



**SPC BENCHMARK 1™  
FULL DISCLOSURE REPORT**

**IBM CORPORATION  
IBM TOTALSTORAGE®  
SAN VOLUME CONTROLLER 1.1.1**

**SPC-1 V1.8**

**Submitted for Review: June 8, 2004**

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**First Edition – June 2004**

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**Notes**

The following terms, used in this document, are defined as:

- Kilobyte (KB) is equal to 1,000 ( $10^3$ ) bytes.
- Megabyte (MB) is equal to 1,000,000 ( $10^6$ ) bytes.
- Gigabyte (GB) is equal to 1,000,000,000 ( $10^9$ ) bytes.
- Terabyte (TB) is equal to 1,000,000,000,000 ( $10^{12}$ ) bytes.

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## AUDIT CERTIFICATION



Bruce McNutt  
 IBM Corporation  
 KBV/9062-2  
 9000 South Rita Road  
 Tucson, AZ 85744

June 4, 2004

The SPC Benchmark 1™ results listed below for the IBM TotalStorage® SAN Volume Controller were produced in compliance with the SPC Benchmark 1™ V1.8 Remote Audit requirements.

SPC Benchmark 1™ V1.8 Results	
Tested Storage Configuration (TSC) Name:	
IBM TotalStorage® SAN Volume Controller	
Metric	Reported Result
SPC-1 IOPS™	44,507.73
SPC-1 Price-Performance	\$15.08/SPC-1 IOPS™
Total ASU Capacity	5,025.112 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	\$671,313.67

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with V1.8 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified using 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).

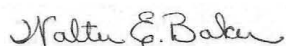
Storage Performance Council  
 643 Bair Island Road, Suite 103  
 Redwood City, CA 94062  
[AuditService@storageperformance.org](mailto:AuditService@storageperformance.org)  
 650.556.9384

- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters.
- Commands and parameters used to configure the SPC-1 Workload Generator.
- The following Host System requirements were reviewed using documentation supplied by IBM Corporation:
  - ✓ The type of Host System including the number of processors and main memory.
  - ✓ The presence and version number of the Workload Generator on the Host System.
  - ✓ The TSC boundary within the Host System.
- The Test Results Files and resultant Summary Results Files received from IBM Corporation for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- There were no differences between the Tested Storage Configuration (TSC) used for the benchmark and Priced Storage Configuration.
- The final version of the pricing spreadsheet 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.

**Audit Notes:**

There were no additional 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](mailto:AuditService@storageperformance.org)  
650.556.9384

**LETTER OF GOOD FAITH**



Office of the General Manager  
Storage Software

Route 100  
Somers, NY 10589

May 7, 2004

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

Subject: SPC-1 Letter of Good Faith for the SAN Volume Controller V1.2.0

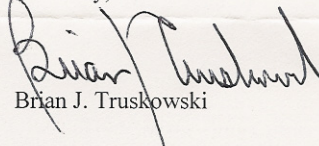
Dear Mr. Baker:

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 the Version 1.8 of the SPC-1 benchmark specification.

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

Should you require additional information please contact Bruce McNutt, Storage Control Systems Performance Evaluation, at IBM in Tucson at 520-799-2460.

Sincerely,

  
Brian J. Truskowski

/lam

cc: Mr. Bruce McNutt



**EXECUTIVE SUMMARY****Test Sponsor and Contact Information**

<b>Test Sponsor and Contact Information</b>	
<b>Test Sponsor Primary Contact</b>	IBM Corporation – <a href="http://www.ibm.com">http://www.ibm.com</a> Bill Bostic – <a href="mailto:wbostic@us.ibm.com">wbostic@us.ibm.com</a> KBV/9062-2 9000 South Rita Road Tucson, AZ 85744 Phone: (520) 799-2942 FAX: (520) 799-5530
<b>Test Sponsor Alternate Contact</b>	IBM Corporation – <a href="http://www.ibm.com">http://www.ibm.com</a> Bruce McNutt – <a href="mailto:bmcnutt@us.ibm.com">bmcnutt@us.ibm.com</a> KBV/9062-2 9000 South Rita Road Tucson, AZ 85744 Phone: (520) 799-2460 FAX: (520) 799-5530
<b>Auditor</b>	Storage Performance Council – <a href="http://www.storageperformance.org">www.storageperformance.org</a> Walter E. Baker – <a href="mailto:AuditService@storageperformance.org">AuditService@storageperformance.org</a> 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9380 FAX: (650) 556-9385

**Revision Information and Key Dates**

<b>Revision Information and Key Dates</b>	
<b>SPC-1 Specification revision number</b>	V1.8
<b>SPC-1 Workload Generator revision number</b>	V2.00.04a
<b>Date Results were first used publicly</b>	June 8, 2004
<b>Date FDR was submitted to the SPC</b>	June 8, 2004
<b>Date the TSC is/was available for shipment to customers</b>	July 25, 2003
<b>Date the TSC completed audit certification</b>	June 4, 2004

## Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: IBM TotalStorage® SAN Volume Controller 1.1.1	
Metric	Reported Result
SPC-1 IOPS™	44,507.73
SPC-1 Price-Performance	\$15.08/SPC-1 IOPS™
Total ASU Capacity	5,025.112 GB
Data Protection Level	Mirroring
Total TSC Price (including three-year maintenance)	\$671,313.67

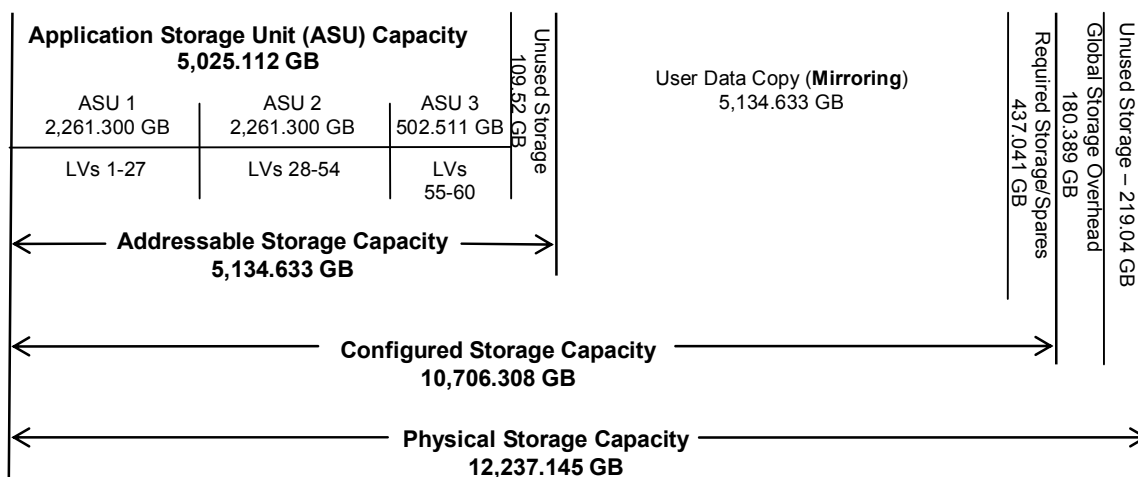
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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 Mirroring configures two or more identical copies of user data. Specifically, the Tested Storage Configuration was configured as “RAID 0+1”, striped and mirrored.

## Storage Capacities and Relationships

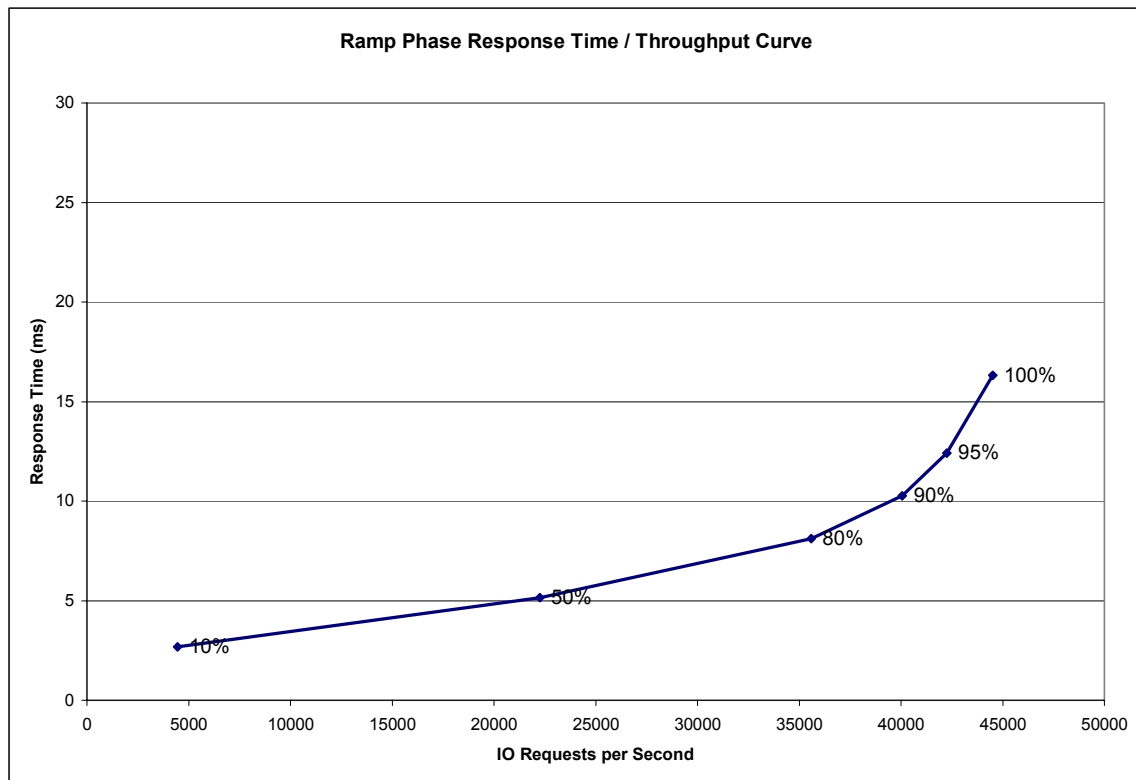
The following diagram documents the various storage capacities, used in this benchmark, and their relationships.



## Response Time – Throughput Curve

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

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



## Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
<b>I/O Request Throughput</b>	4,449.77	22,255.50	35,591.20	40,051.42	42,258.67	44,507.73
<b>Average Response Time (ms):</b>						
<b>All ASUs</b>	2.68	5.15	8.12	10.27	12.42	16.32
<b>ASU-1</b>	3.57	6.54	9.79	11.77	13.62	16.94
<b>ASU-2</b>	3.00	6.36	9.37	11.43	13.38	16.89
<b>ASU-3</b>	0.67	1.66	4.04	6.59	9.46	14.76
<b>Reads</b>	5.95	10.76	14.83	16.58	17.87	20.13
<b>Writes</b>	0.56	1.49	3.76	6.17	8.87	13.84

