SPC Benchmark 1™

Full Disclosure Report

Lenovo
ThinkSystem DS4200

SPC-1 V3.4.0

Submission Identifier: A32002

Submitted For Review: July 19, 2017
First Edition – July 2017

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Benchmark Specification and Glossary

The official SPC Benchmark 1™ (SPC-1™) specification is available on the website of the Storage Performance Council (SPC) at www.storageperformance.org.

The SPC-1™ specification contains a glossary of the SPC-1™ terms used in this publication.
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AUDIT CERTIFICATION

Mr. Gabe Brewington
Lenovo
7001 Development Drive
Morrisville, NC 27560

July 18, 2017

I verified the SPC Benchmark 1™ (SPC-1™ V3.4.0) test execution and performance results of the following Tested Storage Product:

ThinkSystem DS4200

The results were:

<table>
<thead>
<tr>
<th>SPC-1 IOPS™</th>
<th>100,021</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Price-Performance™</td>
<td>$0.14/SPC-1 IOPS™</td>
</tr>
<tr>
<td>SPC-1 IOPS™ Response Time</td>
<td>0.485 ms</td>
</tr>
<tr>
<td>SPC-1 Overall Response Time</td>
<td>0.325 ms</td>
</tr>
<tr>
<td>SPC-1 ASU Capacity</td>
<td>2,267 GB</td>
</tr>
<tr>
<td>SPC-1 ASU Price</td>
<td>$6.00/GB</td>
</tr>
<tr>
<td>SPC-1 Total System Price</td>
<td>$13,580.85</td>
</tr>
</tbody>
</table>

In my opinion, these performance results were produced in compliance with the SPC requirements for the benchmark.

The testing was executed using the SPC-1 Toolkit Version 3.0.2. The audit process was conducted in accordance with the SPC Policies and met the requirements for the benchmark.

A Letter of Good Faith was issued by the Test Sponsor, stating the accuracy and completeness of the documentation and testing data provided in support of the audit of this result.

A Full Disclosure Report for this result was prepared by InfoSizing, reviewed and approved by the Test Sponsor, and can be found at www.storageperformance.org under the Submission Identifier A32002.

63 Lourdes Dr. | Leominster, MA 01453 | 978-343-6562 | www.sizing.com
The independent audit process conducted by InfoSizing included the verifications of the following items:

- The physical capacity of the data repository;
- The total capacity of the Application Storage Unit (ASU);
- The accuracy of the Benchmark Configuration diagram;
- The tuning parameters used to configure the Benchmark Configuration;
- The Workload Generator commands used to execute the testing;
- The validity and integrity of the test result files;
- The compliance of the results from each performance test;
- The compliance of the results from each persistence test;
- The compliance of the submitted pricing model; and
- The differences between the tested and the priced configuration, if any.

The Full Disclosure Report for this result was prepared in accordance with the disclosure requirements set forth in the specification for the benchmark.

The following benchmark requirements, if any, were waived in accordance with the SPC Policies:

None.

Respectfully Yours,

Doug Johnson, Certified SPC Auditor
LETTER OF GOOD FAITH

July 18, 2017

From: Mike Fitzgerald, VP, Data Center Product Group Operations, Lenovo

Subject: SPC-1 Letter of Good Faith for Lenovo ThinkSystem DS4200

Lenovo 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 the 3.4 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.

Sincerely,

Mike Fitzgerald
VP, Data Center Product Group Operations
Lenovo
Tel: 919-294-5813
Email: mfitzge@lenovo.com

Date: 7/18/17
SPC BENCHMARK 1™

EXECUTIVE SUMMARY

LENOVO
THINKSYSTEM DS4200

<table>
<thead>
<tr>
<th>SPC-1 IOPS™</th>
<th>100,021</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Price-Performance™</td>
<td>$0.14/SPC-1 IOPS™</td>
</tr>
<tr>
<td>SPC-1 IOPS™ Response Time</td>
<td>0.485 ms</td>
</tr>
<tr>
<td>SPC-1 Overall Response Time</td>
<td>0.325 ms</td>
</tr>
<tr>
<td>SPC-1 ASU Capacity</td>
<td>2,267 GB</td>
</tr>
<tr>
<td>SPC-1 ASU Price</td>
<td>$6.00/GB</td>
</tr>
<tr>
<td>SPC-1 Total System Price</td>
<td>$13,580.85</td>
</tr>
</tbody>
</table>

