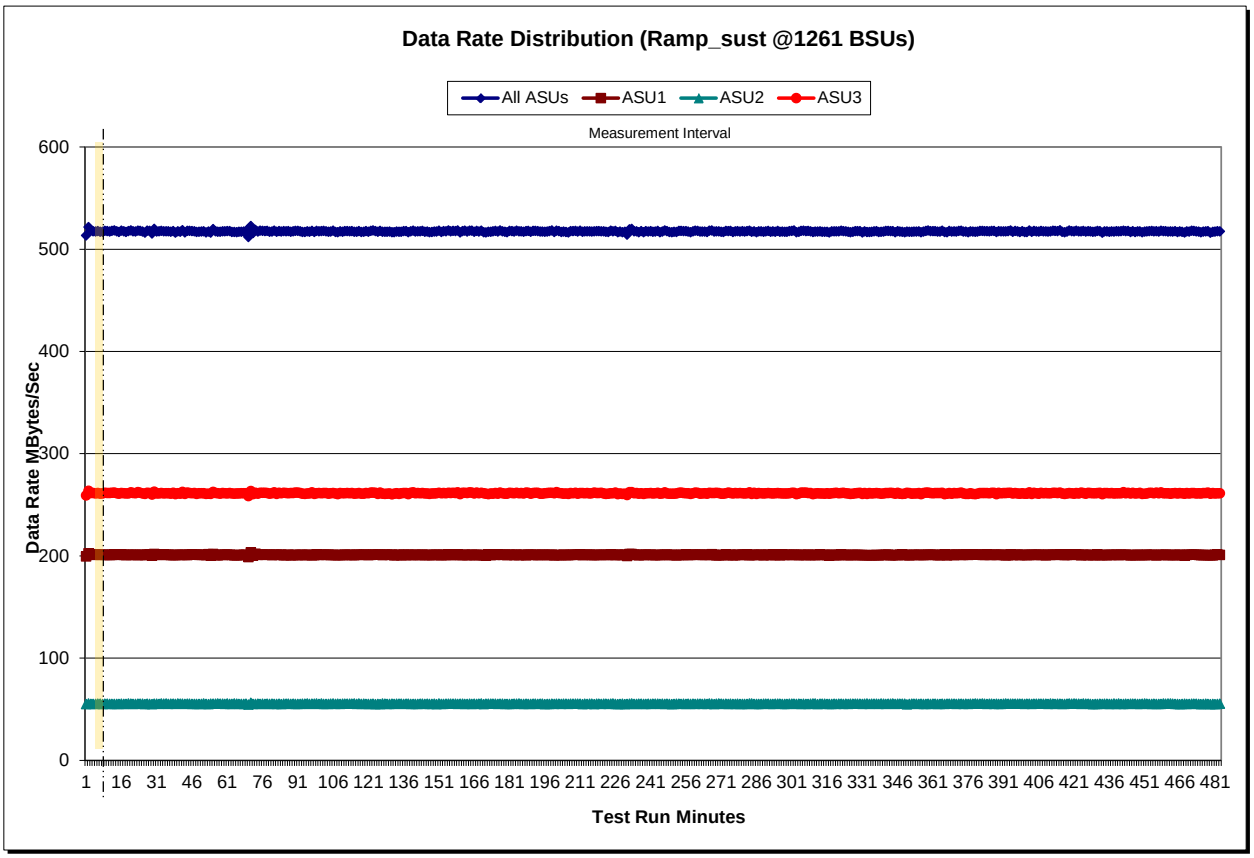
**Sustainability Test Results File**

## 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

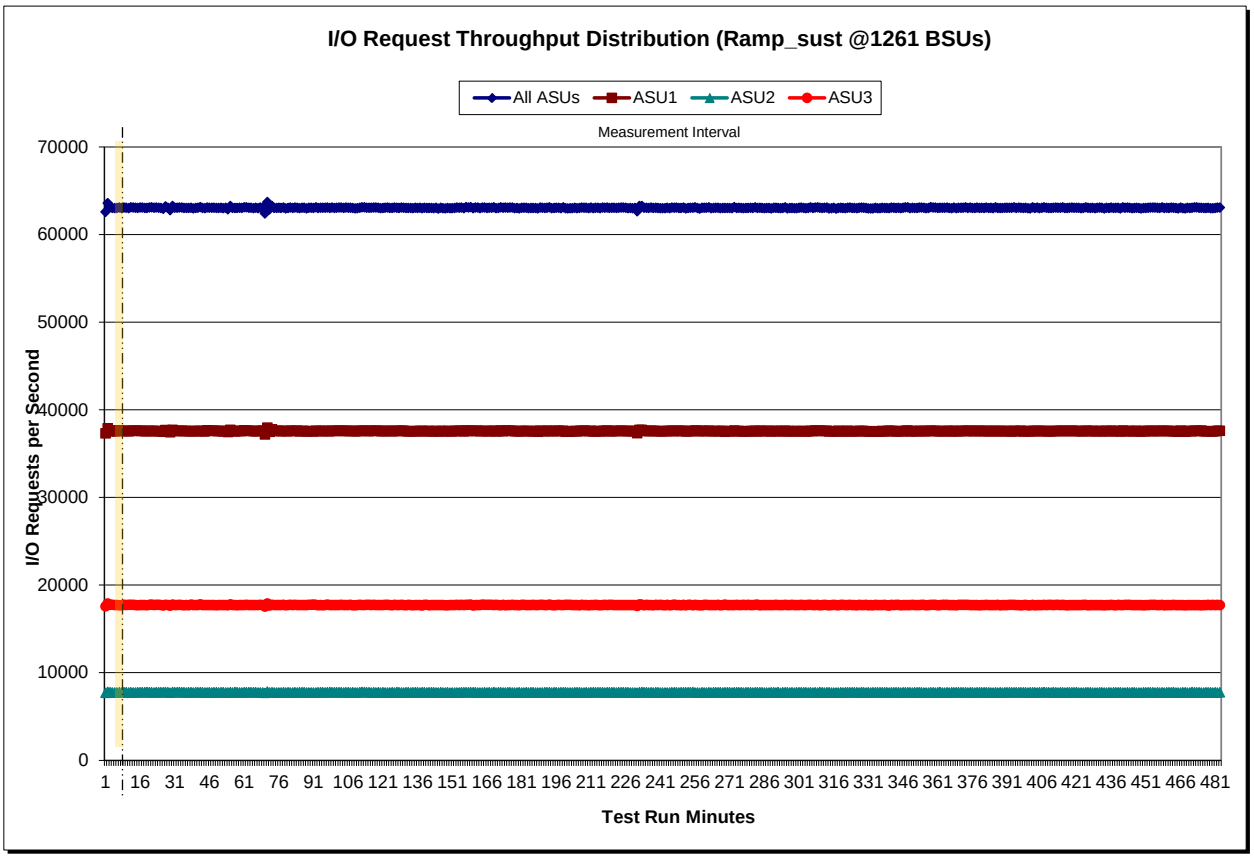


## Sustainability – I/O Request Throughput Distribution Data

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

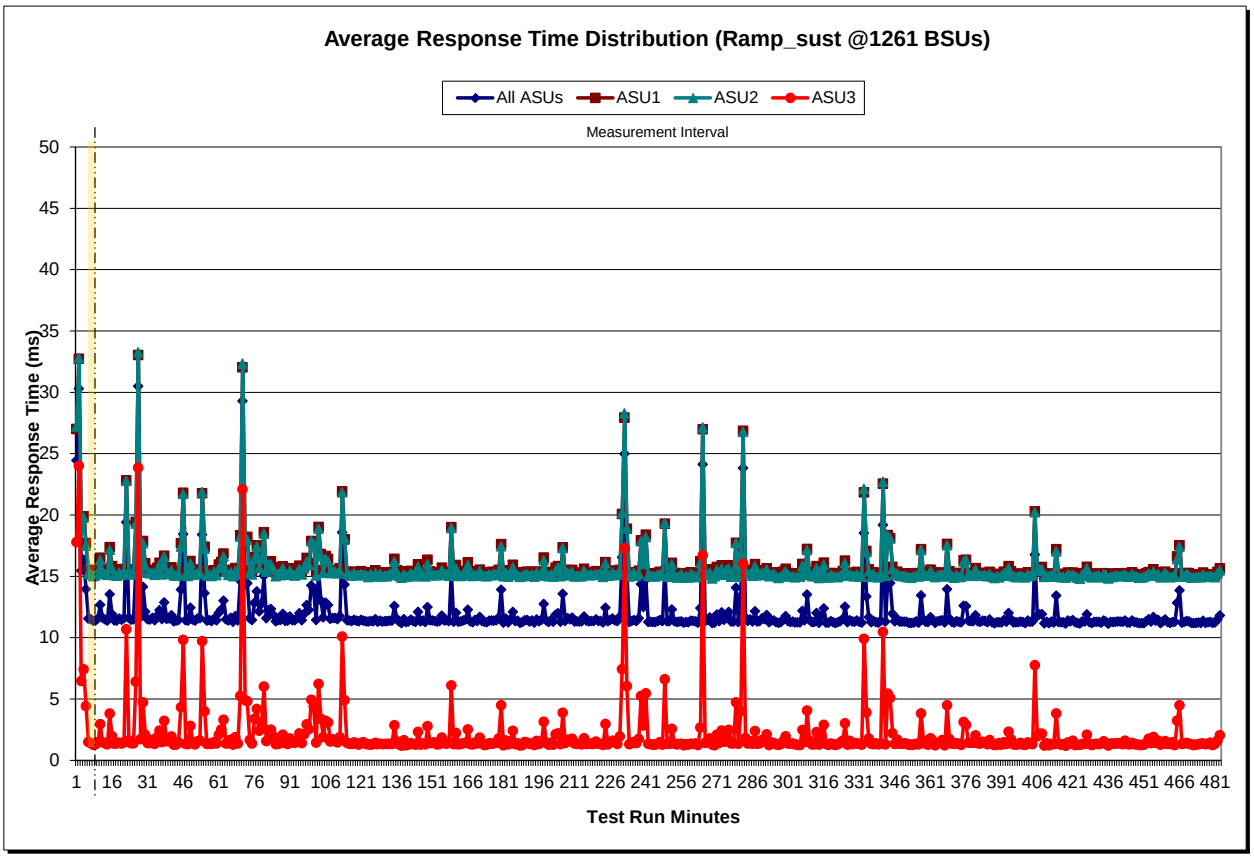


## Sustainability – Average Response Time (ms) Distribution Data

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**

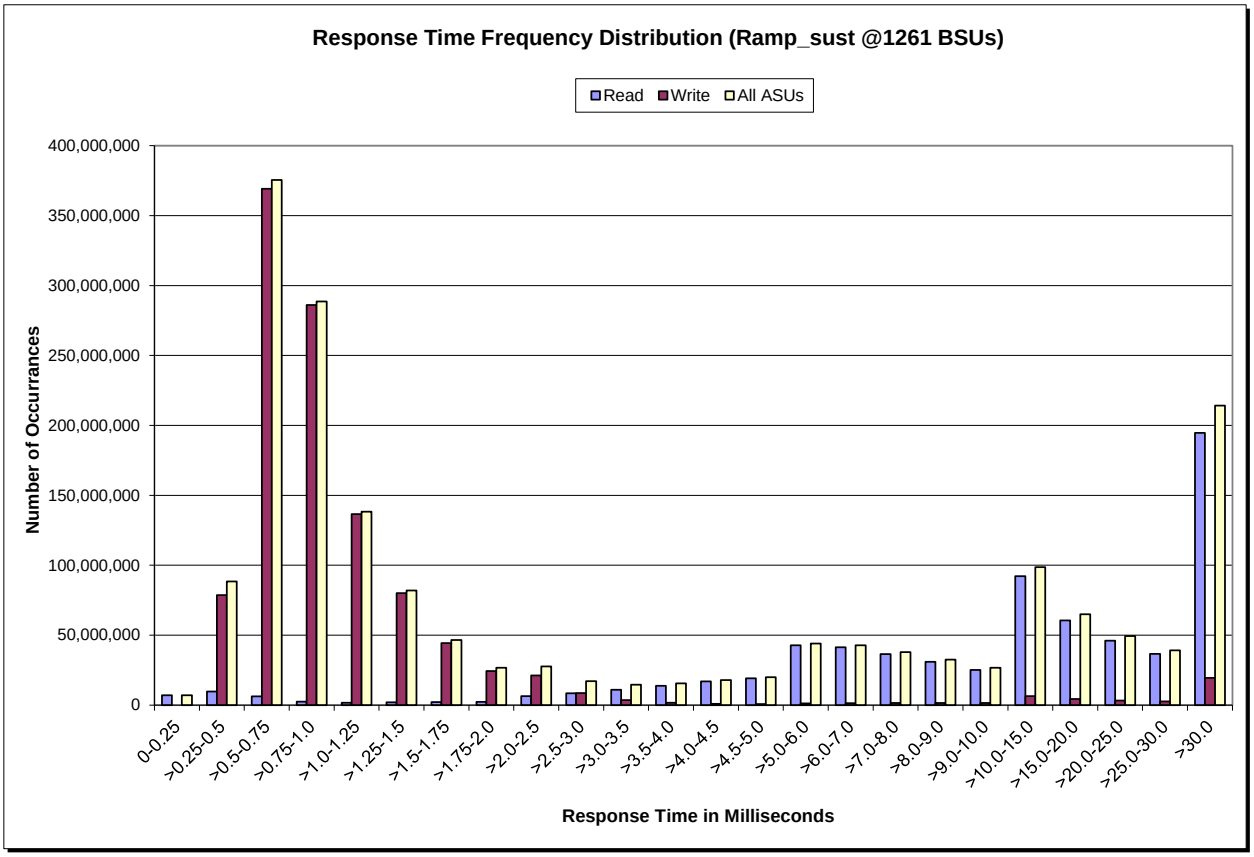
## Sustainability – Average Response Time (ms) Distribution Graph



## 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 | 7,046,100 | 9,695,230 | 6,221,502 | 2,525,927 | 1,776,007 | 1,978,083 | 2,115,770 | 2,368,846 |
| Write | 36 | 78,683,463 | 369,201,988 | 286,047,696 | 136,578,366 | 80,004,197 | 44,389,410 | 24,392,015 |
| All ASUs | 7,046,136 | 88,378,693 | 375,423,490 | 288,573,623 | 138,354,373 | 81,982,280 | 46,505,180 | 26,760,861 |
| ASU1 | 6,566,631 | 42,191,678 | 156,603,278 | 119,580,688 | 59,739,994 | 36,326,938 | 21,252,384 | 12,837,565 |
| ASU2 | 479,490 | 10,553,264 | 38,517,041 | 28,616,719 | 14,056,683 | 8,546,212 | 4,953,305 | 2,893,547 |
| ASU3 | 15 | 35,633,751 | 180,303,171 | 140,376,216 | 64,557,696 | 37,109,130 | 20,299,491 | 11,029,749 |
| **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 | 6,408,529 | 8,427,004 | 10,999,061 | 13,851,792 | 16,930,417 | 19,133,970 | 42,714,280 | 41,407,966 |
| Write | 21,271,702 | 8,655,889 | 3,569,318 | 1,763,876 | 909,445 | 744,002 | 1,292,889 | 1,304,988 |
| All ASUs | 27,680,231 | 17,082,893 | 14,568,379 | 15,615,668 | 17,839,862 | 19,877,972 | 44,007,169 | 42,712,954 |
| ASU1 | 15,205,019 | 11,535,774 | 11,410,234 | 13,026,521 | 15,237,500 | 17,005,017 | 37,732,103 | 36,225,523 |
| ASU2 | 3,065,310 | 1,984,017 | 1,828,938 | 2,030,009 | 2,362,707 | 2,729,127 | 6,086,111 | 6,334,604 |
| ASU3 | 9,409,902 | 3,563,102 | 1,329,207 | 559,138 | 239,655 | 143,828 | 188,955 | 152,827 |
| **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 | 36,449,016 | 30,974,199 | 25,124,052 | 92,177,857 | 60,592,161 | 46,013,786 | 36,572,452 | 194,644,373 |
| Write | 1,479,456 | 1,517,361 | 1,613,393 | 6,444,330 | 4,394,714 | 3,293,108 | 2,605,123 | 19,454,047 |
| All ASUs | 37,928,472 | 32,491,560 | 26,737,445 | 98,622,187 | 64,986,875 | 49,306,894 | 39,177,575 | 214,098,420 |
| ASU1 | 32,196,297 | 27,668,885 | 22,686,401 | 83,343,693 | 54,610,409 | 41,252,538 | 32,673,691 | 175,274,742 |
| ASU2 | 5,568,738 | 4,680,095 | 3,913,302 | 14,782,350 | 10,011,176 | 7,753,395 | 6,242,666 | 35,360,191 |
| ASU3 | 163,437 | 142,580 | 137,742 | 496,144 | 365,290 | 300,961 | 261,218 | 3,463,487 |

## 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 | 0.003 | 0.001 | 0.002 | 0.001 | 0.004 | 0.002 | 0.003 | 0.001 |

## Primary Metrics Test – IOPS Test Phase

*Clause 5.4.4.2*

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

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

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

*Clause 9.4.3.7.2*

*For the IOPS Test Phase the FDR shall contain:*

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

### SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 79.

### IOPS Test Results File

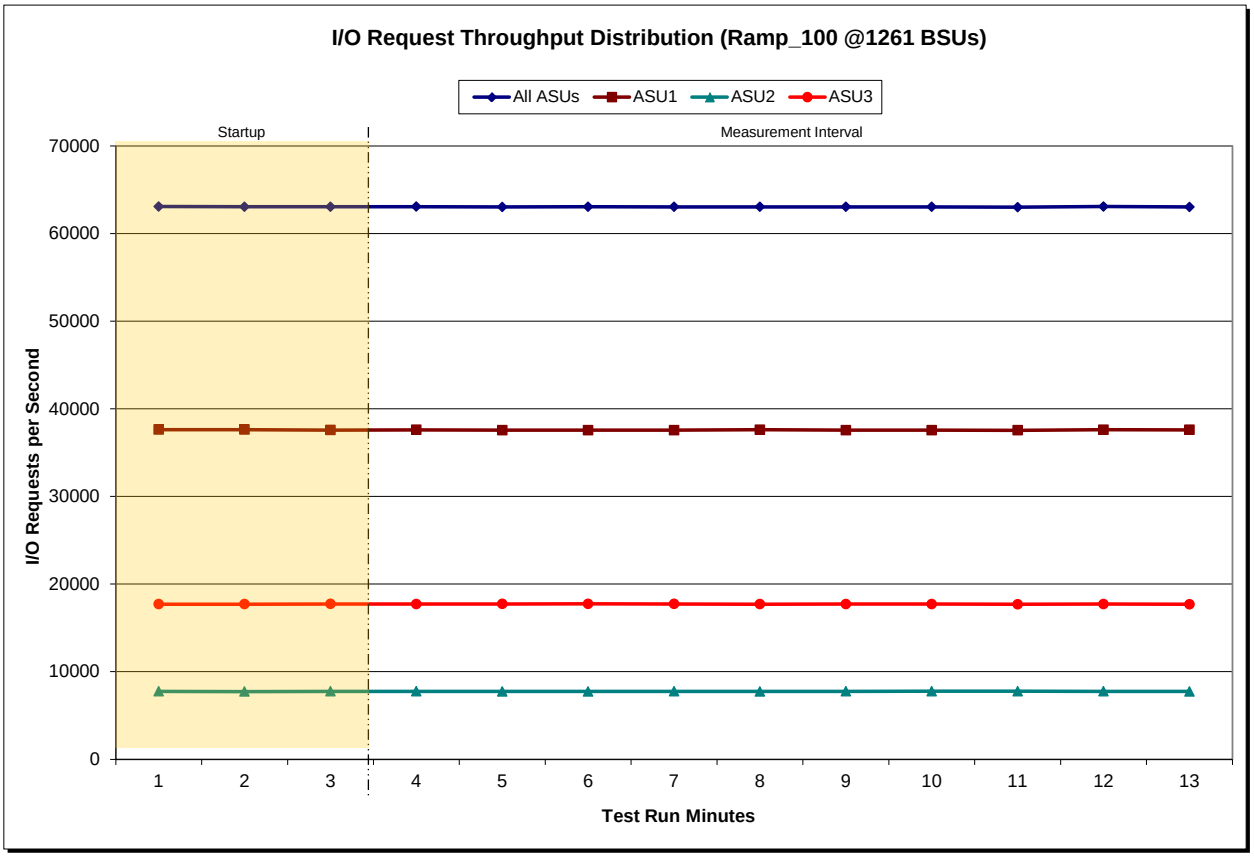
A link to the test results file generated from the IOPS Test Run is listed below.