### Tested Storage Configuration Pricing (*Priced Storage Configuration*)

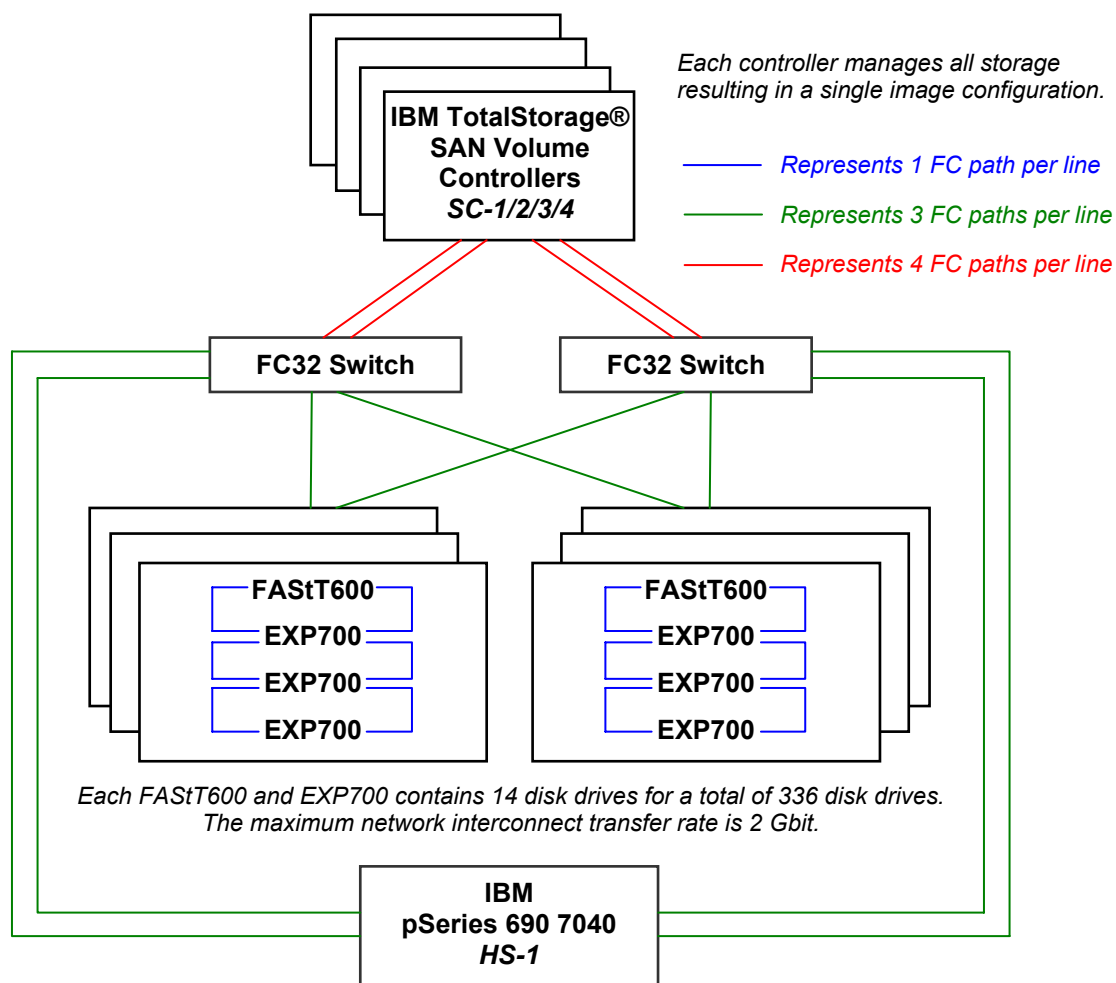
Component	Quantity	List Price	Discount	Unit Price	Total
SVC Processor	4	13,750.00	25%	10,312.50	41,250.00
Dual UPS	1	5,000.00	25%	3,750.00	3,750.00
Master Console	1	7,499.00	25%	5,624.25	5,624.25
SVC Software	1	55,000.00	10%	49,500.00	49,500.00
19 inch rack (7014-T42)	3	6,866.66	50%	3,433.33	10,299.99
32 port fibre channel switch (2109-FC32)	2	58,000.00	42%	33,640.00	67,280.00
Ethernet switch (17P-2423)	1	999.00	42%	579.42	579.42
FASt600 with 14 15K RPM drives (36 GB)	6	30,609.00	20%	24,487.20	146,923.20
EXP700 with 14 15K RPM drives (36 GB)	18	21,610.00	20%	17,288.00	311,184.00
GBIC (included n/c with other components)	140	-	0%	-	-
GBIC (additional)	10	498.75	20%	399.00	3,990.00
Short wave 2Gbit fibre channel cable (25 m)	12	189.00	20%	151.20	1,814.40
Short wave 2Gbit fibre channel cable (5 m)	30	129.00	20%	103.20	3,096.00
Short wave 2 Gbit fibre channel cable (1 m)	48	79.00	20%	63.20	3,033.60
Ethernet cable (7 feet)	9	6.99	0%	6.99	62.91
Ethernet cable (25 feet)	10	14.99	0%	14.99	149.90
2 Gbit fibre channel pSeries HBA adapter (LP9002)	12	930.00	0%	930.00	11,160.00
Maintenance package (2146-4326) standard + 2 years	1	11,616.00	0%	11,616.00	11,616.00
<b>Total Price</b>					<b>671,313.67</b>

The discount listed is the field delegation discount, which is the discount account teams are automatically authorized to offer.

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

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

### Benchmark Configuration/Tested Storage Configuration Diagram



Host Systems:	Tested Storage Configuration (TSC):
<b>UID=HS-1</b>	12 – 2 Gbit FC pSeries HBAs
IBM pSeries 690 7040	<b>UID=SC-1/2/3/4:</b> 4 – TotalStorage® SAN Volume Controllers Per controller: xSeries 335 processor which contains: 2 – 2.4 GHz Intel P4 CPUs 4 GB memory/cache 4 – 2 Gbit FC ports
14 – 1.3 GHz POWER4 CPUs – 2 CPUs/chip 1.5 MB L2 cache per chip 32 MB L3 cache per chip	
24 GB main memory	
AIX 5.1	
PCI/RIO	2 – 32 port FC switches
WG	1 – Ethernet switch
	6 – FAST600 enclosures 18 – EXP700 enclosures 14 – 36 GB, 15K RPM disk drives per enclosure
	3 – 19 inch racks
	1 – Dual UPS

## **CONFIGURATION INFORMATION**

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

#### **Clause 9.2.4.4.1**

*A one page Benchmark Configuration (BC)/Tested Storage Configuration (TSC) diagram shall be included in the Executive Summary...*

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page 13 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

### **Storage Network Configuration**

#### **Clause 9.2.4.4.2**

*If a storage network is employed in the BC/TSC, the FDR shall contain a topology diagram... . This diagram should include, but is not limited to the following components:*

- 1. Storage Controller and Domain Controllers (see Clause 9.2.4.4.1)*
- 2. Host Systems (see Clause 9.2.4.4.1)*
- 3. Routers and Bridges*
- 4. Hubs and Switches*
- 5. HBAs to Host Systems and Front End Port to Storage Controllers*

*Additionally the diagram shall:*

- Illustrate the physical connection between components.*
- Describe the type of each physical connection.*
- Describe the network protocol used over each physical connection.*
- The maximum theoretical transfer rate of each class of interconnect used in the configuration.*
- Correlate with the BC Configuration Diagram in Clause 9.2.4.4.1.*

*The Test Sponsor shall additionally supply (referenced in an appendix) a wiring diagram of the physical connections and physical port assignments used in the storage network. The diagram should allow anyone to exactly replicate the physical configuration of the storage network.*

The storage network configuration is illustrated on page 13 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

### **Host System Configuration**

#### **Clause 9.2.4.4.3**

*The FDR shall minimally contain, for each Host System running the Workload Generator, a listing of the following:*

- 1. Number and type of CPUs.*
- 2. Main memory capacity.*
- 3. Cache memory capacity.*
- 4. Number and type of disk controllers or Host Bus Adapters.*

The details of the Host System configuration may be found on page 13 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

## Customer Tunable Parameters and Options

### Clause 9.2.4.5.1

*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.*

“Appendix A: Customer Tunable Parameters and Options” on page 49 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

## Tested Storage Configuration (TSC) Description

### Clause 9.2.4.5.2

*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 Benchmark Configuration (BC) diagram in Clause 9.2.4.4.1 and, if applicable, 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.*

*In addition the FDR may include listings of scripts and/or commands used to configure the physical components that comprise the TSC.*

“Appendix B: Tested Storage Configuration (TSC) Creation” on page 50 contains the detailed information that describes how to create and configure the logical TSC.

## SPC-1 Workload Generator Storage Configuration

### Clause 9.2.4.5.3

*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 C: SPC-1 Workload Generator Storage Commands and Parameters” on page 53.

## **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 ECC 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.



## Storage Capacities and Relationships

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

### SPC-1 Storage Capacities

SPC-1 Storage Capacities		
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	5,025.112
Addressable Storage Capacity	Gigabytes (GB)	5,134.633
Configured Storage Capacity	Gigabytes (GB)	10,706.308
Physical Storage Capacity	Gigabytes (GB)	12,237.145
Data Protection Overhead (mirror)	Gigabytes (GB)	5,134.633
Required Storage	Gigabytes (GB)	437.041
Global Storage Overhead	Gigabytes (GB)	180.389
Total Unused Storage	Gigabytes (GB)	1,569.492

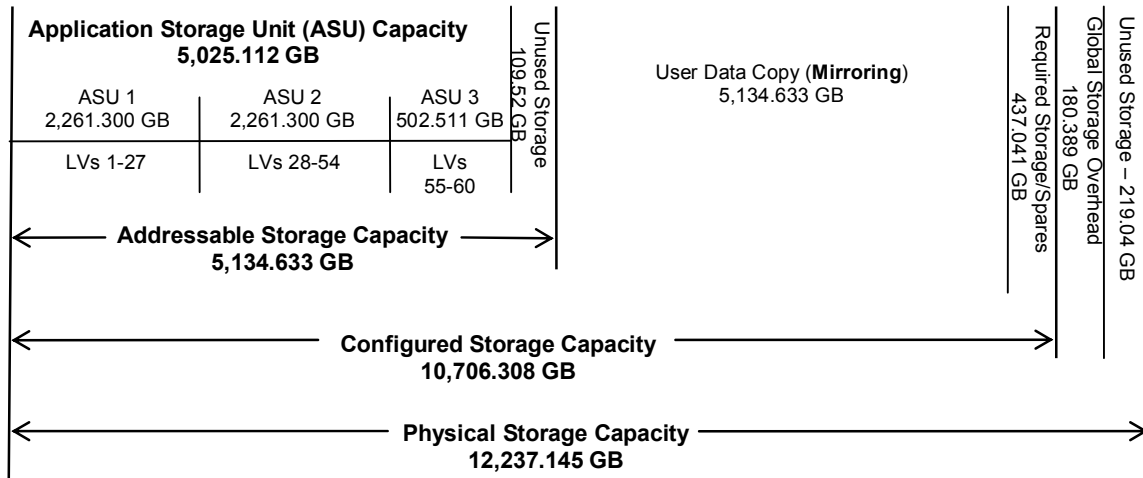
### SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
<b>Total ASU Capacity</b>	97.97%	46.94%	41.06
<b>Required for Data Protection (Mirroring)</b>		47.96%	41.96%
<b>Addressable Storage Capacity</b>		47.96%	41.96%
<b>Required Storage</b>		4.08%	3.57%
<b>Configured Storage Capacity</b>			87.49%
<b>Global Storage Overhead</b>			1.47%
<b>Unused Storage:</b>			
<b>Addressable</b>	2.13%		
<b>Configured</b>		2.05%	
<b>Physical</b>			11.04%

The Physical Storage Capacity consisted of 12,237 GB distributed over 336 disk drives each with a formatted capacity of 36.420 GB. There was 1,350.449 GB (11.04%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0.537 GB per disk drive for a total of 180.389 GB (1.47% of Physical Storage Capacity). There was 219.043 (2.05%) GB of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 97.87% of the Addressable Storage Capacity resulting in 109 GB (2.13%) of Unused Storage.

### SPC-1 Storage Capacities and Relationships Illustration

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



### Logical Volume Capacity and ASU Mapping

Clause 9.2.4.6.2

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

Logical Volume Capacity and Mapping		
ASU-1 (2,261.300 GB)	ASU-2 (2,261.300 GB)	ASU-3 (502.511 GB)
27 Logical Volumes 83.7518 GB per Logical Volume (83.7518 GB used/Logical Volume)	27 Logical Volumes 83.7518 GB per Logical Volume (83.7518 GB used/Logical Volume)	6 Logical Volumes 83.7518GB per Logical Volume (83.7518) GB used/Logical Volume)

The Data Protection Level used for all Logical Volumes was Mirroring as described on page 10. See “ASU Configuration” in the [IOPS Test Results File](#) for more detailed configuration information.

## **SPC-1 BENCHMARK EXECUTION RESULTS**

### **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.*

**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.*

**Measurement Interval:** *The finite and contiguous time period, after the Tested Storage Configuration (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.*

**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. Comment: Steady Stated is achieved only after caches in the TSC have filled and as a result the I/O Request throughput of the TSC has stabilized.*

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

**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.*

**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 Figure 5-1 below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.*

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

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

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 Tests may be executed in any sequence.