Data Protection Level: Protected 1 (RAID-10)
Physical Storage Capacity: 4,800 GB
Pricing Currency / Target Country: U.S. Dollars / USA

SPC-1 V3.4.0
SUBMISSION IDENTIFIER: A32002
SUBMITTED FOR REVIEW: JULY 19, 2017
EXECUTIVE SUMMARY

Benchmark Configuration Diagram

Lenovo x3550 M5 server
2x E5-2650 v3 (2.30 GHz, 10-Core, 25 MB)
16 GB Memory
Windows 2008 R2

Lenovo ThinkSystem DS4200
2x Controllers, each with:
- 8 GB
- 4x 12 Gb SAS Port (SFF-8644) (front end)
- 1x 12 Gb SAS Port (SFF-8644) (back end)
12x 400 GB SSD

Lenovo N2225 8-port
12Gb SAS HBA

Two 12Gb SAS Cables

Lenovo
ThinkSystem DS4200
Tested Storage Product Description

The Lenovo ThinkSystem DS4200 SAN array is performance optimized for primary storage, remote/branch offices, virtualization and backup. Offering 2x the performance of its predecessor, the DS4200 is powered by a Rapid Data Placement Engine and provides industry-leading price/performance and scalability.

With extreme flexibility and impressive performance and capacity, the DS4200 helps you tame the storage monster. Using 3.5-inch (LFF) or 2.5-inch (SFF) HDDs and SSDs, the DS4200 supports up to 240 drives (using 9 expansion units), as well as mixing LFF and SFF enclosures in the same array. The DS4200 offers connectivity options for 12G SAS, 8/16 Gb FC and 1/10 Gb iSCSI.

The ThinkSystem DS4200 is ideal for workloads such as primary storage, virtualized resources, consolidated backup, automated disaster recovery, and other similar-sized workloads. With performance and value in mind, and equipped with enterprise-class features, the DS4200 is designed to fit your needs now and into the future.


Priced Storage Configuration Components

<table>
<thead>
<tr>
<th>1 x N2225 SAS/SATA HBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x ThinkSystem DS4200, with:</td>
</tr>
<tr>
<td>2 x Storage Controllers</td>
</tr>
<tr>
<td>8GB cache (16 GB total)</td>
</tr>
<tr>
<td>4 x 12 Gb SAS Front End Ports</td>
</tr>
<tr>
<td>1 x 12 Gb SAS Back End Connection</td>
</tr>
<tr>
<td>12 x 400 GB SSD</td>
</tr>
</tbody>
</table>
# Storage Configuration Pricing

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
<th>Qty</th>
<th>Unit Price</th>
<th>Ext. Price</th>
<th>Disc.</th>
<th>Disc. Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>4617A21</td>
<td>Lenovo ThinkSystem DS4200 SFF SAS Dual Cont</td>
<td>1</td>
<td>8,279</td>
<td>8,279</td>
<td>45%</td>
<td>4,553.45</td>
</tr>
<tr>
<td>01DC482</td>
<td>400GB 3DWD 2.5&quot; SAS SSD</td>
<td>12</td>
<td>1,499</td>
<td>17,988</td>
<td>55%</td>
<td>8,094.60</td>
</tr>
<tr>
<td>00YL847</td>
<td>0.5M External MiniSAS HD 8644/MiniSAS HD 8</td>
<td>2</td>
<td>49</td>
<td>98</td>
<td>45%</td>
<td>53.90</td>
</tr>
<tr>
<td>00AE912</td>
<td>N2225 12Gb SAS/SATA HBA</td>
<td>1</td>
<td>299</td>
<td>299</td>
<td>45%</td>
<td>164.45</td>
</tr>
<tr>
<td></td>
<td><strong>Hardware Subtotal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>12,866.40</strong></td>
</tr>
<tr>
<td>01JR528</td>
<td>3YR Technician Installed Parts 24x7 4 Hour Re</td>
<td>1</td>
<td>1,299</td>
<td>1,299</td>
<td>45%</td>
<td>714.45</td>
</tr>
<tr>
<td></td>
<td><strong>Support &amp; Maintenance Subtotal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>714.45</strong></td>
</tr>
<tr>
<td></td>
<td><strong>SPC-1 Total System Price</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>13,580.85</strong></td>
</tr>
</tbody>
</table>