**IOPS Test Results File**

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

| 1,261 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 16:20:48 | 16:23:49 | 0-2 | 0:03:01 |
| *Measurement Interval* | 16:23:49 | 16:33:49 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 63,089.63 | 37,626.28 | 7,754.15 | 17,709.20 |
| **1** | 63,062.52 | 37,625.83 | 7,729.85 | 17,706.83 |
| **2** | 63,064.42 | 37,579.35 | 7,753.32 | 17,731.75 |
| **3** | 63,074.73 | 37,604.75 | 7,753.30 | 17,716.68 |
| **4** | 63,035.57 | 37,559.35 | 7,750.85 | 17,725.37 |
| **5** | 63,064.45 | 37,568.78 | 7,747.20 | 17,748.47 |
| **6** | 63,051.57 | 37,567.57 | 7,751.80 | 17,732.20 |
| **7** | 63,055.37 | 37,608.63 | 7,739.17 | 17,707.57 |
| **8** | 63,048.42 | 37,569.17 | 7,755.30 | 17,723.95 |
| **9** | 63,048.12 | 37,561.15 | 7,768.95 | 17,718.02 |
| **10** | 63,010.42 | 37,549.98 | 7,765.25 | 17,695.18 |
| **11** | 63,088.68 | 37,610.28 | 7,757.08 | 17,721.32 |
| **12** | 63,038.70 | 37,602.48 | 7,747.72 | 17,688.50 |
| ***Average*** | ***63,051.60*** | ***37,580.22*** | ***7,753.66*** | ***17,717.73*** |

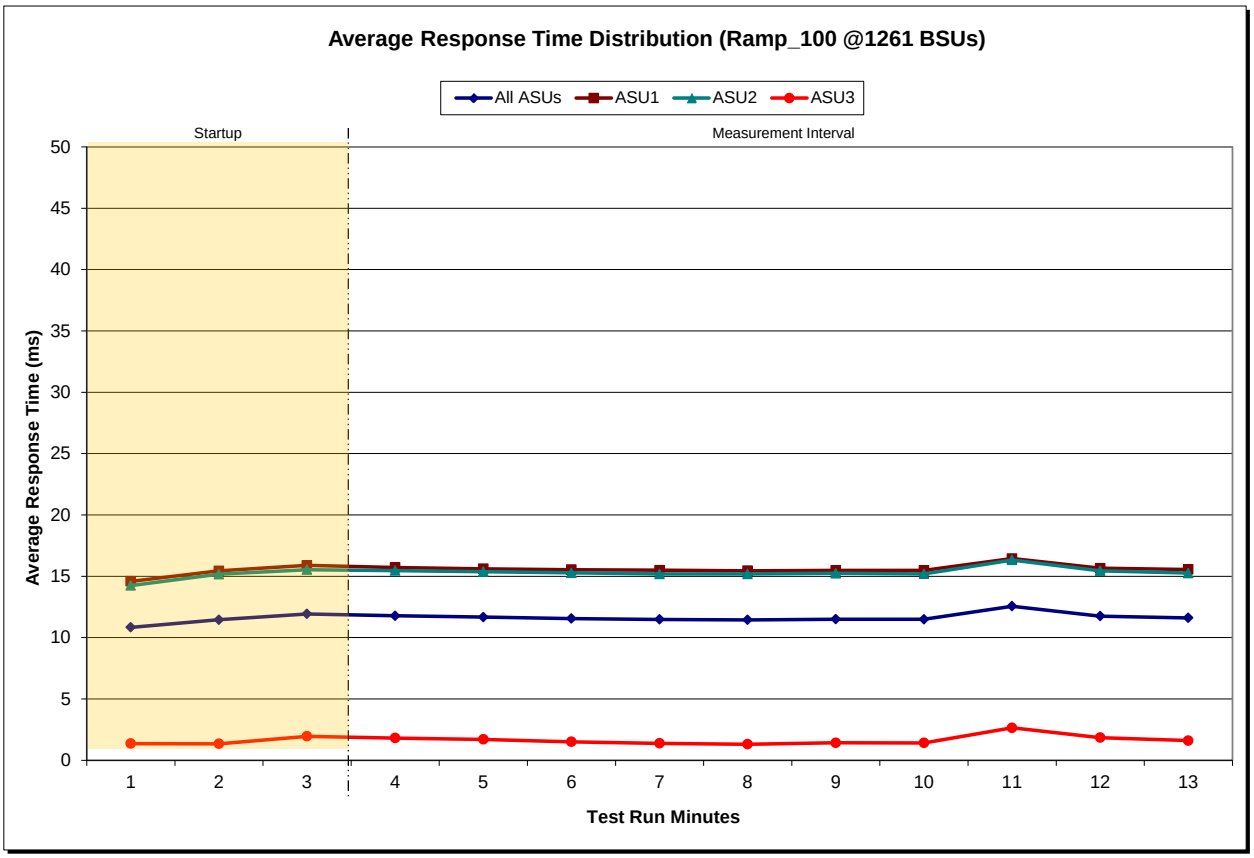
## IOPS Test Run – I/O Request Throughput Distribution Graph



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

| 1,261 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 16:20:48 | 16:23:49 | 0-2 | 0:03:01 |
| *Measurement Interval* | 16:23:49 | 16:33:49 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 10.83 | 14.59 | 14.25 | 1.36 |
| **1** | 11.45 | 15.44 | 15.17 | 1.34 |
| **2** | 11.93 | 15.89 | 15.53 | 1.95 |
| **3** | 11.78 | 15.71 | 15.47 | 1.81 |
| **4** | 11.67 | 15.61 | 15.37 | 1.70 |
| **5** | 11.55 | 15.54 | 15.28 | 1.50 |
| **6** | 11.48 | 15.49 | 15.19 | 1.37 |
| **7** | 11.45 | 15.45 | 15.19 | 1.31 |
| **8** | 11.50 | 15.48 | 15.24 | 1.42 |
| **9** | 11.49 | 15.47 | 15.19 | 1.41 |
| **10** | 12.55 | 16.44 | 16.33 | 2.65 |
| **11** | 11.75 | 15.65 | 15.45 | 1.84 |
| **12** | 11.60 | 15.56 | 15.26 | 1.60 |
| ***Average*** | ***11.68*** | ***15.64*** | ***15.40*** | ***1.66*** |

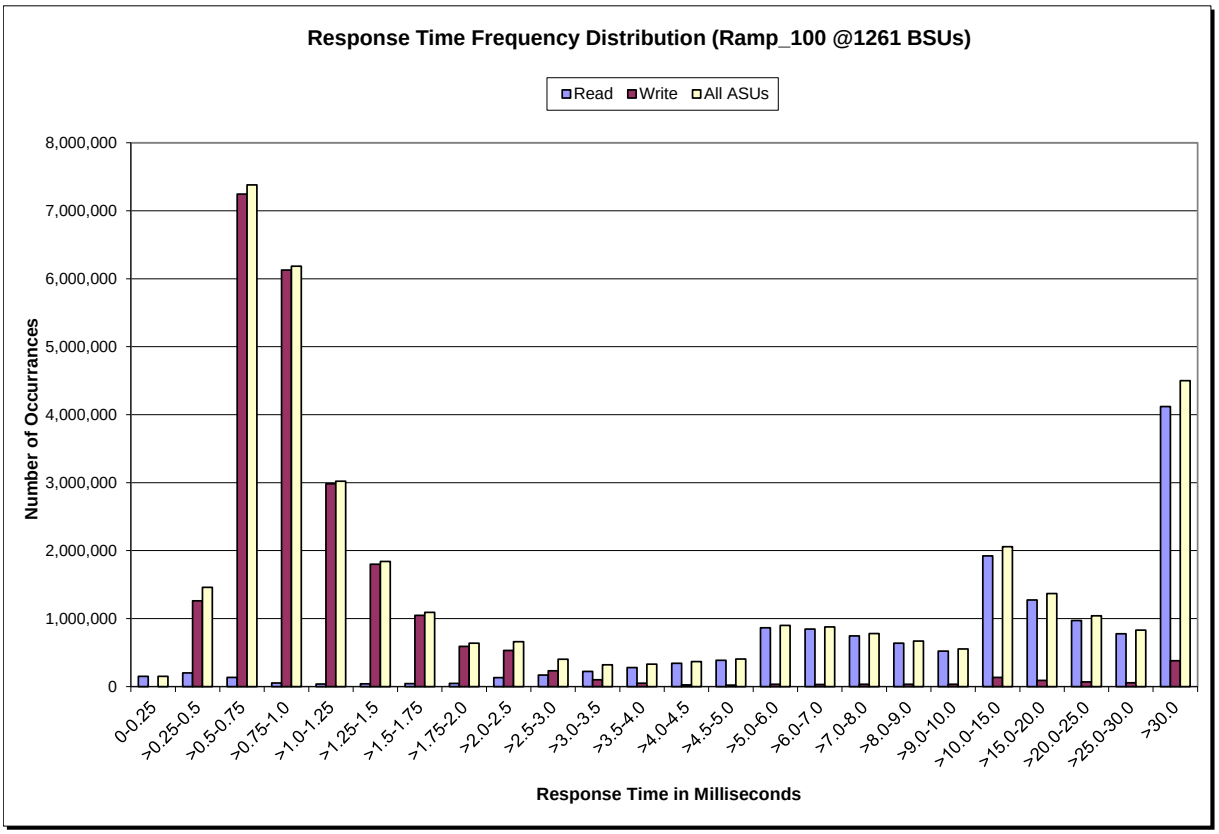
## IOPS Test Run – Average Response Time (ms) Distribution Graph



## 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 | 150,799 | 199,269 | 133,495 | 53,800 | 37,313 | 41,757 | 44,264 | 47,440 |
| Write | 0 | 1,261,846 | 7,245,688 | 6,128,939 | 2,982,644 | 1,799,786 | 1,046,885 | 590,605 |
| All ASUs | 150,799 | 1,461,115 | 7,379,183 | 6,182,739 | 3,019,957 | 1,841,543 | 1,091,149 | 638,045 |
| ASU1 | 141,424 | 710,677 | 3,075,837 | 2,555,327 | 1,297,482 | 814,449 | 497,087 | 302,846 |
| ASU2 | 9,375 | 178,160 | 763,500 | 614,238 | 305,442 | 190,949 | 115,085 | 68,067 |
| ASU3 | 0 | 572,278 | 3,539,846 | 3,013,174 | 1,417,033 | 836,145 | 478,977 | 267,132 |
| **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 | 130,154 | 170,586 | 222,610 | 279,054 | 343,194 | 386,395 | 866,204 | 845,852 |
| Write | 531,101 | 232,103 | 98,538 | 49,997 | 24,877 | 19,917 | 32,612 | 30,235 |
| All ASUs | 661,255 | 402,689 | 321,148 | 329,051 | 368,071 | 406,312 | 898,816 | 876,087 |
| ASU1 | 352,927 | 259,934 | 244,362 | 270,451 | 312,221 | 346,615 | 769,503 | 743,048 |
| ASU2 | 72,354 | 46,094 | 39,758 | 42,427 | 49,131 | 55,709 | 124,790 | 129,787 |
| ASU3 | 235,974 | 96,661 | 37,028 | 16,173 | 6,719 | 3,988 | 4,523 | 3,252 |
| **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 | 745,649 | 638,075 | 520,497 | 1,922,891 | 1,275,285 | 972,676 | 776,217 | 4,120,125 |
| Write | 33,430 | 33,182 | 34,370 | 134,421 | 91,759 | 68,951 | 55,093 | 379,445 |
| All ASUs | 779,079 | 671,257 | 554,867 | 2,057,312 | 1,367,044 | 1,041,627 | 831,310 | 4,499,570 |
| ASU1 | 660,742 | 571,978 | 470,894 | 1,739,086 | 1,149,109 | 872,370 | 693,272 | 3,695,808 |
| ASU2 | 114,966 | 96,372 | 81,004 | 307,250 | 210,274 | 162,784 | 132,432 | 742,090 |
| ASU3 | 3,371 | 2,907 | 2,969 | 10,976 | 7,661 | 6,473 | 5,606 | 61,672 |

## 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 |
|---|---|---|
| 37,830,025 | 33,330,455 | 4,499,570 |

## IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

*Clause 3.4.3*

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

*Clauses 5.1.10 and 5.3.15.2*

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

*Clause 5.3.15.3*

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

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

## Primary Metrics Test – Response Time Ramp Test Phase

*Clause 5.4.4.3*

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

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

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

*Clause 9.4.3.7.3*

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

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

### SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 79.

### Response Time Ramp Test Results File

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

**95% Load Level**

**90% Load Level**

**80% Load Level**

**50% Load Level**

**10% Load Level**

## Response Time Ramp Distribution (IOPS) Data

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

| 100% Load Level - 1261 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| Start-Up/Ramp-Up | 16:20:48 | 16:23:49 | 0-2 | 0:03:01 |
| Measurement Interval | 16:23:49 | 16:33:49 | 3-12 | 0:10:00 |

| (60 second intervals) | All ASUs | ASU-1 | ASU-2 | ASU-3 |
|---|---|---|---|---|
| 0 | 63,089.63 | 37,626.28 | 7,754.15 | 17,709.20 |
| 1 | 63,062.52 | 37,625.83 | 7,729.85 | 17,706.83 |
| 2 | 63,064.42 | 37,579.35 | 7,753.32 | 17,731.75 |
| 3 | 63,074.73 | 37,604.75 | 7,753.30 | 17,716.68 |
| 4 | 63,035.57 | 37,559.35 | 7,750.85 | 17,725.37 |
| 5 | 63,064.45 | 37,568.78 | 7,747.20 | 17,748.47 |
| 6 | 63,051.57 | 37,567.57 | 7,751.80 | 17,732.20 |
| 7 | 63,055.37 | 37,608.63 | 7,739.17 | 17,707.57 |
| 8 | 63,048.42 | 37,569.17 | 7,755.30 | 17,723.95 |
| 9 | 63,048.12 | 37,561.15 | 7,768.95 | 17,718.02 |
| 10 | 63,010.42 | 37,549.98 | 7,765.25 | 17,695.18 |
| 11 | 63,088.68 | 37,610.28 | 7,757.08 | 17,721.32 |
| 12 | 63,038.70 | 37,602.48 | 7,747.72 | 17,688.50 |
| ***Average*** | ***63,051.60*** | ***37,580.22*** | ***7,753.66*** | ***17,717.73*** |

| 95% Load Level - 1197 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| Start-Up/Ramp-Up | 16:34:33 | 16:37:34 | 0-2 | 0:03:01 |
| Measurement Interval | 16:37:34 | 16:47:34 | 3-12 | 0:10:00 |

| (60 second intervals) | All ASUs | ASU-1 | ASU-2 | ASU-3 |
|---|---|---|---|---|
| 0 | 59,833.08 | 35,639.40 | 7,371.55 | 16,822.13 |
| 1 | 59,802.43 | 35,639.73 | 7,358.03 | 16,804.67 |
| 2 | 59,879.62 | 35,692.97 | 7,357.25 | 16,829.40 |
| 3 | 59,841.15 | 35,645.08 | 7,372.00 | 16,824.07 |
| 4 | 59,872.62 | 35,721.57 | 7,364.35 | 16,786.70 |
| 5 | 59,843.48 | 35,664.37 | 7,364.72 | 16,814.40 |
| 6 | 59,821.62 | 35,657.48 | 7,351.33 | 16,812.80 |
| 7 | 59,805.87 | 35,670.47 | 7,351.43 | 16,783.97 |
| 8 | 59,902.90 | 35,721.55 | 7,351.10 | 16,830.25 |
| 9 | 59,869.38 | 35,670.50 | 7,362.07 | 16,836.82 |
| 10 | 59,878.40 | 35,667.95 | 7,367.38 | 16,843.07 |
| 11 | 59,821.93 | 35,654.17 | 7,356.78 | 16,810.98 |
| 12 | 59,827.38 | 35,664.53 | 7,357.45 | 16,805.40 |
| ***Average*** | ***59,848.47*** | ***35,673.77*** | ***7,359.86*** | ***16,814.85*** |

| 90% Load Level - 1134 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| Start-Up/Ramp-Up | 16:48:19 | 16:51:20 | 0-2 | 0:03:01 |
| Measurement Interval | 16:51:20 | 17:01:20 | 3-12 | 0:10:00 |

| (60 second intervals) | All ASUs | ASU-1 | ASU-2 | ASU-3 |
|---|---|---|---|---|
| 0 | 56,699.77 | 33,788.78 | 6,974.85 | 15,936.13 |
| 1 | 56,675.62 | 33,781.82 | 6,984.73 | 15,909.07 |
| 2 | 56,747.60 | 33,843.77 | 6,965.05 | 15,938.78 |
| 3 | 56,658.98 | 33,789.30 | 6,962.25 | 15,907.43 |
| 4 | 56,675.02 | 33,780.65 | 6,967.45 | 15,926.92 |
| 5 | 56,613.75 | 33,728.95 | 6,970.02 | 15,914.78 |
| 6 | 56,739.75 | 33,832.77 | 6,964.72 | 15,942.27 |
| 7 | 56,675.40 | 33,789.88 | 6,970.93 | 15,914.58 |
| 8 | 56,713.50 | 33,823.95 | 6,959.50 | 15,930.05 |
| 9 | 56,654.52 | 33,781.60 | 6,955.65 | 15,917.27 |
| 10 | 56,697.10 | 33,793.38 | 6,972.05 | 15,931.67 |
| 11 | 56,625.33 | 33,770.75 | 6,968.88 | 15,885.70 |
| 12 | 56,688.48 | 33,814.50 | 6,972.08 | 15,901.90 |
| ***Average*** | ***56,674.18*** | ***33,790.57*** | ***6,966.35*** | ***15,917.26*** |

| 80% Load Level - 1008 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| Start-Up/Ramp-Up | 17:02:04 | 17:05:05 | 0-2 | 0:03:01 |
| Measurement Interval | 17:05:05 | 17:15:05 | 3-12 | 0:10:00 |

| (60 second intervals) | All ASUs | ASU-1 | ASU-2 | ASU-3 |
|---|---|---|---|---|
| 0 | 50,425.48 | 30,037.10 | 6,223.50 | 14,164.88 |
| 1 | 50,340.38 | 29,994.83 | 6,181.97 | 14,163.58 |
| 2 | 50,377.48 | 30,045.95 | 6,187.92 | 14,143.62 |
| 3 | 50,450.77 | 30,066.08 | 6,216.07 | 14,168.62 |
| 4 | 50,403.75 | 30,024.57 | 6,190.95 | 14,188.23 |
| 5 | 50,370.18 | 30,027.00 | 6,196.55 | 14,146.63 |
| 6 | 50,435.47 | 30,035.68 | 6,215.40 | 14,184.38 |
| 7 | 50,401.18 | 30,062.65 | 6,188.23 | 14,150.30 |
| 8 | 50,380.23 | 30,023.43 | 6,201.57 | 14,155.23 |
| 9 | 50,379.95 | 30,022.98 | 6,212.85 | 14,144.12 |
| 10 | 50,396.77 | 30,032.00 | 6,205.95 | 14,158.82 |
| 11 | 50,418.72 | 30,056.88 | 6,192.62 | 14,169.22 |
| 12 | 50,408.70 | 30,038.80 | 6,195.37 | 14,174.53 |
| ***Average*** | ***50,404.57*** | ***30,039.01*** | ***6,201.56*** | ***14,164.01*** |

