SPC Benchmark 1™
Full Disclosure Report

IBM Corporation
IBM System Storage
SAN Volume Controller v6.2
with IBM Storwize® V7000 disk storage

SPC-1 V1.12

Submitted for Review: January 30, 2012
Submission Identifier: A00113

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# Table of Contents

Audit Certification...........................................................................................................viii
Audit Certification (cont.).............................................................................................ix
Letter of Good Faith ....................................................................................................x
Executive Summary.....................................................................................................11
  Test Sponsor and Contact Information.................................................................11
  Revision Information and Key Dates .....................................................................11
  Tested Storage Product (TSP) Description.............................................................11
  Summary of Results.................................................................................................12
  Storage Capacities, Relationships, and Utilization ...............................................12
  Response Time – Throughput Curve .......................................................................14
  Response Time – Throughput Data .........................................................................14
  Priced Storage Configuration Pricing ....................................................................15
  Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration..............................................................................................................15
  Priced Storage Configuration Diagram ..................................................................16
  Priced Storage Configuration Components ..........................................................17
Configuration Information .........................................................................................18
  Benchmark Configuration (BC)/Tested Storage Configuration (TSC) Diagram........18
  Storage Network Configuration ...............................................................................18
  Host System and Tested Storage Configuration (TSC) Table of Components ..........18
  Benchmark Configuration/Tested Storage Configuration Diagram ......................19
  Host Systems and Tested Storage Configuration Components ................................20
  Customer Tunable Parameters and Options ............................................................21
  Tested Storage Configuration (TSC) Description ....................................................21
  SPC-1 Workload Generator Storage Configuration ................................................21
SPC-1 Data Repository...............................................................................................22
  Storage Capacities and Relationships ..................................................................22
    SPC-1 Storage Capacities .....................................................................................22
    SPC-1 Storage Hierarchy Ratios ...........................................................................22
    SPC-1 Storage Capacities and Relationships Illustration ....................................23
  Logical Volume Capacity and ASU Mapping .........................................................23
  Storage Capacity Utilization .....................................................................................24
SPC-1 Benchmark Execution Results..........................................................................25
  SPC-1 Tests, Test Phases, and Test Runs.................................................................25
  Primary Metrics Test – Sustainability Test Phase ...................................................26
SPC-1 Workload Generator Input Parameters ................................................................. 26
Sustainability Test Results File...................................................................................... 26
Sustainability – Data Rate Distribution Data (MB/second) ........................................... 27
Sustainability – Data Rate Distribution Graph .............................................................. 27
Sustainability – I/O Request Throughput Distribution Data ......................................... 28
Sustainability – I/O Request Throughput Distribution Graph ....................................... 28
Sustainability – Average Response Time (ms) Distribution Data ............................... 29
Sustainability – Average Response Time (ms) Distribution Graph .............................. 29
Sustainability – Response Time Frequency Distribution Data ....................................... 30
Sustainability – Response Time Frequency Distribution Graph .................................... 30
Sustainability – Measured Intensity Multiplier and Coefficient of Variation ............... 31

Primary Metrics Test – IOPS Test Phase.................................................................... 32
SPC-1 Workload Generator Input Parameters ............................................................... 32
IOPS Test Results File.................................................................................................. 32
IOPS Test Run – I/O Request Throughput Distribution Data ........................................ 33
IOPS Test Run – I/O Request Throughput Distribution Graph ..................................... 33
IOPS Test Run – Average Response Time (ms) Distribution Data ............................... 34
IOPS Test Run – Average Response Time (ms) Distribution Graph ............................ 34
IOPS Test Run – Response Time Frequency Distribution Data .................................... 35
IOPS Test Run – Response Time Frequency Distribution Graph .................................. 35
IOPS Test Run – I/O Request Information .................................................................... 36
IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation ............... 36

Primary Metrics Test – Response Time Ramp Test Phase ....................................... 37
SPC-1 Workload Generator Input Parameters ............................................................... 37
Response Time Ramp Test Results File........................................................................ 37
Response Time Ramp Distribution (IOPS) Data............................................................. 38
Response Time Ramp Distribution (IOPS) Graph ........................................................ 39
SPC-1 LRT™ Average Response Time (ms) Distribution Data ..................................... 40
SPC-1 LRT™ Average Response Time (ms) Distribution Graph .................................. 40
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation ....... 41

Repeatability Test ......................................................................................................... 42
SPC-1 Workload Generator Input Parameters ............................................................... 42
Repeatability Test Results File .................................................................................... 43
Repeatability 1 LRT – I/O Request Throughput Distribution Data ............................... 44
Repeatability 1 LRT – I/O Request Throughput Distribution Graph ............................. 44
Repeatability 1 LRT – Average Response Time (ms) Distribution Data ....................... 45
Repeatability 1 LRT – Average Response Time (ms) Distribution Graph ...................... 45
Repeatability 1 IOPS – I/O Request Throughput Distribution Data ............................. 46
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph ........................... 46
SAN Volume Controller (SVC) Configuration .............................................................62
  Step 1. Define host paths ..........................................................................................62
  Step 2. Define volumes for Host System use ..........................................................63
  Step 3. Define volume mappings ............................................................................63
AIX Configuration ..........................................................................................................63
  Step 1. Discover hdisk (all Host Systems) .................................................................63
  Step 2. Define and export a striped logical volume group (one Host System only) ...63
  Step 3. Import the striped logical volume group (all Host Systems) .......................64
Referenced Scripts.........................................................................................................64
  v7000step1_mkhost.cyg ............................................................................................64
  v7000step2_dochains_separate_10disk.cyg ...............................................................65
  v7000step3_map_byswitch.cyg ..................................................................................66
  svcstep1_mkhost.cyg ...............................................................................................68
  svcstep2_mk192vd_8node_seq.cyg ...........................................................................68
  svcstep3_map_all.cyg ..............................................................................................69
  mapthem.sh .............................................................................................................69

Appendix D: SPC-1 Workload Generator Storage Commands and Parameters ..........71
  Common Command Lines – Primary Metrics and Repeatability Tests .....................71
  Primary Metrics Test ..........................................................................................73
    Sustainability .......................................................................................................73
    Ramp 100 Test Run ..............................................................................................73
    Ramp 95 Test Run ..............................................................................................73
    Ramp 90 Test Run ..............................................................................................74
    Ramp 80 Test Run ..............................................................................................74
    Ramp 50 Test Run ..............................................................................................74
    Ramp 10 Test Run ..............................................................................................74

  Repeatability Test .................................................................................................74
    Repeat1 LRT Test Run Repeat1 IOPS Test Run .....................................................74
    Repeat2 LRT Test Run Repeat2 IOS Test Run .....................................................74

  Persistence Test .....................................................................................................74
    Common Command Lines ....................................................................................74
    Persistence Test Run 1 .......................................................................................77
    Persistence Test Run 2 .......................................................................................77

Appendix E: SPC-1 Workload Generator Input Parameters .................................78
  ‘Master’ Execution Script for Primary Metrics Test, Repeatability Test, and Persistence Test Run 1 .................................................................78
Referenced Scripts .....................................................................................................79
  allhost_jvmstart.sh ..............................................................................................79
refreshslaves.sh.......................................................................................................................... 79
allhost_jvmstop.sh........................................................................................................................ 80
rm slaves.sh.................................................................................................................................... 80

Persistence Test Run 1.................................................................................................................... 80
runpersist1.sh.................................................................................................................................. 80

Persistence Test Run 2.................................................................................................................... 80
runpersist2.sh.................................................................................................................................. 80
AUDIT CERTIFICATION

Bruce McNutt
IBM Corporation
IBM ARC
650 Harry Road
San Jose, CA 95120

January 27, 2012

The SPC Benchmark 1™ Reported Data listed below for the IBM System Storage SAN Volume Controller v6.2 were produced in compliance with the SPC Benchmark 1™ v1.12 Onsite Audit requirements.

<table>
<thead>
<tr>
<th>Tested Storage Product (TSP) Name: IBM System Storage SAN Volume Controller v6.2 with IBM Storwize® V7000 disk storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric</td>
</tr>
<tr>
<td>SPC-1 IOPS™</td>
</tr>
<tr>
<td>SPC-1 Price-Performance</td>
</tr>
<tr>
<td>Total ASU Capacity</td>
</tr>
<tr>
<td>Data Protection Level</td>
</tr>
<tr>
<td>Total TSC Price (including three-year maintenance)</td>
</tr>
</tbody>
</table>

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

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by physical inspection and information supplied by IBM 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.
- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Physical verification of the components to match the above diagram.

Storage Performance Council
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Redwood City, CA 94062
AuditService@storageperformance.org
650.595.9384
AUDIT CERTIFICATION (CONT.)

- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by physical inspection and information supplied by IBM Corporation:
  - The type of Host Systems including the number of processors and main memory.
  - The presence and version number of the SPC-1 Workload Generator on each Host System.
  - The TSC boundary within each Host System.
- The execution of each Test, Test Phase, and Test Run was observed and found compliant with all of the requirements and constraints of Clauses 4, 5, and 11 of the SPC-1 Benchmark Specification.
- The Test Results Files and resultant Summary Results Files received from IBM Corporation for each of the 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 items requiring audit notes or exceptions.

Respectfully,

Walter E. Baker
SPC Auditor

Storage Performance Council
643 Bair Island Road, Suite 103
Redwood City, CA 94062
AuditService@stORAGEperformance.org
650.558.9384
December 9, 2011

Mr. Walter E. Baker, SPC Auditor
Gradesch Systems, Inc.
645 Bar Island Road, Suite 103
Redwood City, CA 94063

Subject: SPC-1 Letter of Good Faith for the IBM SAN Volume Controller Version 6.2

IBM 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 Version 1.12 of the SPC-1 benchmark specification.

Our disclosure of the Benchmark configuration and execution of the benchmark includes all items that, to the best of our knowledge and belief, materially affect the reported results, regardless of whether such items are explicitly required to be disclosed by the SPC-1 benchmark specification.

Sincerely,

Doug Balog
EXECUTIVE SUMMARY

Test Sponsor and Contact Information

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Redwood City, CA 94063  
Phone: (650) 556-9384  
FAX: (650) 556-9385 |

Revision Information and Key Dates

<table>
<thead>
<tr>
<th>Revision Information and Key Dates</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Specification revision number</td>
<td>V1.12</td>
</tr>
<tr>
<td>SPC-1 Workload Generator revision number</td>
<td>V2.2.0</td>
</tr>
<tr>
<td>Date Results were first used publicly</td>
<td>January 30, 2012</td>
</tr>
<tr>
<td>Date the FDR was submitted to the SPC</td>
<td>January 30, 2012</td>
</tr>
<tr>
<td>Date the Priced Storage Configuration is available for shipment to customers</td>
<td>currently available</td>
</tr>
<tr>
<td>Date the TSC completed audit certification</td>
<td>January 27, 2012</td>
</tr>
</tbody>
</table>

Tested Storage Product (TSP) Description

The IBM System Storage SAN Volume Controller (SVC) enables a single point of control for disparate, heterogeneous storage resources to help support improved business application availability and greater resource utilization. SAN Volume Controller is designed to pool storage volumes from IBM and non-IBM storage systems into a single reservoir of capacity for centralized management. The SPC-1 Tested Storage Configuration used SVC Version 6.2 with CG8 storage engines. Each CG8 storage engine is equipped with 24 GB of cache and four 8 Gbps fibre channel ports. The storage engine also features the optional capability, not used to produce this SPC-1 Result, to add 10 Gbps Ethernet or SSD drives managed with EasyTier.
Summary of Results

<table>
<thead>
<tr>
<th>Metric</th>
<th>Reported Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 IOPS™</td>
<td>520,043.99</td>
</tr>
<tr>
<td>SPC-1 Price-Performance™</td>
<td>$6.92/SPC-1 IOPS™</td>
</tr>
<tr>
<td>Total ASU Capacity</td>
<td>97,581.657 GB</td>
</tr>
<tr>
<td>Data Protection Level</td>
<td>Protected (Mirroring)</td>
</tr>
<tr>
<td>Total TSC Price (including three-year maintenance)</td>
<td>$3,598,956.09</td>
</tr>
</tbody>
</table>

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

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

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

Storage Capacities, Relationships, and Utilization

The following diagram and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.
### SPC-1 Storage Capacity Utilization

<table>
<thead>
<tr>
<th></th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Utilization</td>
<td>34.62%</td>
</tr>
<tr>
<td>Protected Application Utilization</td>
<td>69.23%</td>
</tr>
<tr>
<td>Unused Storage Ratio</td>
<td>28.74%</td>
</tr>
</tbody>
</table>

**Application Utilization:** Total ASU Capacity (97,581.657 GB) divided by Physical Storage Capacity (281,886.217 GB)

**Protected Application Utilization:** Total ASU Capacity (97,581.657 GB) plus total Data Protection Capacity (138,085.866 GB) minus unused Data Protection Capacity (38,979.496 GB) divided by Physical Storage Capacity (97,581.657 GB)

**Unused Storage Ratio:** Total Unused Capacity (81,008.418 GB) divided by Physical Storage Capacity (97,581.657 GB) and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 22-23 in the Full Disclosure Report.
Response Time – Throughput Curve

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

<table>
<thead>
<tr>
<th>I/O Request Throughput</th>
<th>10% Load</th>
<th>50% Load</th>
<th>80% Load</th>
<th>90% Load</th>
<th>95% Load</th>
<th>100% Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ASUs</td>
<td>1.35</td>
<td>2.71</td>
<td>4.79</td>
<td>5.69</td>
<td>6.45</td>
<td>7.39</td>
</tr>
<tr>
<td>ASU-1</td>
<td>1.81</td>
<td>3.36</td>
<td>6.75</td>
<td>6.76</td>
<td>7.52</td>
<td>8.47</td>
</tr>
<tr>
<td>ASU-2</td>
<td>1.42</td>
<td>3.76</td>
<td>6.95</td>
<td>8.27</td>
<td>9.19</td>
<td>10.32</td>
</tr>
<tr>
<td>ASU-3</td>
<td>0.35</td>
<td>0.87</td>
<td>1.79</td>
<td>2.31</td>
<td>2.98</td>
<td>3.81</td>
</tr>
<tr>
<td>Reads</td>
<td>2.91</td>
<td>5.59</td>
<td>9.52</td>
<td>11.06</td>
<td>12.02</td>
<td>13.17</td>
</tr>
<tr>
<td>Writes</td>
<td>0.33</td>
<td>0.84</td>
<td>1.71</td>
<td>2.19</td>
<td>2.83</td>
<td>3.62</td>
</tr>
</tbody>
</table>
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 present of a qualified maintenance engineer or provision of a customer replaceable part within four (4) hours of the above acknowledgement for any hardware failure that results in an inoperable Price Storage Configuration that can be remedied by the repair or replacement of a Priced Storage Configuration component.