**Discount Details:** The discounts shown are based on the storage capacity purchased and are generally available.

**Availability Date:** July 20, 2017.
Response Time and Throughput Graph

Contact Information

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gabe Brewington – <a href="mailto:gabe@Lenovo.com">gabe@Lenovo.com</a></td>
</tr>
<tr>
<td>SPC Auditor</td>
<td>InfoSizing – <a href="http://www.sizing.com">www.sizing.com</a></td>
</tr>
<tr>
<td></td>
<td>Doug Johnson – <a href="mailto:doug@sizing.com">doug@sizing.com</a></td>
</tr>
</tbody>
</table>

Revision Information

<table>
<thead>
<tr>
<th>SPC Benchmark 1™ Revision</th>
<th>V3.4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Workload Generator Revision</td>
<td>v 3.0.2</td>
</tr>
<tr>
<td>Publication Revision History</td>
<td>Initial Publication</td>
</tr>
</tbody>
</table>
**CONFIGURATION INFORMATION**

**Benchmark Configuration and Tested Storage Configuration**

The following diagram illustrates the Benchmark Configuration (BC), including the Tested Storage Configuration (TSC) and the Host System(s).

- **Lenovo x3550 M5 server**
  - 2x E5-2650 v3 (2.30 GHz, 10-Core, 25 MB)
  - 16 GB Memory
  - Windows 2008 R2

- **Lenovo ThinkSystem DS4200**
  - 2x Controllers, each with:
    - 8 GB
    - 4x 12 Gb SAS Port (SFF-8644) (front end)
    - 1x 12 Gb SAS Port (SFF-8644) (back end)
  - 12x 400 GB SSD

- **Lenovo N2225 8-port 12Gb SAS HBA**

- **Tested Storage Configuration (TSC)**

- **Two 12Gb SAS Cables**

**Storage Network Configuration**

The Benchmark Configuration utilized direct-attached storage.

**Host System and Tested Storage Configuration Components**

The following table lists the components of the Host System(s) and the Tested Storage Configuration (TSC).

<table>
<thead>
<tr>
<th>Host Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x Lenovo x3550 M5 Server</td>
</tr>
<tr>
<td>2 x E5-2650 v3 (2.30 GHz, 10-Core, 25 MB L3)</td>
</tr>
<tr>
<td>16 GB Memory</td>
</tr>
<tr>
<td>Windows 2008 R2</td>
</tr>
</tbody>
</table>
### Tested Storage Configuration

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x N2225 SAS/SATA HBA</td>
</tr>
<tr>
<td>1 x ThinkSystem DS4200, with:</td>
</tr>
<tr>
<td>2 x Storage Controllers</td>
</tr>
<tr>
<td>8 GB cache (16 GB total)</td>
</tr>
<tr>
<td>4 x 12 Gb SAS Front End Ports</td>
</tr>
<tr>
<td>1 x 12 Gb SAS Back End Connection</td>
</tr>
<tr>
<td>12 x 400 GB SSD</td>
</tr>
</tbody>
</table>

### Differences Between Tested and Priced Storage Configurations

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

### Component Changes in Revised Full Disclosure Report

The following table outlines component changes that were made in revisions to this Full Disclosure Report.

<table>
<thead>
<tr>
<th>Original Component</th>
<th>Revised Component</th>
<th>Description of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/a</td>
<td>n/a</td>
<td>Initial submission</td>
</tr>
</tbody>
</table>
Benchmark Configuration Creation Process

Customer Tuning Parameters and Options

All the customer tuning parameters and options that have been altered from their default values for this benchmark are included in Appendix C and in the Supporting Files (see Appendix A).

Tested Storage Configuration Creation

A detailed description of how the logical representation of the TSC was created is included in Appendix D and in the Supporting Files (see Appendix A).

Tested Storage Configuration Inventory

An inventory of the components in the TSC, as seen by the Benchmark Configuration, is included in Appendix E and in the Supporting Files (see Appendix A).

Workload Generator Storage Configuration

The SPC-1 Workload Generator storage configuration commands and parameters used to invoke the execution of the tests are included in Appendix F and in the Supporting Files (see Appendix A).