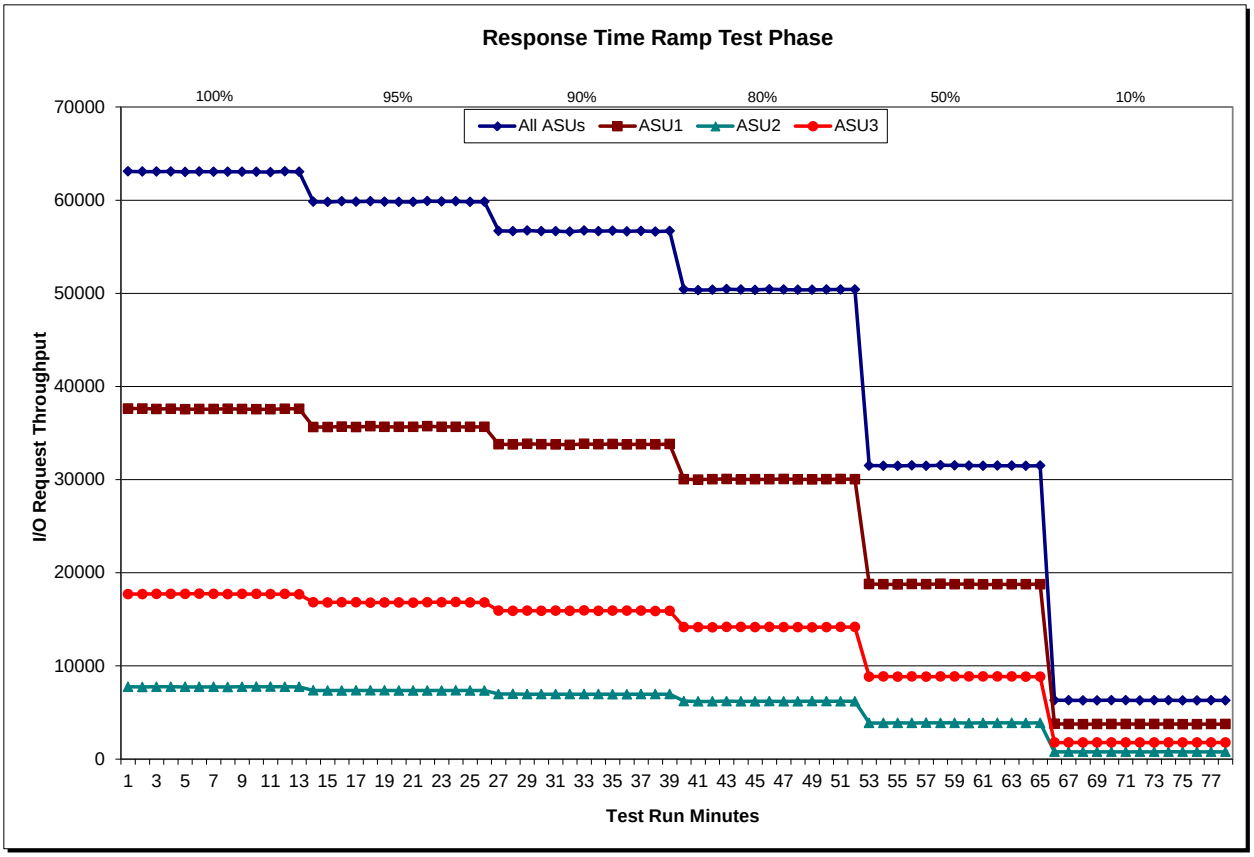
| 50% Load Level - 630 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| Start-Up/Ramp-Up | 17:15:50 | 17:18:51 | 0-2 | 0:03:01 |
| Measurement Interval | 17:18:51 | 17:28:51 | 3-12 | 0:10:00 |

| (60 second intervals) | All ASUs | ASU-1 | ASU-2 | ASU-3 |
|---|---|---|---|---|
| 0 | 31,505.22 | 18,789.85 | 3,874.45 | 8,840.92 |
| 1 | 31,488.10 | 18,757.95 | 3,865.02 | 8,865.13 |
| 2 | 31,477.50 | 18,751.53 | 3,886.93 | 8,839.03 |
| 3 | 31,515.35 | 18,782.33 | 3,876.02 | 8,857.00 |
| 4 | 31,483.07 | 18,752.75 | 3,893.08 | 8,837.23 |
| 5 | 31,543.87 | 18,800.22 | 3,882.60 | 8,861.05 |
| 6 | 31,526.42 | 18,775.40 | 3,883.47 | 8,867.55 |
| 7 | 31,507.77 | 18,794.35 | 3,856.18 | 8,857.23 |
| 8 | 31,480.02 | 18,736.43 | 3,879.90 | 8,863.68 |
| 9 | 31,498.00 | 18,763.43 | 3,877.82 | 8,856.75 |
| 10 | 31,494.32 | 18,753.45 | 3,886.60 | 8,854.27 |
| 11 | 31,474.30 | 18,758.20 | 3,867.93 | 8,848.17 |
| 12 | 31,495.20 | 18,775.90 | 3,883.30 | 8,836.00 |
| ***Average*** | ***31,501.83*** | ***18,769.25*** | ***3,878.69*** | ***8,853.89*** |

| 10% Load Level - 126 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| Start-Up/Ramp-Up | 17:29:36 | 17:32:37 | 0-2 | 0:03:01 |
| Measurement Interval | 17:32:37 | 17:42:37 | 3-12 | 0:10:00 |

| (60 second intervals) | All ASUs | ASU-1 | ASU-2 | ASU-3 |
|---|---|---|---|---|
| 0 | 6,321.72 | 3,770.65 | 779.08 | 1,771.98 |
| 1 | 6,310.53 | 3,762.22 | 775.07 | 1,773.25 |
| 2 | 6,295.93 | 3,744.72 | 772.82 | 1,778.40 |
| 3 | 6,298.47 | 3,754.97 | 772.28 | 1,771.22 |
| 4 | 6,317.95 | 3,762.23 | 777.45 | 1,778.27 |
| 5 | 6,301.88 | 3,763.13 | 773.55 | 1,765.20 |
| 6 | 6,288.80 | 3,751.47 | 770.93 | 1,766.40 |
| 7 | 6,302.05 | 3,757.33 | 772.98 | 1,771.73 |
| 8 | 6,317.27 | 3,759.07 | 780.93 | 1,777.27 |
| 9 | 6,282.85 | 3,737.52 | 774.12 | 1,771.22 |
| 10 | 6,290.60 | 3,744.52 | 777.20 | 1,768.88 |
| 11 | 6,300.62 | 3,754.25 | 772.25 | 1,774.12 |
| 12 | 6,294.13 | 3,751.62 | 775.63 | 1,766.88 |
| ***Average*** | ***6,299.46*** | ***3,753.61*** | ***774.73*** | ***1,771.12*** |

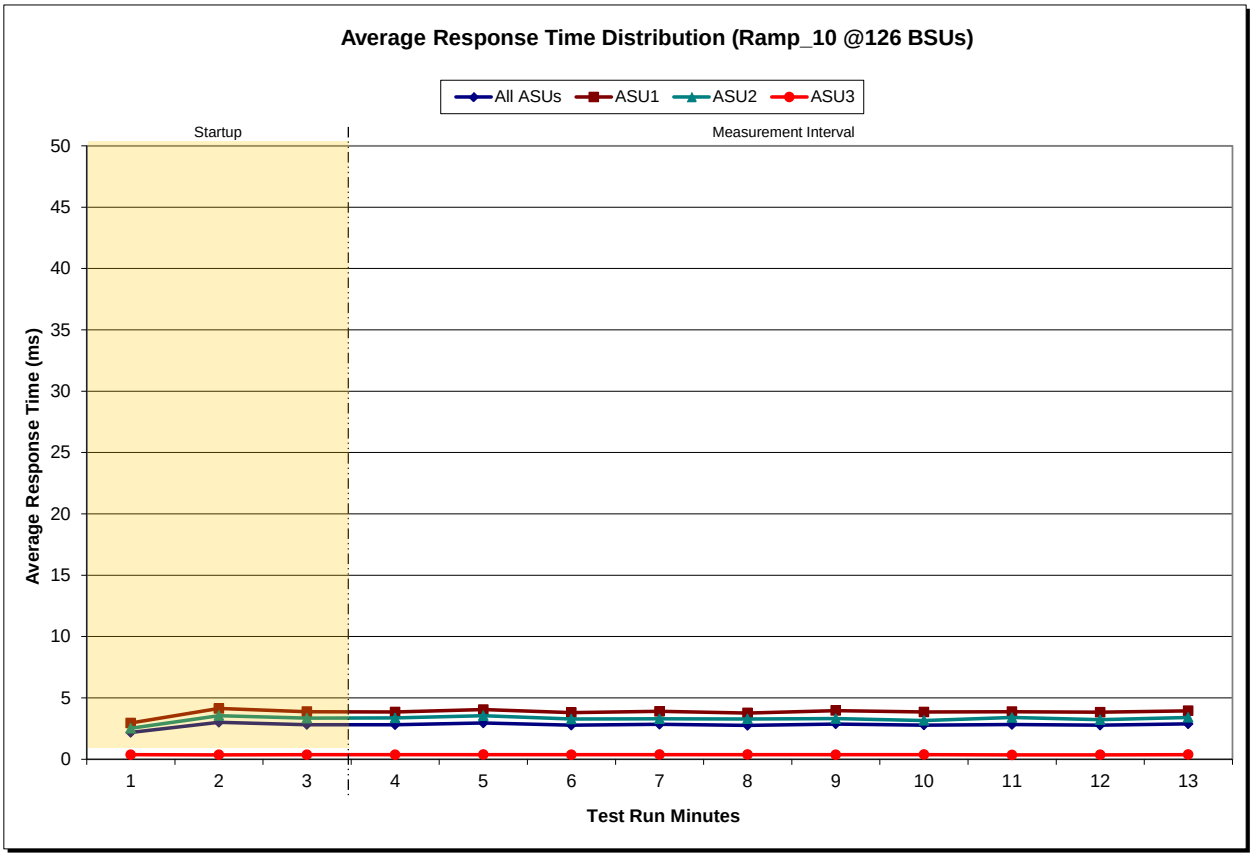
## Response Time Ramp Distribution (IOPS) Graph



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

| 126 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 17:29:36 | 17:32:37 | 0-2 | 0:03:01 |
| *Measurement Interval* | 17:32:37 | 17:42:37 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 2.17 | 2.95 | 2.52 | 0.37 |
| **1** | 3.00 | 4.13 | 3.55 | 0.35 |
| **2** | 2.81 | 3.87 | 3.35 | 0.36 |
| **3** | 2.81 | 3.85 | 3.36 | 0.36 |
| **4** | 2.95 | 4.04 | 3.54 | 0.38 |
| **5** | 2.77 | 3.80 | 3.27 | 0.36 |
| **6** | 2.84 | 3.90 | 3.29 | 0.38 |
| **7** | 2.75 | 3.77 | 3.28 | 0.37 |
| **8** | 2.87 | 3.97 | 3.31 | 0.36 |
| **9** | 2.78 | 3.84 | 3.15 | 0.37 |
| **10** | 2.82 | 3.87 | 3.39 | 0.35 |
| **11** | 2.77 | 3.83 | 3.22 | 0.35 |
| **12** | 2.87 | 3.94 | 3.41 | 0.37 |
| ***Average*** | ***2.82*** | ***3.88*** | ***3.32*** | ***0.37*** |

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



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

*Clause 3.4.3*

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

*Clauses 5.1.10 and 5.3.15.2*

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

*Clause 5.3.15.3*

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

| | ASU1-1 | ASU1-2 | ASU1-3 | ASU1-4 | ASU2-1 | ASU2-2 | ASU2-3 | ASU3-1 |
|---|---|---|---|---|---|---|---|---|
| ***IM*** | ***0.0350*** | ***0.2810*** | ***0.0700*** | ***0.2100*** | ***0.0180*** | ***0.0700*** | ***0.0350*** | ***0.2810*** |
| MIM | 0.0350 | 0.2809 | 0.0701 | 0.2098 | 0.0179 | 0.0700 | 0.03510 | 0.2812 |
| COV | 0.007 | 0.002 | 0.005 | 0.002 | 0.009 | 0.004 | 0.010 | 0.002 |

## Repeatability Test

*Clause 5.4.5*

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

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

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

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

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

*Clause 9.4.3.7.4*

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

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

### SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 79.

### 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*** | ***63,051.60*** |
| **Repeatability Test Phase 1** | 63,056.43 |
| **Repeatability Test Phase 2** | 63,056.99 |

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

| | SPC-1 LRT™ |
|---|---|
| ***Primary Metrics*** | ***2.82 ms*** |
| **Repeatability Test Phase 1** | 2.87 ms |
| **Repeatability Test Phase 2** | 2.83 ms |

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

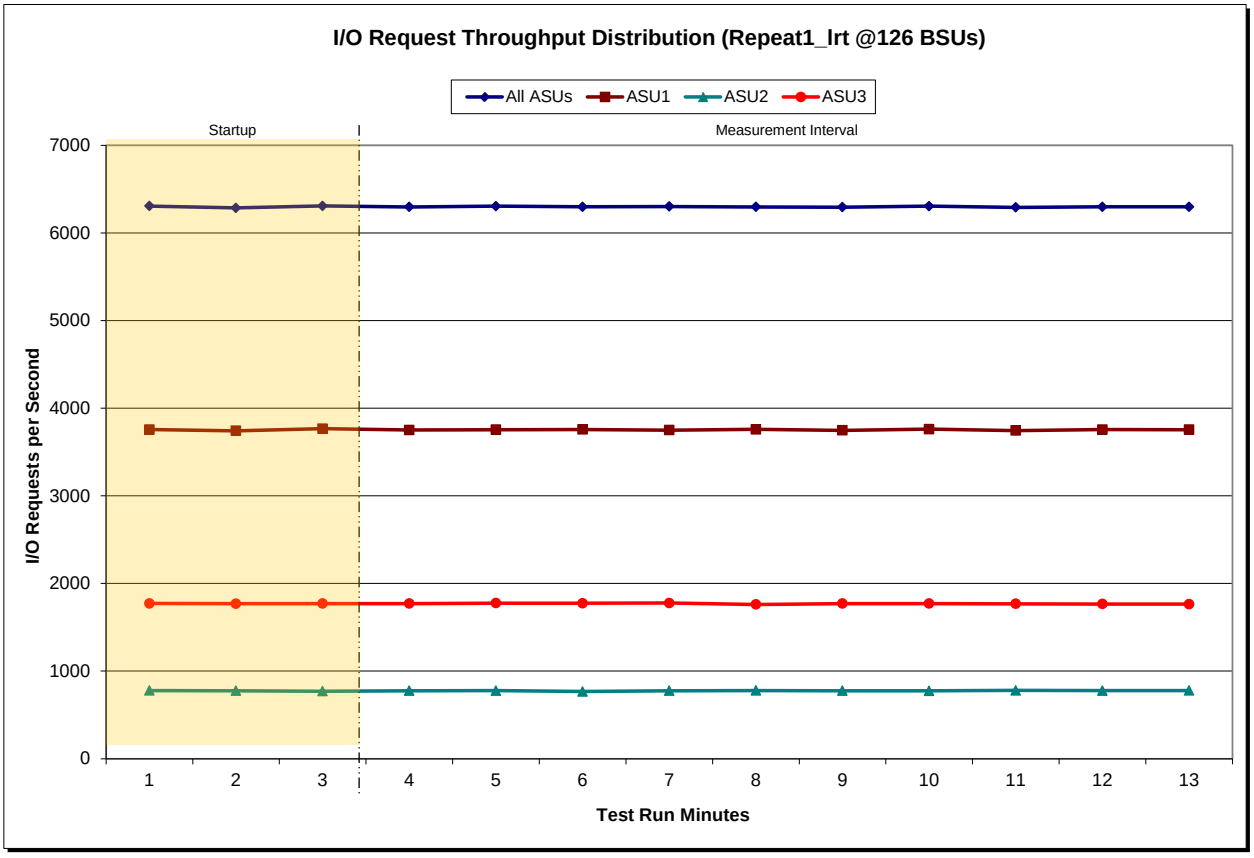
A link to the test result file generated from each Repeatability Test Run is listed below.