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

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

16 FC HBAs total with 16 ports used

Eight HBAs (9117-5735) 1 port used per HBA

32 – FC HBAs (1 port used per HBA)
1 – Master Console
32 – FC HBAs
4 – Brocade switches (2498-B24)
8 – SAN Volume Controller (SVC) Nodes
16 – Storwize® V7000

Each Storwize® V7000 includes:
1 – V7000 Controller with
24 – 2.5" 146 GB 15K RPM disks
4 – V7000 Expansion Enclosures each with
24 – 2.5" 146 GB, 15K RPM disks
1,920 – 2.5" 146 GB, 15K RPM disks (total)

Notes:
All storage is managed by each node (single image).
Each switch has one zone for node-to-storage traffic, one zone for node-to-host traffic.
## Priced Storage Configuration Components

<table>
<thead>
<tr>
<th>Priced Storage Configuration:</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 – 8 Gbps dual port FC HBAs</td>
</tr>
</tbody>
</table>
| **IBM System Storage SAN Volume Controller**  
  (8 node SVC 6.2 cluster)  
  Each SVC node includes:  
  24 GB cache  
  4 – 8 Gbps FC connections  
  *(all 4 used for both node to Host System and node to V7000 connectivity)* |
| 16 – **IBM Storwize® V7000** each with 2 nodes  
  Each V7000 includes:  
  1 – V7000 Controller with  
  16 GB cache, 2 SFPs  
  24 – 2.5” 146 GB, 15K RPM disk drives  
  2 – front-end 8 Gbps FC connections *(2 used)*  
  4 – SAS backend 4x6Gbps connections *(4 used)*  
  4 – V7000 Expansion Enclosures each with  
  24 – 2.5” 146 GB, 15K RPM disk drives  
  1,920 – 2.5” 146 GB, 15K RPM disk drives *(total)*  
  4 – 24 port Fibre Channel Brocade switches  
  each with 24 ports enabled and 24 SFPs  
  1 – Master Console  
  2 – Ethernet switches  
  8 - UPS  
  5 – 19 inch racks |
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 and Tested Storage Configuration (TSC) Table of Components**

*Clause 9.4.3.4.3*

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

The Host System and TSC table of components may be found on page 20 (Host Systems and Tested Storage Configuration Components).
Notes:
- Each switch has one zone for node-to-storage traffic, one zone for node-to-host traffic.

1 – IBM Power® 770 server each with 16 FC HBAs (single image)

2 – IBM Power® 770 servers (partitioned into 4 logical Host Systems)
32 – FC HBAs (8 HBAs per server) (1 port used per HBA)
1 – Master Console
4 – Brocade switches (2498-B24 2)
8 – SAN Volume Controller (SVC) Nodes
16 – Storwize® V7000

Each Storwize® V7000 includes:
- 1 – V7000 Controller with 24 – 2.5” 146 GB 15K RPM disks
- 4 – V7000 Expansion Enclosures each with 24 – 2.5” 146 GB 15K RPM disks

1,920 – 2.5” 146 GB, 15K RPM disks (total)

SAS link (4x6 Gbps)
- Represents 2 FC paths (8 Gbps) per line (1 FC path per HBA)
- Represents 4 FC paths (8 Gbps) per line (1 FC path per Storwize® V7000)
- Represents 8 FC paths (8 Gbps) per line (1 FC path per SVC Node)

Notes:
- All storage is managed by each node (single image).
- Each switch has one zone for node-to-storage traffic, one zone for node-to-host traffic.
## Host Systems and Tested Storage Configuration Components

<table>
<thead>
<tr>
<th>Host Systems:</th>
<th>Tested Storage Configuration (TSC)</th>
</tr>
</thead>
</table>
| **2 – IBM Power® 770 servers**  
(partitioned as 4 logical Host Systems)  
each server includes  
8 – 3.3 GHz POWER7 processor modules,  
8 cores/processor module  
(64 cores total)  
256 KiB L2 cache per core  
4 MiB L3 cache per core  
256 GiB main memory  
PcIe | 32 – 8 Gbps dual port FC HBAs |
| **IBM System Storage SAN Volume Controller**  
(8 node SVC 6.2 cluster)  
Each SVC node includes:  
24 GB cache  
4 – 8 Gbps FC connections  
(all 4 used for both node to Host System  
and node to V7000 connectivity) | |
| Each of the 4 logical Host Systems includes:  
4 – 3.3 GHz POWER7 processor modules  
128 GiB main memory  
AIX 7.1  
AIX Logical Volume Manager | **16 – IBM Storwize® V7000 each with 2 nodes**  
Each V7000 includes:  
1 – V7000 Controller with  
16 GB cache, 2 SFPs  
24 – 2.5" 146 GB, 15K RPM disk drives  
2 – front-end 8 Gbps FC connections (2 used)  
4 – SAS backend 4x6Gbps connections (4 used)  
4 – V7000 Expansion Enclosures each with  
24 – 2.5" 146 GB, 15K RPM disk drives  
1,920 – 2.5" 146 GB, 15K RPM disk drives (total) | |
| **4 – 24 port Fibre Channel Brocade switches**  
each with 24 ports enabled and 24 SFPs | |
| **1 – Master Console** | |
| **2 – Ethernet switches** | |
| **8 - UPS** | |
| **5 – 19 inch racks** | |
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 61 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 62 contains the detailed information that describes how to create and configure the logical TSC.

SPC-1 Workload Generator Storage Configuration

Clause 9.4.3.5.3
The FDR must include all SPC-1 Workload Generator storage configuration commands and parameters.

The SPC-1 Workload Generator storage configuration commands and parameters for this measurement appear in “Appendix D: SPC-1 Workload Generator Storage Commands and Parameters” on page 71.
SPC-1 DATA REPOSITORY

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-1 storage capacities and mappings used in the Tested Storage Configuration. “SPC-1 Data Repository Definitions” on page 57 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

<table>
<thead>
<tr>
<th>Storage Hierarchy Component</th>
<th>Units</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total ASU Capacity</td>
<td>Gigabytes (GB)</td>
<td>97,581.657</td>
</tr>
<tr>
<td>Addressable Storage Capacity</td>
<td>Gigabytes (GB)</td>
<td>99,106.370</td>
</tr>
<tr>
<td>Configured Storage Capacity</td>
<td>Gigabytes (GB)</td>
<td>280,852.609</td>
</tr>
<tr>
<td>Physical Storage Capacity</td>
<td>Gigabytes (GB)</td>
<td>281,866.217</td>
</tr>
<tr>
<td>Data Protection (Mirroring)</td>
<td>Gigabytes (GB)</td>
<td>138,085.866</td>
</tr>
<tr>
<td>Required Storage (spares)</td>
<td>Gigabytes (GB)</td>
<td>4,680.877</td>
</tr>
<tr>
<td>Global Storage Overhead</td>
<td>Gigabytes (GB)</td>
<td>1,033.608</td>
</tr>
<tr>
<td>Total Unused Storage</td>
<td>Gigabytes (GB)</td>
<td>81,008.418</td>
</tr>
</tbody>
</table>

SPC-1 Storage Hierarchy Ratios

<table>
<thead>
<tr>
<th>Storage Hierarchy Component</th>
<th>Addressable Storage Capacity</th>
<th>Configured Storage Capacity</th>
<th>Physical Storage Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total ASU Capacity</td>
<td>98.46%</td>
<td>34.74%</td>
<td>34.62%</td>
</tr>
<tr>
<td>Required for Data Protection (Mirroring)</td>
<td>49.17%</td>
<td>48.99%</td>
<td></td>
</tr>
<tr>
<td>Addressable Storage Capacity</td>
<td>35.29%</td>
<td>35.16%</td>
<td></td>
</tr>
<tr>
<td>Required Storage (spares)</td>
<td>1.67%</td>
<td>1.66%</td>
<td></td>
</tr>
<tr>
<td>Configured Storage Capacity</td>
<td></td>
<td>99.63%</td>
<td></td>
</tr>
<tr>
<td>Global Storage Overhead</td>
<td></td>
<td>0.37%</td>
<td></td>
</tr>
<tr>
<td>Unused Storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Addressable</td>
<td>1.54%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configured</td>
<td></td>
<td>27.76%</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td></td>
<td></td>
<td>0.00%</td>
</tr>
</tbody>
</table>
The Physical Storage Capacity consisted of 281,866.217 GB distributed over 1,920 disk drives, each with a formatted capacity of 146.816 GB. There was 0.000 GB (0.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 1,033.608 GB (0.37%) of the Physical Storage Capacity. There was 77,958.992 GB (27.76%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 98.46% of the Addressable Storage Capacity resulting in 1,524.713 GB (1.54%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (Mirroring) capacity was 138,085.866 GB of which 99,106.370 GB was utilized. The total Unused Storage was 81,008.418 GB.

**SPC-1 Storage Capacities and Relationships Illustration**

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

![Storage Capacities Illustration](image-url)

**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.

<table>
<thead>
<tr>
<th>Logical Volume Capacity and Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASU-1 (43,980.465 GB)</strong></td>
</tr>
<tr>
<td>64 Logical Volumes</td>
</tr>
<tr>
<td>697.932 GB per Logical Volume</td>
</tr>
<tr>
<td>(687.195 used per Logical Volume)</td>
</tr>
<tr>
<td><strong>ASU-2 (43,980.465 GB)</strong></td>
</tr>
<tr>
<td>64 Logical Volumes</td>
</tr>
<tr>
<td>697.932 GB per Logical Volume</td>
</tr>
<tr>
<td>(687.195 used per Logical Volume)</td>
</tr>
<tr>
<td><strong>ASU-3 (9,620.727 GB)</strong></td>
</tr>
<tr>
<td>14 Logical Volumes</td>
</tr>
<tr>
<td>697.932 GB per Logical Volume</td>
</tr>
<tr>
<td>(687.195 used per Logical Volume)</td>
</tr>
</tbody>
</table>

The Data Protection Level used for all Logical Volumes was “Mirrored” as described on page 12. See “ASU Configuration” in the [IOPS Test Results File](#) for more detailed configuration information.
Storage Capacity Utilization

Clause 9.4.3.6.2
The FDR will include a table illustrating the storage capacity utilization values defined for Application Utilization (Clause 2.8.1), Protected Application Utilization (Clause 2.8.2), and Unused Storage Ratio (Clause 2.8.3).

Clause 2.8.1
Application Utilization is defined as Total ASU Capacity divided by Physical Storage Capacity.

Clause 2.8.2
Protected Application Utilization is defined as (Total ASU Capacity plus total Data Protection Capacity minus unused Data Protection Capacity) divided by Physical Storage Capacity.

Clause 2.8.3
Unused Storage Ratio is defined as Total Unused Capacity divided by Physical Storage Capacity and may not exceed 45%.

<table>
<thead>
<tr>
<th>SPC-1 Storage Capacity Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Utilization</td>
</tr>
<tr>
<td>Protected Application Utilization</td>
</tr>
<tr>
<td>Unused Storage Ratio</td>
</tr>
</tbody>
</table>
SPC-1 BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. “SPC-1 Test Execution Definitions” on page 58 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

Clause 5.4.3

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

SPC-1 Tests, Test Phases, and Test Runs

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

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

- **Repeatability Test**
  - Repeatability Test Phase 1
    - 10% of IOPS Test Run (LRT)
    - IOPS Test Run
  - Repeatability Test Phase 2
    - 10% of IOPS Test Run (LRT)
    - IOPS Test Run

- **Data Persistence Test**
  - Data Persistence Test Run 1
  - Data Persistence Test Run 2

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

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

Clause 5.4.4.1.1
The Sustainability Test Phase has exactly one Test Run and shall demonstrate the maximum sustainable I/O Request Throughput within at least a continuous three (3) hour Measurement Interval. This Test Phase also serves to insure that the TSC has reached Steady State prior to reporting the final maximum I/O Request Throughput result (SPC-1 IOPSTM).

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 IOPSTM 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-millisecond 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 78.

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 Tables

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 Data Tables

Sustainability – I/O Request Throughput Distribution Graph

[Graph showing I/O Request Throughput Distribution (Ramp_sust @10400 BSUs) with measurement intervals for All ASUs, ASU1, ASU2, and ASU3 over time in minutes.]
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 Data Tables]

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

<table>
<thead>
<tr>
<th>Response Time (ms)</th>
<th>0-0.25</th>
<th>&gt;0.25-0.5</th>
<th>&gt;0.5-0.75</th>
<th>&gt;0.75-1.0</th>
<th>&gt;1.0-1.25</th>
<th>&gt;1.25-1.5</th>
<th>&gt;1.5-1.75</th>
<th>&gt;1.75-2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td>30,426,203</td>
<td>119,117,681</td>
<td>94,105,950</td>
<td>63,255,249</td>
<td>41,398,549</td>
<td>31,076,321</td>
<td>30,371,411</td>
<td></td>
</tr>
<tr>
<td>Write</td>
<td>1,852,706</td>
<td>994,467,552</td>
<td>1,122,722,784</td>
<td>1,039,996,928</td>
<td>989,754,036</td>
<td>844,423,629</td>
<td>678,813,278</td>
<td></td>
</tr>
<tr>
<td>All ASUs</td>
<td>32,278,909</td>
<td>1,113,585,233</td>
<td>1,216,828,734</td>
<td>1,157,252,177</td>
<td>1,031,152,585</td>
<td>875,499,950</td>
<td>709,184,689</td>
<td></td>
</tr>
<tr>
<td>ASU1</td>
<td>30,008,921</td>
<td>552,409,028</td>
<td>128,765,933</td>
<td>79,111,353</td>
<td>72,757,838</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASU2</td>
<td>1,741,653</td>
<td>73,056,325</td>
<td>105,150,798</td>
<td>56,425,834</td>
<td>57,242,465</td>
<td>50,331,145</td>
<td>42,977,788</td>
<td></td>
</tr>
<tr>
<td>ASU3</td>
<td>528,335</td>
<td>105,150,798</td>
<td>163,113,539</td>
<td>216,621,523</td>
<td>258,778,087</td>
<td>281,940,886</td>
<td>576,247,421</td>
<td>499,343,984</td>
</tr>
<tr>
<td>Response Time (ms)</td>
<td>&gt;2.0-2.5</td>
<td>&gt;2.5-3.0</td>
<td>&gt;3.0-3.5</td>
<td>&gt;3.5-4.0</td>
<td>&gt;4.0-4.5</td>
<td>&gt;4.5-5.0</td>
<td>&gt;5.0-6.0</td>
<td>&gt;6.0-7.0</td>
</tr>
<tr>
<td>Read</td>
<td>73,056,325</td>
<td>261,401,495</td>
<td>229,715,262</td>
<td>815,595,942</td>
<td>459,122,049</td>
<td>321,289,314</td>
<td>207,857,848</td>
<td>571,590,514</td>
</tr>
<tr>
<td>Write</td>
<td>46,478,774</td>
<td>65,493,616</td>
<td>37,067,984</td>
<td>28,485,147</td>
<td>22,916,455</td>
<td>203,925,621</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All ASUs</td>
<td>405,581,880</td>
<td>881,089,558</td>
<td>496,190,033</td>
<td>349,774,461</td>
<td>230,574,303</td>
<td>775,516,135</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASU1</td>
<td>311,265,374</td>
<td>711,273,924</td>
<td>400,091,358</td>
<td>277,912,963</td>
<td>178,925,393</td>
<td>126,159,228</td>
<td>72,757,838</td>
<td></td>
</tr>
<tr>
<td>ASU2</td>
<td>69,689,714</td>
<td>136,925,536</td>
<td>210,529,845</td>
<td>166,168,287</td>
<td>126,159,228</td>
<td>72,757,838</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASU3</td>
<td>24,626,792</td>
<td>32,890,098</td>
<td>98,856,898</td>
<td>98,856,898</td>
<td>98,856,898</td>
<td>98,856,898</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sustainability – Response Time Frequency Distribution Graph

![Response Time Frequency Distribution Graph](image-url)
Sustainability – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

<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>IM</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>MIM</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>COV</td>
<td>0.001</td>
<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.000</td>
</tr>
</tbody>
</table>
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 IOPSTM 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).
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 78.