Logical Volume Capacity and ASU Mapping

The following table details the capacity of each ASU and how they are mapped to logical volumes (LV).

<table>
<thead>
<tr>
<th>LV per ASU</th>
<th>LV Capacity</th>
<th>Used per LV</th>
<th>Total per ASU</th>
<th>% ASU Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASU-1</td>
<td>1</td>
<td>1,019</td>
<td>1,019</td>
<td>45.0%</td>
</tr>
<tr>
<td>ASU-2</td>
<td>1</td>
<td>1,019</td>
<td>1,019</td>
<td>45.0%</td>
</tr>
<tr>
<td>ASU-3</td>
<td>1</td>
<td>227</td>
<td>227</td>
<td>10.1%</td>
</tr>
</tbody>
</table>

| SPC-1 ASU Capacity | 2,267 |

Physical Storage Capacity and Utilization

The following table details the Physical Capacity of the storage devices and the Physical Capacity Utilization (percentage of Total Physical Capacity used) in support of hosting the ASUs.

<table>
<thead>
<tr>
<th>Devices</th>
<th>Count</th>
<th>Physical Capacity</th>
<th>Total Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 GB SSD</td>
<td>12</td>
<td>400.0</td>
<td>4,800.0</td>
</tr>
<tr>
<td>Total Physical Capacity</td>
<td>4,800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Capacity Utilization</td>
<td>47.23%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data Protection

The data protection level used for all logical volumes was Protected 1 (RAID-10), which was accomplished by configuring 2 pools of 6 drives into 2 RAID-10 arrays.
BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs.

Benchmark Execution Overview

Workload Generator Input Parameters

The SPC-1 Workload Generator commands and input parameters for the Test Phases are presented in the Supporting Files (see Appendix A).

Primary Metrics Test Phases

The benchmark execution consists of the Primary Metrics Test Phases, including the Test Phases SUSTAIN, RAMPD_100 to RAMPD_10, RAMPU_50 to RAMPU_100, RAMP_0, REPEAT_1 and REPEAT_2.

Each Test Phase starts with a transition period followed by a Measurement Interval.

Measurement Intervals by Test Phase Graph

The following graph presents the average IOPS and the average Response Times measured over the Measurement Interval (MI) of each Test Phase.

Exception and Waiver

None.
SUSTAIN Test Phase

SUSTAIN – Results File

The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

SUSTAIN – Execution Times

<table>
<thead>
<tr>
<th>Interval</th>
<th>Start Date</th>
<th>Start Time</th>
<th>End Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement Interval</td>
<td>13-Jul-17</td>
<td>23:33:19.000</td>
<td>07:33:19.000</td>
<td>8:00:00.000</td>
</tr>
</tbody>
</table>

SUSTAIN – Throughput Graph
SUSTAIN – Response Time Graph

SUSTAIN – Data Rate Graph
**SUSTAIN – Response Time Frequency Graph**

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percentage of difference (Difference) between Target and Measured.

<table>
<thead>
<tr>
<th>ASU</th>
<th>Defined</th>
<th>Measured</th>
<th>Variation</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0350</td>
<td>0.0350</td>
<td>0.0022</td>
<td>0.003%</td>
</tr>
<tr>
<td>2</td>
<td>0.2810</td>
<td>0.2810</td>
<td>0.0006</td>
<td>0.003%</td>
</tr>
<tr>
<td>3</td>
<td>0.0700</td>
<td>0.0700</td>
<td>0.0015</td>
<td>0.010%</td>
</tr>
<tr>
<td>4</td>
<td>0.2100</td>
<td>0.2100</td>
<td>0.0009</td>
<td>0.003%</td>
</tr>
<tr>
<td>5</td>
<td>0.0180</td>
<td>0.0180</td>
<td>0.0031</td>
<td>0.014%</td>
</tr>
<tr>
<td>6</td>
<td>0.0700</td>
<td>0.0700</td>
<td>0.0016</td>
<td>0.005%</td>
</tr>
<tr>
<td>7</td>
<td>0.0350</td>
<td>0.0350</td>
<td>0.0021</td>
<td>0.020%</td>
</tr>
<tr>
<td>8</td>
<td>0.2810</td>
<td>0.2810</td>
<td>0.0007</td>
<td>0.002%</td>
</tr>
</tbody>
</table>
RAMPD_100 Test Phase