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

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

| 126 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 17:43:52 | 17:46:52 | 0-2 | 0:03:00 |
| *Measurement Interval* | 17:46:52 | 17:56:52 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 6,308.07 | 3,756.85 | 778.87 | 1,772.35 |
| **1** | 6,286.52 | 3,742.08 | 775.45 | 1,768.98 |
| **2** | 6,308.53 | 3,766.88 | 770.88 | 1,770.77 |
| **3** | 6,297.55 | 3,751.67 | 775.23 | 1,770.65 |
| **4** | 6,306.93 | 3,754.63 | 777.03 | 1,775.27 |
| **5** | 6,298.93 | 3,757.77 | 767.27 | 1,773.90 |
| **6** | 6,302.47 | 3,750.42 | 775.77 | 1,776.28 |
| **7** | 6,297.58 | 3,759.53 | 778.03 | 1,760.02 |
| **8** | 6,294.88 | 3,747.77 | 776.12 | 1,771.00 |
| **9** | 6,306.93 | 3,761.08 | 774.78 | 1,771.07 |
| **10** | 6,292.75 | 3,745.17 | 780.08 | 1,767.50 |
| **11** | 6,298.67 | 3,755.93 | 777.33 | 1,765.40 |
| **12** | 6,298.17 | 3,755.28 | 778.00 | 1,764.88 |
| ***Average*** | ***6,299.49*** | ***3,753.93*** | ***775.97*** | ***1,769.60*** |

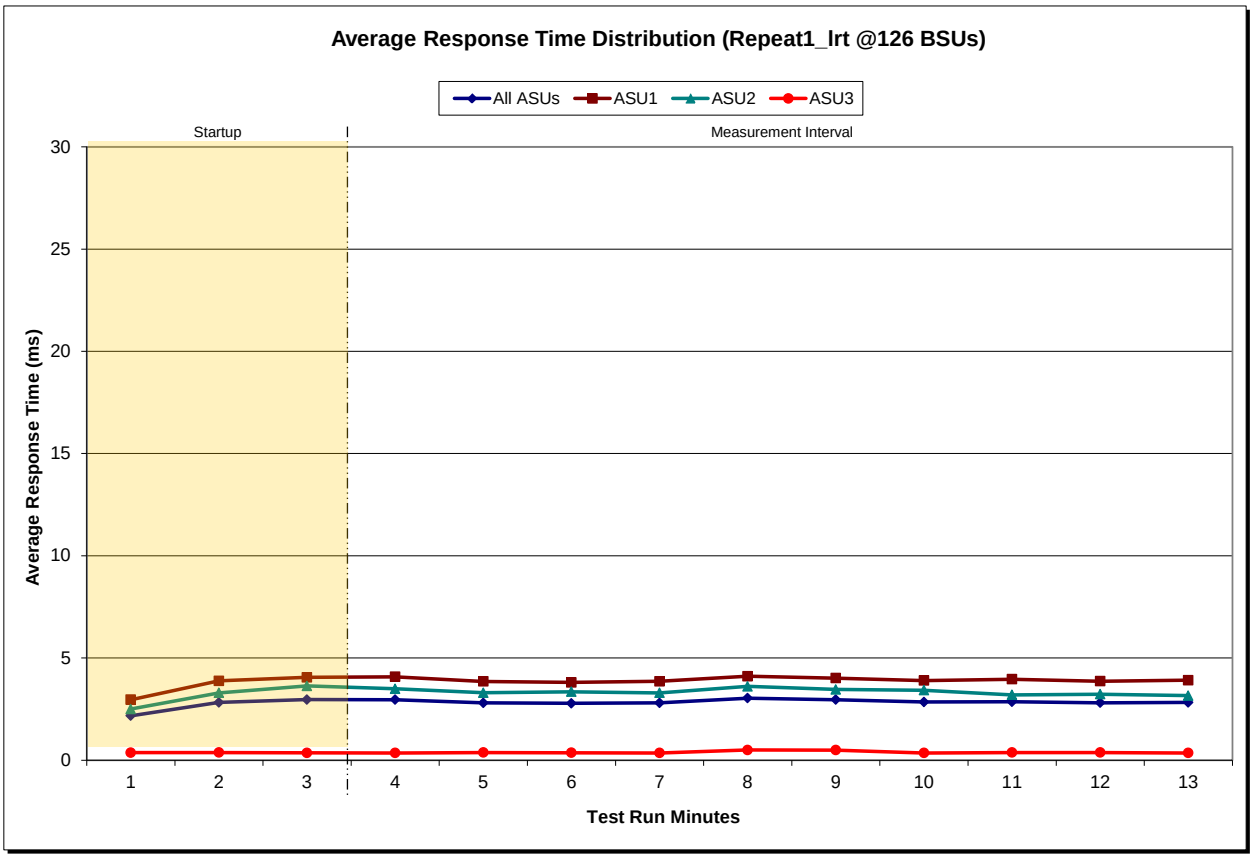
## Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

| 126 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 17:43:52 | 17:46:52 | 0-2 | 0:03:00 |
| *Measurement Interval* | 17:46:52 | 17:56:52 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 2.17 | 2.96 | 2.50 | 0.37 |
| **1** | 2.82 | 3.88 | 3.29 | 0.37 |
| **2** | 2.96 | 4.05 | 3.63 | 0.36 |
| **3** | 2.96 | 4.08 | 3.49 | 0.35 |
| **4** | 2.80 | 3.85 | 3.30 | 0.37 |
| **5** | 2.78 | 3.80 | 3.35 | 0.36 |
| **6** | 2.80 | 3.86 | 3.29 | 0.35 |
| **7** | 3.04 | 4.11 | 3.61 | 0.50 |
| **8** | 2.96 | 4.02 | 3.46 | 0.49 |
| **9** | 2.84 | 3.90 | 3.42 | 0.35 |
| **10** | 2.86 | 3.96 | 3.20 | 0.37 |
| **11** | 2.81 | 3.86 | 3.23 | 0.37 |
| **12** | 2.82 | 3.91 | 3.16 | 0.35 |
| ***Average*** | ***2.87*** | ***3.93*** | ***3.35*** | ***0.39*** |

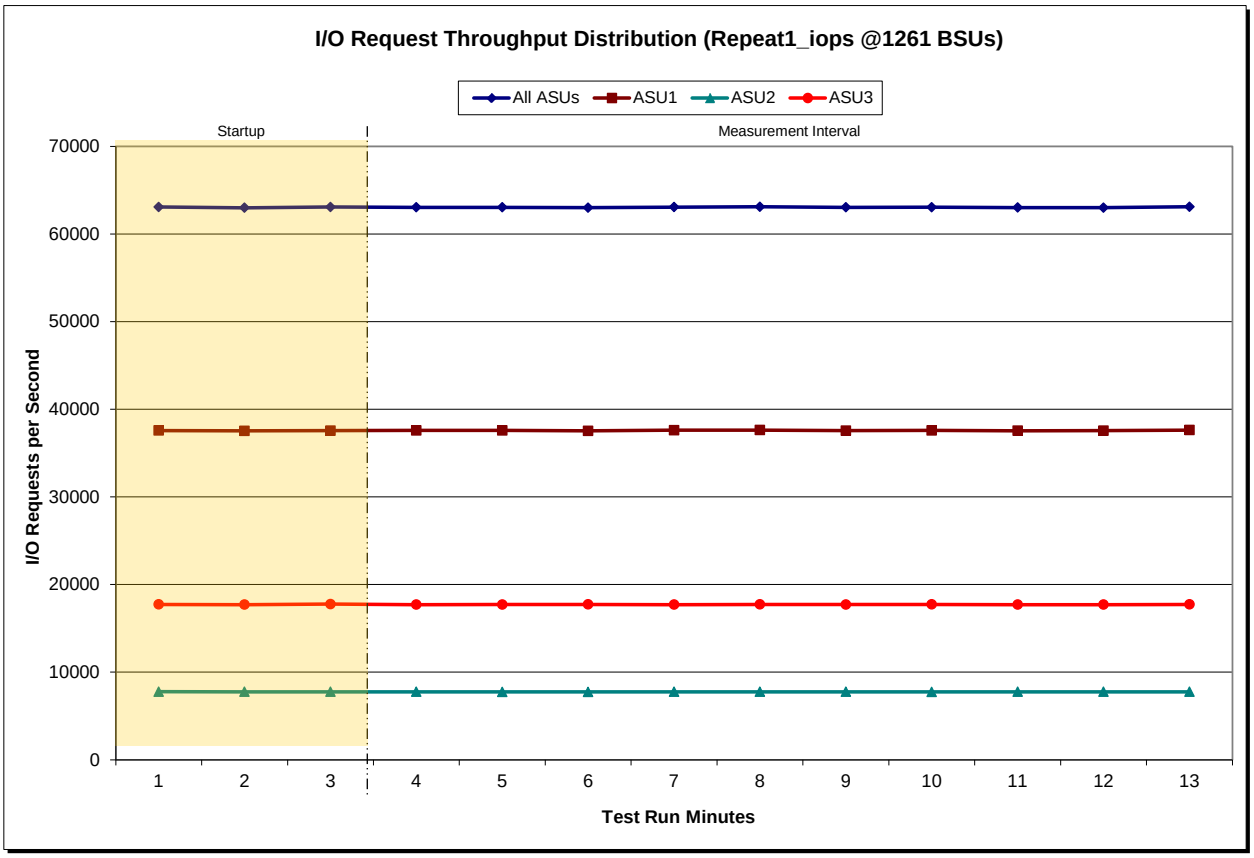
## Repeatability 1 LRT –Average Response Time (ms) Distribution Graph



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

| 1,261 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 17:57:36 | 18:00:37 | 0-2 | 0:03:01 |
| *Measurement Interval* | 18:00:37 | 18:10:37 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 63,084.55 | 37,579.68 | 7,769.60 | 17,735.27 |
| **1** | 63,002.90 | 37,543.63 | 7,752.75 | 17,706.52 |
| **2** | 63,092.97 | 37,567.67 | 7,759.32 | 17,765.98 |
| **3** | 63,050.85 | 37,590.23 | 7,756.57 | 17,704.05 |
| **4** | 63,053.50 | 37,591.50 | 7,745.78 | 17,716.22 |
| **5** | 63,010.77 | 37,533.52 | 7,750.27 | 17,726.98 |
| **6** | 63,072.28 | 37,609.28 | 7,756.75 | 17,706.25 |
| **7** | 63,111.65 | 37,623.68 | 7,762.08 | 17,725.88 |
| **8** | 63,046.52 | 37,564.97 | 7,759.20 | 17,722.35 |
| **9** | 63,068.35 | 37,589.93 | 7,743.58 | 17,734.83 |
| **10** | 63,022.68 | 37,553.18 | 7,758.57 | 17,710.93 |
| **11** | 63,018.37 | 37,558.47 | 7,751.30 | 17,708.60 |
| **12** | 63,109.30 | 37,629.32 | 7,753.35 | 17,726.63 |
| ***Average*** | ***63,056.43*** | ***37,584.41*** | ***7,753.75*** | ***17,718.27*** |

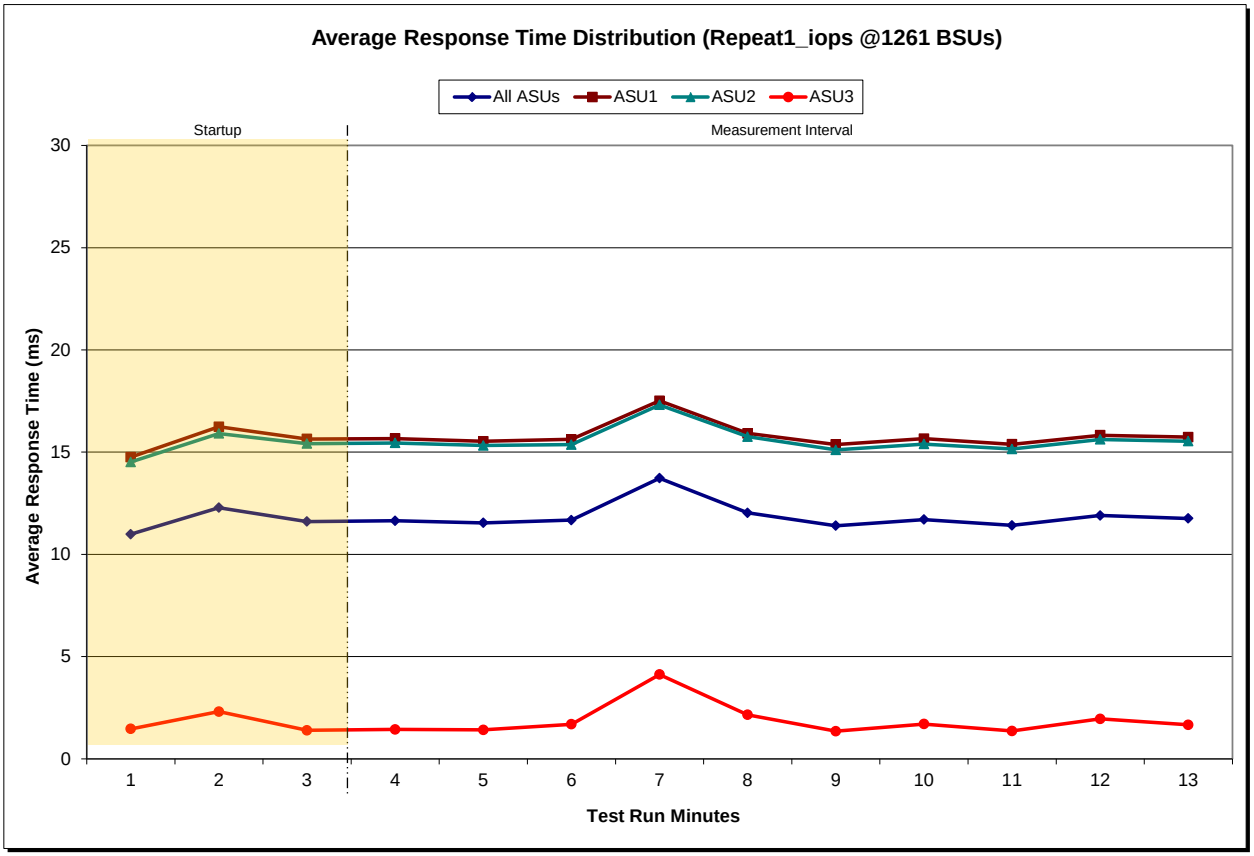
## Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

| 1,261 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 17:57:36 | 18:00:37 | 0-2 | 0:03:01 |
| *Measurement Interval* | 18:00:37 | 18:10:37 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 10.99 | 14.75 | 14.51 | 1.46 |
| **1** | 12.28 | 16.24 | 15.91 | 2.31 |
| **2** | 11.60 | 15.64 | 15.42 | 1.39 |
| **3** | 11.64 | 15.66 | 15.45 | 1.43 |
| **4** | 11.54 | 15.53 | 15.32 | 1.41 |
| **5** | 11.67 | 15.63 | 15.37 | 1.69 |
| **6** | 13.73 | 17.51 | 17.31 | 4.12 |
| **7** | 12.03 | 15.92 | 15.75 | 2.15 |
| **8** | 11.40 | 15.37 | 15.11 | 1.35 |
| **9** | 11.70 | 15.66 | 15.39 | 1.70 |
| **10** | 11.41 | 15.38 | 15.15 | 1.36 |
| **11** | 11.90 | 15.82 | 15.62 | 1.95 |
| **12** | 11.76 | 15.73 | 15.53 | 1.66 |
| ***Average*** | ***11.88*** | ***15.82*** | ***15.60*** | ***1.88*** |

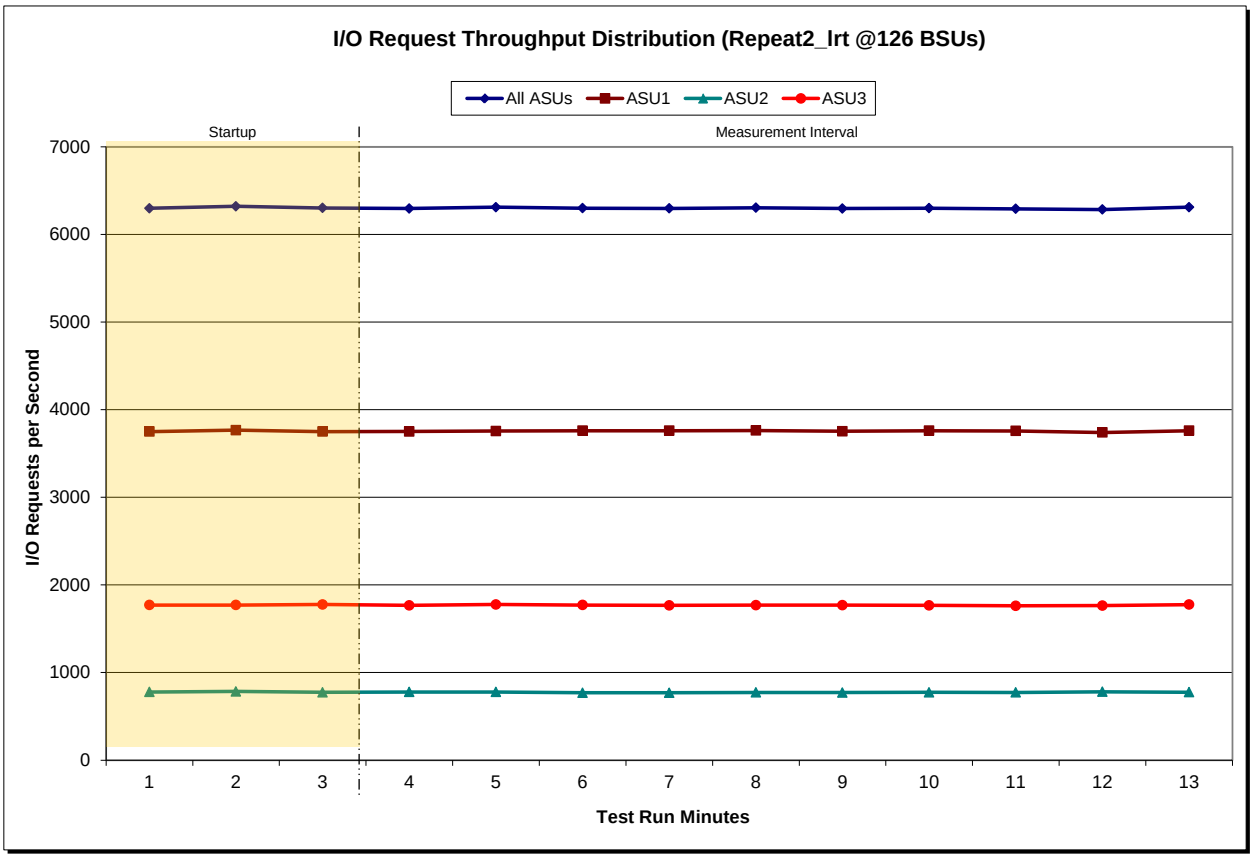
## Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph