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

<table>
<thead>
<tr>
<th>10,400 BSUs</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Up/Ramp-Up</td>
<td>14:40:31</td>
<td>14:43:31</td>
<td>0-2</td>
<td>0:03:00</td>
</tr>
<tr>
<td>Measurement Interval</td>
<td>14:43:31</td>
<td>14:53:42</td>
<td>3-12</td>
<td>0:10:11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>60 second intervals</th>
<th>All ASUs</th>
<th>ASU1</th>
<th>ASU2</th>
<th>ASU3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>520,506.62</td>
<td>310,178.92</td>
<td>64,049.72</td>
<td>146,277.98</td>
</tr>
<tr>
<td>1</td>
<td>519,928.83</td>
<td>309,927.23</td>
<td>63,889.53</td>
<td>146,112.07</td>
</tr>
<tr>
<td>2</td>
<td>520,269.58</td>
<td>310,051.40</td>
<td>63,965.95</td>
<td>146,252.23</td>
</tr>
<tr>
<td>3</td>
<td>520,065.15</td>
<td>309,928.17</td>
<td>63,992.28</td>
<td>146,144.70</td>
</tr>
<tr>
<td>4</td>
<td>520,046.03</td>
<td>309,963.27</td>
<td>63,950.22</td>
<td>146,132.55</td>
</tr>
<tr>
<td>5</td>
<td>520,002.92</td>
<td>309,879.87</td>
<td>63,960.73</td>
<td>146,162.32</td>
</tr>
<tr>
<td>6</td>
<td>520,151.87</td>
<td>309,971.93</td>
<td>64,030.65</td>
<td>146,149.28</td>
</tr>
<tr>
<td>7</td>
<td>519,937.53</td>
<td>309,859.90</td>
<td>63,976.38</td>
<td>146,101.25</td>
</tr>
<tr>
<td>8</td>
<td>520,050.98</td>
<td>309,964.85</td>
<td>63,948.58</td>
<td>146,137.55</td>
</tr>
<tr>
<td>9</td>
<td>520,097.37</td>
<td>309,970.48</td>
<td>64,017.72</td>
<td>146,109.17</td>
</tr>
<tr>
<td>10</td>
<td>520,114.28</td>
<td>309,939.88</td>
<td>64,006.20</td>
<td>146,168.20</td>
</tr>
<tr>
<td>11</td>
<td>519,934.27</td>
<td>309,829.43</td>
<td>63,976.77</td>
<td>146,128.07</td>
</tr>
<tr>
<td>12</td>
<td>520,039.45</td>
<td>309,940.18</td>
<td>63,946.15</td>
<td>146,153.12</td>
</tr>
</tbody>
</table>

Average 520,043.99 309,924.80 63,980.57 146,138.62

IOPS Test Run – I/O Request Throughput Distribution Graph
IOPS Test Run – Average Response Time (ms) Distribution Data

<table>
<thead>
<tr>
<th>10,400 BSUs</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14:40:31</td>
<td>14:43:31</td>
<td>0-2</td>
<td>0:03:00</td>
</tr>
<tr>
<td></td>
<td>14:43:31</td>
<td>14:53:42</td>
<td>3-12</td>
<td>0:10:11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>60 second intervals</th>
<th>All ASUs</th>
<th>ASU1</th>
<th>ASU2</th>
<th>ASU3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7.80</td>
<td>8.25</td>
<td>9.15</td>
<td>6.24</td>
</tr>
<tr>
<td>1</td>
<td>7.36</td>
<td>8.35</td>
<td>10.12</td>
<td>4.05</td>
</tr>
<tr>
<td>2</td>
<td>7.20</td>
<td>8.30</td>
<td>10.16</td>
<td>3.58</td>
</tr>
<tr>
<td>3</td>
<td>6.95</td>
<td>8.04</td>
<td>9.88</td>
<td>3.33</td>
</tr>
<tr>
<td>4</td>
<td>7.88</td>
<td>8.89</td>
<td>10.69</td>
<td>4.53</td>
</tr>
<tr>
<td>5</td>
<td>8.17</td>
<td>9.18</td>
<td>11.06</td>
<td>4.77</td>
</tr>
<tr>
<td>6</td>
<td>7.04</td>
<td>8.14</td>
<td>10.00</td>
<td>3.41</td>
</tr>
<tr>
<td>7</td>
<td>7.85</td>
<td>8.90</td>
<td>10.77</td>
<td>4.35</td>
</tr>
<tr>
<td>8</td>
<td>7.33</td>
<td>8.38</td>
<td>10.18</td>
<td>3.83</td>
</tr>
<tr>
<td>9</td>
<td>7.10</td>
<td>8.21</td>
<td>10.06</td>
<td>3.46</td>
</tr>
<tr>
<td>10</td>
<td>6.98</td>
<td>8.14</td>
<td>10.04</td>
<td>3.19</td>
</tr>
<tr>
<td>11</td>
<td>7.25</td>
<td>8.36</td>
<td>10.23</td>
<td>3.59</td>
</tr>
<tr>
<td>12</td>
<td>7.30</td>
<td>8.41</td>
<td>10.26</td>
<td>3.65</td>
</tr>
</tbody>
</table>

Average | 7.39 | 8.47 | 10.32 | 3.81 |

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

![Average Response Time Distribution Graph](image)
### IOPS Test Run – Response Time Frequency Distribution Data

<table>
<thead>
<tr>
<th>Response Time (ms)</th>
<th>0-0.25</th>
<th>&gt;0.25-0.5</th>
<th>&gt;0.5-0.75</th>
<th>&gt;0.75-1.0</th>
<th>&gt;1.0-1.25</th>
<th>&gt;1.25-1.5</th>
<th>&gt;1.5-1.75</th>
<th>&gt;1.75-2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td>690,699</td>
<td>2,215,761</td>
<td>2,449,629</td>
<td>1,964,354</td>
<td>1,383,574</td>
<td>924,060</td>
<td>686,169</td>
<td>647,522</td>
</tr>
<tr>
<td>Write</td>
<td>63,403</td>
<td>13,545,732</td>
<td>16,510,738</td>
<td>16,999,438</td>
<td>18,012,796</td>
<td>18,911,149</td>
<td>18,449,700</td>
<td>17,123,652</td>
</tr>
<tr>
<td>All ASUs</td>
<td>754,102</td>
<td>15,761,493</td>
<td>18,960,367</td>
<td>18,963,792</td>
<td>19,396,370</td>
<td>19,835,209</td>
<td>19,135,869</td>
<td>17,232,767</td>
</tr>
<tr>
<td>ASU1</td>
<td>697,688</td>
<td>8,541,956</td>
<td>9,442,101</td>
<td>9,294,372</td>
<td>9,230,096</td>
<td>9,221,059</td>
<td>8,734,589</td>
<td>7,735,730</td>
</tr>
<tr>
<td>ASU2</td>
<td>38,301</td>
<td>1,651,387</td>
<td>2,009,594</td>
<td>2,078,228</td>
<td>2,113,849</td>
<td>2,130,877</td>
<td>2,012,647</td>
<td>1,755,155</td>
</tr>
<tr>
<td>ASU3</td>
<td>18,113</td>
<td>5,568,150</td>
<td>7,508,672</td>
<td>7,591,192</td>
<td>8,052,425</td>
<td>8,483,273</td>
<td>8,388,633</td>
<td>7,632,767</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Response Time (ms)</th>
<th>&gt;2.0-2.5</th>
<th>&gt;2.5-3.0</th>
<th>&gt;3.0-3.5</th>
<th>&gt;3.5-4.0</th>
<th>&gt;4.0-4.5</th>
<th>&gt;4.5-5.0</th>
<th>&gt;5.0-6.0</th>
<th>&gt;6.0-7.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td>1,530,836</td>
<td>2,187,364</td>
<td>3,377,309</td>
<td>4,523,322</td>
<td>5,403,805</td>
<td>5,875,650</td>
<td>11,993,749</td>
<td>10,344,604</td>
</tr>
<tr>
<td>Write</td>
<td>24,339,254</td>
<td>14,022,936</td>
<td>7,968,138</td>
<td>4,874,203</td>
<td>3,335,731</td>
<td>2,493,744</td>
<td>3,162,734</td>
<td>1,650,150</td>
</tr>
<tr>
<td>All ASUs</td>
<td>25,870,190</td>
<td>16,210,300</td>
<td>11,345,447</td>
<td>9,397,525</td>
<td>8,739,394</td>
<td>8,156,483</td>
<td>11,994,754</td>
<td>9,427,569</td>
</tr>
<tr>
<td>ASU1</td>
<td>11,688,369</td>
<td>7,727,612</td>
<td>6,317,085</td>
<td>6,054,658</td>
<td>6,116,519</td>
<td>6,150,961</td>
<td>9,427,569</td>
<td>7,735,730</td>
</tr>
<tr>
<td>ASU2</td>
<td>2,534,497</td>
<td>1,476,122</td>
<td>966,621</td>
<td>872,949</td>
<td>967,439</td>
<td>1,008,098</td>
<td>1,950,218</td>
<td>1,755,155</td>
</tr>
<tr>
<td>ASU3</td>
<td>11,647,324</td>
<td>7,006,566</td>
<td>4,061,741</td>
<td>2,469,918</td>
<td>1,655,787</td>
<td>1,516,104</td>
<td>812,960</td>
<td>647,522</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Response Time (ms)</th>
<th>&gt;7.0-8.0</th>
<th>&gt;8.0-9.0</th>
<th>&gt;9.0-10.0</th>
<th>&gt;10.0-15.0</th>
<th>&gt;15.0-20.0</th>
<th>&gt;20.0-25.0</th>
<th>&gt;25.0-30.0</th>
<th>&gt;30.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td>7,395,077</td>
<td>5,394,078</td>
<td>4,784,301</td>
<td>17,246,559</td>
<td>9,420,167</td>
<td>6,686,566</td>
<td>4,245,883</td>
<td>11,692,112</td>
</tr>
<tr>
<td>Write</td>
<td>972,484</td>
<td>597,671</td>
<td>417,631</td>
<td>1,160,089</td>
<td>639,363</td>
<td>458,492</td>
<td>371,989</td>
<td>3,525,701</td>
</tr>
<tr>
<td>All ASUs</td>
<td>8,367,561</td>
<td>5,991,749</td>
<td>5,201,932</td>
<td>18,406,648</td>
<td>10,059,530</td>
<td>7,145,058</td>
<td>4,617,872</td>
<td>15,217,813</td>
</tr>
<tr>
<td>ASU1</td>
<td>6,417,752</td>
<td>4,741,756</td>
<td>4,196,748</td>
<td>14,903,708</td>
<td>8,148,167</td>
<td>5,711,734</td>
<td>3,611,067</td>
<td>10,150,804</td>
</tr>
<tr>
<td>ASU2</td>
<td>1,434,353</td>
<td>906,515</td>
<td>765,877</td>
<td>2,905,371</td>
<td>1,621,027</td>
<td>840,952</td>
<td>3,364,983</td>
<td>1,702,026</td>
</tr>
<tr>
<td>ASU3</td>
<td>515,456</td>
<td>343,478</td>
<td>239,307</td>
<td>597,569</td>
<td>290,316</td>
<td>165,853</td>
<td>809,526</td>
<td>3,525,701</td>
</tr>
</tbody>
</table>

### IOPS Test Run – Response Time Frequency Distribution Graph

![Response Time Frequency Distribution Graph](image-url)
### IOPS Test Run – I/O Request Information

<table>
<thead>
<tr>
<th></th>
<th>I/O Requests Completed in the Measurement Interval</th>
<th>I/O Requests Completed with Response Time = or &lt; 30 ms</th>
<th>I/O Requests Completed with Response Time &gt; 30 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>312,022,646</td>
<td>296,804,833</td>
<td>15,217,813</td>
</tr>
</tbody>
</table>

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

**Clause 3.4.3**

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

**Clauses 5.1.10 and 5.3.13.2**

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

**Clause 5.3.13.3**

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

<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>IM</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>MIM</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>COV</td>
<td>0.001</td>
<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.000</td>
</tr>
</tbody>
</table>
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 IOPSTM 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 78.

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 IOPSTM primary metric. The 100% BSU load level is included in the following Response Time Ramp data tables and graphs for completeness.