RAMPD_100 – Results File

The results file generated during the execution of the RAMPD_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

RAMPD_100 – Execution Times

<table>
<thead>
<tr>
<th>Interval</th>
<th>Start Date</th>
<th>Start Time</th>
<th>End Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition Period</td>
<td>14-Jul-17</td>
<td>07:34:19.000</td>
<td>07:37:19.000</td>
<td>0:03:00.000</td>
</tr>
<tr>
<td>Measurement Interval</td>
<td>14-Jul-17</td>
<td>07:37:19.000</td>
<td>07:47:19.000</td>
<td>0:10:00.000</td>
</tr>
</tbody>
</table>

RAMPD_100 – Throughput Graph

![Throughput Graph (RAMPD_100 @ 100,000 IOPS)](image-url)
**RAMPD_100 – Response Time Graph**

![Response Time Graph](image)

**RAMPD_100 – Data Rate Graph**

![Data Rate Graph](image)
**RAMPD_100 – Response Time Frequency Graph**

The following graph shows the response time frequency distribution for RAMPD_100 at 100,000 IOPS. It distinguishes between reads and writes. The x-axis represents the response time in milliseconds, while the y-axis shows the percentage of occurrences.

**RAMPD_100 – Intensity Multiplier**

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percentage of difference (Difference) between Target and Measured.

<table>
<thead>
<tr>
<th>ASU</th>
<th>Defined</th>
<th>Measured</th>
<th>Variation</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0350</td>
<td>0.0350</td>
<td>0.0022</td>
<td>0.015%</td>
</tr>
<tr>
<td>2</td>
<td>0.2810</td>
<td>0.2811</td>
<td>0.0007</td>
<td>0.026%</td>
</tr>
<tr>
<td>3</td>
<td>0.0700</td>
<td>0.0700</td>
<td>0.0023</td>
<td>0.053%</td>
</tr>
<tr>
<td>4</td>
<td>0.2100</td>
<td>0.2100</td>
<td>0.0006</td>
<td>0.021%</td>
</tr>
<tr>
<td>1</td>
<td>0.0180</td>
<td>0.0180</td>
<td>0.0028</td>
<td>0.021%</td>
</tr>
<tr>
<td>2</td>
<td>0.0700</td>
<td>0.0700</td>
<td>0.0016</td>
<td>0.003%</td>
</tr>
<tr>
<td>3</td>
<td>0.0350</td>
<td>0.0350</td>
<td>0.0015</td>
<td>0.038%</td>
</tr>
</tbody>
</table>

**RAMPD_100 – I/O Request Summary**

<table>
<thead>
<tr>
<th>I/O Requests</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed in Measurement Interval</td>
<td>60,012,547</td>
</tr>
<tr>
<td>Completed with Response Time &lt;= 30 ms</td>
<td>60,012,424</td>
</tr>
<tr>
<td>Completed with Response Time &gt; 30 ms</td>
<td>123</td>
</tr>
</tbody>
</table>
Response Time Ramp Test

Response Time Ramp Test – Results File

The results file generated during the execution of the Response Time Ramp Test is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

Response Time Ramp Test – Phases

The Response Time Ramp Test is comprised of 11 Test Phases, including six Ramp-Down Phases (executed at 100%, 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit) and five Ramp-Up Phases (executed at 50%, 80%, 90%, 95%, and 100% of the Business Scaling Unit).

Response Time Ramp Test – Average Throughput Graph

![Average Throughput Graph (Response Time Ramp Test)](image-url)
Response Time Ramp Test – Average Response Time Graph

Response Time Ramp Test – RAMPD_10 Response Time Graph
Repeatability Test

Repeatability Test Results File

The results file generated during the execution of the Repeatability Test is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

Repeatability Test Results

The throughput measurements for the Response Time Ramp Test (RAMPD) and the Repeatability Test Phases (REPEAT_1 and REPEAT_2) are listed in the tables below.