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

| 126 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 18:11:24 | 18:14:24 | 0-2 | 0:03:00 |
| *Measurement Interval* | 18:14:24 | 18:24:24 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 6,299.33 | 3,750.78 | 778.27 | 1,770.28 |
| **1** | 6,321.58 | 3,766.42 | 784.37 | 1,770.80 |
| **2** | 6,302.05 | 3,750.22 | 774.75 | 1,777.08 |
| **3** | 6,296.13 | 3,751.00 | 777.82 | 1,767.32 |
| **4** | 6,311.93 | 3,756.77 | 778.27 | 1,776.90 |
| **5** | 6,300.15 | 3,759.63 | 769.88 | 1,770.63 |
| **6** | 6,297.02 | 3,760.27 | 769.58 | 1,767.17 |
| **7** | 6,304.77 | 3,762.17 | 773.48 | 1,769.12 |
| **8** | 6,295.83 | 3,754.37 | 772.43 | 1,769.03 |
| **9** | 6,300.27 | 3,759.73 | 774.37 | 1,766.17 |
| **10** | 6,292.23 | 3,757.10 | 772.78 | 1,762.35 |
| **11** | 6,285.18 | 3,740.13 | 780.40 | 1,764.65 |
| **12** | 6,311.97 | 3,760.42 | 775.85 | 1,775.70 |
| ***Average*** | ***6,299.55*** | ***3,756.16*** | ***774.49*** | ***1,768.90*** |

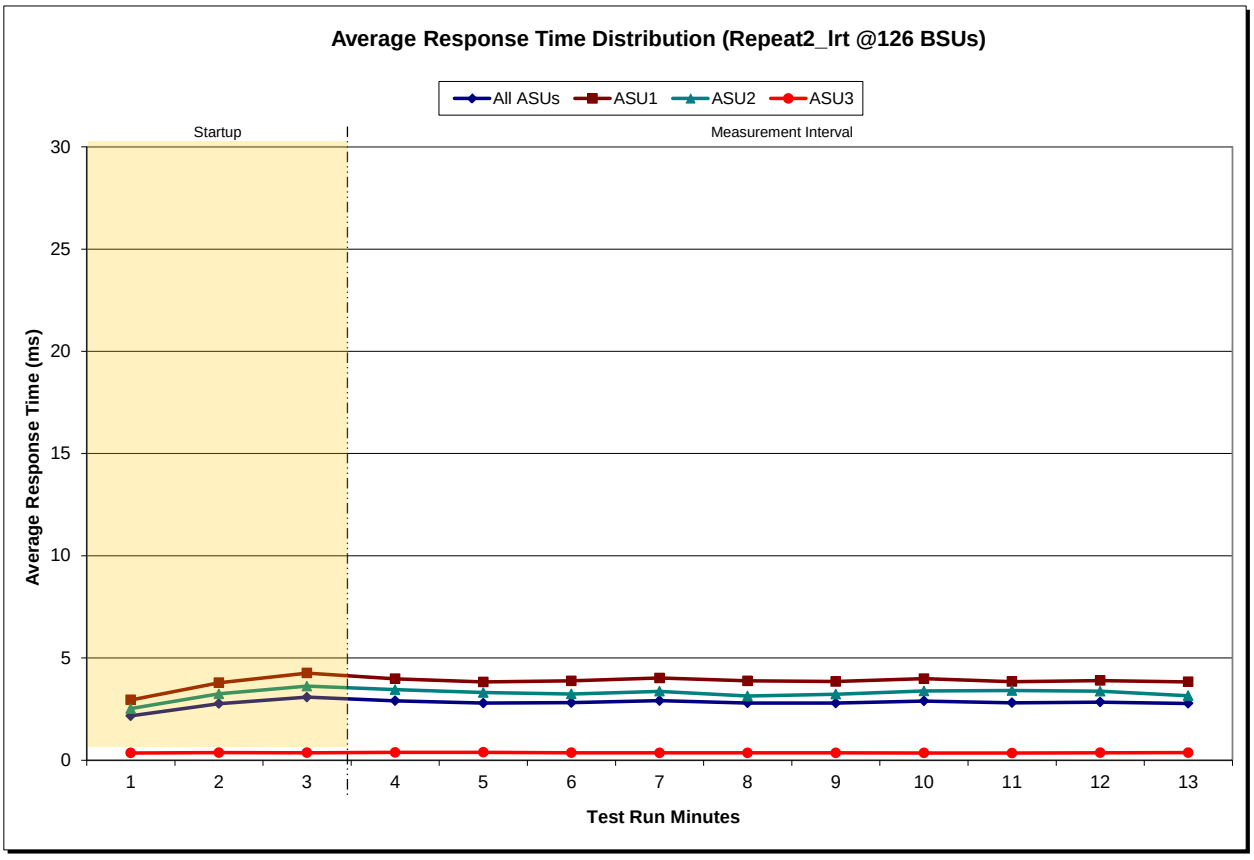
## Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

| 126 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 18:11:24 | 18:14:24 | 0-2 | 0:03:00 |
| *Measurement Interval* | 18:14:24 | 18:24:24 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 2.17 | 2.95 | 2.52 | 0.36 |
| **1** | 2.76 | 3.79 | 3.24 | 0.37 |
| **2** | 3.08 | 4.26 | 3.62 | 0.36 |
| **3** | 2.90 | 3.98 | 3.45 | 0.38 |
| **4** | 2.79 | 3.83 | 3.31 | 0.39 |
| **5** | 2.81 | 3.88 | 3.24 | 0.36 |
| **6** | 2.91 | 4.02 | 3.37 | 0.36 |
| **7** | 2.80 | 3.88 | 3.14 | 0.36 |
| **8** | 2.79 | 3.85 | 3.23 | 0.36 |
| **9** | 2.89 | 3.99 | 3.39 | 0.35 |
| **10** | 2.81 | 3.84 | 3.40 | 0.35 |
| **11** | 2.84 | 3.90 | 3.37 | 0.36 |
| **12** | 2.77 | 3.83 | 3.15 | 0.37 |
| ***Average*** | ***2.83*** | ***3.90*** | ***3.30*** | ***0.36*** |

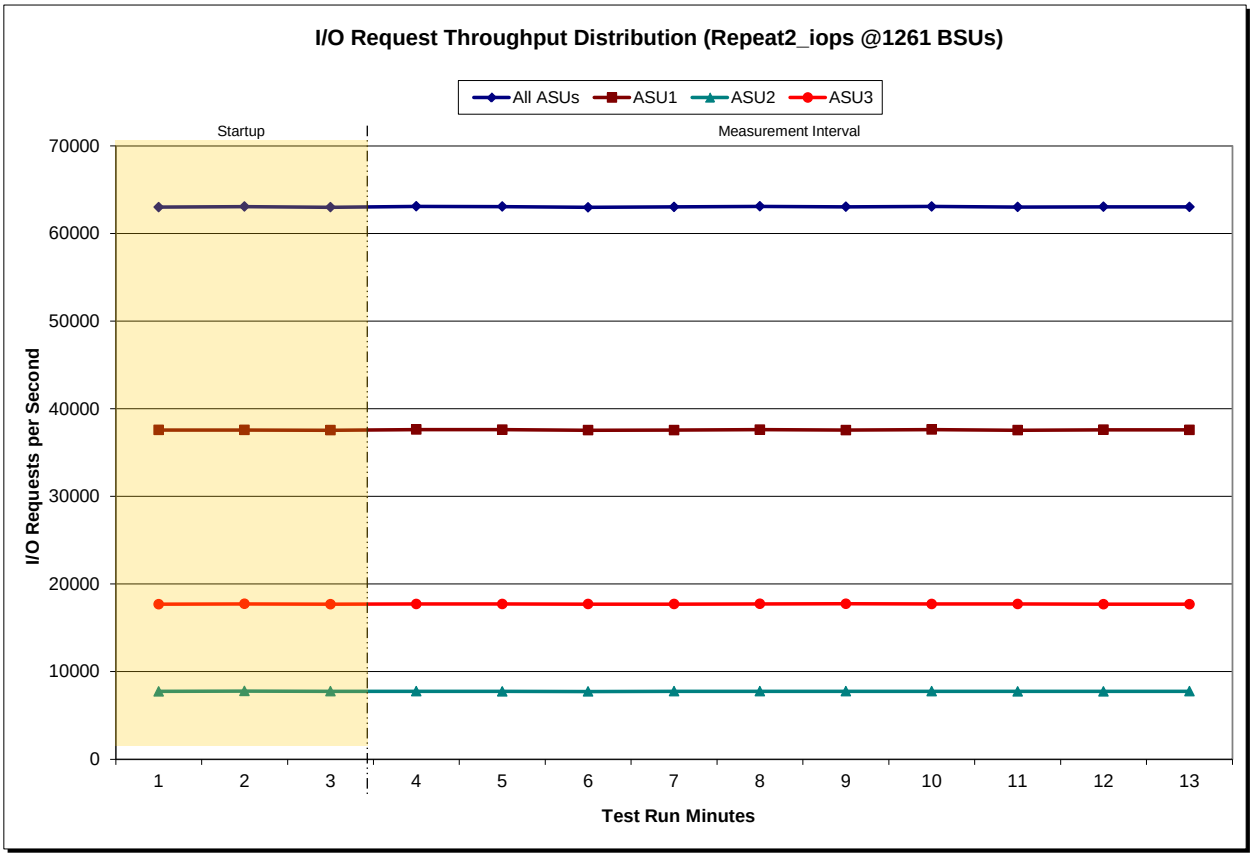
## Repeatability 2 LRT –Average Response Time (ms) Distribution Graph



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

| 1,261 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 18:25:10 | 18:28:11 | 0-2 | 0:03:01 |
| *Measurement Interval* | 18:28:11 | 18:38:11 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 63,009.30 | 37,573.32 | 7,739.63 | 17,696.35 |
| **1** | 63,079.65 | 37,573.60 | 7,778.00 | 17,728.05 |
| **2** | 63,006.33 | 37,555.42 | 7,757.70 | 17,693.22 |
| **3** | 63,103.87 | 37,626.12 | 7,761.95 | 17,715.80 |
| **4** | 63,081.53 | 37,612.05 | 7,747.43 | 17,722.05 |
| **5** | 62,993.67 | 37,549.83 | 7,737.32 | 17,706.52 |
| **6** | 63,033.20 | 37,565.43 | 7,759.43 | 17,708.33 |
| **7** | 63,104.53 | 37,616.35 | 7,751.78 | 17,736.40 |
| **8** | 63,056.42 | 37,562.42 | 7,756.60 | 17,737.40 |
| **9** | 63,091.25 | 37,622.18 | 7,751.77 | 17,717.30 |
| **10** | 63,025.02 | 37,557.80 | 7,750.37 | 17,716.85 |
| **11** | 63,045.92 | 37,607.03 | 7,750.78 | 17,688.10 |
| **12** | 63,034.47 | 37,583.47 | 7,762.65 | 17,688.35 |
| ***Average*** | ***63,056.99*** | ***37,590.27*** | ***7,753.01*** | ***17,713.71*** |

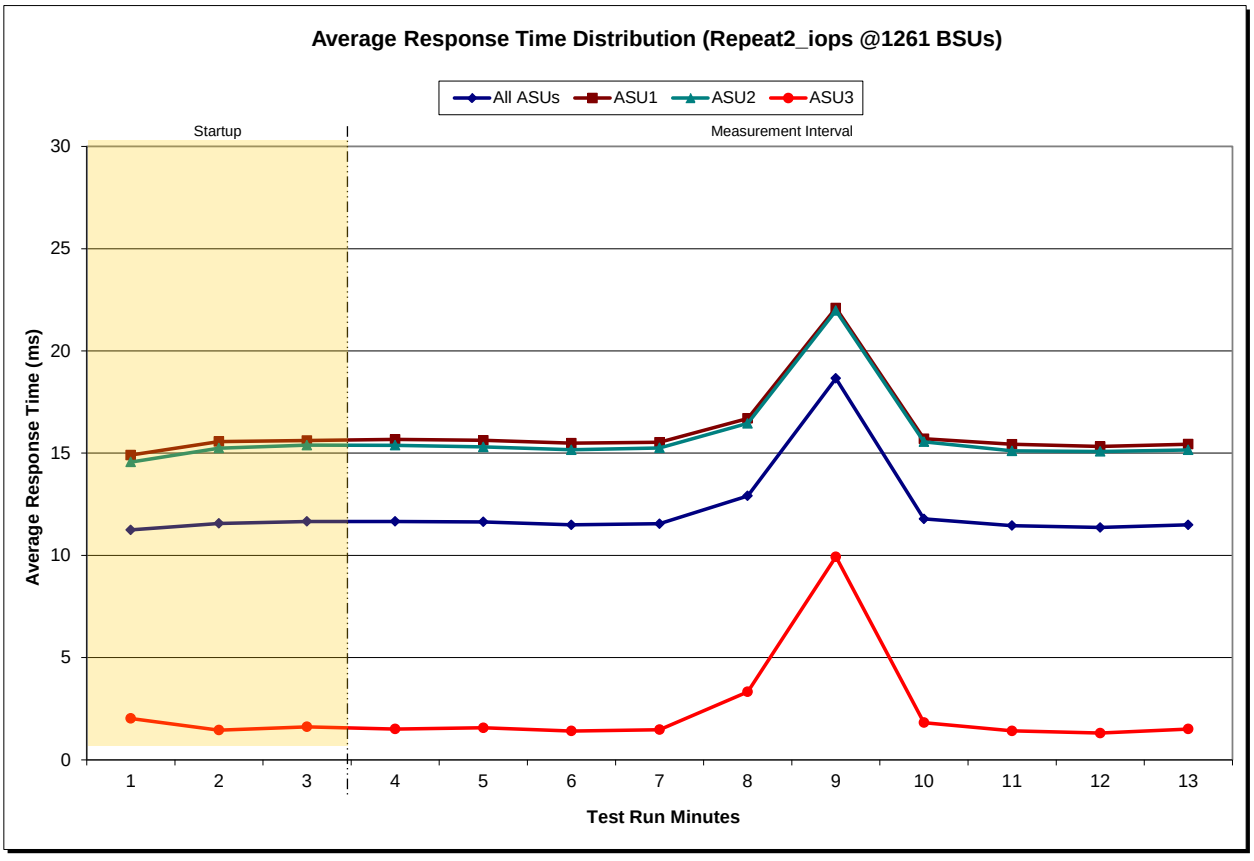
## Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

| 1,261 BSUs | Start | Stop | Interval | Duration |
|---|---|---|---|---|
| *Start-Up/Ramp-Up* | 18:25:10 | 18:28:11 | 0-2 | 0:03:01 |
| *Measurement Interval* | 18:28:11 | 18:38:11 | 3-12 | 0:10:00 |
| **60 second intervals** | **All ASUs** | **ASU1** | **ASU2** | **ASU3** |
| **0** | 11.25 | 14.91 | 14.57 | 2.02 |
| **1** | 11.56 | 15.57 | 15.24 | 1.45 |
| **2** | 11.66 | 15.62 | 15.39 | 1.61 |
| **3** | 11.66 | 15.67 | 15.38 | 1.51 |
| **4** | 11.63 | 15.62 | 15.30 | 1.56 |
| **5** | 11.49 | 15.48 | 15.16 | 1.41 |
| **6** | 11.55 | 15.53 | 15.26 | 1.47 |
| **7** | 12.91 | 16.69 | 16.46 | 3.33 |
| **8** | 18.66 | 22.10 | 21.97 | 9.93 |
| **9** | 11.78 | 15.70 | 15.56 | 1.82 |
| **10** | 11.45 | 15.43 | 15.11 | 1.41 |
| **11** | 11.36 | 15.32 | 15.08 | 1.30 |
| **12** | 11.49 | 15.44 | 15.16 | 1.50 |
| ***Average*** | ***12.40*** | ***16.30*** | ***16.04*** | ***2.52*** |

## 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 | 0.0349 | 0.2811 | 0.0699 | 0.2100 | 0.0180 | 0.0701 | 0.0351 | 0.2809 |
| COV | 0.005 | 0.003 | 0.004 | 0.003 | 0.010 | 0.007 | 0.011 | 0.003 |

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

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

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

| | ASU1-1 | ASU1-2 | ASU1-3 | ASU1-4 | ASU2-1 | ASU2-2 | ASU2-3 | ASU3-1 |
|---|---|---|---|---|---|---|---|---|
| ***IM*** | ***0.0350*** | ***0.2810*** | ***0.0700*** | ***0.2100*** | ***0.0180*** | ***0.0700*** | ***0.0350*** | ***0.2810*** |
| MIM | 0.0351 | 0.2810 | 0.0700 | 0.2102 | 0.0180 | 0.0699 | 0.0350 | 0.2808 |
| COV | 0.005 | 0.002 | 0.006 | 0.004 | 0.010 | 0.006 | 0.009 | 0.002 |

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

| | ASU1-1 | ASU1-2 | ASU1-3 | ASU1-4 | ASU2-1 | ASU2-2 | ASU2-3 | ASU3-1 |
|---|---|---|---|---|---|---|---|---|
| ***IM*** | ***0.0350*** | ***0.2810*** | ***0.0700*** | ***0.2100*** | ***0.0180*** | ***0.0700*** | ***0.0350*** | ***0.2810*** |
| MIM | 0.0350 | 0.2812 | 0.0700 | 0.2100 | 0.0180 | 0.0699 | 0.0350 | 0.2809 |
| COV | 0.002 | 0.001 | 0.001 | 0.001 | 0.004 | 0.002 | 0.003 | 0.001 |

## Data Persistence Test

*Clause 6*

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

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

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

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

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

*Clause 9.4.3.8*

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

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

### SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in *Appendix E: SPC-1 Workload Generator Input Parameters* on Page 79.

### 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 | 151,199,600 |
| Total Number of Logical Blocks Verified | 79,790,800 |
| 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 NEC Storage M500 as documented in this Full Disclosure Report will become available on March 1, 2013 for customer purchase and shipment.

## PRICING INFORMATION

*Clause 9.4.3.3.6*

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

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

## TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

*Clause 9.4.3.3.8*

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

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

## ANOMALIES OR IRREGULARITIES

*Clause 9.4.3.10*

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

There were no anomalies or irregularities encountered during the SPC-1 Remote Audit of the NEC Storage M500.