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 5.4.2.1

*The Sustainability Test Phase consists of one Test Run at the 100% load point with a Measurement Interval of three (3) hours. The intent is to demonstrate a sustained maximum I/O Request Throughput as well as insuring the Tested Storage Configuration (TSC) has reached steady state prior to measuring the maximum I/O Request Throughput (SPC-1™ IOPS).*

*The reported I/O Request Throughput of the Sustainability Test Run must be within 5% of the reported SPC-1™ IOPS primary metric. The Average Response Time measured in Sustainability Test Run cannot exceed thirty (30) milliseconds.*

### Clause 9.2.4.7.1

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

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

## SPC-1 Workload Generator Input Parameters

The following script containing SPC-1 Workload Generator input parameters was used for the Sustainability, IOPS, and Response Time Ramp Test Runs :

```
export CLASSPATH=.
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaopts.cfg metrics -b 890
```

The “javaopts.cfg” file contain the following Java parameters:

```
-Xms384m -Xmx768m -Xss1024k -Xgcpolicy:optavgpause
```

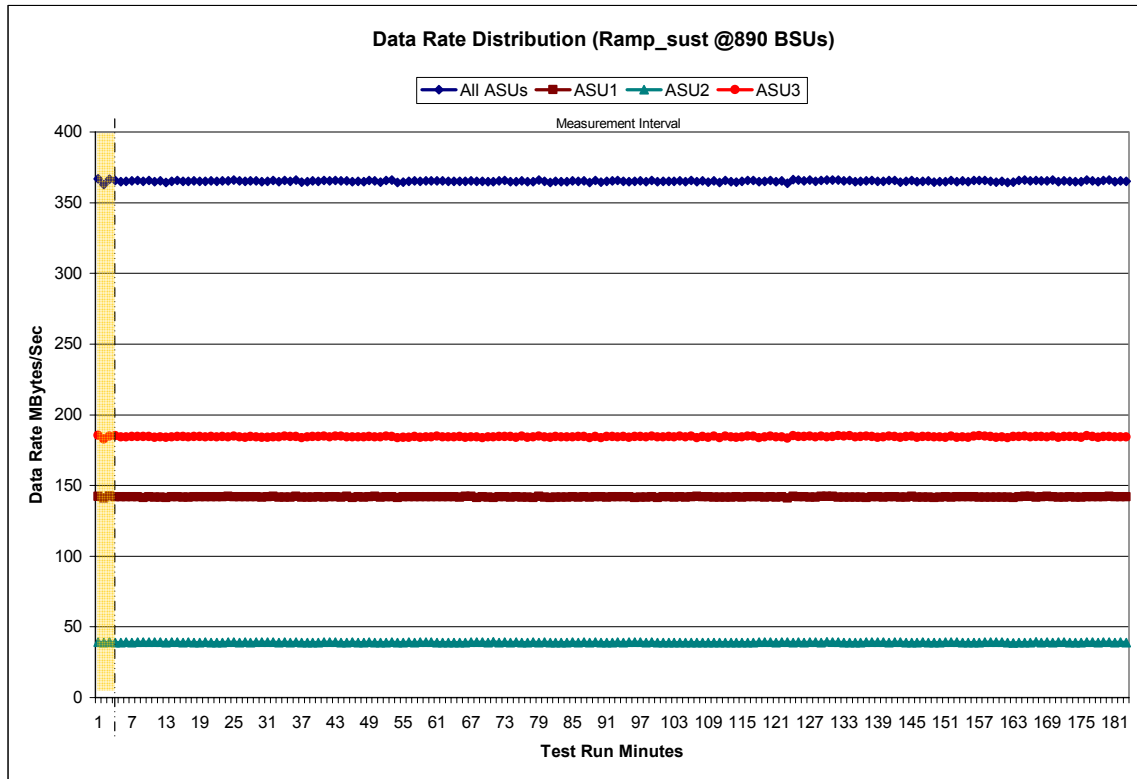
## Sustainability Test Results File

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

[Sustainability Test Results File](#)

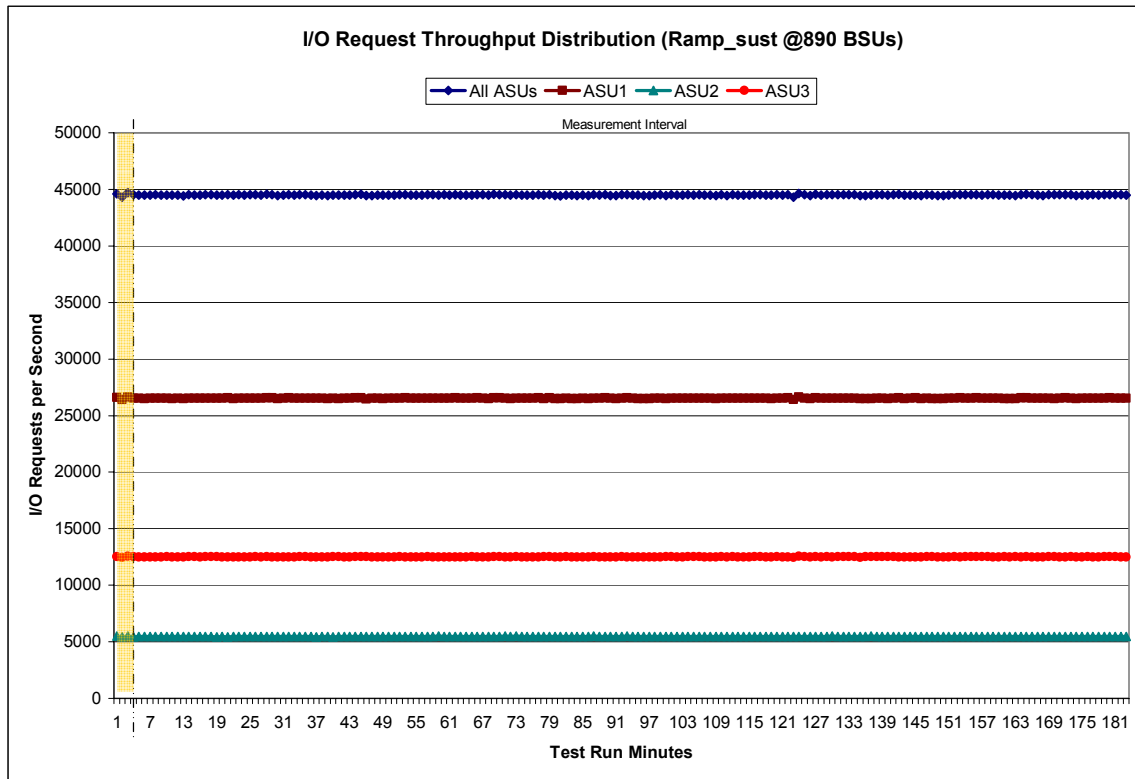


### Sustainability – Data Rate Distribution Graph





### Sustainability – I/O Request Throughput Distribution Graph



### Sustainability – Measured Intensity Multiplier and Coefficient of Variation

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

**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.

**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%.

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



## Primary Metrics Test – IOPS Test Phase

### Clause 5.4.2.2

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

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

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

### Clause 9.2.4.7.2

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

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

## SPC-1 Workload Generator Input Parameters

The following script containing SPC-1 Workload Generator input parameters was used for the Sustainability, IOPS, and Response Time Ramp Test Runs :

```
export CLASSPATH=.
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaopts.cfg metrics -b 890
```

The “javaopts.cfg” file contain the following Java parameters:

```
-Xms384m -Xmx768m -Xss1024k -Xgcpolicy:optavgpause
```

## IOPS Test Results File

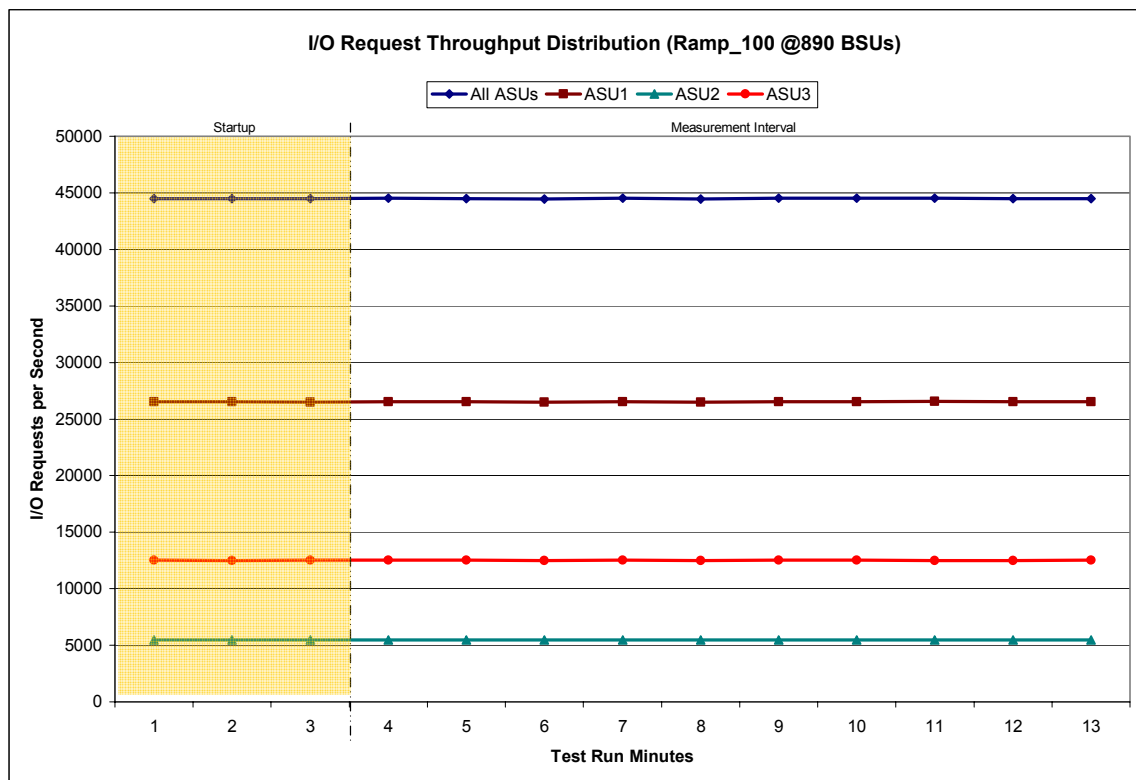
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

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

890 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	10:37:21	10:40:22	0-2	0:03:01
<i>Measurement Interval</i>	10:40:22	10:50:22	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	44,508.22	26,519.47	5,476.05	12,512.70
1	44,479.43	26,522.47	5,482.95	12,474.02
2	44,491.77	26,482.77	5,481.75	12,527.25
3	44,534.13	26,538.82	5,464.50	12,530.82
4	44,509.23	26,516.30	5,464.15	12,528.78
5	44,450.40	26,479.42	5,478.88	12,492.10
6	44,525.92	26,539.65	5,475.47	12,510.80
7	44,467.05	26,495.13	5,468.62	12,503.30
8	44,515.83	26,525.02	5,481.52	12,509.30
9	44,527.98	26,537.63	5,477.63	12,512.72
10	44,544.55	26,557.73	5,479.42	12,507.40
11	44,499.68	26,524.15	5,479.40	12,496.13
12	44,502.47	26,519.53	5,469.23	12,513.70
<b>Average</b>	44,507.73	26,523.34	5,473.88	12,510.51

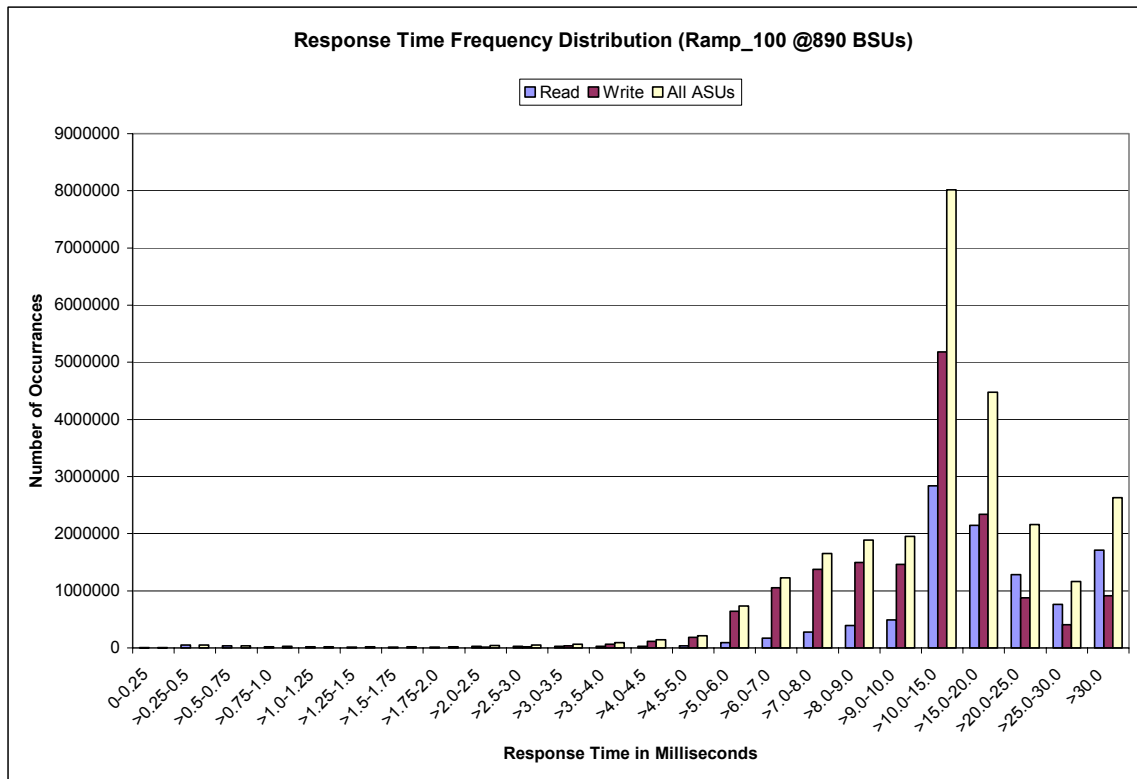
### IOPS Test Run – I/O Request Throughput Distribution Graph