<table>
<thead>
<tr>
<th>Test Phase</th>
<th>100% IOPS</th>
<th>10% IOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAMPD</td>
<td>100,021.8</td>
<td>9,988.3</td>
</tr>
<tr>
<td>REPEAT_1</td>
<td>100,014.4</td>
<td>10,009.8</td>
</tr>
<tr>
<td>REPEAT_2</td>
<td>99,993.0</td>
<td>9,993.7</td>
</tr>
</tbody>
</table>

REPEAT_1_100 – Throughput Graph

![Throughput Graph (REPEAT_1_100 @ 100,000 IOPS)](image)
REPEAT 1 100 – Response Time Graph

Response Time Graph (REPEAT_1_100 @ 100,000 IOPS)

- ASU1
- ASU2
- ASU3
- All ASUs

REPEAT 2 100 – Throughput Graph

Throughput Graph (REPEAT_2_100 @ 100,000 IOPS)

- ASU1
- ASU2
- ASU3
- All ASUs
**REPEAT 2_100 – Response Time Graph**

![Response Time Graph (REPEAT_2_100 @ 100,000 IOPS)](chart.png)

**Repeatability Test – Intensity Multiplier**

The following tables lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percent of difference (Difference) between Target and Measured.

### REPEAT_1_100 Test Phase

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0031</td>
<td>0.0010</td>
<td>0.0009</td>
<td>0.0005</td>
<td>0.0036</td>
<td>0.0009</td>
<td>0.0018</td>
<td>0.0008</td>
</tr>
<tr>
<td>Difference</td>
<td>0.041%</td>
<td>0.004%</td>
<td>0.030%</td>
<td>0.010%</td>
<td>0.058%</td>
<td>0.051%</td>
<td>0.068%</td>
<td>0.017%</td>
</tr>
</tbody>
</table>

### REPEAT_2_100 Test Phase

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0028</td>
<td>0.0008</td>
<td>0.0013</td>
<td>0.0005</td>
<td>0.0024</td>
<td>0.0014</td>
<td>0.0028</td>
<td>0.0006</td>
</tr>
<tr>
<td>Difference</td>
<td>0.035%</td>
<td>0.015%</td>
<td>0.054%</td>
<td>0.002%</td>
<td>0.045%</td>
<td>0.062%</td>
<td>0.041%</td>
<td>0.006%</td>
</tr>
</tbody>
</table>
Data Persistence Test

Data Persistence Test Results file

The results files generated during the execution of the Data Persistence Test is included in the Supporting Files (see Appendix A) as follows:

- SPC1_PERSIST_1_0_Raw_Results.xlsx
- SPC1_PERSIST_2_0_Raw_Results.xlsx

Data Persistence Test Execution

The Data Persistence Test was executed using the following sequence of steps:

- The PERSIST_1_0 Test Phase was executed to completion.
- The Benchmark Configuration was taken through an orderly shutdown process and powered off.
- The Benchmark Configuration was powered on and taken through an orderly startup process.
- The PERSIST_2_0 Test Phase was executed to completion.

Data Persistence Test Results

<table>
<thead>
<tr>
<th>Data Persistence Test Phase: Persist1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Logical Blocks Written</td>
<td>12,365,840</td>
</tr>
<tr>
<td>Total Number of Logical Blocks Verified</td>
<td>12,098,920</td>
</tr>
<tr>
<td>Total Number of Logical Blocks Overwritten</td>
<td>266,920</td>
</tr>
<tr>
<td>Total Number of Logical Blocks that Failed Verification</td>
<td>0</td>
</tr>
<tr>
<td>Time Duration for Writing Test Logical Blocks (sec.)</td>
<td>300</td>
</tr>
<tr>
<td>Size in bytes of each Logical Block</td>
<td>8,192</td>
</tr>
<tr>
<td>Number of Failed I/O Requests in the process of the Test</td>
<td>0</td>
</tr>
</tbody>
</table>

Committed Data Persistence Implementation

The DS4200 uses Supercapacitors and a local Compact Flash for cache protection. Each controller in the subsystem has a local Compact Flash which can be used to store and restore data in the case of an emergency shutdown during power loss. Data persists when the supercapacitors maintain power to the memory subsystem and processor to allow a fire hose dump of the data to the Compact Flash during an unexpected power loss.
APPENDIX A: SUPPORTING FILES

The following table details the content of the Supporting Files provided as part of this Full Disclosure Report.