# APPENDIX A: SPC-1 GLOSSARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## SPC-1 Data Repository Definitions

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

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

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

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

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

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

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

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

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

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

## SPC-1 Data Protection Levels

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

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

## SPC-1 Test Execution Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

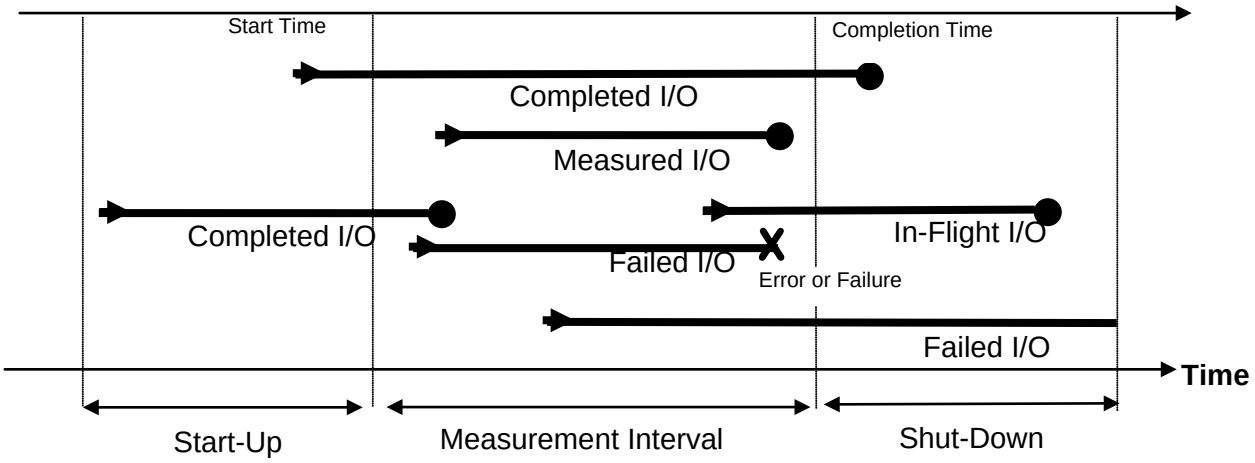
**Steady State:** The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

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

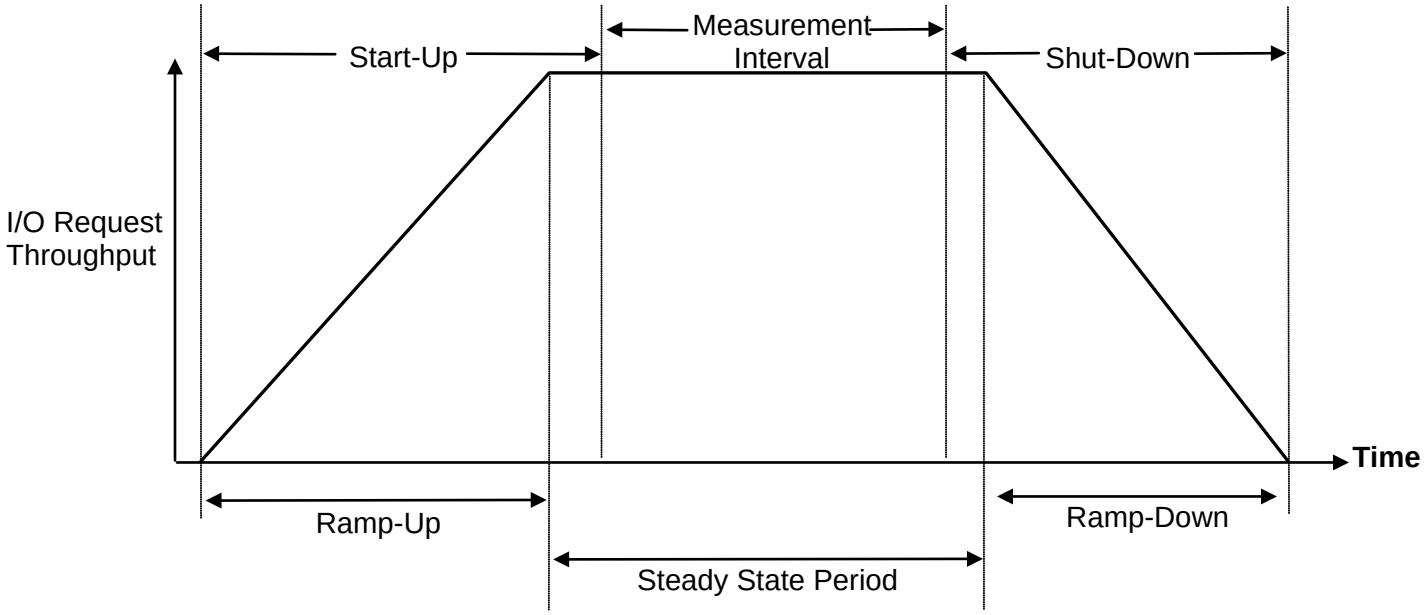
**Test Run:** The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall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

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

## I/O Completion Types




## SPC-1 Test Run Components



# APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

There were no customer tunable parameters or options changed from their default values for the benchmark measurements.

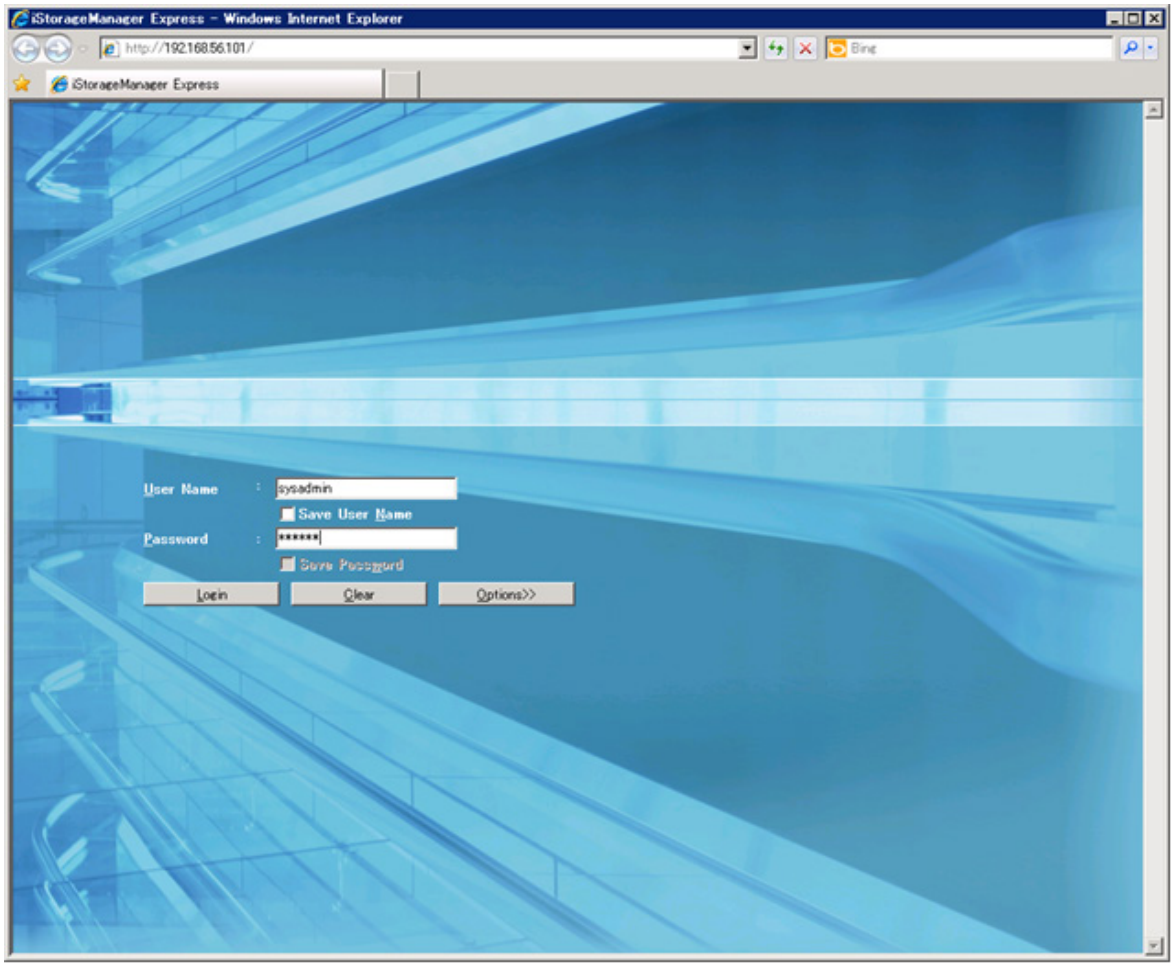
# APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The NEC Storage Manager was used to create and configure the Tested Storage Configuration. That storage management utility was installed and used from one of the two Host Systems.

## Starting the NEC Storage Manager Client

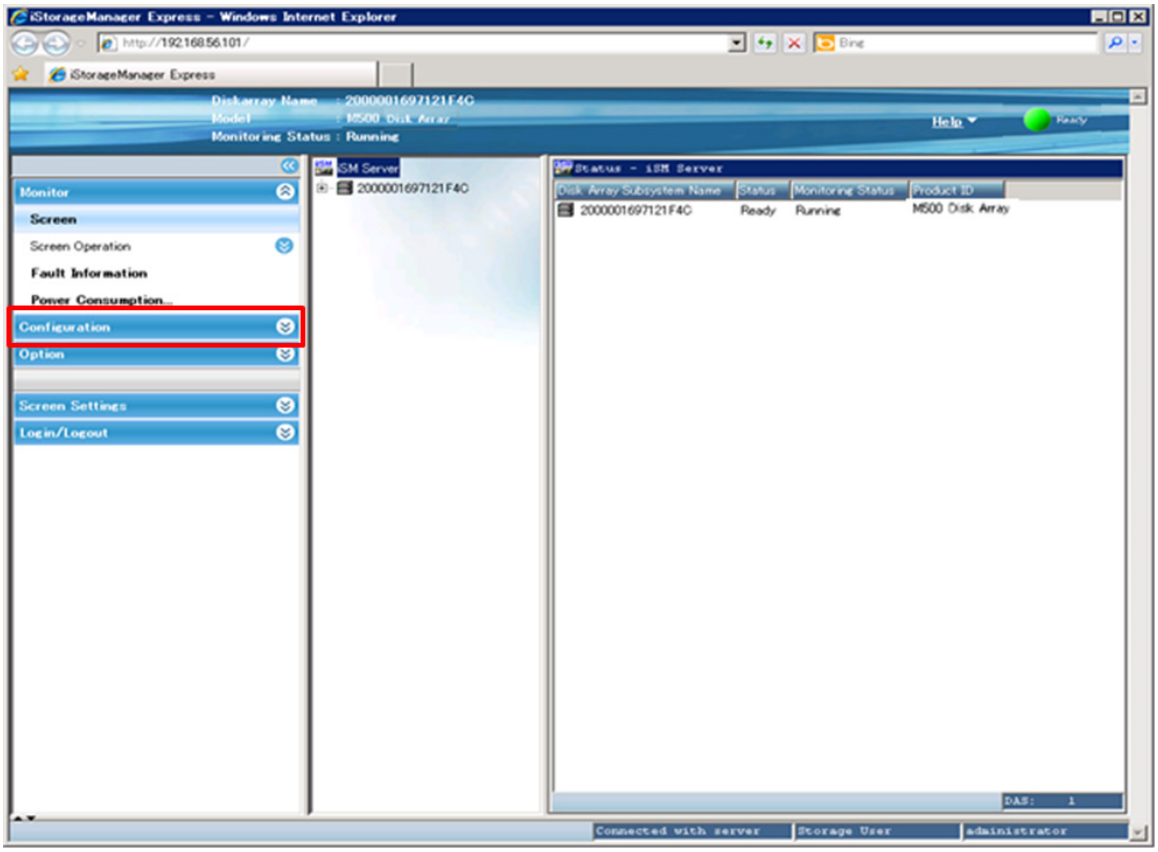
The NEC Storage Manager client is started as follows:

1. Start a web browser on the Host System where the NEC Storage Manager client is installed.
2. Start the NEC Storage Manager client by entering the IP address of the NEC Storage M500 in the address bar of the web browser.
3. Perform the following to logon to the NEC Storage Manager client:
   a) Enter **sysadmin** in the **User Name** box
   b) Enter **sys123** *(default value)* in the **Password** box
4. Click **Login** to open the client main menu.

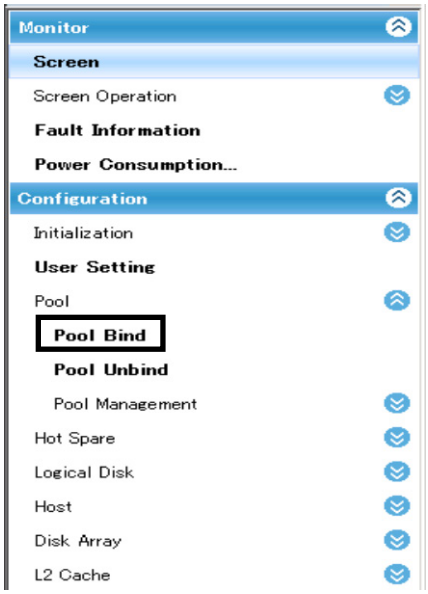


## Create Volume Groups *(Pool Bind)*

Click **Configuration** and **Pool** on the main menu to open the appropriate submenu.




Then click **Pool Bind** on that submenu.

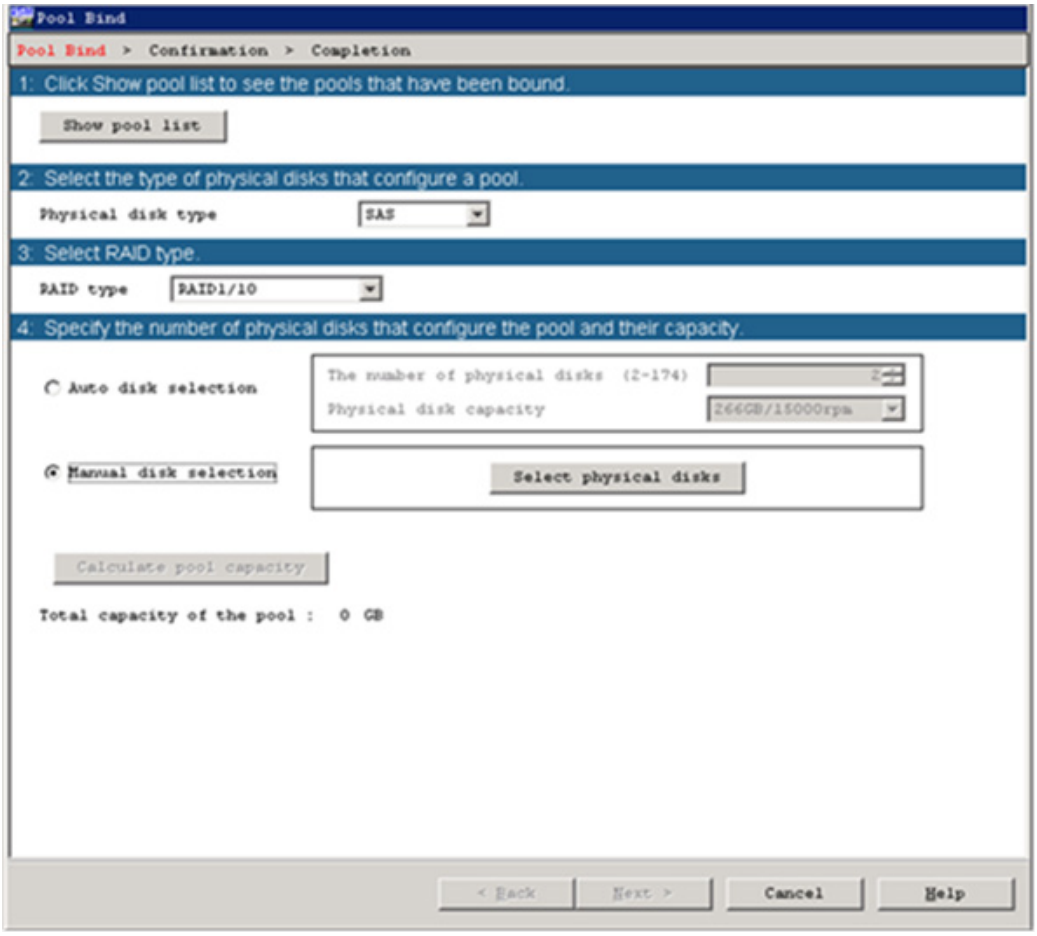


There were 25 volume groups created, each of which contained a single RAID1/10 *(mirrored)* volume.

Examples of the Pool Bind menus are listed below. The values displayed in menu were not the values used to configure the TSC. The specific parameter values for each of the 25 volume groups are listed in the Volume Group Parameters section.