### 100% Load Level - 1,400 BSUs

<table>
<thead>
<tr>
<th>Start-Up/Ramp-Up</th>
<th>Stop Stop</th>
<th>Interval</th>
<th>Duration</th>
<th>Start-Up/Ramp-Up</th>
<th>Stop Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ASUs</td>
<td>14:40:31</td>
<td>14:43:31</td>
<td>0:2</td>
<td>0:03:00</td>
<td>All ASUs</td>
<td>15:09:02</td>
<td>15:12:02</td>
</tr>
<tr>
<td>ASU-1</td>
<td>14:40:31</td>
<td>14:43:31</td>
<td>0:2</td>
<td>0:03:00</td>
<td>ASU-1</td>
<td>15:09:02</td>
<td>15:12:02</td>
</tr>
<tr>
<td>ASU-2</td>
<td>14:40:31</td>
<td>14:43:31</td>
<td>0:2</td>
<td>0:03:00</td>
<td>ASU-2</td>
<td>15:09:02</td>
<td>15:12:02</td>
</tr>
<tr>
<td>ASU-3</td>
<td>14:40:31</td>
<td>14:43:31</td>
<td>0:2</td>
<td>0:03:00</td>
<td>ASU-3</td>
<td>15:09:02</td>
<td>15:12:02</td>
</tr>
</tbody>
</table>

### 90% Load Level - 9,880 BSUs

<table>
<thead>
<tr>
<th>Start-Up/Ramp-Up</th>
<th>Stop Stop</th>
<th>Interval</th>
<th>Duration</th>
<th>Start-Up/Ramp-Up</th>
<th>Stop Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ASUs</td>
<td>15:37:07</td>
<td>15:40:07</td>
<td>0:2</td>
<td>0:03:00</td>
<td>All ASUs</td>
<td>16:04:22</td>
<td>16:07:22</td>
</tr>
<tr>
<td>ASU-1</td>
<td>15:37:07</td>
<td>15:40:07</td>
<td>0:2</td>
<td>0:03:00</td>
<td>ASU-1</td>
<td>16:04:22</td>
<td>16:07:22</td>
</tr>
<tr>
<td>ASU-2</td>
<td>15:37:07</td>
<td>15:40:07</td>
<td>0:2</td>
<td>0:03:00</td>
<td>ASU-2</td>
<td>16:04:22</td>
<td>16:07:22</td>
</tr>
<tr>
<td>ASU-3</td>
<td>15:37:07</td>
<td>15:40:07</td>
<td>0:2</td>
<td>0:03:00</td>
<td>ASU-3</td>
<td>16:04:22</td>
<td>16:07:22</td>
</tr>
</tbody>
</table>

### 90% Load Level - 5,360 BSUs

### 90% Load Level - 3,200 BSUs

### 90% Load Level - 1,600 BSUs

### 90% Load Level - 800 BSUs

### 90% Load Level - 50 BSUs

### 90% Load Level - 20 BSUs

### 90% Load Level - 10 BSUs

### 90% Load Level - 5 BSUs

### 90% Load Level - 2.5 BSUs

### 90% Load Level - 1 BSU
Response Time Ramp Distribution (IOPS) Graph
SPC-1 LRT™ Average Response Time (ms) Distribution Data

<table>
<thead>
<tr>
<th>1,040 BSUs</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Up/Ramp-Up Measurement Interval</td>
<td>16:52:03</td>
<td>16:55:03</td>
<td>0-2</td>
<td>0:03:00</td>
</tr>
<tr>
<td>60 second intervals</td>
<td>All ASUs</td>
<td>ASU1</td>
<td>ASU2</td>
<td>ASU3</td>
</tr>
<tr>
<td>0</td>
<td>2.50</td>
<td>2.99</td>
<td>2.67</td>
<td>1.38</td>
</tr>
<tr>
<td>1</td>
<td>1.35</td>
<td>1.80</td>
<td>1.42</td>
<td>0.34</td>
</tr>
<tr>
<td>2</td>
<td>1.35</td>
<td>1.81</td>
<td>1.42</td>
<td>0.35</td>
</tr>
<tr>
<td>3</td>
<td>1.37</td>
<td>1.83</td>
<td>1.43</td>
<td>0.35</td>
</tr>
<tr>
<td>4</td>
<td>1.37</td>
<td>1.82</td>
<td>1.45</td>
<td>0.38</td>
</tr>
<tr>
<td>5</td>
<td>1.37</td>
<td>1.83</td>
<td>1.43</td>
<td>0.38</td>
</tr>
<tr>
<td>6</td>
<td>1.35</td>
<td>1.81</td>
<td>1.43</td>
<td>0.35</td>
</tr>
<tr>
<td>7</td>
<td>1.34</td>
<td>1.80</td>
<td>1.41</td>
<td>0.33</td>
</tr>
<tr>
<td>8</td>
<td>1.34</td>
<td>1.81</td>
<td>1.40</td>
<td>0.33</td>
</tr>
<tr>
<td>9</td>
<td>1.33</td>
<td>1.78</td>
<td>1.39</td>
<td>0.33</td>
</tr>
<tr>
<td>10</td>
<td>1.33</td>
<td>1.79</td>
<td>1.41</td>
<td>0.33</td>
</tr>
<tr>
<td>11</td>
<td>1.33</td>
<td>1.79</td>
<td>1.41</td>
<td>0.33</td>
</tr>
<tr>
<td>12</td>
<td>1.34</td>
<td>1.80</td>
<td>1.40</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>1.35</strong></td>
<td><strong>1.81</strong></td>
<td><strong>1.42</strong></td>
<td><strong>0.35</strong></td>
</tr>
</tbody>
</table>

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

Average Response Time Distribution (Ramp_10 @1040 BSUs)
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

<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>IM</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>MIM</td>
<td>0.0349</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0699</td>
<td>0.0350</td>
<td>0.2811</td>
</tr>
<tr>
<td>COV</td>
<td>0.004</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.005</td>
<td>0.002</td>
<td>0.003</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Repeatability Test

Clause 5.4.5
The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPSTM primary metric and the SPC-1 LRTSTM 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 LRTSTM metric. Each Average Response Time value must be less than the SPC-1 LRTSTM metric plus 5% or less than the SPC-1 LRTSTM 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 IOPSTM primary metric. Each I/O Request Throughput value must be greater than the SPC-1 IOPSTM 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 78.
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.

<table>
<thead>
<tr>
<th></th>
<th>SPC-1 IOPS™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Metrics</td>
<td>520,043.99</td>
</tr>
<tr>
<td>Repeatability Test Phase 1</td>
<td>519,975.34</td>
</tr>
<tr>
<td>Repeatability Test Phase 2</td>
<td>520,045.87</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th></th>
<th>SPC-1 LRT™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Metrics</td>
<td>1.35 ms</td>
</tr>
<tr>
<td>Repeatability Test Phase 1</td>
<td>1.34 ms</td>
</tr>
<tr>
<td>Repeatability Test Phase 2</td>
<td>1.34 ms</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>1,040 BSUs</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start-Up/Ramp-Up</td>
<td>Measurement Interval</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17:14:33</td>
<td>17:17:33</td>
<td>0-2</td>
<td>0:03:00</td>
</tr>
<tr>
<td></td>
<td>17:17:33</td>
<td>17:27:40</td>
<td>3-12</td>
<td>0:10:07</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>60 second intervals</th>
<th>All ASUs</th>
<th>ASU1</th>
<th>ASU2</th>
<th>ASU3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>52,027.92</td>
<td>30,987.62</td>
<td>6,399.77</td>
<td>14,640.53</td>
</tr>
<tr>
<td>1</td>
<td>52,014.18</td>
<td>31,024.33</td>
<td>6,389.52</td>
<td>14,600.33</td>
</tr>
<tr>
<td>2</td>
<td>52,010.37</td>
<td>30,995.95</td>
<td>6,414.27</td>
<td>14,600.15</td>
</tr>
<tr>
<td>3</td>
<td>51,992.25</td>
<td>30,981.48</td>
<td>6,400.83</td>
<td>14,609.93</td>
</tr>
<tr>
<td>4</td>
<td>52,015.28</td>
<td>31,002.88</td>
<td>6,391.67</td>
<td>14,620.73</td>
</tr>
<tr>
<td>5</td>
<td>52,033.82</td>
<td>31,001.82</td>
<td>6,412.65</td>
<td>14,619.35</td>
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<tr>
<td>6</td>
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<td>30,981.98</td>
<td>6,405.65</td>
<td>14,626.12</td>
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<tr>
<td>7</td>
<td>52,001.98</td>
<td>31,017.13</td>
<td>6,391.95</td>
<td>14,592.90</td>
</tr>
<tr>
<td>8</td>
<td>52,017.05</td>
<td>31,012.82</td>
<td>6,391.82</td>
<td>14,612.42</td>
</tr>
<tr>
<td>9</td>
<td>52,002.20</td>
<td>30,980.48</td>
<td>6,394.13</td>
<td>14,627.58</td>
</tr>
<tr>
<td>10</td>
<td>51,937.58</td>
<td>30,965.65</td>
<td>6,385.03</td>
<td>14,586.90</td>
</tr>
<tr>
<td>11</td>
<td>51,996.17</td>
<td>30,976.40</td>
<td>6,366.72</td>
<td>14,633.05</td>
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<tr>
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<td>52,008.77</td>
<td>30,966.73</td>
<td>6,414.45</td>
<td>14,627.58</td>
</tr>
</tbody>
</table>

Average: 52,001.89 ASU1, 30,988.74 ASU2, 6,397.49 ASU3, 14,615.66

Repeatability 1 LRT – I/O Request Throughput Distribution Graph

---

IBM Corporation

Submitted for Review: JANUARY 30, 2012

IBM System Storage SAN Volume Controller v6.2 with IBM Storwize® V7000 disk storage
### Repeatability 1 LRT –Average Response Time (ms) Distribution Data

<table>
<thead>
<tr>
<th>1,040 BSUs</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17:14:33</td>
<td>17:17:33</td>
<td>0-2</td>
<td>0:03:00</td>
</tr>
</tbody>
</table>

#### Start-Up/Ramp-Up Measurement Interval

<table>
<thead>
<tr>
<th>60 second intervals</th>
<th>All ASUs</th>
<th>ASU1</th>
<th>ASU2</th>
<th>ASU3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.34</td>
<td>2.82</td>
<td>2.47</td>
<td>1.27</td>
</tr>
<tr>
<td>1</td>
<td>1.33</td>
<td>1.78</td>
<td>1.41</td>
<td>0.33</td>
</tr>
<tr>
<td>2</td>
<td>1.33</td>
<td>1.79</td>
<td>1.39</td>
<td>0.33</td>
</tr>
<tr>
<td>3</td>
<td>1.34</td>
<td>1.80</td>
<td>1.41</td>
<td>0.34</td>
</tr>
<tr>
<td>4</td>
<td>1.33</td>
<td>1.78</td>
<td>1.40</td>
<td>0.34</td>
</tr>
<tr>
<td>5</td>
<td>1.33</td>
<td>1.79</td>
<td>1.40</td>
<td>0.33</td>
</tr>
<tr>
<td>6</td>
<td>1.34</td>
<td>1.80</td>
<td>1.41</td>
<td>0.33</td>
</tr>
<tr>
<td>7</td>
<td>1.34</td>
<td>1.80</td>
<td>1.41</td>
<td>0.32</td>
</tr>
<tr>
<td>8</td>
<td>1.34</td>
<td>1.80</td>
<td>1.41</td>
<td>0.34</td>
</tr>
<tr>
<td>9</td>
<td>1.33</td>
<td>1.78</td>
<td>1.40</td>
<td>0.33</td>
</tr>
<tr>
<td>10</td>
<td>1.33</td>
<td>1.79</td>
<td>1.40</td>
<td>0.34</td>
</tr>
<tr>
<td>11</td>
<td>1.35</td>
<td>1.81</td>
<td>1.41</td>
<td>0.34</td>
</tr>
<tr>
<td>12</td>
<td>1.34</td>
<td>1.80</td>
<td>1.41</td>
<td>0.34</td>
</tr>
</tbody>
</table>

#### Average

- **All ASUs**: 1.34 ms
- **ASU1**: 1.79 ms
- **ASU2**: 1.41 ms
- **ASU3**: 0.33 ms

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

![Average Response Time Distribution (Repeat1_lrt @1040 BSUs)](image-url)
Repeatability 1 IOPS – I/O Request Throughput Distribution Data

<table>
<thead>
<tr>
<th>10,400 BSUs</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Up/Ramp-Up</td>
<td>17:40:49</td>
<td>17:43:50</td>
<td>0-2</td>
<td>0:03:01</td>
</tr>
<tr>
<td>Measurement Interval</td>
<td>17:43:50</td>
<td>17:54:00</td>
<td>3-12</td>
<td>0:10:10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>60 second intervals</th>
<th>All ASUs</th>
<th>ASU1</th>
<th>ASU2</th>
<th>ASU3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>520,316.07</td>
<td>310,041.42</td>
<td>64,030.20</td>
<td>146,244.45</td>
</tr>
<tr>
<td>1</td>
<td>520,036.77</td>
<td>309,886.80</td>
<td>63,995.13</td>
<td>146,154.83</td>
</tr>
<tr>
<td>2</td>
<td>519,989.60</td>
<td>309,927.85</td>
<td>63,959.27</td>
<td>146,102.48</td>
</tr>
<tr>
<td>3</td>
<td>519,932.32</td>
<td>309,837.25</td>
<td>63,896.70</td>
<td>146,198.37</td>
</tr>
<tr>
<td>4</td>
<td>519,811.60</td>
<td>309,661.80</td>
<td>63,913.05</td>
<td>146,036.75</td>
</tr>
<tr>
<td>5</td>
<td>520,119.48</td>
<td>309,976.00</td>
<td>63,959.10</td>
<td>146,184.38</td>
</tr>
<tr>
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<td>519,979.90</td>
<td>310,024.07</td>
<td>63,901.18</td>
<td>146,054.65</td>
</tr>
<tr>
<td>7</td>
<td>520,046.82</td>
<td>309,943.90</td>
<td>63,924.45</td>
<td>146,178.47</td>
</tr>
<tr>
<td>8</td>
<td>520,044.78</td>
<td>309,975.18</td>
<td>63,927.52</td>
<td>146,142.08</td>
</tr>
<tr>
<td>9</td>
<td>520,140.22</td>
<td>309,950.92</td>
<td>64,020.35</td>
<td>146,168.95</td>
</tr>
<tr>
<td>10</td>
<td>519,918.15</td>
<td>309,851.33</td>
<td>63,997.32</td>
<td>146,069.50</td>
</tr>
<tr>
<td>11</td>
<td>519,698.93</td>
<td>309,732.20</td>
<td>63,920.83</td>
<td>146,045.90</td>
</tr>
<tr>
<td>12</td>
<td>520,061.17</td>
<td>310,026.10</td>
<td>63,906.52</td>
<td>146,128.55</td>
</tr>
</tbody>
</table>

Average | 519,975.34 | 309,917.88 | 63,936.70 | 146,120.76 |

Repeatability 1 IOPS – I/O Request Throughput Distribution Graph
Repeatable Test

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

<table>
<thead>
<tr>
<th>10,400 BSUs</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Up/Ramp-Up</td>
<td>17:40:49</td>
<td>17:43:50</td>
<td>0-2</td>
<td>0:03:01</td>
</tr>
<tr>
<td>Measurement Interval</td>
<td>17:43:50</td>
<td>17:54:00</td>
<td>3-12</td>
<td>0:10:10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>60 second intervals</th>
<th>All ASUs</th>
<th>ASU1</th>
<th>ASU2</th>
<th>ASU3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8.40</td>
<td>8.76</td>
<td>9.55</td>
<td>7.14</td>
</tr>
<tr>
<td>1</td>
<td>7.52</td>
<td>8.56</td>
<td>10.34</td>
<td>4.09</td>
</tr>
<tr>
<td>2</td>
<td>7.18</td>
<td>8.25</td>
<td>10.06</td>
<td>3.65</td>
</tr>
<tr>
<td>3</td>
<td>7.44</td>
<td>8.49</td>
<td>10.36</td>
<td>3.94</td>
</tr>
<tr>
<td>4</td>
<td>7.95</td>
<td>9.01</td>
<td>10.85</td>
<td>4.45</td>
</tr>
<tr>
<td>5</td>
<td>7.76</td>
<td>8.76</td>
<td>10.60</td>
<td>4.38</td>
</tr>
<tr>
<td>6</td>
<td>6.98</td>
<td>8.10</td>
<td>9.95</td>
<td>3.32</td>
</tr>
<tr>
<td>7</td>
<td>8.06</td>
<td>9.07</td>
<td>10.88</td>
<td>4.68</td>
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<tr>
<td>8</td>
<td>7.44</td>
<td>8.52</td>
<td>10.40</td>
<td>3.87</td>
</tr>
<tr>
<td>9</td>
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<td>8.16</td>
<td>10.03</td>
<td>3.47</td>
</tr>
<tr>
<td>10</td>
<td>7.29</td>
<td>8.35</td>
<td>10.20</td>
<td>3.77</td>
</tr>
<tr>
<td>11</td>
<td>6.74</td>
<td>7.86</td>
<td>9.74</td>
<td>3.07</td>
</tr>
<tr>
<td>12</td>
<td>7.02</td>
<td>8.08</td>
<td>9.90</td>
<td>3.53</td>
</tr>
</tbody>
</table>