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>/SPC1_RESULTS</td>
<td>Data reduction worksheets</td>
<td>root</td>
</tr>
<tr>
<td>SPC1_INIT_0_Raw_Results.xlsx</td>
<td>Raw results for INIT Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Quick_Look.xlsx</td>
<td>Quick Look Test Run Overview</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Raw_Results.xlsx</td>
<td>Raw results for Primary Metrics Test</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Summary_Results.xlsx</td>
<td>Primary Metrics Summary</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_PERSIST_1_0_Raw_Results.xlsx</td>
<td>Raw results for PERSIST1 Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_PERSIST_2_0_Raw_Results.xlsx</td>
<td>Raw results for PERSIST2 Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_Run_Set_Overview.xlsx</td>
<td>Run Set Overview Worksheet</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_VERIFY_0_Raw_Results.xlsx</td>
<td>Raw results for first VERIFY Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_VERIFY_1_Raw_Results.xlsx</td>
<td>Raw results for second VERIFY Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>/C_Tuning</td>
<td>Tuning parameters and options</td>
<td>root</td>
</tr>
<tr>
<td>/D_Creation</td>
<td>Storage configuration creation</td>
<td>root</td>
</tr>
<tr>
<td>DS4200_volume_map.sh</td>
<td>Create Disk Groups, Volumes and Mapping</td>
<td>/D_Creation</td>
</tr>
<tr>
<td>/E_Inventory</td>
<td>Configuration inventory</td>
<td>root</td>
</tr>
<tr>
<td>DS4200_BEFORE_LOG_0713</td>
<td>Configuration before the run</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>DS4200_AFTER_log_0713</td>
<td>Configuration after the run</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>/F_Generator</td>
<td>Workload generator</td>
<td>root</td>
</tr>
<tr>
<td>SPC1.asu</td>
<td>ASU configuration file</td>
<td>/F_generator</td>
</tr>
<tr>
<td>Basic_full_run_4200_0713.bat</td>
<td>Execute all test phases exclude PERSIST_2</td>
<td>/F_generator</td>
</tr>
</tbody>
</table>

Tuning was done using the CLI (see Appendix C)
APPENDIX B: THIRD PARTY QUOTATION

None.
APPENDIX C: TUNING PARAMETERS AND OPTIONS

The standard DS4200 Controller CLI was used to apply the necessary tuning parameters for the test.

1. You first must create a user account with the proper privileges to enable the tuning.
2. To do that, login with the manage user account and run the following command:
   ```
   create user roles diagnostic interfaces wbi,cli,ftp type diagnostic new_user
   ```
3. Once you have created the user you must login with that user account.
4. Then run the following command:

```bash
set advanced-settings random-io-performance-optimization enabled
```

![Command Output]

5. Disable disk groups background scrub command:

```bash
set advanced-settings background-scrub disabled
```
APPENDIX D: STORAGE CONFIGURATION CREATION

Storage groups and volumes are created using the following script (DS4200_volume_map.sh):

```
ssh manage@10.243.177.182 "add disk-group disks 0.0,0.1:0.2,0.3:0.4,0.5 level raid10 pool a type virtual; add disk-group disks 0.6,0.7:0.8,0.9:0.10,0.11 level raid10 pool b type virtual; create volume pool a size 510GB ASU1-A; create volume pool a size 510GB ASU2-A; create volume pool a size 114GB ASU3-A; create volume pool b size 510GB ASU1-B; create volume pool b size 510GB ASU2-B; create volume pool b size 114GB ASU3-B; map volume lun 10 ports A0 ASU1-A; map volume lun 11 ports A0 ASU2-A; map volume lun 12 ports A0 ASU3-A; map volume lun 13 ports B0 ASU1-B; map volume lun 14 ports B0 ASU2-B; map volume lun 15 ports B0 ASU3-B"
```