**IOPS Test Run – Response Time Frequency Distribution Data**

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	9009	49,950	33,341	23,898	19,055	16,861	16,096	16,076
Write	0	293	919	1,280	1,590	2,081	2,787	3,488
All ASUs	9009	50,243	34,260	25,178	20,645	18,942	18,883	19,564
ASU1	8507	47,591	32,107	23,091	18,623	16,701	16,181	16,497
ASU2	502	2,577	1,857	1,574	1,420	1,462	1,628	1,744
ASU3	0	75	296	513	602	779	1,074	1,323
Response Time (ms)	>2.0-2.5	>2.5-3.0	>3.0-3.5	>3.5-4.0	>4.0-4.5	>4.5-5.0	>5.0-6.0	>6.0-7.0
Read	31,357	30,661	29,180	27,946	28,533	32,425	94,460	170,587
Write	10,930	19,584	36,480	66,291	113,506	182,276	641,593	1,054,015
All ASUs	42,287	50,245	65,660	94,237	142,039	214,701	736,053	1,224,602
ASU1	34,214	37,776	44,517	58,512	82,146	119,856	400,400	661,937
ASU2	4,041	5,288	7,653	11,423	17,293	26,115	89,383	147,226
ASU3	4,032	7,181	13,490	24,302	42,600	68,730	246,270	415,439
Response Time (ms)	>7.0-8.0	>8.0-9.0	>9.0-10.0	>10.0-15.0	>15.0-20.0	>20.0-25.0	>25.0-30.0	>30.0
Read	277,486	393,939	491,421	2,837,930	2,141,545	1,279,571	761,629	1,711,885
Write	1,372,939	1,496,179	1,463,150	5,178,093	2,334,191	879,435	402,992	914,686
All ASUs	1,650,425	1,890,118	1,954,571	8,016,023	4,475,736	2,159,006	1,164,621	2,626,571
ASU1	896,030	1,038,705	1,089,782	4,647,967	2,707,817	1,368,231	770,268	1,775,892
ASU2	196,598	223,843	232,232	963,647	553,241	276,823	154,820	361,812
ASU3	557,797	627,570	632,557	2,404,409	1,214,678	513,952	239,533	488,867

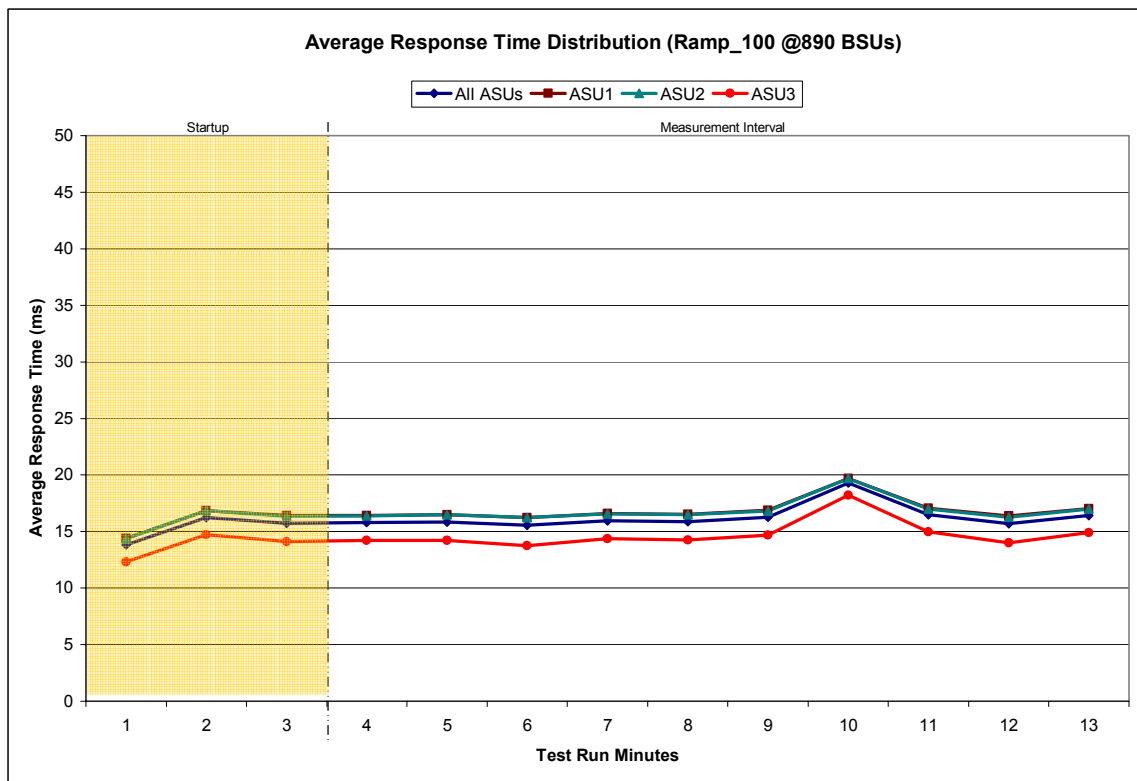
**IOPS Test Run –Response Time Frequency Distribution Graph**



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

890 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	10:37:21	10:40:22	0-2	0:03:01
<i>Measurement Interval</i>	10:40:22	10:50:22	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	13.81	14.41	14.35	12.31
1	16.25	16.85	16.85	14.71
2	15.75	16.40	16.34	14.10
3	15.80	16.42	16.38	14.23
4	15.86	16.50	16.48	14.21
5	15.54	16.24	16.22	13.76
6	15.95	16.58	16.54	14.35
7	15.88	16.54	16.48	14.24
8	16.25	16.88	16.80	14.69
9	19.28	19.70	19.69	18.21
10	16.47	17.07	17.00	14.97
11	15.70	16.38	16.27	14.00
12	16.43	17.04	17.01	14.89
<b>Average</b>	16.32	16.94	16.89	14.76

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



### IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
26,703,619	24,077,048	2,626,571

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2810	0.0700	0.2099	0.0180	0.0700	0.0350	0.2811
COV	0.002	0.001	0.003	0.001	0.005	0.001	0.004	0.001

**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.

**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%.

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

## Primary Metrics Test – Response Time Ramp Test Phase

### Clause 5.4.2.3

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

*The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 11.*

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

### Clause 9.2.4.7.3

*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 following script containing SPC-1 Workload Generator input parameters was used for the Sustainability, IOPS, and Response Time Ramp Test Runs :

```
export CLASSPATH=  
export IBM_JAVADUMP_OUTOFMEMORY=false  
export IBM_HEAPDUMP_OUTOFMEMORY=false  
java -Xoptionsfile=javaopts.cfg metrics -b 890
```

The “javaopts.cfg” file contain the following Java parameters:

```
-Xms384m -Xmx768m -Xss1024k -Xgcpolicy:optavgpause
```

## Response Time Ramp Test Results File

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

[95% Load Level](#)

[90% Load Level](#)

[80% Load Level](#)

[50% Load Level](#)

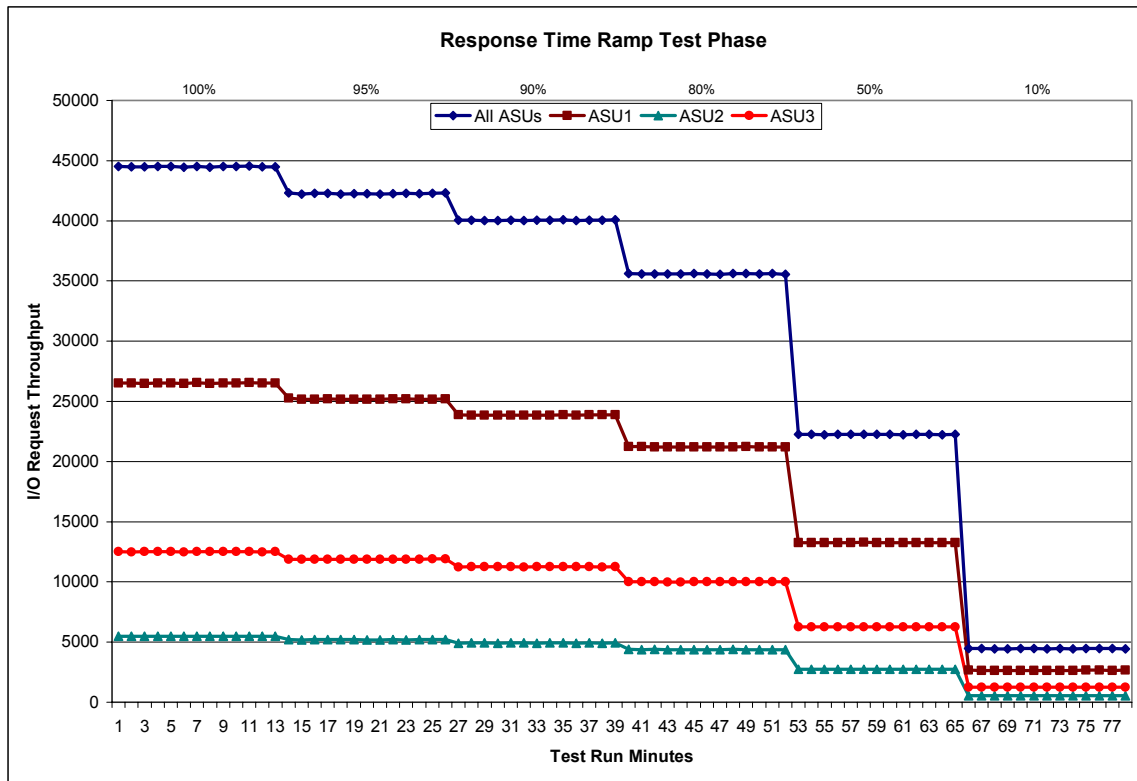
[10% Load Level](#)

**Response Time Ramp Distribution (IOPS) Data**

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

100% Load Level - 890 BSUs					95% Load Level - 845 BSUs				
Start	Stop	Interval	Duration		Start	Stop	Interval	Duration	
10:37:21	10:40:22	0-2	0:03:01		10:50:38	10:53:39	0-2	0:03:01	
<b>Start-Up/Ramp-Up Measurement Interval</b>					<b>Start-Up/Ramp-Up Measurement Interval</b>				
10:40:22 10:50:22 3-12 0:10:00					10:53:39 11:03:39 3-12 0:10:00				
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>		<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	
0	44,508.22	26,519.47	5,476.05	12,512.70	0	42,316.77	25,260.22	5,193.02	11,863.53
1	44,479.43	26,522.47	5,482.95	12,474.02	1	42,223.08	25,165.88	5,187.27	11,869.93
2	44,491.77	26,482.77	5,481.75	12,527.25	2	42,276.20	25,181.60	5,210.47	11,884.13
3	44,534.13	26,538.82	5,464.50	12,530.82	3	42,272.62	25,187.48	5,214.68	11,870.45
4	44,509.23	26,516.30	5,464.15	12,528.78	4	42,223.07	25,163.12	5,198.23	11,861.72
5	44,450.40	26,479.42	5,478.88	12,492.10	5	42,245.77	25,163.20	5,217.85	11,864.72
6	44,525.92	26,539.65	5,475.47	12,510.80	6	42,239.13	25,170.25	5,179.78	11,889.10
7	44,467.05	26,495.13	5,468.62	12,503.30	7	42,220.18	25,161.80	5,186.67	11,871.72
8	44,515.83	26,525.02	5,481.52	12,509.30	8	42,250.80	25,187.20	5,194.72	11,868.88
9	44,527.98	26,537.63	5,477.63	12,512.72	9	42,280.63	25,203.40	5,190.40	11,886.83
10	44,544.55	26,557.73	5,479.42	12,507.40	10	42,266.32	25,181.02	5,202.38	11,882.92
11	44,499.68	26,524.15	5,479.40	12,496.13	11	42,283.33	25,176.62	5,214.72	11,892.00
12	44,502.47	26,519.53	5,469.23	12,513.70	12	42,304.80	25,211.55	5,192.98	11,900.27
<b>Average</b>	<b>44,507.73</b>	<b>26,523.34</b>	<b>5,473.88</b>	<b>12,510.51</b>	<b>Average</b>	<b>42,258.67</b>	<b>25,180.56</b>	<b>5,199.24</b>	<b>11,878.86</b>
90% Load Level - 801 BSUs					80% Load Level - 712 BSUs				
11:03:55	11:06:56	0-2	0:03:01		11:17:11	11:20:12	0-2	0:03:01	
<b>Start-Up/Ramp-Up Measurement Interval</b>					<b>Start-Up/Ramp-Up Measurement Interval</b>				
11:06:56 11:16:56 3-12 0:10:00					11:20:12 11:30:12 3-12 0:10:00				
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>		<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	
0	40,053.08	23,885.10	4,921.93	11,246.05	0	35,637.15	21,237.42	4,384.40	10,015.33
1	40,043.68	23,853.77	4,929.22	11,260.70	1	35,604.03	21,231.75	4,372.10	10,000.18
2	40,035.37	23,854.93	4,926.40	11,254.03	2	35,582.40	21,201.78	4,382.37	9,998.25
3	40,023.60	23,851.95	4,911.25	11,260.40	3	35,587.23	21,223.80	4,377.55	9,985.88
4	40,044.73	23,855.40	4,931.38	11,257.95	4	35,574.98	21,204.95	4,379.77	9,990.27
5	40,035.32	23,863.55	4,933.83	11,237.93	5	35,613.12	21,218.62	4,369.40	10,025.10
6	40,037.75	23,852.57	4,919.55	11,265.63	6	35,577.87	21,201.75	4,373.78	10,002.33
7	40,055.93	23,856.45	4,922.35	11,277.13	7	35,564.48	21,194.98	4,372.58	9,996.92
8	40,088.47	23,891.78	4,946.05	11,250.63	8	35,611.05	21,224.13	4,381.65	10,005.27
9	40,023.33	23,852.87	4,917.37	11,253.10	9	35,618.48	21,231.37	4,371.95	10,015.17
10	40,067.63	23,872.60	4,932.55	11,262.48	10	35,595.27	21,209.98	4,373.82	10,011.47
11	40,063.48	23,898.67	4,921.02	11,243.80	11	35,608.30	21,222.33	4,380.57	10,005.40
12	40,073.93	23,881.95	4,925.55	11,266.43	12	35,561.22	21,200.43	4,361.55	9,999.23
<b>Average</b>	<b>40,051.42</b>	<b>23,867.78</b>	<b>4,926.09</b>	<b>11,257.55</b>	<b>Average</b>	<b>35,591.20</b>	<b>21,213.24</b>	<b>4,374.26</b>	<b>10,003.70</b>
50% Load Level - 445 BSUs					10% Load Level - 89 BSUs				
11:30:26	11:33:27	0-2	0:03:01		11:43:38	11:46:39	0-2	0:03:01	
<b>Start-Up/Ramp-Up Measurement Interval</b>					<b>Start-Up/Ramp-Up Measurement Interval</b>				
11:33:27 11:43:27 3-12 0:10:00					11:46:39 11:56:39 3-12 0:10:00				
<i>(60 second intervals)</i>					<i>(60 second intervals)</i>				
<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>		<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	
0	22,246.87	13,258.57	2,728.78	6,259.52	0	4,457.67	2,656.68	551.85	1,249.13
1	22,263.23	13,263.27	2,735.93	6,264.03	1	4,456.30	2,651.67	544.63	1,260.00
2	22,230.27	13,251.50	2,730.77	6,248.00	2	4,447.78	2,652.72	548.00	1,247.07
3	22,253.25	13,272.67	2,729.85	6,250.73	3	4,430.35	2,632.42	547.05	1,250.88
4	22,256.97	13,270.48	2,732.30	6,254.18	4	4,452.13	2,650.20	547.48	1,254.45
5	22,269.65	13,279.18	2,736.37	6,254.10	5	4,455.20	2,654.82	546.18	1,254.20
6	22,264.48	13,275.02	2,733.37	6,256.10	6	4,446.02	2,645.07	545.18	1,255.77
7	22,262.85	13,272.78	2,738.08	6,251.98	7	4,449.52	2,651.77	548.27	1,249.48
8	22,239.33	13,254.57	2,733.37	6,251.40	8	4,447.00	2,651.35	548.48	1,247.17
9	22,258.22	13,265.43	2,731.42	6,261.37	9	4,467.00	2,658.13	546.98	1,261.88
10	22,263.17	13,263.97	2,750.18	6,249.02	10	4,450.45	2,658.92	548.18	1,243.35
11	22,242.18	13,254.03	2,731.57	6,256.58	11	4,453.53	2,654.13	547.57	1,251.83
12	22,244.85	13,258.45	2,741.10	6,245.30	12	4,446.50	2,657.62	545.05	1,243.83
<b>Average</b>	<b>22,255.50</b>	<b>13,266.66</b>	<b>2,735.76</b>	<b>6,253.08</b>	<b>Average</b>	<b>4,449.77</b>	<b>2,651.44</b>	<b>547.04</b>	<b>1,251.29</b>