**Average** | **7.38** | **8.44** | **10.29** | **3.85**

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

Average Response Time Distribution (Repeat1_iops @10400 BSUs)

---

IBM Corporation

Submitted for Review: JANUARY 30, 2012

IBM System Storage SAN Volume Controller v6.2 with IBM Storwize® V7000 disk storage
Repeatability 2 LRT – I/O Request Throughput Distribution Data

1,040 BSUs

<table>
<thead>
<tr>
<th>Start-Up/Ramp-Up Measurement Interval</th>
<th>All ASUs</th>
<th>ASU1</th>
<th>ASU2</th>
<th>ASU3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Up/Ramp-Up</td>
<td>Start</td>
<td>Stop</td>
<td>Interval</td>
<td>Duration</td>
</tr>
<tr>
<td>18:03:26</td>
<td>18:06:26</td>
<td>0-2</td>
<td>0:03:00</td>
<td></td>
</tr>
<tr>
<td>18:06:26</td>
<td>18:16:32</td>
<td>3-12</td>
<td>0:10:06</td>
<td></td>
</tr>
</tbody>
</table>

60 second intervals

| 0 | 52,031.58 | 31,031.88 | 6,402.07 | 14,597.63 |
| 1 | 51,999.17 | 30,984.95 | 6,395.90 | 14,618.32 |
| 2 | 52,024.15 | 31,011.08 | 6,412.50 | 14,600.57 |
| 3 | 52,011.93 | 30,981.42 | 6,394.05 | 14,636.47 |
| 4 | 51,981.98 | 30,979.65 | 6,401.18 | 14,601.15 |
| 5 | 51,999.35 | 30,984.48 | 6,396.38 | 14,618.48 |
| 6 | 52,008.20 | 30,976.22 | 6,408.20 | 14,623.78 |
| 7 | 52,013.28 | 30,999.77 | 6,404.25 | 14,609.27 |
| 8 | 51,993.48 | 30,996.90 | 6,382.63 | 14,613.95 |
| 9 | 52,024.38 | 31,013.22 | 6,410.87 | 14,600.30 |
| 10| 52,010.30 | 30,989.72 | 6,401.18 | 14,619.40 |
| 11| 51,981.83 | 30,968.98 | 6,385.23 | 14,627.62 |
| 12| 52,036.10 | 31,030.72 | 6,399.53 | 14,605.85 |

Average | 52,006.09 | 30,992.11 | 6,398.35 | 14,615.63 |

Repeatability 2 LRT – I/O Request Throughput Distribution Graph

I/O Request Throughput Distribution (Repeat2_lrt @1040 BSUs)

SPC Benchmark 1™ V1.12  FULL DISCLOSURE REPORT  Submission Identifier: A00113
IBM Corporation  Submitted for Review: JANUARY 30, 2012
IBM System Storage SAN Volume Controller v6.2 with IBM Storwize® V7000 disk storage
Repeatability 2 LRT –Average Response Time (ms) Distribution Data

<table>
<thead>
<tr>
<th>1,040 BSUs</th>
<th>Start-Up/Ramp-Up Measurement Interval</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>18:03:26</td>
<td>18:06:26</td>
<td>0-2</td>
<td>0:03:00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18:06:26</td>
<td>18:16:32</td>
<td>3-12</td>
<td>0:10:06</td>
</tr>
<tr>
<td>60 second intervals</td>
<td>All ASUs</td>
<td>ASU1</td>
<td>ASU2</td>
<td>ASU3</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>2.30</td>
<td>2.79</td>
<td>2.44</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.34</td>
<td>1.80</td>
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<td>1.42</td>
<td>0.35</td>
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<td>4</td>
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<tr>
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<td>1.41</td>
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<tr>
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<tr>
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<tr>
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<td>1.79</td>
<td>1.42</td>
<td>0.34</td>
<td></td>
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<tr>
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<td>1.33</td>
<td>1.80</td>
<td>1.41</td>
<td>0.32</td>
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<tr>
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<td>1.34</td>
<td>1.80</td>
<td>1.42</td>
<td>0.33</td>
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<tr>
<td>12</td>
<td>1.34</td>
<td>1.80</td>
<td>1.40</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>1.34</td>
<td>1.80</td>
<td>1.41</td>
<td>0.33</td>
<td></td>
</tr>
</tbody>
</table>

Repeatability 2 LRT –Average Response Time (ms) Distribution Graph
# Repeatability 2 IOPS – I/O Request Throughput Distribution Data

<table>
<thead>
<tr>
<th>10,400 BSUs</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Up/Ramp-Up Measurement Interval</td>
<td>15:29:45</td>
<td>15:32:45</td>
<td>0-2</td>
<td>0:03:01</td>
</tr>
<tr>
<td>60 second intervals</td>
<td>All ASUs</td>
<td>ASU1</td>
<td>ASU2</td>
<td>ASU3</td>
</tr>
<tr>
<td>0</td>
<td>520,379.80</td>
<td>310,223.02</td>
<td>64,014.22</td>
<td>146,142.57</td>
</tr>
<tr>
<td>1</td>
<td>520,070.32</td>
<td>310,028.38</td>
<td>63,939.98</td>
<td>146,101.95</td>
</tr>
<tr>
<td>2</td>
<td>519,935.78</td>
<td>309,955.58</td>
<td>63,857.57</td>
<td>146,125.63</td>
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<tr>
<td>3</td>
<td>520,104.40</td>
<td>309,926.43</td>
<td>63,949.58</td>
<td>146,228.38</td>
</tr>
<tr>
<td>4</td>
<td>520,034.45</td>
<td>309,952.03</td>
<td>63,953.02</td>
<td>146,129.40</td>
</tr>
<tr>
<td>5</td>
<td>520,048.35</td>
<td>310,068.53</td>
<td>63,915.15</td>
<td>146,064.67</td>
</tr>
<tr>
<td>6</td>
<td>520,114.58</td>
<td>310,014.58</td>
<td>63,964.65</td>
<td>146,135.35</td>
</tr>
<tr>
<td>7</td>
<td>519,941.55</td>
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<td>63,921.45</td>
<td>146,049.32</td>
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<tr>
<td>8</td>
<td>519,892.53</td>
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<td>146,101.35</td>
</tr>
<tr>
<td>9</td>
<td>520,123.60</td>
<td>309,998.37</td>
<td>63,931.70</td>
<td>146,193.53</td>
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<tr>
<td>10</td>
<td>519,935.17</td>
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<td>63,880.70</td>
<td>146,080.75</td>
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<tr>
<td>11</td>
<td>519,998.55</td>
<td>309,963.33</td>
<td>63,905.52</td>
<td>146,129.70</td>
</tr>
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<td>520,265.48</td>
<td>310,030.23</td>
<td>64,008.70</td>
<td>146,226.55</td>
</tr>
</tbody>
</table>

**Average** | 520,045.87 | 309,976.04 | 63,935.93 | 146,133.90 |

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

![I/O Request Throughput Distribution Graph](image-url)
## Repeatability 2 IOPS –Average Response Time (ms) Distribution Data

<table>
<thead>
<tr>
<th>10,400 BSUs</th>
<th>Start</th>
<th>Stop</th>
<th>Interval</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Up/Ramp-Up Measurement Interval</td>
<td>18:29:44</td>
<td>18:32:45</td>
<td>0-2</td>
<td>0:03:01</td>
</tr>
<tr>
<td>60 second intervals</td>
<td>All ASUs</td>
<td>ASU1</td>
<td>ASU2</td>
<td>ASU3</td>
</tr>
<tr>
<td>0</td>
<td>8.74</td>
<td>9.05</td>
<td>10.05</td>
<td>7.51</td>
</tr>
<tr>
<td>1</td>
<td>6.60</td>
<td>7.72</td>
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</tr>
<tr>
<td>2</td>
<td>7.16</td>
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<td>10.09</td>
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<td>3</td>
<td>6.91</td>
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<tr>
<td>4</td>
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<td>8.45</td>
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<td>3.14</td>
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<tr>
<td>8</td>
<td>7.75</td>
<td>8.76</td>
<td>10.54</td>
<td>4.40</td>
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<tr>
<td>9</td>
<td>6.80</td>
<td>7.96</td>
<td>9.83</td>
<td>3.02</td>
</tr>
<tr>
<td>10</td>
<td>6.98</td>
<td>8.07</td>
<td>9.91</td>
<td>3.40</td>
</tr>
<tr>
<td>11</td>
<td>7.67</td>
<td>8.72</td>
<td>10.59</td>
<td>4.16</td>
</tr>
<tr>
<td>12</td>
<td>6.98</td>
<td>8.08</td>
<td>9.88</td>
<td>3.40</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>7.19</strong></td>
<td><strong>8.27</strong></td>
<td><strong>10.10</strong></td>
<td><strong>3.63</strong></td>
</tr>
</tbody>
</table>

## Repeatability 2 IOPS –Average Response Time (ms) Distribution Graph
Repeatability 1 (LRT)
-measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

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

Clauses 5.1.10 and 5.3.13.2

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

Clause 5.3.13.3

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

<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><strong>IM</strong></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><strong>MIM</strong></td>
<td>0.0350</td>
<td>0.2811</td>
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<td>0.2099</td>
<td>0.0180</td>
<td>0.0701</td>
<td>0.0350</td>
<td>0.2811</td>
</tr>
<tr>
<td><strong>COV</strong></td>
<td>0.003</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
<td>0.004</td>
<td>0.002</td>
<td>0.003</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Repeatability 1 (IOPS)
-measured Intensity Multiplier and Coefficient of Variation

<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><strong>IM</strong></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><strong>MIM</strong></td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2099</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td><strong>COV</strong></td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Repeatability 2 (LRT)
-measured Intensity Multiplier and Coefficient of Variation

<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><strong>IM</strong></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><strong>MIM</strong></td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2099</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td><strong>COV</strong></td>
<td>0.004</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
<td>0.004</td>
<td>0.002</td>
<td>0.003</td>
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</tbody>
</table>
### Repeatability 2 (IOPS)
#### Measured Intensity Multiplier and Coefficient of Variation

<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>IM</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>MIM</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>COV</td>
<td>0.001</td>
<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Data Persistence Test

Clause 6

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

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

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

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

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

Clause 9.4.3.8

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

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

SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in “Appendix E: SPC-1 Workload Generator Input Parameters” on Page 78.

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

<table>
<thead>
<tr>
<th>Data Persistence Test Run Number: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Logical Blocks Written</td>
</tr>
<tr>
<td>Total Number of Logical Blocks Verified</td>
</tr>
<tr>
<td>Total Number of Logical Blocks that Failed Verification</td>
</tr>
<tr>
<td>Time Duration for Writing Test Logical Blocks</td>
</tr>
<tr>
<td>Size in Bytes of each Logical Block</td>
</tr>
<tr>
<td>Number of Failed I/O Requests in the process of the Test</td>
</tr>
</tbody>
</table>

If approved by the SPC Auditor, the SPC-2 Persistence Test may be used to meet the SPC-1 persistence requirements. Both the SPC-1 and SPC-2 Persistence Tests provide the same level of functionality and verification of data integrity. The SPC-2 Persistence Test may be easily configured to address an SPC-1 storage configuration. The SPC-2 Persistence Test extends the size of storage configurations that may be tested and significantly reduces the test duration of such configurations.

The SPC-2 Persistence Test was approved for use in this set of audited measurements.

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

*Clause 9.2.4.9*

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

The IBM System Storage SAN Volume Controller v6.2 as documented in this Full Disclosure Report is currently available for customer purchase and shipment.

**PRICING INFORMATION**

*Clause 9.4.3.3.6*

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

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

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

*Clause 9.4.3.3.7*

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

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

**ANOMALIES OR IRREGULARITIES**

*Clause 9.4.3.10*

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

There were no anomalies or irregularities encountered during the SPC-1 Onsite Audit of the IBM System Storage SAN Volume Controller v6.2 with IBM Storwize® V7000 disk storage.
APPENDIX A: SPC-1 GLOSSARY

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

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

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

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

SPC-1 Data Repository Definitions

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

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

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

**Addressable Storage Capacity:** The total storage (sum of Logical Volumes) that can be read and written by application programs such as the SPC-1 Workload Generator.
Configured Storage Capacity: This capacity includes the Addressable Storage Capacity and any other storage (parity disks, hot spares, etc.) necessary to implement the Addressable Storage Capacity.

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

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

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

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

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

SPC-1 Data Protection Levels

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

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

SPC-1 Test Execution Definitions

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

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

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

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

Expected I/O Count: For any given I/O Stream and Test Phase, the product of 50 times the BSU level, the duration of the Test Phase in seconds, and the Intensity Multiplier for that I/O Stream.
**Failed I/O Request:** Any I/O Request issued by the Workload Generator that could not be completed or was signaled as failed by System Software. A Failed I/O Request has no Completion Time (see “I/O Completion Types” below).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

### I/O Completion Types

<table>
<thead>
<tr>
<th>I/O Completion Type</th>
<th>Start Time</th>
<th>Completion Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured I/O</td>
<td></td>
<td></td>
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<tr>
<td>In-Flight I/O</td>
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<tr>
<td>Failed I/O</td>
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<td></td>
</tr>
<tr>
<td>Error or Failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shut-Down</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SPC-1 Test Run Components
APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

There were no customer tunable parameter or options changed from their default values.
APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

Each script reference, in the following TSC creation sections, is a hyperlink to the actual script. All scripts appear following the last TSC creation section, AIX Configuration.

Storwize V7000 Configuration

The scripts, referenced below, are executed in a Cygwin command window, on the Windows 2003 Server Master Console, by invoking the name of the script from the directory where it is located.