1. The add disk group commands are used to create 2 pools with a single disk group per pool
   - `add disk-group disks 0.0,0.1:0.2,0.3:0.4,0.5 level raid10 pool a type virtual`
   - `add disk-group disks 0.6,0.7:0.8,0.9:0.10,0.11 level raid10 pool b type virtual`
2. Each Disk group is configured with (6) 400GB SSDs in a RAID 10 layout
3. The create volume commands are used to assign (3) volumes to each of the disk groups configured in step 1
   - `create volume pool a size 510GB ASU1-A`
   - `create volume pool a size 510GB ASU2-A`
   - `create volume pool a size 114GB ASU3-A`
   - `create volume pool b size 510GB ASU1-B`
   - `create volume pool b size 510GB ASU2-B`
   - `create volume pool b size 114GB ASU3-B`
4. The volumes are then mapped to either the A0 or B0 SAS port in the final 6 commands.
   - `map volume lun 10 ports A0 ASU1-A`
   - `map volume lun 11 ports A0 ASU2-A`
   - `map volume lun 12 ports A0 ASU3-A`
   - `map volume lun 13 ports B0 ASU1-B`
   - `map volume lun 14 ports B0 ASU2-B`
   - `map volume lun 15 ports B0 ASU3-B`

The Host will see the Disks after mapping. Make the disks online and initialized.

Next, use Windows Disk Management to create the striped ASU volumes.

<table>
<thead>
<tr>
<th>&quot;Physical Disk&quot;</th>
<th>LUN #</th>
<th>ASU</th>
<th>Drive Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 4</td>
<td>10 and 13</td>
<td>ASU-1</td>
<td>I:</td>
</tr>
</tbody>
</table>
1. Start Disk Management
2. Right click on Disk 1, and select New Striped Volume...

3. Wizard pops up. Select Next
4. On New Striped Volume window, highlight Disk 4 and click on Add>
5. Disk 1 and Disk 4 in the selected area, click Next

6. Click Assign the following drive letter, select I, then Next
7. On **Format Volume** window, select **Do not format this volume**, then **Next**

8. **Completing the New Striped Volume Wizard**, click **Finish**
Completing the New Striped Volume Wizard

You have successfully completed the wizard.

You selected the following settings:
- Volume type: Striped
- Disks selected: Disk 1, Disk 4
- Volume size: 572238 MB
- Drive letter or path: \n- File system: None
- Allocation unit size: Default

To close this wizard, click Finish.

9. **Disk Management** confirmation, click Yes

10. **Microsoft Windows** asking to format disk, click Cancel
11. Repeat steps 2 – 10 for drives J: and K:

12. After all three logical volumes have been created, Disk Management will look as this:
APPENDIX E: CONFIGURATION INVENTORY
The Test Storage Configuration was collected before and after the test phases. The CLI commands were used.

# show system
# show controllers
# show versions detail
# show ports
# show disks encl
# show volumes detail
# show disk-groups

The outputs of the commands were in the log files:

/DS4200_BEFOR_0713  Before the test
/DS4200_AFTER_0713   After the test
APPENDIX F: WORKLOAD GENERATOR

The ASU Definition file is included in the Supporting Files.

**SPC1.asu**
OFFSET=0
SIZE=0
ASU=1
DEVICE=\\\i:
ASU=2
DEVICE=\\\j:
ASU=3
DEVICE=\\\k:

The full-run of the test used the script `basic_full_run_4200_0713.bat` and manually invoke the PERSIST_2 after the TSC was restarted.

**basic_full_run_4200_0713.bat**

```bash
set IOPS=100000
set INIT_IOPS=600
set PERSIST_IOPS=25000
set OUTPUT=full_run_output_S4200_0713
set STORAGE=SPC1.asu
set SPC1=spc1_v3.0.2

%SPC1% -run SPC1_INIT -output %OUTPUT% -iops %INIT_IOPS% -storage %STORAGE%
%SPC1% -run SPC1_VERIFY -output %OUTPUT% -iops 100 -storage %STORAGE%
%SPC1% -run SPC1_METRICS -output %OUTPUT% -iops %IOPS% -storage %STORAGE%
%SPC1% -run SPC1_VERIFY -output %OUTPUT% -iops 100 -storage %STORAGE%
%SPC1% -run SPC1_PERSIST_1 -output %OUTPUT% -iops %PERSIST_IOPS% -storage %STORAGE%

echo "Now Restart the TSC and run:"
echo "4200run > .\SPC1_v3.0.2 -run SPC1_PERSIST_2 -output full_run_output_S4200_0713 -iops 25000 -storage SPC1.asu"
```

Manually invoke PERSIST_2:

```
.SPCL_v3.0.2 -run SPC1_PERSIST_2 -output full_run_output_S4200_0713 -iops 25000 -storage SPC1.asu
```