### Response Time Ramp Distribution (IOPS) Graph

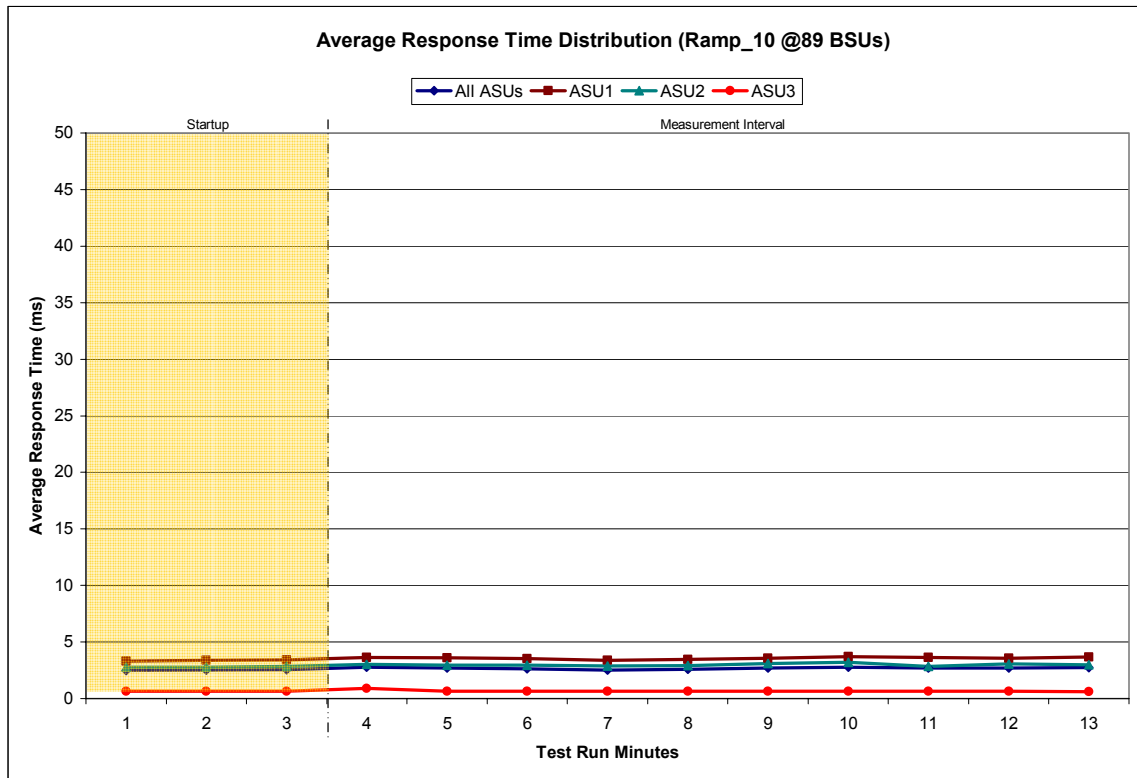




**SPC-1 LRT™ Average Response Time (ms) Distribution Data**

89 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	11:43:38	11:46:39	0-2	0:03:01
<i>Measurement Interval</i>	14:53:09	14:53:09	3-12	0:00:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.50	3.31	2.76	0.65
1	2.53	3.37	2.79	0.64
2	2.57	3.41	2.85	0.65
3	2.78	3.62	3.04	0.91
4	2.69	3.60	2.96	0.64
5	2.64	3.52	2.96	0.64
6	2.54	3.37	2.87	0.63
7	2.60	3.45	2.93	0.64
8	2.69	3.58	3.09	0.64
9	2.78	3.70	3.21	0.64
10	2.71	3.64	2.86	0.63
11	2.69	3.58	3.05	0.64
12	2.73	3.66	3.00	0.63
<b>Average</b>	2.68	3.57	3.00	0.67

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



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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<i>IM</i>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
<i>MIM</i>	0.0350	0.2809	0.0698	0.2101	0.0181	0.007	0.0349	0.2812
<i>COV</i>	0.011	0.002	0.006	0.005	0.008	0.006	0.012	0.004

***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.

***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%.

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

## Repeatability Test

### Clause 5.4.3

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

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

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

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

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

### Clause 9.2.4.7.3

*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 two Repeatability Test Phases. The content, appearance, and format of the table are specified in Table 9-11.*
- 2. An I/O Request Throughput Distribution (data and graph).*
- 3. An Average Response Time Distribution (data and graph).*
- 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 following script containing SPC-1 Workload Generator input parameters was used for the Repeatability Test Runs:

```
export CLASSPATH=.
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaopts.cfg repeat1 -b 890
java -Xoptionsfile=javaopts.cfg repeat2 -b 890
```

The “javaopts.cfg” file contain the following Java parameters:

```
-Xms384m -Xmx768m -Xss1024k -Xgcpolicy:optavgpause
```

### Repeatability Test Results File

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

	SPC-1 IOPS™	SPC-1 LRT™
<b>Primary Metrics</b>	44,507.73	2.68
<b>Repeatability Test Phase 1</b>	44,496.04	2.59
<b>Repeatability Test Phase 2</b>	4,507.05	2.72

A link to the test result file generated from each Repeatability Test Run list 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 \(IOPS\)](#)

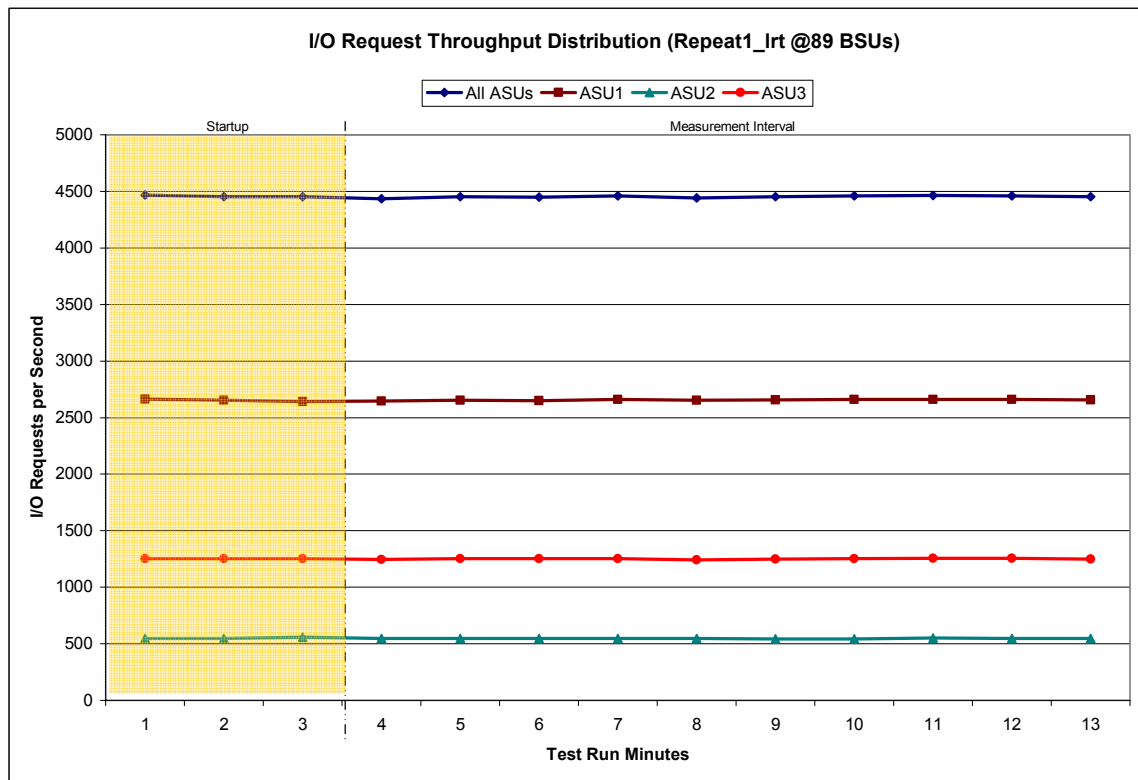
**Repeatability 1 LRT – I/O Request Throughput Distribution Data**

89 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	11:57:11	12:00:11	0-2	0:03:00
<i>Measurement Interval</i>	12:00:11	12:10:11	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	4,465.70	2,663.58	548.32	1,253.80
1	4,452.38	2,652.48	546.82	1,253.08
2	4,452.90	2,642.12	556.45	1,254.33
3	4,435.85	2,644.55	547.30	1,244.00
4	4,453.65	2,652.47	547.67	1,253.52
5	4,448.80	2,650.58	546.45	1,251.77
6	4,459.23	2,658.43	547.92	1,252.88
7	4,441.88	2,651.97	547.42	1,242.50
8	4,451.35	2,657.50	544.95	1,248.90
9	4,459.50	2,661.07	544.55	1,253.88
10	4,464.92	2,660.90	549.10	1,254.92
11	4,459.95	2,658.50	546.07	1,255.38
12	4,452.73	2,656.98	547.57	1,248.18
<b>Average</b>	<b>4,452.79</b>	<b>2,655.30</b>	<b>546.90</b>	<b>1,250.59</b>