The scripts use the PuTTY command plink, invoked as plink ‘name of system’ to give a command to a specific Storwize V7000 system previously placed into PuTTY’s cache of known network location. This command sequence was used to perform the same configuration processing on each of the 16 Storwize V7000 systems.

Step 1. Define upper paths

Each V7000 system is connected to two switches; with each switch enabling the V7000 to connect to any of the SVC nodes. The WWPN’s associated with each SVC node on each switch are defined by the script v7000step1_mkhost.cyg.

Step 2. Define RAID ranks

Each V7000 system has 120 disk drives. Of these, two drives were assigned as spares. Twelve RAID-10 ranks were defined using the remaining drives. There is one RAID-10 rank in each V7000 system that contains eight drives, while the remaining eleven RAID-10 ranks contain ten drives. The actions needed to configure the RAID-10 ranks and spare drives were taken using the script v7000step2_dochains_separate_10disk.cyg.

Step 3. Map volumes for use by SVC

Each RAID rank, created above in Step 3, is presented to the SVC cluster as a volume (Vdisk as defined in the V7000). The logical volume mappings needed so that each volume is made available to each SVC node, via either of two switches, are created by the script v7000step3_map_byswitch.cyg.

SAN Volume Controller (SVC) Configuration

The configuration of the SVC, like that of the V7000 systems, uses Cygwin and PuTTY.

Step 1. Define host paths

The Tested Storage Configuration (TSC) includes thirty-two 8 Gbps fibre channel paths which are connected to the SVC via 4 switches. Each Host System is connected via 8 paths which are divided between a pair of switches. The WWPNs associated with each host connection are defined by running the script svcstep1_mkhost.cyg.
Step 2. Define volumes for Host System use
Each V7000 rank is presented as a Host System volume. Thus, there are a total of 16*12 or 192 Host System volumes. These are defined in SVC by the script `svcstep2_mk192vd_8node_seq.cyg`.

Step 3. Define volume mappings
Each Host System volume is mapped to every Host System WWPN. This arrangement does not result in an excessive number of paths to select from at the Host System level, since each Host System has just eight FC connections. The needed mappings are performed by the script `svcstep3_map_all.cyg`.

AIX Configuration
There were two physical AIX servers partitioned into four distinct logical Host Systems. The logical Host Systems were configured in the following sequence of steps. Note that Step 2 was performed on one Host System only. The other steps were performance on all Host Systems.

Step 1. Discover hdisks (all Host Systems)
Execute the command `cfgmgr` on each Host System, in a standard command shell window, to discover the available 192 Host System volumes, described above. Each discovered hdisk corresponds to a Host System volume, resulting in 192 hdisks, accessible by each Host System.

Step 2. Define and export a striped logical volume group (one Host System only)
Define a logical volume group which is striped across all volumes in such a way that the usage of each hdisk is in approximate proportion to its size. The volume group consists of 142 striped logical volumes, each containing 10,400 partitions of size 64 MiB. It is striped across 176 hdisks of size 10846 partitions and 16 hdisks of size 8670 partitions. For each 11 partitions placed on one of the larger volumes, there are 9 partitions placed on one of the smaller volumes. This is accomplished by invoking the script `mapthem.sh` on a single Host System as follows: `mapthem.sh 10400 64 10846 11 8670 9 142`.

The resulting logical volume group is called `mapstripevg`. Export this logical volume group as follows by executing the following commands, in a standard shell window, on a single Host System:

- `varyoffvg mapstripevg`
- `exportvg mapstripevg`
Step 3. Import the striped logical volume group (all Host Systems)

The striped logical volume group must be imported by each Host System in a shared manner. This is accomplished as follows by executing the following commands, in a standard command shell window, on each Host System:

- `importvg -ny mapstripevg hdisk2`
- `varyonvg –bu mapstripevg`

At the completion of this step, each Host System sees an identical image of the same 142 striped logical volumes referred to as map1, map2...map142. These are the volumes used to define the required three SPC-1 ASUs.

Referenced Scripts

`v7000step1_mkhost.cyg`

```bash
#!/usr/bin/bash
# run in cygwin command line
for v in 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
do
    plink="plink perfv$v"
    $plink svctask mkhost -force -name s1path1 -hbawwpn 500507680140c928
    $plink svctask mkhost -force -name s1path2 -hbawwpn 500507680140c907
    $plink svctask mkhost -force -name s1path3 -hbawwpn 500507680140c934
    $plink svctask mkhost -force -name s1path4 -hbawwpn 500507680140c8b9
    $plink svctask mkhost -force -name s1path5 -hbawwpn 500507680140c966
    $plink svctask mkhost -force -name s1path6 -hbawwpn 500507680140c94e
    $plink svctask mkhost -force -name s1path7 -hbawwpn 500507680140c94c
    $plink svctask mkhost -force -name s2path1 -hbawwpn 500507680130c928
    $plink svctask mkhost -force -name s2path2 -hbawwpn 500507680130c907
    $plink svctask mkhost -force -name s2path3 -hbawwpn 500507680130c934
    $plink svctask mkhost -force -name s2path4 -hbawwpn 500507680130c94e
    $plink svctask mkhost -force -name s2path5 -hbawwpn 500507680130c94c
    $plink svctask mkhost -force -name s2path6 -hbawwpn 500507680130c94c
    $plink svctask mkhost -force -name s2path7 -hbawwpn 500507680130c94c
    $plink svctask mkhost -force -name s2path8 -hbawwpn 500507680130c94c
    $plink svctask mkhost -force -name s3path1 -hbawwpn 500507680110c928
    $plink svctask mkhost -force -name s3path2 -hbawwpn 500507680110c907
    $plink svctask mkhost -force -name s3path3 -hbawwpn 500507680110c934
    $plink svctask mkhost -force -name s3path4 -hbawwpn 500507680110c94e
    $plink svctask mkhost -force -name s3path5 -hbawwpn 500507680110c94c
    $plink svctask mkhost -force -name s3path6 -hbawwpn 500507680110c94c
    $plink svctask mkhost -force -name s3path7 -hbawwpn 500507680110c94c
    $plink svctask mkhost -force -name s3path8 -hbawwpn 500507680110c94c
    $plink svctask mkhost -force -name s4path1 -hbawwpn 500507680120c928
    $plink svctask mkhost -force -name s4path2 -hbawwpn 500507680120c907
    $plink svctask mkhost -force -name s4path3 -hbawwpn 500507680120c934
    $plink svctask mkhost -force -name s4path4 -hbawwpn 500507680120c94e
    $plink svctask mkhost -force -name s4path5 -hbawwpn 500507680120c94c
    $plink svctask mkhost -force -name s4path6 -hbawwpn 500507680120c94c
    $plink svctask mkhost -force -name s4path7 -hbawwpn 500507680120c94c
    $plink svctask mkhost -force -name s4path8 -hbawwpn 500507680120c94c
    done
```
#!/usr/bin/bash
# run in cygwin command line
# Creates 12 RAID-5 arrays 10 disks each, except for one array (fifth) which leaves out 2 spare disks.

for v in 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
do
  plink="plink perfv$v"
  $plink svctask mkmdiskgrp -name v7000group -ext 256
  drives="$plink svcinfo lsdrive -nohdr | awk '{ print $1 }'`
  for d in $drives
  do
    svctask chdrive -use candidate $d
  done
  #the first 2 elements show enclosures in chain 1, the last 3 those in chain 2
  c_enc=( -1 -1 -2 -2 -2 )
  n=0
  for cnum in 1 2
  do
    chain="$plink svcinfo lssasfabric -nohdr -delim : | \n      grep "^[^:]*:[^:]*:[^:]*:[^:]*:[^:]*:$cnum:[^:]*:[^:]*:[^:]*:[^:]*:[^:]*:lode1" | cut -d: -f1 -n -"
    for i in $chain
    do
c_enc[$n]=$i
      let n="n+1"
    done
  done
  arrcount=0
  s0=0
  e0=0
  while [[ $arrcount -le 3 ]]
  do
    devlist="for d in 0 1 2 3 4 5 6 7 8 9; do let s="(s0+d)%24 + 1"; let
e="e0+(s0+d)/24"; \
      $plink svcinfo lsenclosureslot -slot $s ${c_enc[$e]} 2>/dev/null | \
      awk '(FNR==8) { print $2 }'; done | awk -v ORS="" '{ print (FNR==1?"":") $1 }'"
    echo $devlist
    $plink svctask mkarray -level raid10 -drive $devlist -name md$arrcount v7000group
    capbytes="$plink svcinfo lsmdisk -bytes md$arrcount | grep capacity | awk '{print $2}"
    let cap="(capbytes-1610612736)/1073741824"
    let lode="1+(arrcount/6)"
    $plink svctask mkvdisk -vtype seq -mdisk md$arrcount \n      -size $cap -unit gb -mdiskgrp v7000group -iogr 0 \n      -vtype seq -mdisk md$arrcount -node lode$lode
    let e0="e0+(s0+6)/24"
    let s0="(s0+6)%24"
    let arrcount="arrcount+1"
  done
  #one pass for a smaller array, leaving room for 2 spares.
  devlist="for d in 0 1 2 3 4 5 6 7; do let s="(s0+d)%24 + 1"; let e="e0+(s0+d)/24"; \
      $plink svcinfo lsenclosureslot -slot $s ${c_enc[$e]} 2>/dev/null | \
      awk '(FNR==8) { print $2 }'; done | awk -v ORS="" '{ print (FNR==1?"":") $1 }'"
  echo $devlist
  $plink svctask mkarray -level raid10 -drive $devlist -name md$arrcount v7000group
APPENDIX C: Tested Storage Configuration (TSC) Creation

capbytes=`$plink svcinfo lsmdisk -bytes md$arrcount | grep capacity | awk '{print $2}'`
let cap="(capbytes-1610612736)/1073741824"
let lode="1+(arrcount/6)"
$plink svctask mkvdisk -vtype seq -mdisk md$arrcount \
-"size $cap -unit gb -mdiskgrp v7000group -iogrp 0 -name vd$arrcount -node lode$lode"
let e0="s0+(s0+6)/24"
let s0="(s0+6)%24"
$plink svctask mkarray -level raid10 -drive $devlist -name md$arrcount v7000group
capbytes=`$plink svcinfo lsmdisk -bytes md$arrcount | grep capacity | awk '{print $2}'`
let cap="(capbytes-1610612736)/1073741824"
let lode="1+(arrcount/6)"
$plink svctask mkvdisk -vtype seq -mdisk md$arrcount \
-"size $cap -unit gb -mdiskgrp v7000group -iogrp 0 -name vd$arrcount -node lode$lode"
let e0="e0+(s0+6)/24"
let s0="(s0+6)%24"
let arrcount="arrcount+1"
#one pass for smaller array done
s0=0
e0=0
while [[ $arrcount -le 11 ]]
do
devlist=`for d in 0 1 2 3 4 5 6 7 8 9; do let s="(s0+d)%24 + 1"; let
e="e0+(s0+d)/24"; \
   $plink svcinfo lsenclosureslot -slot $s ${c_enc[2+$e]} 2>/dev/null | \
   awk "'(FNR==8) { print $2 }'; done | awk -v ORS="" '{ print (FNR==1?"":":") $1 }'`
   echo $devlist
   $plink svctask mkarray -level raid10 -drive $devlist -name md$arrcount v7000group
capbytes=`$plink svcinfo lsmdisk -bytes md$arrcount | grep capacity | awk '{print $2}'`
let cap="(capbytes-1610612736)/1073741824"
let lode="1+(arrcount/6)"
$plink svctask mkvdisk -vtype seq -mdisk md$arrcount \
-"size $cap -unit gb -mdiskgrp v7000group -iogrp 0 -name vd$arrcount -node lode$lode"
let e0="e0+(s0+6)/24"
let s0="(s0+6)%24"
let arrcount="arrcount+1"
done

#we used 11*10 + 8 = 118 drives, now assign the last 2 as spares.
sparedr=`$plink svcinfo lsenclosureslot -slot 23 ${c_enc[4]} | grep drive_id | awk '{ print $2 }'`
$plink svctask chdrive -use spare $sparedr
sparedr=`$plink svcinfo lsenclosureslot -slot 24 ${c_enc[4]} | grep drive_id | awk '{ print $2 }'`
$plink svctask chdrive -use spare $sparedr
done

v7000step3_map_byswitch.cyg

#!/usr/bin/bash
# run in cygwin command line
# maps all V7000 volumes based on the switch to which the owning node connects,
# with alternate path of the partner node connection.
plink perfclus svctask detectmdisk
sleep 5
for S in 1 2 3 4
do
   if [[ $S -le 2 ]]
      then firstv=1
   else firstv=9
   fi
   let lastv="firstv+7"
   if [[ $S%2 -eq 1 ]]
      then vollist="0 1 2 3 4 5"
   else vollist="6 7 8 9 10 11"
fi
v=$firstv
while [[ $v -le $lastv ]]
do
   plink="plink perfv$v"
   for p in 1 2 3 4 5 6 7 8
do
      for vol in $vollist
do
         $plink svctask mkvdiskhostmap -force -host s$S\path$p vd$vol
done
   done
   let v="v+1"
done
sleep 5
plink perfclus svctask detectmdisk
sleep 5
mlist=`plink perfclus svcinfo lsmdisk -nohdr | grep unmanaged | awk -v ORS="\n" '{
   print (FNR==1?"":":") $2 }'`
plink perfclus svctask mkmdiskgrp -name group$S -ext 256 -mdisk $mlist
done
for S in 1 2 3 4
do
   if [[ $S -le 2 ]]
   then firstv=1
   else firstv=9
   fi
   let lastv="firstv+7"
   if [[ $S%2 -eq 0 ]]
   then vollist="0 1 2 3 4 5"
   else vollist="6 7 8 9 10 11"
   fi
   v=$firstv
while [[ $v -le $lastv ]]
do
   plink="plink perfv$v"
   for p in 1 2 3 4 5 6 7 8
do
      for vol in $vollist
do
         $plink svctask mkvdiskhostmap -force -host s$S\path$p vd$vol
done
   done
   let v="v+1"
done
done
sleep 5
plink perfclus svctask detectmdisk
sleep 5
APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