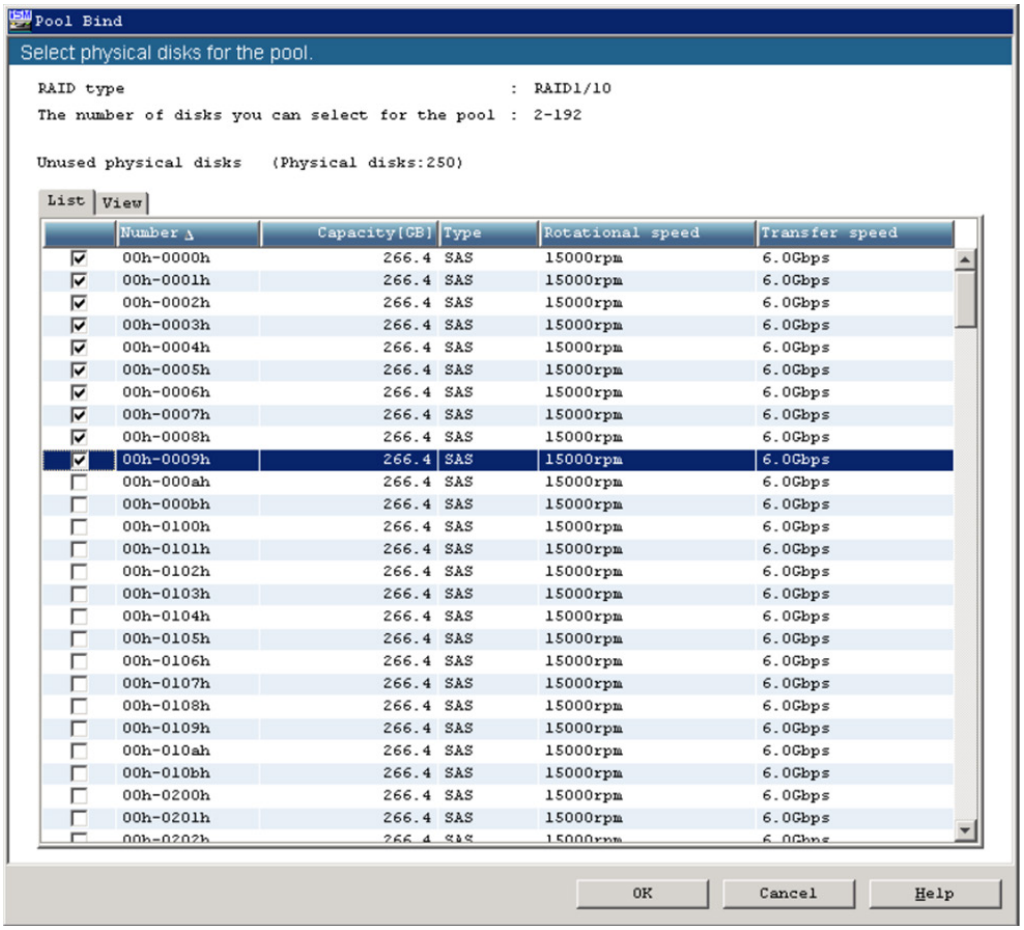
Each volume group is created, starting with the first Pool Bind menu, by selecting the following specifications:

- **Physical disk type** of ***SAS***
- **RAID type** of ***RAID1/10***

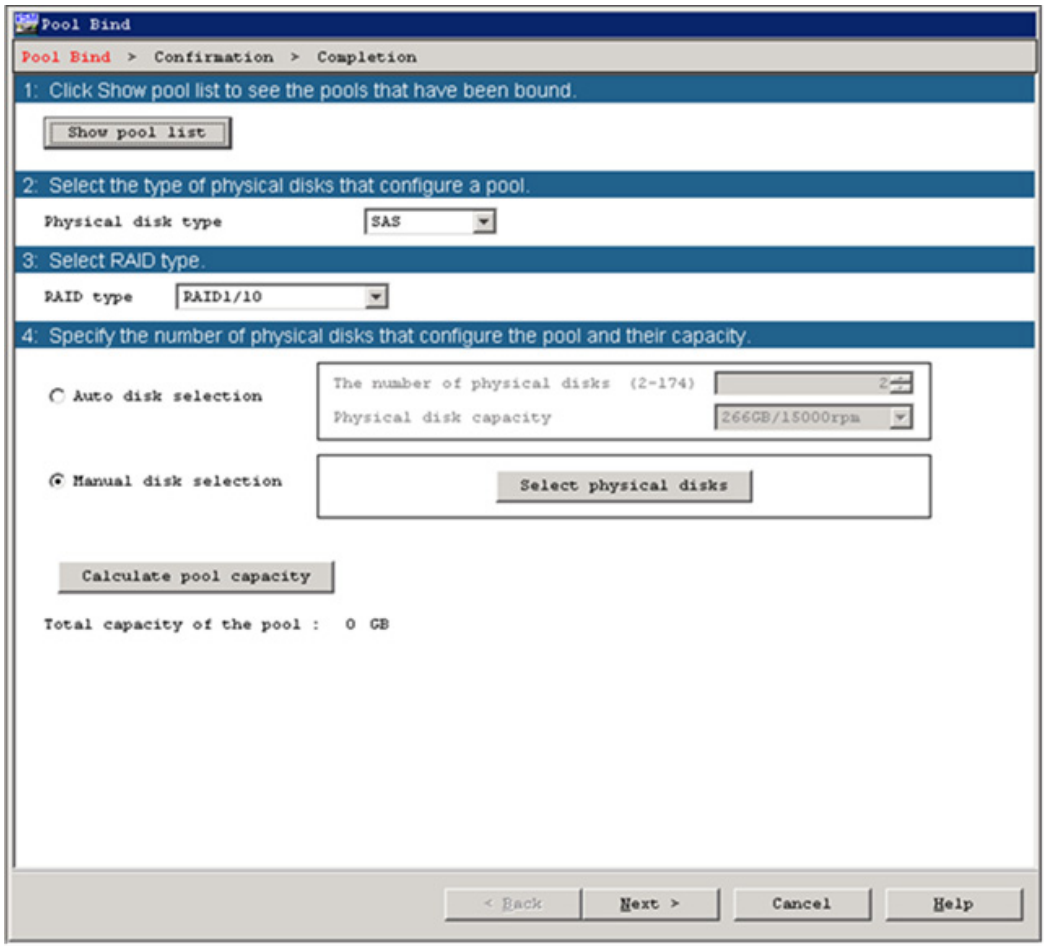



Specify 10 physical disks to be assigned to a pool by selecting the **Manual disk selection** option and clicking on **Select physical disks**, which will display the second Pool Bind menu.

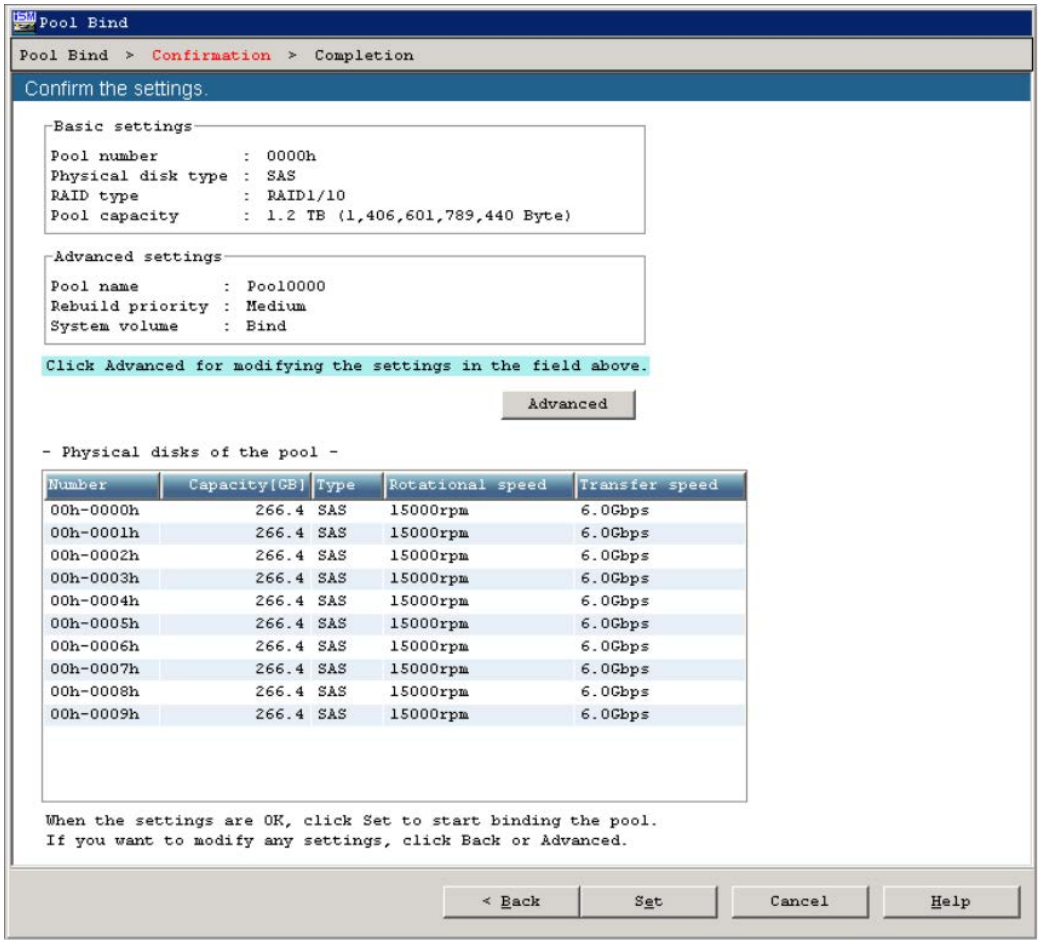
Select the appropriate 10 physical disks and then click the **OK** button, which will return to the first Pool Bind menu.



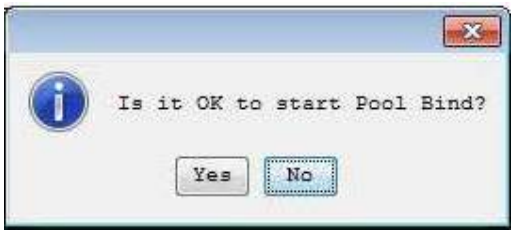
Click on the **Next** button, which will cause a confirmation menu to be displayed.



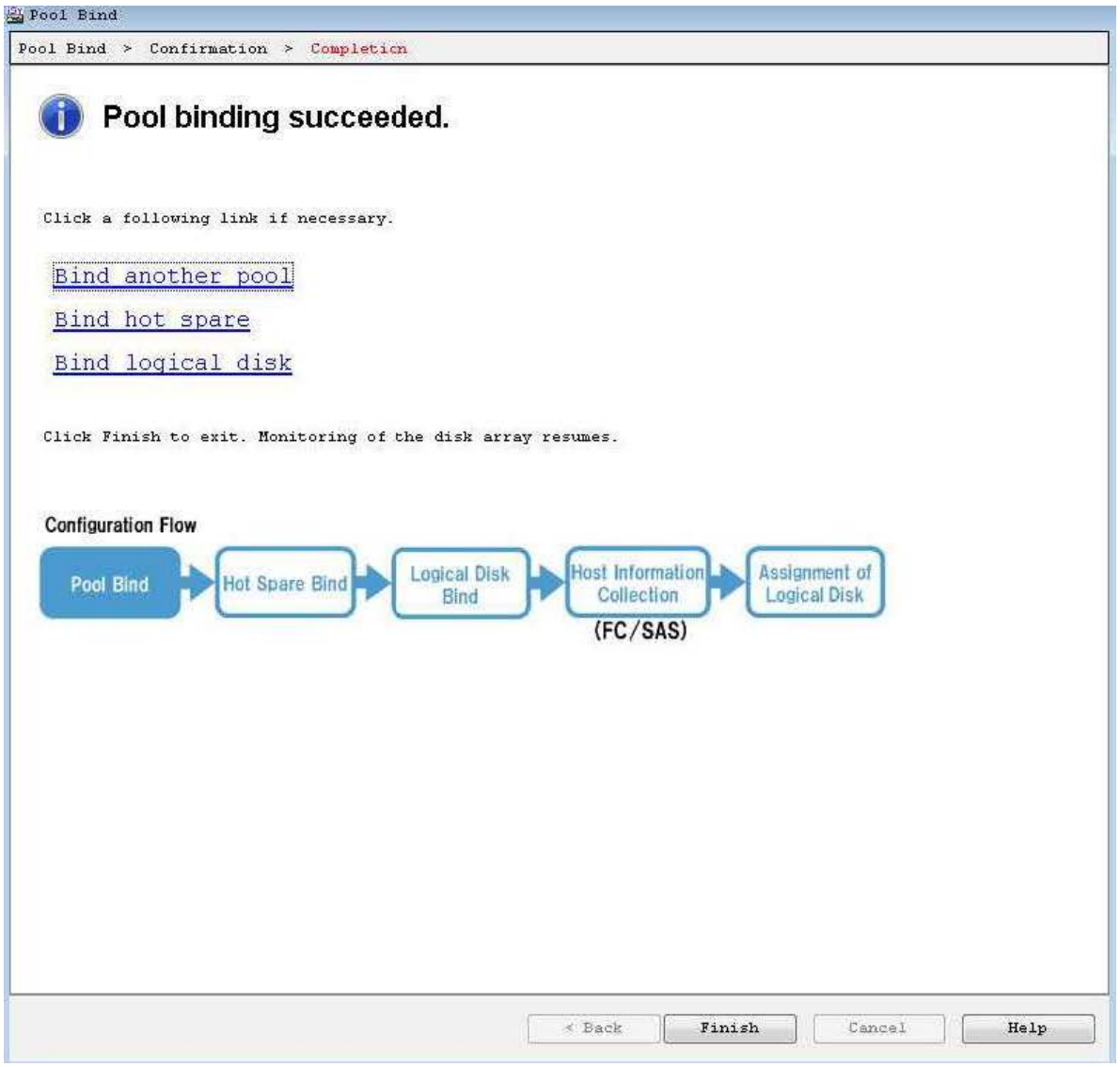
This menu will display the pool number, physical disk type, RAID type and physical disks selected to configure the pool. The pool number is automatically assigned.




If all of the displayed information is correct, click on the **Set** button to display the following confirmation message.




Click on the **Yes** button to complete the pool bind and creation of the volume group. When the pool binding is successfully completed the following window is displayed.




Click on **Bind another pool** to create another volume group or **Bind logical disk** to create the logical disks described in the next step.

## Create Logical Disks *(Logical Disk Bind)*

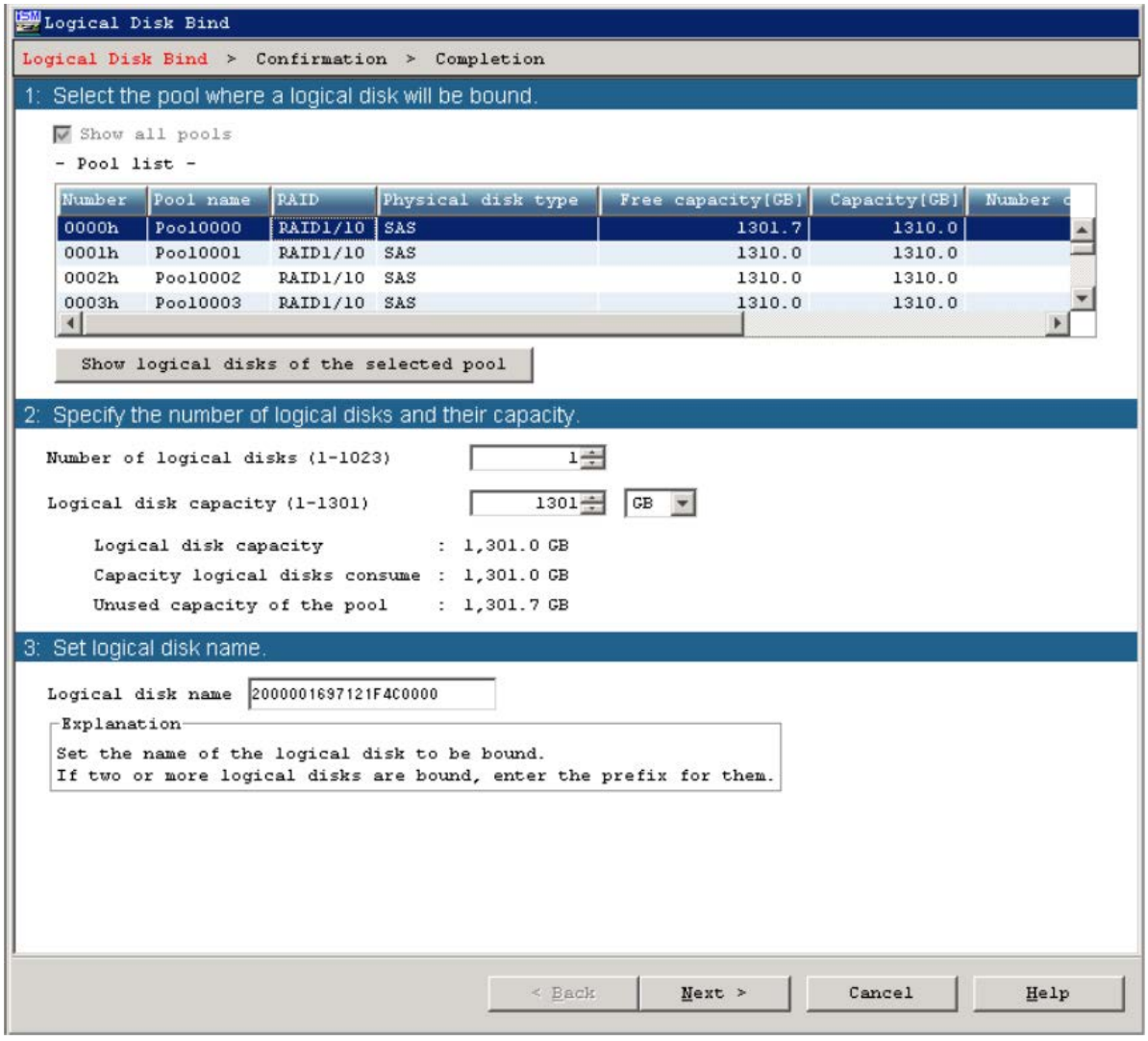
The logical disks can be created by clicking the **Bind logical disk** option in the Pool Disk completion menu or by clicking **Configuration** then **Logical Disk Bind** in the main menu.


One logical disk was created from each of the 25 RAID1/10 volumes.

Examples of the Logical Disk Bind menus are listed below. The values displayed in example menus were not the values used to configure the TSC. The specific parameter values for each of the 25 logical disks are listed in the Logical Disk Parameters section.