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



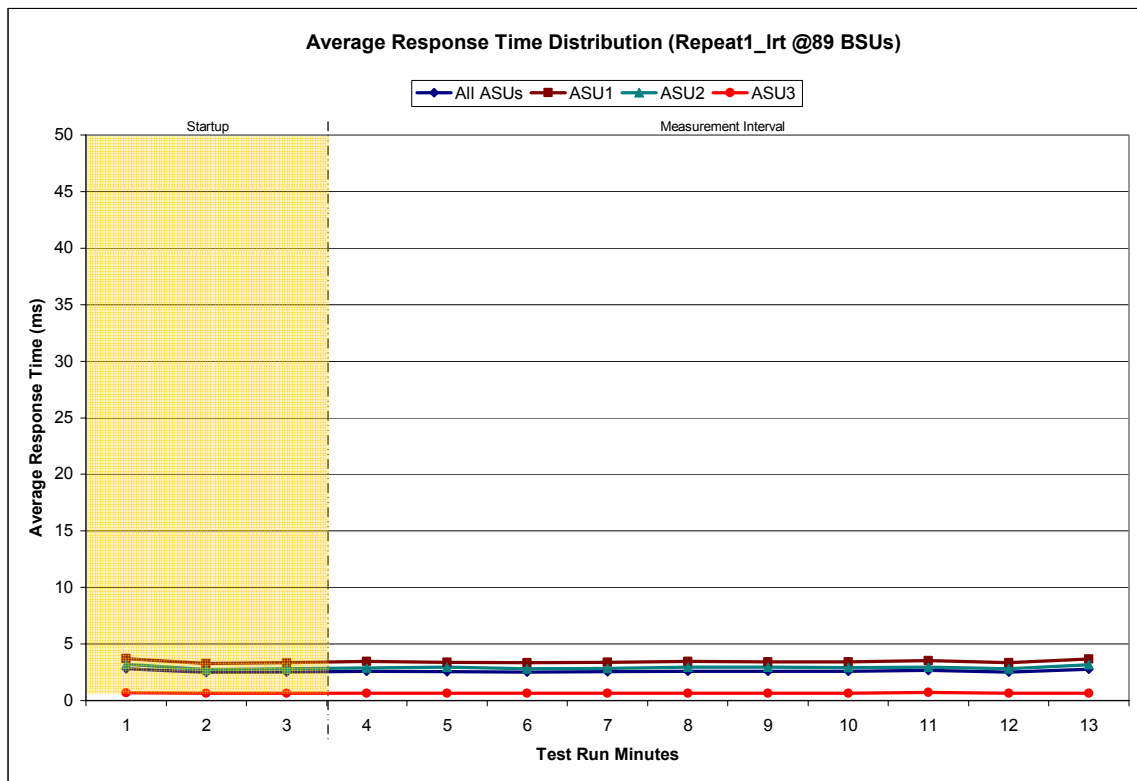
**Repeatability 1 LRT –Average Response Time (ms) Distribution Data**

89 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	11:57:11	12:00:11	0-2	0:03:00
<i>Measurement Interval</i>	12:00:11	12:10:11	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.80	3.71	3.20	0.69
1	2.48	3.29	2.74	0.64
2	2.52	3.34	2.83	0.64
3	2.60	3.47	2.89	0.63
4	2.57	3.40	2.94	0.65
5	2.51	3.34	2.80	0.64
6	2.55	3.40	2.84	0.63
7	2.61	3.46	2.94	0.63
8	2.58	3.42	2.93	0.64
9	2.58	3.42	2.93	0.64
10	2.65	3.51	2.95	0.71
11	2.52	3.35	2.81	0.65
12	2.76	3.68	3.17	0.64
<b>Average</b>	2.59	3.44	2.92	0.65

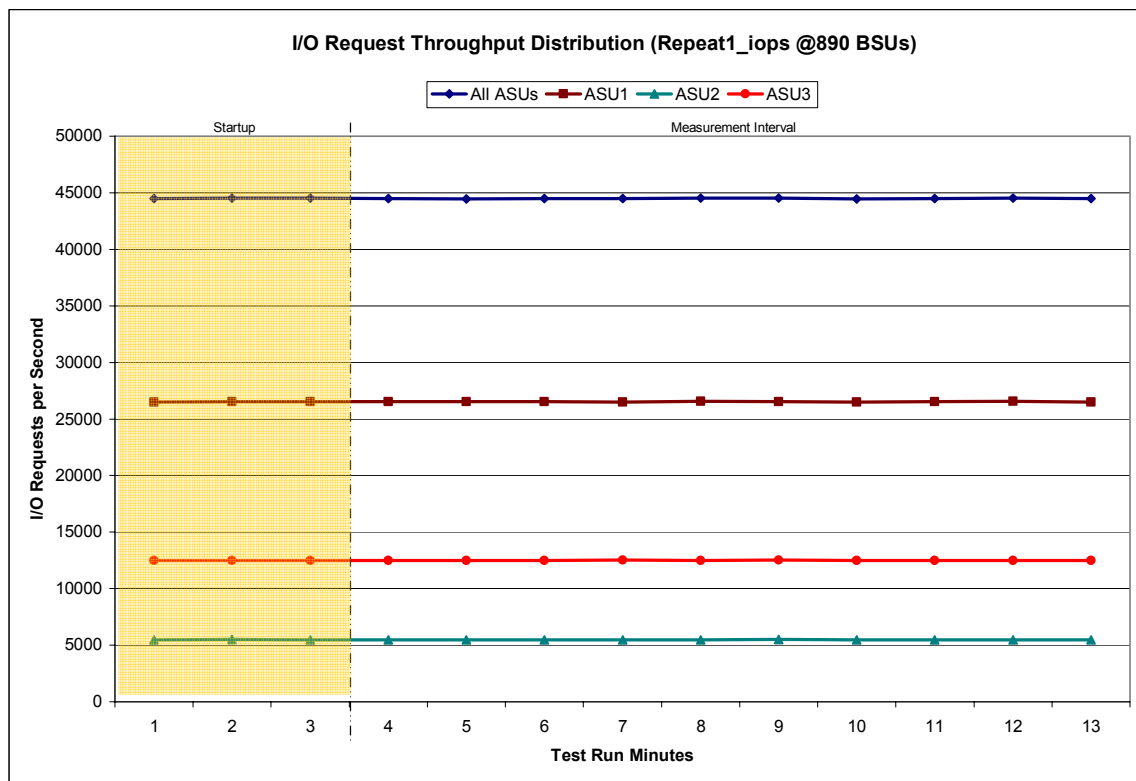
**Repeatability 1 LRT –Average Response Time (ms) Distribution Graph**



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

890 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	12:10:31	12:13:32	0-2	0:03:01
<i>Measurement Interval</i>	12:13:32	12:23:32	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	44,481.77	26,495.33	5,481.03	12,505.40
1	44,515.87	26,533.17	5,491.52	12,491.18
2	44,511.75	26,520.55	5,485.10	12,506.10
3	44,482.95	26,517.77	5,477.63	12,487.55
4	44,462.75	26,515.12	5,461.13	12,486.50
5	44,474.98	26,512.90	5,480.30	12,481.78
6	44,494.47	26,488.00	5,478.23	12,528.23
7	44,538.05	26,557.40	5,482.23	12,498.42
8	44,524.90	26,521.52	5,489.65	12,513.73
9	44,464.40	26,487.23	5,476.52	12,500.65
10	44,493.28	26,534.77	5,462.87	12,495.65
11	44,526.28	26,558.98	5,479.60	12,487.70
12	44,498.37	26,505.37	5,485.37	12,507.63
<b>Average</b>	44,496.04	26,519.91	5,477.35	12,498.79

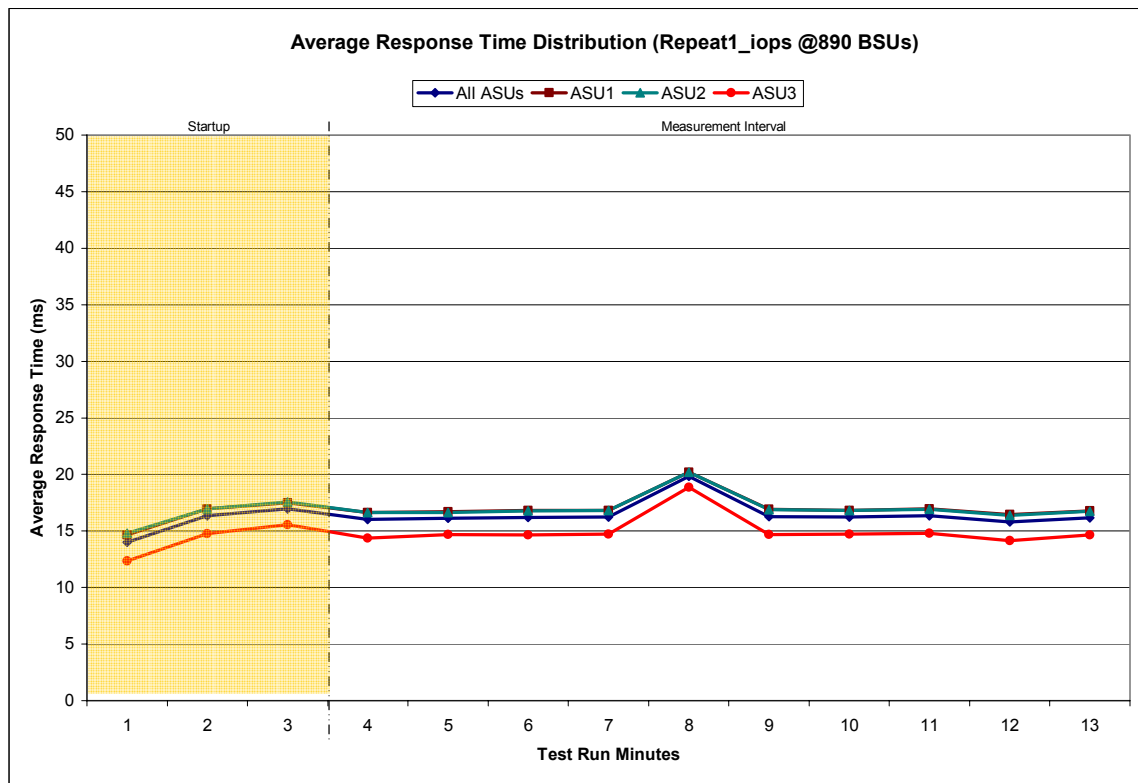
**Repeatability 1 IOPS – I/O Request Throughput Distribution Graph**



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

890 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	12:10:31	12:13:32	0-2	0:03:01
<i>Measurement Interval</i>	12:13:32	12:23:32	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	14.01	14.63	14.80	12.36
1	16.35	16.97	16.97	14.76
2	16.95	17.49	17.57	15.53
3	16.00	16.64	16.64	14.37
4	16.12	16.69	16.62	14.68
5	16.19	16.80	16.76	14.65
6	16.22	16.81	16.82	14.73
7	19.82	20.20	20.21	18.85
8	16.28	16.91	16.89	14.69
9	16.22	16.82	16.81	14.71
10	16.34	16.95	16.90	14.81
11	15.81	16.46	16.39	14.16
12	16.17	16.77	16.74	14.64
<b>Average</b>	16.52	17.10	17.08	15.03

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

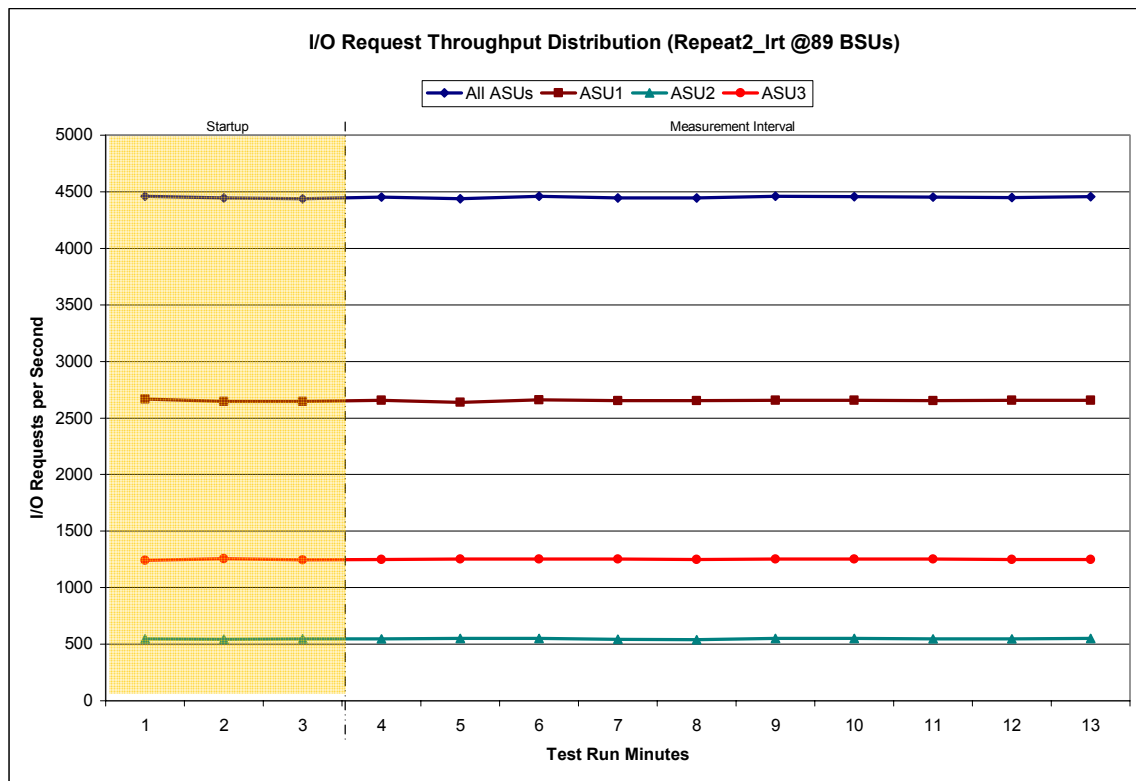




**Repeatability 2 LRT – I/O Request Throughput Distribution Data**

89 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	12:24:05	12:27:05	0-2	0:03:00
<i>Measurement Interval</i>	12:27:05	12:37:05	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	4,460.32	2,668.37	548.72	1,243.23
1	4,445.90	2,645.33	542.52	1,258.05
2	4,437.17	2,645.03	546.07	1,246.07
3	4,454.50	2,656.10	547.87	1,250.53
4	4,440.23	2,639.50	549.18	1,251.55
5	4,460.02	2,658.83	548.98	1,252.20
6	4,447.42	2,653.63	542.68	1,251.10
7	4,444.45	2,653.22	541.55	1,249.68
8	4,460.52	2,655.83	550.68	1,254.00
9	4,457.87	2,655.07	551.83	1,250.97
10	4,453.07	2,652.08	547.02	1,253.97
11	4,449.88	2,655.28	545.87	1,248.73
12	4,455.90	2,655.13	551.42	1,249.35
<b>Average</b>	4,452.39	2,653.47	547.71	1,251.21