svcstep1_mkhost.cyg

plink="plink perfclus"
$plink svctask mkhost -force -name fcsa1 -hbawwpn 10000000C9E3A76B
$plink svctask mkhost -force -name fcsa3 -hbawwpn 10000000C9E3DA97
$plink svctask mkhost -force -name fcsa9 -hbawwpn 10000000C9E3E32B
$plink svctask mkhost -force -name fcsa11 -hbawwpn 10000000C9E3C79B
$plink svctask mkhost -force -name fcsa15 -hbawwpn 10000000C9E3E09D
$plink svctask mkhost -force -name fcsa21 -hbawwpn 10000000C9E3D3CB
$plink svctask mkhost -force -name fcsa23 -hbawwpn 10000000C9E3E83
$plink svctask mkhost -force -name fcsb1 -hbawwpn 10000000C9E3C4C1
$plink svctask mkhost -force -name fcsb3 -hbawwpn 10000000C9E3D12D
$plink svctask mkhost -force -name fcsb11 -hbawwpn 10000000C9E36D73
$plink svctask mkhost -force -name fcsb13 -hbawwpn 10000000C9E3C63D
$plink svctask mkhost -force -name fcsb15 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsb21 -hbawwpn 10000000C9E3C643
$plink svctask mkhost -force -name fcsb23 -hbawwpn 10000000C9E3C59B
$plink svctask mkhost -force -name fcsb9 -hbawwpn 10000000C9E3E683
$plink svctask mkhost -force -name fcsb11 -hbawwpn 10000000C9E3C4C1
$plink svctask mkhost -force -name fcsb13 -hbawwpn 10000000C9E3C63D
$plink svctask mkhost -force -name fcsb15 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsb21 -hbawwpn 10000000C9E3C673
$plink svctask mkhost -force -name fcsb23 -hbawwpn 10000000C9E3E683
$plink svctask mkhost -force -name fcsc1 -hbawwpn 10000000C9E3E683
$plink svctask mkhost -force -name fcsc3 -hbawwpn 10000000C9E3C4C1
$plink svctask mkhost -force -name fcsc9 -hbawwpn 10000000C9E3C63D
$plink svctask mkhost -force -name fcsc11 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsc13 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsc15 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsc21 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsc23 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsc11 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsc13 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsc15 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsc21 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsc23 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsd1 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsd3 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsd9 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsd11 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsd13 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsd15 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsd21 -hbawwpn 10000000C9E3C6DD
$plink svctask mkhost -force -name fcsd23 -hbawwpn 10000000C9E3C6DD

svcstep2_mk192vd_8node_seq.cyg

#!/usr/bin/bash
#execute in cygwin command line
plink="plink perfclus"
i=0
while [[ $i -le 191 ]]
do
    let lode="1 + ((i%32) / 4)"
    let iogrp="((i%32) / 8)"
    let k="i%192"
    #192 = no. of mdisks
    let j="((k%4)*/48 + (k/4))"
    #4 is fixed, 48*4 = no. of mdisks
    let mdgrp="1+(j/40)"
    capbytes=`$plink svcinfo lsmdisk -bytes md$j | grep capacity | awk  '{print $2}'`
    let cap="(capbytes-1073741824)/1073741824"
    $plink svctask mkvdisk -vtype seq -mdisk md$j -size $cap -unit gb -mdiskgrp group$mdgrp -iogrp io_grp$iogrp -name vd$i -node lode$lode
    let i="i+1"
done
svcstep3_map_all.cyg

```
plink="plink perfclus"
i=0
while [[ $i -le 191 ]]
  do
    j=0
    while [[ $j -le 31 ]]
      do
        $plink svctask mkvdiskhostmap -force -host $j vd$i
        let j="j+1"
      done
    let i="i+1"
  done
```

mapthem.sh

```
# makes striped volume group from two hdisk sizes using map; makes vols with a
# specified number of specified meg partitions.
# important: assumes MPIO, assumes specified map rotation divides LV partitions.
if [[ ($# -lt 6) ]]
  then
    echo "Usage: mapthem LV partitions psize \n\nLarge hdisk total & 1 pass partitions \n\nSmall hdisk total & 1 pass partitions \n\n[Number of LVs to be made (optional)] \nLV partitions must be divisible by total partitions in a pass (not checked)"
    return
  fi
partspervol=$1
psize=$2

hfield=$(lsdev -Cc disk | grep 'IBM 2145' | awk '{print $1}')
if [ -e /dev/mapstripevg ]
  then echo "Volume group already exists; using existing LVG"
else mkvg -fy mapstripevg -S -P 2048 -s $psize $hfield
  fi

hnum=`echo $hfield | wc -w`
parts=`lsvg mapstripevg | grep "FREE PPs:" | awk '{print $6}'`
let numlv="parts / partspervol"
let usedparts="partspervol * numlv"
print "At most $numlv logical volumes can be made,"
print "using $usedparts out of $parts available partitions."
if [[ ($# -eq 7) ]]
  then making=$7
else making=$numlv
  fi

mapplate1=`lsvg -p mapstripevg | awk '{print $1 " $4"}' | grep " $3" | awk '{print $1 ":"}'}`
mapplate2=`lsvg -p mapstripevg | awk '{print $1 " $4"}' | grep " $5" | awk '{print $1 ":"}'}`

hnum1=`echo $mapplate1 | wc -w`
hnum2=`echo $mapplate2 | wc -w`
let passsize="$4*hnum1 + $6*hnum2"
let lvpass="$1/passsize"
```

i=1
j=1
l=1
while [[ $1 -le $making ]]
  do
    let mapend="l*$4*$lvpass"
    echo "" > mapstripevg.map
    while [[ $i -le $mapend ]]
      do
        echo "$maplate1" | sed "s/:/:$i/g" >> mapstripevg.map
        let k="(i-1)$$4+1"
        if [[ $k -le $6 ]]
          then
            echo "$maplate2" | sed "s/:/:$j/g" >> mapstripevg.map
            let j="j+1"
          fi
        let i="i+1"
      done
    mklv -b n -y map$l -x 32512 -m mapstripevg.map mapstripevg $partspervol
    let l="l+1"
  done
APPENDIX D: SPC-1 WORKLOAD GENERATOR STORAGE COMMANDS AND PARAMETERS

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

**Common Command Lines – Primary Metrics and Repeatability Tests**

The following command lines appear at the beginning of each command and parameter file for the Primary Metrics and Repeatability Test. The command lines are only listed below to eliminate redundancy.

```
host=master
slaves=(slav1,slav2,slav3,slav4,slav5,slav6,slav7,slav8,slav9,slav10,slav11,slav12,slav13,slav14,slav15,slav16,slav17,slav18,slav19,slav20,slav21,slav22,slav23,slav24,slav25,slav26,slav27,slav28,slav29,slav30,slav31,slav32,slav33,slav34,slav35,slav36,slav37,slav38,slav39,slav40,slav41,slav42,slav43,slav44,slav45,slav46,slav47,slav48,slav49,slav50,slav51,slav52,slav53,slav54,slav55,slav56,slav57,slav58,slav59,slav60,slav61,slav62,slav63,slav64,slav65,slav66,slav67,slav68,slav69,slav70,slav71,slav72,slav73,slav74,slav75,slav76,slav77,slav78,slav79,slav80,slav81,slav82,slav83,slav84,slav85,slav86,slav87,slav88,slav89,slav90,slav91,slav92,slav93,slav94,slav95,slav96,slav97,slav98,slav99,slav100,slav101,slav102,slav103,slav104,slav105,slav106,slav107,slav108,slav109,slav110,slav111,slav112,slav113,slav114,slav115,slav116,slav117,slav118,slav119,slav120,slav121,slav122,slav123,slav124,slav125,slav126,slav127,slav128)
javaparms="-Xms1280m -Xmx1280m -Xss128k -Xgcpolicy:optavgpause"
sd=default,size=687194767360
sd=asu1_1,lun=/dev/rmap1
sd=asu1_2,lun=/dev/rmap2
sd=asu1_3,lun=/dev/rmap3
sd=asu1_4,lun=/dev/rmap4
sd=asu1_5,lun=/dev/rmap5
sd=asu1_6,lun=/dev/rmap6
sd=asu1_7,lun=/dev/rmap7
sd=asu1_8,lun=/dev/rmap8
sd=asu1_9,lun=/dev/rmap9
sd=asu1_10,lun=/dev/rmap10
sd=asu1_11,lun=/dev/rmap11
sd=asu1_12,lun=/dev/rmap12
sd=asu1_13,lun=/dev/rmap13
sd=asu1_14,lun=/dev/rmap14
sd=asu1_15,lun=/dev/rmap15
sd=asu1_16,lun=/dev/rmap16
sd=asu1_17,lun=/dev/rmap17
sd=asu1_18,lun=/dev/rmap18
sd=asu1_19,lun=/dev/rmap19
sd=asu1_20,lun=/dev/rmap20
sd=asu1_21,lun=/dev/rmap21
sd=asu1_22,lun=/dev/rmap22
sd=asu1_23,lun=/dev/rmap23
sd=asu1_24,lun=/dev/rmap24
sd=asu1_25,lun=/dev/rmap25
sd=asu1_26,lun=/dev/rmap26
sd=asu1_27,lun=/dev/rmap27
sd=asu1_28,lun=/dev/rmap28
sd=asu1_29,lun=/dev/rmap29
sd=asu1_30,lun=/dev/rmap30
sd=asu1_31,lun=/dev/rmap31
sd=asu1_32,lun=/dev/rmap32
sd=asu1_33,lun=/dev/rmap33
```

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

sd=asu1_34,lun=/dev/rmap34
sd=asu1_35,lun=/dev/rmap35
sd=asu1_36,lun=/dev/rmap36
sd=asu1_37,lun=/dev/rmap37
sd=asu1_38,lun=/dev/rmap38
sd=asu1_39,lun=/dev/rmap39
sd=asu1_40,lun=/dev/rmap40
sd=asu1_41,lun=/dev/rmap41
sd=asu1_42,lun=/dev/rmap42
sd=asu1_43,lun=/dev/rmap43
sd=asu1_44,lun=/dev/rmap44
sd=asu1_45,lun=/dev/rmap45
sd=asu1_46,lun=/dev/rmap46
sd=asu1_47,lun=/dev/rmap47
sd=asu1_48,lun=/dev/rmap48
sd=asu1_49,lun=/dev/rmap49
sd=asu1_50,lun=/dev/rmap50
sd=asu1_51,lun=/dev/rmap51
sd=asu1_52,lun=/dev/rmap52
sd=asu1_53,lun=/dev/rmap53
sd=asu1_54,lun=/dev/rmap54
sd=asu1_55,lun=/dev/rmap55
sd=asu1_56,lun=/dev/rmap56
sd=asu1_57,lun=/dev/rmap57
sd=asu1_58,lun=/dev/rmap58
sd=asu1_59,lun=/dev/rmap59
sd=asu1_60,lun=/dev/rmap60
sd=asu1_61,lun=/dev/rmap61
sd=asu1_62,lun=/dev/rmap62
sd=asu1_63,lun=/dev/rmap63
sd=asu1_64,lun=/dev/rmap64
sd=asu2_1,lun=/dev/rmap65
sd=asu2_2,lun=/dev/rmap66
sd=asu2_3,lun=/dev/rmap67
sd=asu2_4,lun=/dev/rmap68
sd=asu2_5,lun=/dev/rmap69
sd=asu2_6,lun=/dev/rmap70
sd=asu2_7,lun=/dev/rmap71
sd=asu2_8,lun=/dev/rmap72
sd=asu2_9,lun=/dev/rmap73
sd=asu2_10,lun=/dev/rmap74
sd=asu2_11,lun=/dev/rmap75
sd=asu2_12,lun=/dev/rmap76
sd=asu2_13,lun=/dev/rmap77
sd=asu2_14,lun=/dev/rmap78
sd=asu2_15,lun=/dev/rmap79
sd=asu2_16,lun=/dev/rmap80
sd=asu2_17,lun=/dev/rmap81
sd=asu2_18,lun=/dev/rmap82
sd=asu2_19,lun=/dev/rmap83
sd=asu2_20,lun=/dev/rmap84
sd=asu2_21,lun=/dev/rmap85
sd=asu2_22,lun=/dev/rmap86
sd=asu2_23,lun=/dev/rmap87
sd=asu2_24,lun=/dev/rmap88
sd=asu2_25,lun=/dev/rmap89
sd=asu2_26,lun=/dev/rmap90
sd=asu2_27,lun=/dev/rmap91
sd=asu2_28,lun=/dev/rmap92
sd=asu2_29,lun=/dev/rmap93
sd=asu2_30,lun=/dev/rmap94
sd=asu2_31,lun=/dev/rmap95
sd=asu2_32,lun=/dev/rmap96
APPENDIX C:
TESTED STORAGE CONFIGURATION (TSC) CREATION

sd=asu2_33,lun=/dev/rmap97
sd=asu2_34,lun=/dev/rmap98
sd=asu2_35,lun=/dev/rmap99
sd=asu2_36,lun=/dev/rmap100
sd=asu2_37,lun=/dev/rmap101
sd=asu2_38,lun=/dev/rmap102
sd=asu2_39,lun=/dev/rmap103
sd=asu2_40,lun=/dev/rmap104
sd=asu2_41,lun=/dev/rmap105
sd=asu2_42,lun=/dev/rmap106
sd=asu2_43,lun=/dev/rmap107
sd=asu2_44,lun=/dev/rmap108
sd=asu2_45,lun=/dev/rmap109
sd=asu2_46,lun=/dev/rmap110
sd=asu2_47,lun=/dev/rmap111
sd=asu2_48,lun=/dev/rmap112
sd=asu2_49,lun=/dev/rmap113
sd=asu2_50,lun=/dev/rmap114
sd=asu2_51,lun=/dev/rmap115
sd=asu2_52,lun=/dev/rmap116
sd=asu2_53,lun=/dev/rmap117
sd=asu2_54,lun=/dev/rmap118
sd=asu2_55,lun=/dev/rmap119
sd=asu2_56,lun=/dev/rmap120
sd=asu2_57,lun=/dev/rmap121
sd=asu2_58,lun=/dev/rmap122
sd=asu2_59,lun=/dev/rmap123
sd=asu2_60,lun=/dev/rmap124
sd=asu2_61,lun=/dev/rmap125
sd=asu2_62,lun=/dev/rmap126
sd=asu2_63,lun=/dev/rmap127
sd=asu2_64,lun=/dev/rmap128
sd=asu3_1,lun=/dev/rmap129
sd=asu3_2,lun=/dev/rmap130
sd=asu3_3,lun=/dev/rmap131
sd=asu3_4,lun=/dev/rmap132
sd=asu3_5,lun=/dev/rmap133
sd=asu3_6,lun=/dev/rmap134
sd=asu3_7,lun=/dev/rmap135
sd=asu3_8,lun=/dev/rmap136
sd=asu3_9,lun=/dev/rmap137
sd=asu3_10,lun=/dev/rmap138
sd=asu3_11,lun=/dev/rmap139
sd=asu3_12,lun=/dev/rmap140
sd=asu3_13,lun=/dev/rmap141
sd=asu3_14,lun=/dev/rmap142

Primary Metrics Test

Sustainability
rd=sustain,bsus=10400,startup=180,elapsed=28800,interval=60

Ramp 100 Test Run
rd=ramp_100,bsus=10400,startup=180,elapsed=600,interval=6

Ramp 95 Test Run
rd=ramp_95,bsus=9880,startup=180,elapsed=600,interval=60
Ramp 90 Test Run
\[ rd=ramp_90,bsus=9360,startup=180,elapsed=600,interval=60 \]