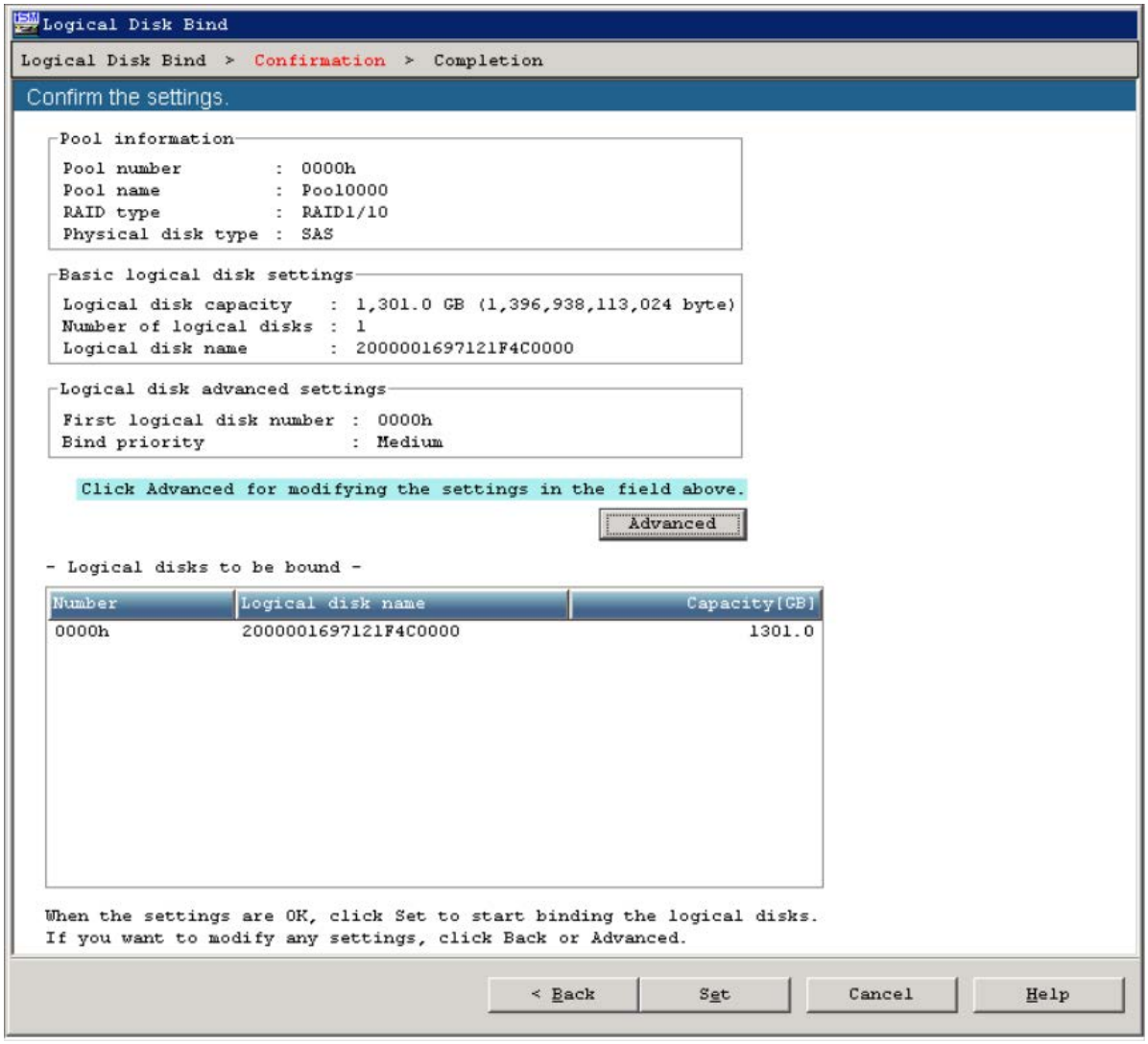
Each logical disk was created, starting from the first Logical Disk Bind menu, with the following specifications:

- **Pool list:** Select the pool in which the logical disk will be bound.
- **Number of logical disks:** Select ***1*** as the number of logical disks.
- **Logical disk capacity:** Enter the capacity in GiB.
- The **logical disk name** is assigned automatically.

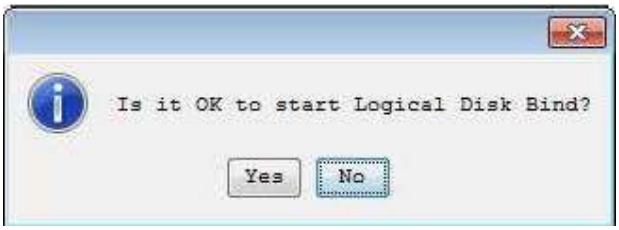



After entering the appropriate parameter values, click on the **Next** button, which will display.the following confirmation menu.

This menu will list the settings of the logical disk to be bound. If all of the displayed information is correct, click on the **Set** button, which will display the following final confirmation menu.

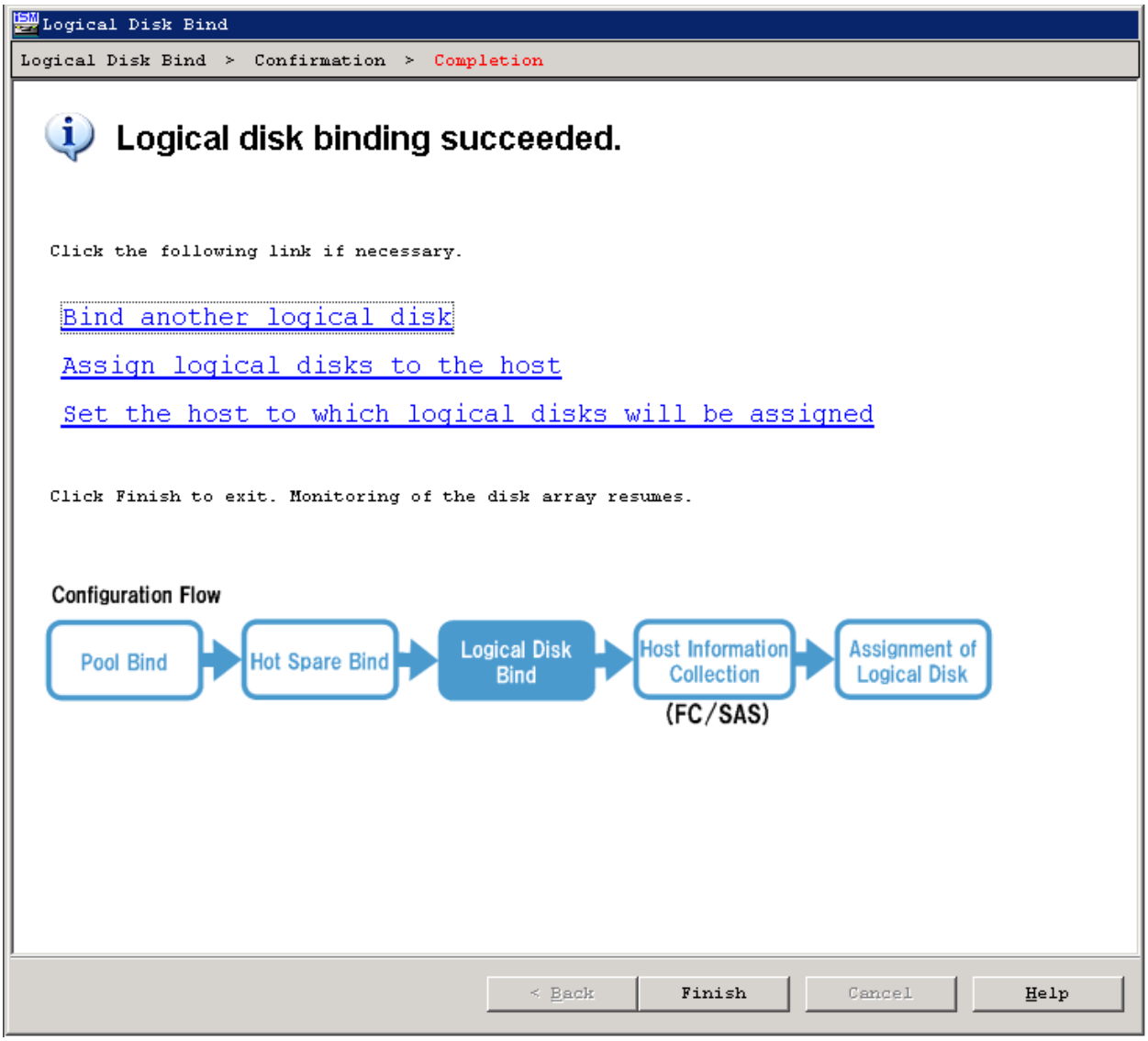



Click on the **Yes** button to create the logical disk.




After that is completed, the following window is displayed.

Select **Bind another logical disk** to create another logical disk or click the **Finish** button after creating the last logical disk.



## SPC-1 Logical Volume Creation

The following steps are executed on a single Host System, using the Windows Disk Management utility, to create the SPC-1 Logical Volumes.

1. Start the Windows Disk Management utility and confirm that the 25 logical disks, created above, are present as 25 Windows "Disks".
2. Convert all 25 Windows "Disks" to Dynamic Disks.
3. Create a Windows striped (RAID-0) volume for ASU-1 as follows:
   a. Select all 25 Windows "Disks".
   b. Set the capacity of each stripe to 599,498 MB *(MiB)*
   c. Assign drive letter "F" to the volume.
   d. Do not format the volume.
4. Create a Windows striped (RAID-0) volume for ASU-2 as follows:
   a. Select all 25 Windows "Disks".
   b. Set the capacity of each stripe to 599,498 MB *(MiB)*
   c. Assign drive letter "E" to the volume.
   d. Do not format the volume.
5. Create a Windows striped (RAID-0) volume for ASU-3 as follows:
   a. Select all 25 Windows "Disks".
   b. Set the capacity of each stripe to 133,222 MB *(MiB)*
   c. Assign drive letter "G" to the volume.
   d. Do not format the volume.
6. Reboot the Host Systems.
7. After the reboot completes, start the Windows Disk Management utility on each of the Host Systems.
8. On each Host System, select either the import foreign disk or reactivate Windows stripe sets option, as necessary, then assign drive letters to the stripe sets as were defined in steps 3-5 above.

## Referenced Parameter Details

### Volume Group Parameters

```
0000    SAS     RAID1/10    00-0000,00-0001,00-0002,00-0003,00-0004,
                            00-0005,00-0006,00-0007,00-0008,00-0009
0001    SAS     RAID1/10    00-000a,00-000b,00-0100,00-0101,00-0102,
                            00-0103,00-0104,00-0105,00-0106,00-0107
0002    SAS     RAID1/10    00-0108,00-0109,00-010a,00-010b,00-0200,
                            00-0201,00-0202,00-0203,00-0204,00-0205
0003    SAS     RAID1/10    00-0206,00-0207,00-0208,00-0209,00-020a,
                            00-020b,00-0300,00-0301,00-0302,00-0303
0004    SAS     RAID1/10    00-0304,00-0305,00-0306,00-0307,00-0308,
                            00-0309,00-030a,00-030b,00-0400,00-0401
0005    SAS     RAID1/10    00-0402,00-0403,00-0404,00-0405,00-0406,
                            00-0407,00-0408,00-0409,00-040a,00-040b
0006    SAS     RAID1/10    00-0500,00-0501,00-0502,00-0503,00-0504,
                            00-0505,00-0506,00-0507,00-0508,00-0509
0007    SAS     RAID1/10    00-0800,00-0801,00-0802,00-0803,00-0804,
                            00-0805,00-0806,00-0807,00-0808,00-0809
0008    SAS     RAID1/10    00-080a,00-080b,00-0900,00-0901,00-0902,
                            00-0903,00-0904,00-0905,00-0906,00-0907
0009    SAS     RAID1/10    00-0908,00-0909,00-090a,00-090b,00-0a00,
                            00-0a01,00-0a02,00-0a03,00-0a04,00-0a05
000a    SAS     RAID1/10    00-0a06,00-0a07,00-0a08,00-0a09,00-0a0a,
                            00-0a0b,00-0b00,00-0b01,00-0b02,00-0b03
000b    SAS     RAID1/10    00-0b04,00-0b05,00-0b06,00-0b07,00-0b08,
                            00-0b09,00-0b0a,00-0b0b,00-0c00,00-0c01
000c    SAS     RAID1/10    00-0c02,00-0c03,00-0c04,00-0c05,00-0c06,
                            00-0c07,00-0c08,00-0c09,00-0c0a,00-0c0b
000d    SAS     RAID1/10    00-1000,00-1001,00-1002,00-1003,00-1004,
                            00-1005,00-1006,00-1007,00-1008,00-1009
000e    SAS     RAID1/10    00-100a,00-100b,00-1100,00-1101,00-1102,
                            00-1103,00-1104,00-1105,00-1106,00-1107
000f    SAS     RAID1/10    00-1108,00-1109,00-110a,00-110b,00-1200,
                            00-1201,00-1202,00-1203,00-1204,00-1205
0010    SAS     RAID1/10    00-1206,00-1207,00-1208,00-1209,00-120a,
                            00-120b,00-1300,00-1301,00-1302,00-1303
0011    SAS     RAID1/10    00-1304,00-1305,00-1306,00-1307,00-1308,
                            00-1309,00-130a,00-130b,00-1400,00-1401
0012    SAS     RAID1/10    00-1402,00-1403,00-1404,00-1405,00-1406,
                            00-1407,00-1408,00-1409,00-140a,00-140b
0013    SAS     RAID1/10    00-1800,00-1801,00-1802,00-1803,00-1804,
                            00-1805,00-1806,00-1807,00-1808,00-1809
0014    SAS     RAID1/10    00-180a,00-180b,00-1900,00-1901,00-1902,
                            00-1903,00-1904,00-1905,00-1906,00-1907
0015    SAS     RAID1/10    00-1908,00-1909,00-190a,00-190b,00-1a00,
                            00-1a01,00-1a02,00-1a03,00-1a04,00-1a05
```

| Pool Number | Physical Disk | RAID type | Select physical disks |
|---|---|---|---|
| 0016 | SAS | RAID1/10 | 00-1a06,00-1a07,00-1a08,00-1a09,00-1a0a,<br>00-1a0b,00-1b00,00-1b01,00-1b02,00-1b03 |
| 0017 | SAS | RAID1/10 | 00-1b04,00-1b05,00-1b06,00-1b07,00-1b08,<br>00-1b09,00-1b0a,00-1b0b,00-1c00,00-1c01 |
| 0018 | SAS | RAID1/10 | 00-1c02,00-1c03,00-1c04,00-1c05,00-1c06,<br>00-1c07,00-1c08,00-1c09,00-1c0a,00-1c0b |

### Logical Disk Parameters

| Pool list | Number of Logical Disks | Logical disk Capacity | Logical disk name |
|---|---|---|---|
| 0000 | 1 | 1301 | 2000001697121F4C0000 |
| 0001 | 1 | 1309 | 2000001697121F4C0001 |
| 0002 | 1 | 1309 | 2000001697121F4C0002 |
| 0003 | 1 | 1309 | 2000001697121F4C0003 |
| 0004 | 1 | 1309 | 2000001697121F4C0004 |
| 0005 | 1 | 1309 | 2000001697121F4C0005 |
| 0006 | 1 | 1309 | 2000001697121F4C0006 |
| 0007 | 1 | 1309 | 2000001697121F4C0007 |
| 0008 | 1 | 1309 | 2000001697121F4C0008 |
| 0009 | 1 | 1309 | 2000001697121F4C0009 |
| 000a | 1 | 1309 | 2000001697121F4C000A |
| 000b | 1 | 1309 | 2000001697121F4C000B |
| 000c | 1 | 1309 | 2000001697121F4C000C |
| 000d | 1 | 1309 | 2000001697121F4C000D |
| 000e | 1 | 1309 | 2000001697121F4C000E |
| 000f | 1 | 1309 | 2000001697121F4C000F |
| 0010 | 1 | 1309 | 2000001697121F4C0010 |
| 0011 | 1 | 1309 | 2000001697121F4C0011 |
| 0012 | 1 | 1309 | 2000001697121F4C0012 |
| 0013 | 1 | 1309 | 2000001697121F4C0013 |
| 0014 | 1 | 1309 | 2000001697121F4C0014 |
| 0015 | 1 | 1309 | 2000001697121F4C0015 |
| 0016 | 1 | 1309 | 2000001697121F4C0016 |
| 0017 | 1 | 1309 | 2000001697121F4C0017 |
| 0018 | 1 | 1309 | 2000001697121F4C0018 |

# 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=default,threads=32
sd=sd1,lun=\\.\e:
sd=sd2,lun=\\.\f:
sd=sd3,lun=\\.\g:

wd=default,rdpct=0,seek=-1,xfersize=4K
wd=wd1,sd=sd1
wd=wd2,sd=sd2
wd=wd3,sd=sd3

rd=PREPSSD,wd=wd*,iorate=max,elapsed=999990,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 and Repeatability Tests, is listed below.

```
* spc1_metrics.cfg

host=master
slaves=(ns58_1,ns58_2,ns58_3,ns58_4,ns58_5,ns58_6,ns58_7,ns57_1,ns57_2,ns57_3,ns57_4
,ns57_5,ns57_6)

sd=asu1_1,lun=\\.\e:,size=15715480371200
sd=asu2_1,lun=\\.\f:,size=15715480371200
sd=asu3_1,lun=\\.\g:,size=3492334796800
```

## 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.

```
* spc1_persist.cfg

sd=asu1_1,lun=\\.\e:,size=15715480371200
sd=asu2_1,lun=\\.\f:,size=15715480371200
sd=asu3_1,lun=\\.\g:,size=3492334796800
```

# APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

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

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

The script also included the appropriate commands to capture the detailed TSC profile listings required for a Remote Audit.

```
call profile.bat
call prepssd.bat

copy /y spc1_metrics.cfg spc1.cfg
java -Xmx1024m -Xms1024m metrics -b 1261 -t 28800
java -Xmx1024m -Xms1024m repeat1 -b 1261
java -Xmx1024m -Xms1024m repeat2 -b 1261

copy /y spc1_persist.cfg spc1.cfg
java -Xmx1024m -Xms1024m persist1 -b 1261

call shutdown.bat
```

## Detailed TSC System Profile

The following script and command file were used to capture the detailed TSC profile required for a Remote Audit.

### profile.bat

```
c:\Bench_ns58\teraterm\ttermpro.exe /M=c:\Bench_ns58\teraterm\M500_profile.ttl
```

### M500_profile.ttl

```
;; connection user/password
HOSTADDR = '192.168.56.101'
USERNAME = '[redacted]'
PASSWORD = '[redacted]'
;================================================
;; config
COMMAND = HOSTADDR
strconcat COMMAND ':23 /nossh /T=1'

;; connect
connect COMMAND

;; login
wait 'login: '
sendln USERNAME
wait 'Password: '
sendln PASSWORD

;; command1
```

```
wait 'sysadmin@2000001697121F4C-0# '
sendln 'iSMview -all'

;; command2
wait 'sysadmin@2000001697121F4C-0# '
sendln 'iSMenv gettime'

;; command3
wait 'sysadmin@2000001697121F4C-0# '
sendln 'exit'

;; finish
end
```

## ASU Pre-Fill

The following script was invoked to execute the required ASU pre-fill using the command and parameter file documented in *"Appendix D: SPC-1 Workload Generator Storage Commands and Parameters"* on page78.

### prepssd.bat

```
c:\Bench_ns58\vdbench503rc11\vdbench -f c:\Bench_ns58\prepssd.txt -o
c:\Bench_ns58\ssdprep
```

## Persistence Test Run 2

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

```
call profile.bat

java -Xmx1024m -Xms1024m persist2

call profile.bat
```

## Slave JVMs

There were 13 Slave JVMs used in the Primary Metrics and Repeatability Tests. The two files, listed below, illustrate the command to start the first Slave JVM (**ns58_s1.bat**) with the appropriate parameter file (**ns58_s1.parm**). A similar pair of files was used to start the remaining 12 Slave JVMs ***(ns58_s2*** – **ns58_s7** *and* ***ns57_s1*** – ***ns57_s6)***.

### ns58_s1.bat

```
java -Xmx1024m -Xms1024m spc1 -fns58_s1.parm -ons58_s1
```

### ns58_s1.parm

```
host=ns58_1
master=ns58

sd=asu1,lun=\\.\e:
sd=asu2,lun=\\.\f:
sd=asu3,lun=\\.\g:
```