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



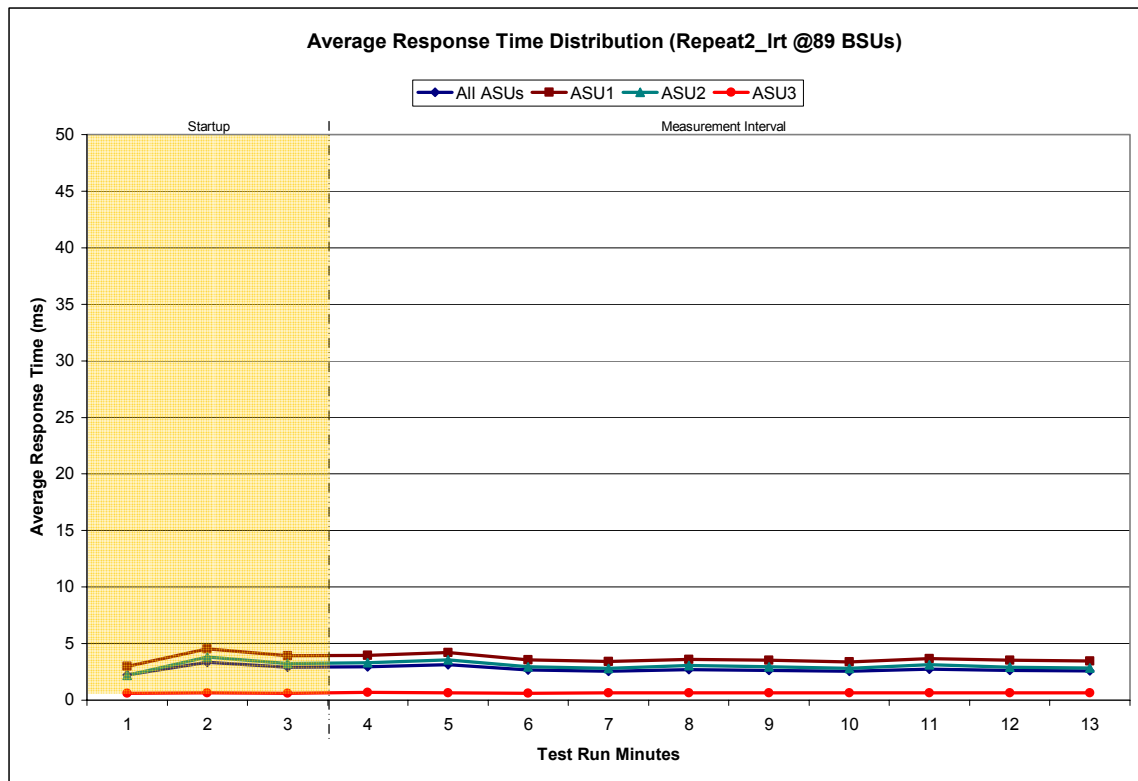
**Repeatability 2 LRT –Average Response Time (ms) Distribution Data**

89 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	12:24:05	12:27:05	0-2	0:03:00
<i>Measurement Interval</i>	12:27:05	12:37:05	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.24	3.00	2.20	0.62
1	3.34	4.52	3.81	0.63
2	2.92	3.94	3.23	0.62
3	2.97	3.97	3.32	0.69
4	3.13	4.21	3.58	0.65
5	2.66	3.56	2.95	0.63
6	2.55	3.40	2.80	0.64
7	2.70	3.59	3.06	0.63
8	2.63	3.51	2.94	0.65
9	2.55	3.40	2.80	0.63
10	2.74	3.66	3.12	0.64
11	2.64	3.54	2.90	0.64
12	2.59	3.46	2.85	0.64
<b>Average</b>	<b>2.72</b>	<b>3.63</b>	<b>3.03</b>	<b>0.64</b>

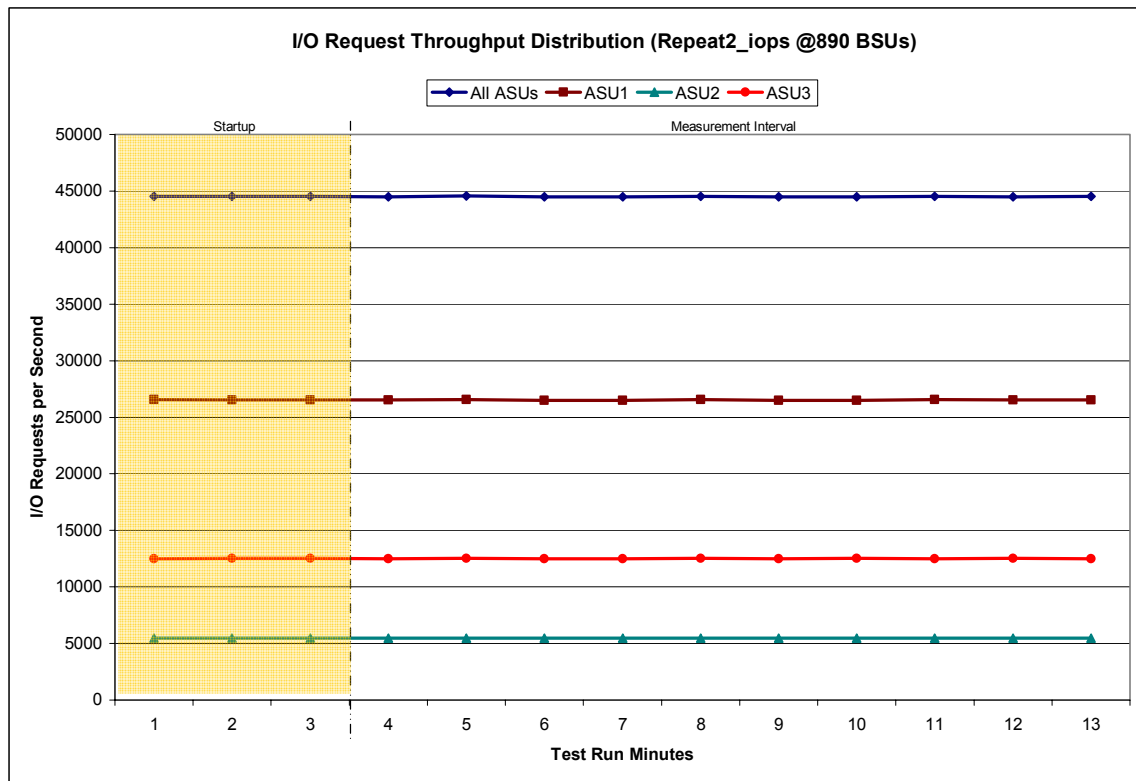
**Repeatability 2 LRT –Average Response Time (ms) Distribution Graph**



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

890 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	12:37:25	12:40:26	0-2	0:03:01
<i>Measurement Interval</i>	12:40:26	12:50:26	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	44,539.73	26,558.30	5,477.47	12,503.97
1	44,519.90	26,514.03	5,488.37	12,517.50
2	44,545.03	26,537.37	5,477.97	12,529.70
3	44,506.48	26,515.08	5,485.18	12,506.22
4	44,548.58	26,556.68	5,480.92	12,510.98
5	44,482.20	26,506.50	5,486.62	12,489.08
6	44,474.85	26,502.07	5,475.55	12,497.23
7	44,534.22	26,549.80	5,465.82	12,518.60
8	44,477.60	26,506.12	5,465.80	12,505.68
9	44,493.70	26,503.18	5,473.25	12,517.27
10	44,526.32	26,554.22	5,481.97	12,490.13
11	44,506.72	26,517.87	5,475.28	12,513.57
12	44,519.78	26,547.80	5,463.50	12,508.48
<b>Average</b>	<b>44,507.05</b>	<b>26,525.93</b>	<b>5,475.39</b>	<b>12,505.73</b>

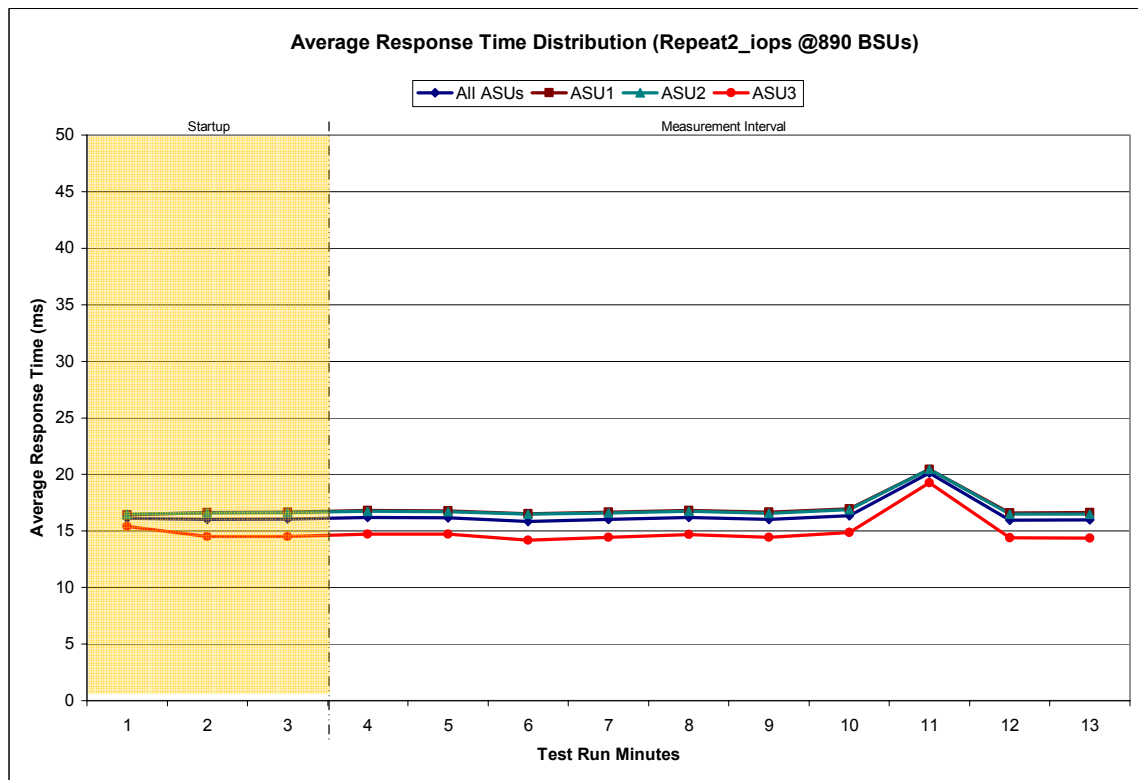
**Repeatability 2 IOPS – I/O Request Throughput Distribution Graph**



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

890 BSUs		Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>		12:37:25	12:40:26	0-2	0:03:01
<i>Measurement Interval</i>		12:40:26	12:50:26	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3	
0	16.13	16.41	16.48	15.39	
1	16.03	16.63	16.58	14.51	
2	16.05	16.67	16.61	14.49	
3	16.21	16.79	16.73	14.73	
4	16.18	16.77	16.71	14.71	
5	15.85	16.51	16.47	14.19	
6	16.02	16.65	16.59	14.42	
7	16.21	16.81	16.75	14.70	
8	16.02	16.65	16.57	14.44	
9	16.36	16.96	16.89	14.87	
10	20.11	20.44	20.43	19.27	
11	15.96	16.60	16.48	14.38	
12	15.98	16.63	16.50	14.38	
<b>Average</b>	16.49	17.08	17.01	15.01	