Ramp 80 Test Run
\[ rd=ramp_80,bsus=8320,startup=180,elapsed=600,interval=60 \]

Ramp 50 Test Run
\[ rd=ramp_50,bsus=5200,startup=180,elapsed=600,interval=60 \]

Ramp 10 Test Run
\[ rd=ramp_10,bsus=1040,startup=180,elapsed=600,interval=60 \]

Repeatability Test

Repeat1 LRT Test Run
Repeat1 IOPS Test Run
\[ rd=repeat1_lrt,bsus=1040,startup=180,elapsed=600,interval=60 \]
\[ rd=repeat1_iops,bsus=10400,startup=180,elapsed=600,interval=60 \]

Repeat2 LRT Test Run
Repeat2 IOS Test Run
\[ rd=repeat2_lrt,bsus=1040,startup=180,elapsed=600,interval=60 \]
\[ rd=repeat2_iops,bsus=10400,startup=180,elapsed=600,interval=60 \]

Persistence Test

Common Command Lines
The following command lines appear at the beginning of each command and parameter file for both Persistence Test Runs. The command lines are only listed once to eliminate redundancy.

\[ host=localhost,jvms=8,maxstreams=200 \]
\[ sd=default,host=localhost,size=640g \]
\[ sd=sd1,lun=/dev/rmap1 \]
\[ sd=sd2,lun=/dev/rmap2 \]
\[ sd=sd3,lun=/dev/rmap3 \]
\[ sd=sd4,lun=/dev/rmap4 \]
\[ sd=sd5,lun=/dev/rmap5 \]
\[ sd=sd6,lun=/dev/rmap6 \]
\[ sd=sd7,lun=/dev/rmap7 \]
\[ sd=sd8,lun=/dev/rmap8 \]
\[ sd=sd9,lun=/dev/rmap9 \]
\[ sd=sd10,lun=/dev/rmap10 \]
\[ sd=sd11,lun=/dev/rmap11 \]
\[ sd=sd12,lun=/dev/rmap12 \]
\[ sd=sd13,lun=/dev/rmap13 \]
\[ sd=sd14,lun=/dev/rmap14 \]
\[ sd=sd15,lun=/dev/rmap15 \]
\[ sd=sd16,lun=/dev/rmap16 \]
APPENDIX C: Tested Storage Configuration (TSC) Creation

sd=sd17,lun=/dev/rmap17
sd=sd18,lun=/dev/rmap18
sd=sd19,lun=/dev/rmap19
sd=sd20,lun=/dev/rmap20
sd=sd21,lun=/dev/rmap21
sd=sd22,lun=/dev/rmap22
sd=sd23,lun=/dev/rmap23
sd=sd24,lun=/dev/rmap24
sd=sd25,lun=/dev/rmap25
sd=sd26,lun=/dev/rmap26
sd=sd27,lun=/dev/rmap27
sd=sd28,lun=/dev/rmap28
sd=sd29,lun=/dev/rmap29
sd=sd30,lun=/dev/rmap30
sd=sd31,lun=/dev/rmap31
sd=sd32,lun=/dev/rmap32
sd=sd33,lun=/dev/rmap33
sd=sd34,lun=/dev/rmap34
sd=sd35,lun=/dev/rmap35
sd=sd36,lun=/dev/rmap36
sd=sd37,lun=/dev/rmap37
sd=sd38,lun=/dev/rmap38
sd=sd39,lun=/dev/rmap39
sd=sd40,lun=/dev/rmap40
sd=sd41,lun=/dev/rmap41
sd=sd42,lun=/dev/rmap42
sd=sd43,lun=/dev/rmap43
sd=sd44,lun=/dev/rmap44
sd=sd45,lun=/dev/rmap45
sd=sd46,lun=/dev/rmap46
sd=sd47,lun=/dev/rmap47
sd=sd48,lun=/dev/rmap48
sd=sd49,lun=/dev/rmap49
sd=sd50,lun=/dev/rmap50
sd=sd51,lun=/dev/rmap51
sd=sd52,lun=/dev/rmap52
sd=sd53,lun=/dev/rmap53
sd=sd54,lun=/dev/rmap54
sd=sd55,lun=/dev/rmap55
sd=sd56,lun=/dev/rmap56
sd=sd57,lun=/dev/rmap57
sd=sd58,lun=/dev/rmap58
sd=sd59,lun=/dev/rmap59
sd=sd60,lun=/dev/rmap60
sd=sd61,lun=/dev/rmap61
sd=sd62,lun=/dev/rmap62
sd=sd63,lun=/dev/rmap63
sd=sd64,lun=/dev/rmap64
sd=sd65,lun=/dev/rmap65
sd=sd66,lun=/dev/rmap66
sd=sd67,lun=/dev/rmap67
sd=sd68,lun=/dev/rmap68
sd=sd69,lun=/dev/rmap69
sd=sd70,lun=/dev/rmap70
sd=sd71,lun=/dev/rmap71
sd=sd72,lun=/dev/rmap72
sd=sd73,lun=/dev/rmap73
sd=sd74,lun=/dev/rmap74
sd=sd75,lun=/dev/rmap75
sd=sd76,lun=/dev/rmap76
sd=sd77,lun=/dev/rmap77
sd=sd78,lun=/dev/rmap78
sd=sd79,lun=/dev/rmap79
APPENDIX C:  
TESTED STORAGE CONFIGURATION (TSC) CREATION

sd=sd80,lun=/dev/rmap80
sd=sd81,lun=/dev/rmap81
sd=sd82,lun=/dev/rmap82
sd=sd83,lun=/dev/rmap83
sd=sd84,lun=/dev/rmap84
sd=sd85,lun=/dev/rmap85
sd=sd86,lun=/dev/rmap86
sd=sd87,lun=/dev/rmap87
sd=sd88,lun=/dev/rmap88
sd=sd89,lun=/dev/rmap89
sd=sd90,lun=/dev/rmap90
sd=sd91,lun=/dev/rmap91
sd=sd92,lun=/dev/rmap92
sd=sd93,lun=/dev/rmap93
sd=sd94,lun=/dev/rmap94
sd=sd95,lun=/dev/rmap95
sd=sd96,lun=/dev/rmap96
sd=sd97,lun=/dev/rmap97
sd=sd98,lun=/dev/rmap98
sd=sd99,lun=/dev/rmap99
sd=sd100,lun=/dev/rmap100
sd=sd101,lun=/dev/rmap101
sd=sd102,lun=/dev/rmap102
sd=sd103,lun=/dev/rmap103
sd=sd104,lun=/dev/rmap104
sd=sd105,lun=/dev/rmap105
sd=sd106,lun=/dev/rmap106
sd=sd107,lun=/dev/rmap107
sd=sd108,lun=/dev/rmap108
sd=sd109,lun=/dev/rmap109
sd=sd110,lun=/dev/rmap110
sd=sd111,lun=/dev/rmap111
sd=sd112,lun=/dev/rmap112
sd=sd113,lun=/dev/rmap113
sd=sd114,lun=/dev/rmap114
sd=sd115,lun=/dev/rmap115
sd=sd116,lun=/dev/rmap116
sd=sd117,lun=/dev/rmap117
sd=sd118,lun=/dev/rmap118
sd=sd119,lun=/dev/rmap119
sd=sd120,lun=/dev/rmap120
sd=sd121,lun=/dev/rmap121
sd=sd122,lun=/dev/rmap122
sd=sd123,lun=/dev/rmap123
sd=sd124,lun=/dev/rmap124
sd=sd125,lun=/dev/rmap125
sd=sd126,lun=/dev/rmap126
sd=sd127,lun=/dev/rmap127
sd=sd128,lun=/dev/rmap128
sd=sd129,lun=/dev/rmap129
sd=sd130,lun=/dev/rmap130
sd=sd131,lun=/dev/rmap131
sd=sd132,lun=/dev/rmap132
sd=sd133,lun=/dev/rmap133
sd=sd134,lun=/dev/rmap134
sd=sd135,lun=/dev/rmap135
sd=sd136,lun=/dev/rmap136
sd=sd137,lun=/dev/rmap137
sd=sd138,lun=/dev/rmap138
sd=sd139,lun=/dev/rmap139
sd=sd140,lun=/dev/rmap140
sd=sd141,lun=/dev/rmap141
sd=sd142,lun=/dev/rmap142
maxlatestart=1
reportinginterval=5
segmentlength=512m

Persistence Test Run 1
  rd=default, rampup=180, periods=90, measurement=300, runout=0, rampdown=0, buffers=1
  rd=default, rdpct=0, xfersize=1024k
  rd=TR1-5s_SPC-2-persist-w, streams=512

Persistence Test Run 2
  maxpersistenceerrors=10
  *corruptstreams=3
  rd=default, buffers=1, rdpct=100, xfersize=1024k
  rd=TR1-5s_SPC-2-persist-r
APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

‘Master’ Execution Script for
Primary Metrics Test, Repeatability Test, and Persistence Test Run 1

The following script, invoked from a standard command shell window on a single Host System, executes the Primary Metrics Test (Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase), Repeatability Test (Repeatability Test Phase 1 and Repeatability Test Phase 2), and Persistence Test Run 1 in an uninterrupted sequence.

The Slave JVMs were started prior to each Test Run (allhost_jvmstart.sh) and terminated at the completion of each Test Run (allhost_jvmstop.sh) to address a Java memory allocation issue.

```bash
export PATH=$PATH:/usr/java6/bin
export SPC1HOME=/perform/spc1install
export CLASSPATH=$SPC1HOME
export LIBPATH=$SPC1HOME/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false

allhost_jvmstop.sh
java -Xoptionsfile=javaopts.cfg spc1 -w SPC1 -fmetrics1.txt -ometrics1 SPCOut
allhost_jvmstart.sh
java -Xoptionsfile=javaopts.cfg spc1 -w SPC1 -fmetrics2.txt -ometrics2 SPCOut
allhost_jvmstart.sh
java -Xoptionsfile=javaopts.cfg spc1 -w SPC1 -fmetrics3.txt -ometrics3 SPCOut
allhost_jvmstart.sh
java -Xoptionsfile=javaopts.cfg spc1 -w SPC1 -fmetrics4.txt -ometrics4 SPCOut
allhost_jvmstart.sh
java -Xoptionsfile=javaopts.cfg spc1 -w SPC1 -fmetrics5.txt -ometrics5 SPCOut
allhost_jvmstart.sh
java -Xoptionsfile=javaopts.cfg spc1 -w SPC1 -fmetrics6.txt -ometrics6 SPCOut
allhost_jvmstart.sh
java -Xoptionsfile=javaopts.cfg spc1 -w SPC1 -fmetrics7.txt -ometrics7 SPCOut
allhost_jvmstart.sh
java -Xoptionsfile=javaopts.cfg spc1 -w SPC1 -frepeat1.txt -orepeat1 SPCOut
allhost_jvmstop.sh
java -Xoptionsfile=javaopts.cfg spc1 -w SPC1 -frepeat2.txt -orepeat2 SPCOut
allhost_jvmstop.sh
```

SPC BENCHMARK 1M V1.12 FULL DISCLOSURE REPORT Submission Identifier: A00113
IBM Corporation Submitted for Review: JANUARY 30, 2012
IBM System Storage SAN Volume Controller v6.2 with IBM Storwize® V7000 disk storage
rundir=`pwd`
cd /perform/spc2runs/persistrun
rm -fr persistw
./runpersist1.sh
cd $rundir
getaixdata.sh
getsvcdata.sh
getv7000data.sh

Referenced Scripts

The following scripts are invoked from within a previously invoked script.

allhost_jvmstart.sh

The following script, invoked from the 'master' execution script, starts all of the Slave JVMs by invoking refreshslaves.sh on each of the four Host Systems.

#use SSH commands to start JVMs on all hosts
export HERE=`pwd`
refreshslaves.sh 1 32 $HERE
ssh -i /home/root/.ssh/id_internal root@perfsh1b $HERE/refreshslaves.sh 33 64 $HERE
ssh -i /home/root/.ssh/id_internal root@perfsh1c $HERE/refreshslaves.sh 65 96 $HERE
ssh -i /home/root/.ssh/id_internal root@perfsh1d $HERE/refreshslaves.sh 97 128 $HERE

refreshslaves.sh

The following script starts the Slave JVMs on each Host System, specifying the range of Slave JVMs that should be started.

if [ $# -lt 2 ]
then
  echo "usage: refreshslaves.sh first last"
  return
fi
export PATH=/usr/java6/bin:$PATH
export SPC1HOME=/perform/spc1install
export CLASSPATH=$SPC1HOME
export LIBPATH=$SPC1HOME/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
i=$1
run_dir=$3
while [[ $i -le $2 ]]
do
  ps -af | grep slav$i | grep -v grep > /dev/null
  if [ $? -ne 0 ]
  then
    nohup java -Xoptionsfile=$run_dir/javaopts.cfg spc1 -f $run_dir/slav$i.txt > $run_dir/slav$i.out &
    fi
  let i="i+1"
done
allhost_jvmstop.sh

The following script, invoked from the ‘master’ execution script, stops all of the Slave JVMs by invoking *rmslaves.sh* on each of the four Host Systems.

```bash
# use SSH commands to stop JVMs on all hosts
HERE=`pwd`
$HERE/rmslaves.sh >> /dev/null
ssh -i /home/root/.ssh/id_internal root@perfsh1b $HERE/rmslaves.sh >> /dev/null
ssh -i /home/root/.ssh/id_internal root@perfsh1c $HERE/rmslaves.sh >> /dev/null
ssh -i /home/root/.ssh/id_internal root@perfsh1d $HERE/rmslaves.sh >> /dev/null
```

**rmslaves.sh**

This script stops the Slave JVMs on each Host System.

```bash
proc_num=$(ps -ef |grep slav|grep -v "grep"|grep -v "rmslaves"|awk '{print $2}')
print $proc_num
if [[ -n $proc_num ]];then
  kill -9 $proc_num
fi
```

**Persistence Test Run 1**

The following script, invoked from the ‘master’ execution script, executes Persistence Test Run 1 (*write phase*).

**runpersist1.sh**

```bash
export PATH=$PATH:/usr/java6/bin
export SPC2HOME=/perform/spc2install
export CLASSPATH=$SPC2HOME
export LIBPATH=$SPC2HOME/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
rm -fr persistw
java -Xoptionsfile=javaopts.cfg vdbench -f persistw.cfg -o persistw
```

**Persistence Test Run 2**

The following script, invoked from a standard command shell window on a single Host System, executes Persistence Test Run 2 (*read phase*).

**runpersist2.sh**

```bash
export PATH=$PATH:/usr/java6/bin
export SPC2HOME=/perform/spc2install
export CLASSPATH=$SPC2HOME
export LIBPATH=$SPC2HOME/aix
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
rm -fr persistr
java -Xoptionsfile=javaopts.cfg vdbench -f persistr.cfg -o persistr
```