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



**Repeatability 1 (LRT)**

**Measured Intensity Multiplier and Coefficient of Variation**

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0351	0.2812	0.0701	0.2099	0.0178	0.0700	0.0350	0.2809
COV	0.008	0.004	0.009	0.003	0.013	0.007	0.009	0.002

**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.

**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%.

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

**Repeatability 1 (IOPS)**

**Measured Intensity Multiplier and Coefficient of Variation**

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

**Repeatability 2 (LRT)**

**Measured Intensity Multiplier and Coefficient of Variation**

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0351	0.2809	0.0699	0.2101	0.0180	0.0701	0.0349	0.2810
COV	0.010	0.003	0.005	0.004	0.014	0.009	0.014	0.002

**Repeatability 2 (IOPS)**

**Measured Intensity Multiplier and Coefficient of Variation**

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2811	0.0700	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.001	0.001	0.005	0.002	0.003	0.001

## Data Persistence Test

### Clause 6

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

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

*The SPC-1 Workload Generator will write 16 block I/O requests at random over the total Addressable Storage Capacity of the TSC for ten (10) minutes at a minimum of 25% of the load used to generate the SPC-1 IOP™ 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 Benchmark Configuration 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 9.2.4.8

*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, able 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 scripts containing SPC-1 Workload Generator input parameters for the Data Persistence Test are listed below:

```
export CLASSPATH=.
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaoptsp.cfg persist1 -b 890

export CLASSPATH=.
export IBM_JAVADUMP_OUTOFMEMORY=false
export IBM_HEAPDUMP_OUTOFMEMORY=false
java -Xoptionsfile=javaoptsp.cfg persist2
```

The “javaoptsp.cfg” file contain the following Java parameters:

```
-Xmx2048m -Xms384m -Xgcpolicy:optavgpause
```

## Data Persistence Test Results File

A link to each test result file generated from each Data Persistence Test is listed below.

[Persistence 1 Test Results File](#)

[Persistence 2 Test Results File](#)

### Data Persistence Test Results

Data Persistence Test Results	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	106,605,448
Total Number of Logical Blocks Verified	86,459,136
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in Bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

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

## **PRICED STORAGE CONFIGURATION AVAILABILITY DATE**

### **Clause 9.2.4.9**

*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 must be the date at which all components are committed to be available.*

*The FDR shall state: "The Priced Storage Configuration, as documented in this Full Disclosure Report will be available for shipment to customers on MMMM DD, YYYY." Where Priced Storage Configuration is the TSC Configuration Name as described in Clause 9.2.4.3.3 and MMMM is the alphanumeric month, DD is the numeric day, and YYYY is the numeric year of the date that the Priced Storage Configuration, as documented, is available for shipment to customers as described above.*

The IBM TotalStorage® SAN Volume Controller 1.1.1, as documented in this Full Disclosure Report became available for customer purchase and shipment on July 25, 2003.

## **PRICING INFORMATION**

### **Clause 9.2.4.11**

*A statement of the respective calculations for pricing must be included.*

Pricing information may found in the Tested Storage Configuration Pricing section on page 12.

## **ANOMALIES OR IRREGULARITIES**

### **Clause 9.2.4.10**

*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 TotalStorage® SAN Volume Controller 1.1.1.



## **APPENDIX A: CUSTOMER TUNABLE PARAMETERS AND OPTIONS**

The AIX queue depth was set to 128 via the following script:

```
#setq128.sh: sets queue depths to 128
for h in $hlist
do
chdev -l hdisk$h -a queue_depth=128
done
```

The SVC extent size was set to 256 MiB (268.435 MB).

## **APPENDIX B: TESTED STORAGE CONFIGURATION (TSC) CREATION**

### **Configuring the TotalStorage® SAN Volume Controller (SVC)**

#### **Define the available SVC-to-host path:**

```
#defines host paths.
#$VCreq svctask mkhost -force -name Cfcs10 -hbawwpn 10000000C92BA46C
#$VCreq svctask mkhost -force -name Cfcs11 -hbawwpn 10000000C92BA5E5
#$VCreq svctask mkhost -force -name Cfcs6 -hbawwpn 10000000C92B9E13
#$VCreq svctask mkhost -force -name Cfcs7 -hbawwpn 10000000C92BB4D5
#$VCreq svctask mkhost -force -name Cfcs2 -hbawwpn 10000000C92BB57C
#$VCreq svctask mkhost -force -name Cfcs3 -hbawwpn 10000000C92A950C
#$VCreq svctask mkhost -force -name Cfcs13 -hbawwpn 10000000C92BB525
#$VCreq svctask mkhost -force -name Cfcs14 -hbawwpn 10000000C92F86E4

$VCreq svctask mkhost -force -name Cfcs8 -hbawwpn 10000000C92BB5D4
$VCreq svctask mkhost -force -name Cfcs4 -hbawwpn 10000000C92BB50F
$VCreq svctask mkhost -force -name Cfcs0 -hbawwpn 10000000C92BA597
$VCreq svctask mkhost -force -name Cfcs12 -hbawwpn 10000000C92B9FDE
```

#### **Define the underlying storage available to the SVC:**

```
#makes an mdisk group, extent size 512MB (RAID-5)
#           256MB (RAID-10)
$VCreq svctask mkmdiskgrp -name thebiggroup -ext 256 -mdisk \
md0:md1:md2:md3:md4:md5:md6:md7:md8:md9:md10:md11
```

#### **Define the volumes presented to AIX:**

```
#makes 24 vdisks, size 797 extents of 512 MB each = req of 408000 MB (RAID-5)
#           256 MB each = req of 204000 MB (RAID-10)
next=0
ioset=0
while [ $next -le 11 ]
do
    let nextnode="2 - ( $next % 2 )"
    $VCreq svctask mkvdisk -size 204000 -unit mb -mdiskgrp thebiggroup -iogrp $ioset \
        -name vd$next -node lode$nextnode
    echo $next $ioset $nextnode
    let next="$next + 1"
done

ioset=1
while [ $next -le 23 ]
do
    let nextnode="4 - ( $next % 2 )"
    $VCreq svctask mkvdisk -size 204000 -unit mb -mdiskgrp thebiggroup -iogrp $ioset \
        -name vd$next -node lode$nextnode
    echo $next $ioset $nextnode
    let next="$next + 1"
done
```

**Define which paths are used for which volumes:**

```
./maplist.sh Cfcs10 0 23 12  
./maplist.sh Cfcs10 1 23 12  
./maplist.sh Cfcs11 0 23 12  
./maplist.sh Cfcs11 1 23 12
```

```
./maplist.sh Cfcs6 2 23 12  
./maplist.sh Cfcs6 3 23 12  
./maplist.sh Cfcs7 2 23 12  
./maplist.sh Cfcs7 3 23 12
```

```
./maplist.sh Cfcs2 4 23 12  
./maplist.sh Cfcs2 5 23 12  
./maplist.sh Cfcs3 4 23 12  
./maplist.sh Cfcs3 5 23 12
```

```
./maplist.sh Cfcs13 6 23 12  
./maplist.sh Cfcs13 7 23 12  
./maplist.sh Cfcs14 6 23 12  
./maplist.sh Cfcs14 7 23 12
```

```
./maplist.sh Cfcs8 8 23 12  
./maplist.sh Cfcs8 9 23 12  
./maplist.sh Cfcs4 8 23 12  
./maplist.sh Cfcs4 9 23 12
```

```
./maplist.sh Cfcs0 10 23 12  
./maplist.sh Cfcs0 11 23 12  
./maplist.sh Cfcs12 10 23 12  
./maplist.sh Cfcs12 11 23 12
```

**Invoked by the previous step as a utility:**

```
#sets vd$2 through vd$3 by $4 to use host path $1  
if [[ $# -lt 3 ]]  
then  
    echo "usage: maplist pathname startvd endvd step"  
fi  
next=$2  
while [ $next -le $3 ]  
do  
    echo vd$next $1  
    $VCreq svctask mkvdiskhostmap -force -host $1 vd$next  
    let next="$next + $4"  
done
```

## Configuring the AIX volumes

### Define variables used by other scripts:

```
#!/usr/bin/ksh
# sets lists of numbers needed for config actions
hlist=""
vfield=""
next=2
while [ $next -le 97 ]
do
hlist="$hlist $next"
let v="$next - 2"
vfield="$vfield vpath$v"
let next="$next + 1"
done

vfield=""
next=0
while [ $next -le 23 ]
do
vfield="$vfield vpath$next"
let next="$next + 1"
done

export hlist
export vfield

export pathsets="p"
```

### Discover the available storage:

```
# runs config manager on a list of fcs's
for f in fcs10 fcs11 fcs6 fcs7 fcs2 fcs3 fcs13 fcs14 fcs8 fcs4 fcs0 fcs12
do
cfgmgr -vl $f > $flist
done
```

### Define SSD vpaths:

Invoke the system management panel command:

“devices=>data path devices=>define and configure all data path devices”

### Make 60 striped logical volumes with the LVM:

```
# creates 60 logical volumes in a volume group with fine striping
# for full stroke, use -d 24 -u 24 and 312 partitions

mkvg4vp -f -y thinstripevg -d 24 -s 256 $vfield
if [[ $? -ne 0 ]] then exit; fi
for l in 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 \
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 \
41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60
do
mklv -y thin$l -x 1016 -u 24 -S 128K thinstripevg 312
done
```

## APPENDIX C: SPC-1 WORKLOAD GENERATOR STORAGE COMMANDS AND PARAMETERS

```
*javaparms="-Xms384m -Xmx768m -Xss1024k -Xgcpolicy:optavgpause"  
*host=master  
*slaves=(S1,S2,S3,S4,S5,S6,S7,S8,S9,S10)  
sd=asu1_1,lun=/dev/rthin1  
sd=asu1_2,lun=/dev/rthin2  
sd=asu1_3,lun=/dev/rthin3  
sd=asu1_4,lun=/dev/rthin4  
sd=asu1_5,lun=/dev/rthin5  
sd=asu1_6,lun=/dev/rthin6  
sd=asu1_7,lun=/dev/rthin7  
sd=asu1_8,lun=/dev/rthin8  
sd=asu1_9,lun=/dev/rthin9  
sd=asu1_10,lun=/dev/rthin10  
sd=asu1_11,lun=/dev/rthin11  
sd=asu1_12,lun=/dev/rthin12  
sd=asu1_13,lun=/dev/rthin13  
sd=asu1_14,lun=/dev/rthin14  
sd=asu1_15,lun=/dev/rthin15  
sd=asu1_16,lun=/dev/rthin16  
sd=asu1_17,lun=/dev/rthin17  
sd=asu1_18,lun=/dev/rthin18  
sd=asu1_19,lun=/dev/rthin19  
sd=asu1_20,lun=/dev/rthin20  
sd=asu1_21,lun=/dev/rthin21  
sd=asu1_22,lun=/dev/rthin22  
sd=asu1_23,lun=/dev/rthin23  
sd=asu1_24,lun=/dev/rthin24  
sd=asu1_25,lun=/dev/rthin25  
sd=asu1_26,lun=/dev/rthin26  
sd=asu1_27,lun=/dev/rthin27  
sd=asu2_1,lun=/dev/rthin28  
sd=asu2_2,lun=/dev/rthin29  
sd=asu2_3,lun=/dev/rthin30  
sd=asu2_4,lun=/dev/rthin31  
sd=asu2_5,lun=/dev/rthin32  
sd=asu2_6,lun=/dev/rthin33  
sd=asu2_7,lun=/dev/rthin34  
sd=asu2_8,lun=/dev/rthin35  
sd=asu2_9,lun=/dev/rthin36  
sd=asu2_10,lun=/dev/rthin37  
sd=asu2_11,lun=/dev/rthin38  
sd=asu2_12,lun=/dev/rthin39  
sd=asu2_13,lun=/dev/rthin40  
sd=asu2_14,lun=/dev/rthin41  
sd=asu2_15,lun=/dev/rthin42  
sd=asu2_16,lun=/dev/rthin43  
sd=asu2_17,lun=/dev/rthin44  
sd=asu2_18,lun=/dev/rthin45  
sd=asu2_19,lun=/dev/rthin46  
sd=asu2_20,lun=/dev/rthin47  
sd=asu2_21,lun=/dev/rthin48  
sd=asu2_22,lun=/dev/rthin49
```

sd=asu2\_23,lun=/dev/rthin50  
sd=asu2\_24,lun=/dev/rthin51  
sd=asu2\_25,lun=/dev/rthin52  
sd=asu2\_26,lun=/dev/rthin53  
sd=asu2\_27,lun=/dev/rthin54  
sd=asu3\_1,lun=/dev/rthin55  
sd=asu3\_2,lun=/dev/rthin56  
sd=asu3\_3,lun=/dev/rthin57  
sd=asu3\_4,lun=/dev/rthin58  
sd=asu3\_5,lun=/dev/rthin59  
sd=asu3\_6,lun=/dev/rthin60