



**SPC BENCHMARK 1™  
FULL DISCLOSURE REPORT**

**SUN MICROSYSTEMS, INC.  
SUN STOREEDGE™ 6320**

**SPC-1 V1.6**

**Submitted for Review: April 7, 2003**

**Accepted: June 5, 2003**



**First Edition – April 2003**

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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



Sun Microsystems, Inc.  
Leah Schoeb  
500 Eldorado Blvd. UBRM5-194  
Broomfield, CO 80021

April 7, 2003

The SPC Benchmark 1™ results listed below for the Sun StorEdge™ 6320 were produced in compliance with the SPC Benchmark 1™ Remote Audit requirements.

SPC Benchmark 1™ Results	
Tested Storage Configuration (TSC) Name: Sun StorEdge™ 6320	
Metric	Reported Result
SPC-1 IOPS™	25,340.29
SPC-1 Price-Performance	\$15.40/SPC-1 IOPS™
Total ASU Capacity	1,960.13 GB
Data Protection Level	Mirroring
SPC-1 LRT™	3.75 ms
Total TSC Price (including three-year maintenance)	\$390,189

The following SPC Benchmark 1™ Remote Audit requirements were verified:

- A Letter of Good Faith, signed by a senior executive on company letterhead.
- The following Data Repository storage items were remotely verified by information supplied by the Test Sponsor:
  - ✓ 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).
- Listings and commands to configure the BC/TSC.
- The type of Host System including the number of processors and main memory.

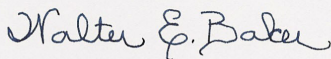
Storage Performance Council  
1060 El Camino Real, Suite F  
Redwood City, CA 94062-1623  
[AuditService@storageperformance.org](mailto:AuditService@storageperformance.org)  
650.556.9384

- 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 for each of following were authentic, accurate, and compliant:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- There were no differences between the benchmarked TSC and priced TSC.
- A final copy of the pricing spreadsheet.
- The Full Disclosure Report (FDR) meets 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  
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## **LETTER OF GOOD FAITH**

Date: 3/24/2003

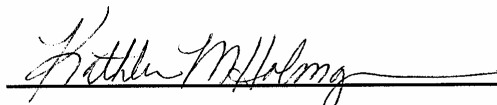
From: Kathleen Holmgren, Network Storage Marketing VP, Sun Microsystems

To: Walter Baker, SPC Auditor, Gradient System

Subject: Letter of Good Faith for the SPC Benchmark-1™ results published on the SE6320 Configuration.

This Letter of Good Faith between Sun Microsystems Corporation ("hereafter known as the Test Sponsor") and the Storage Performance Council (hereafter known as the SPC), documents that:

1. Fidelity and candor has been and will be maintained in reporting any anomalies in the SPC Benchmark-1™ results, even if not explicitly required for disclosure in the SPC Benchmark-1™ specification.
2. No attempt has been or will be made to deceive the SPC Audit Service, SPC, customers, or the public regarding the authenticity or accuracy of SPC Benchmark-1™ results on the SE6320 Configuration. As such, the SPC-1 Full Disclosure Report that will document SPC Benchmark-1™ results (per Clause 10 of the SPC Benchmark-1™ Specification) on the SE6320 Configuration is authentic and accurate.
3. The SE6320 configuration used for reporting SPC Benchmark-1™ results, as documented in the Full Disclosure Report (per Clause 10 of the SPC Benchmark-1™ Specification), has not been misrepresented to the SPC or SPC Audit Service in any way.
4. SPC Benchmark-1™ results on the SE6320 Configuration are compliant with the spirit, intent, and letter of the SPC Benchmark-1™.
5. That the SPC Benchmark-1™ results do not represent a "Benchmark Special" as documented in Clause 0.2 of the SPC Benchmark-1™ specification.



Kathleen Holmgren, Network Storage Marketing VP of Sun Microsystems

Date: 3/24/2003



## **EXECUTIVE SUMMARY**

### **Test Sponsor and Contact Information**

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### **Revision Information and Key Dates**

<b>Revision Information and Key Dates</b>	
<b>SPC-1 Specification revision number</b>	V1.6
<b>SPC-1 Workload Generator revision number</b>	V2.1
<b>Date Results were first used publicly</b>	April 7, 2003
<b>Date FDR was submitted to the SPC</b>	April 7, 2003
<b>Date the TSC is/was available for shipment to customers</b>	April 7, 2003
<b>Date the TSC completed audit certification</b>	April 4, 2003

## Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: Sun StorEdge™ 6320	
Metric	Reported Result
SPC-1 IOPS™	25,340.29
SPC-1 Price-Performance	\$15.40/SPC-1 IOPS™
Total ASU Capacity	1,960.13 GB
Data Protection Level	Mirroring
SPC-1 LRT™	3.75 ms
Total TSC Price (including three-year maintenance)	\$390,189

**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. The Addressable Storage Capacity, which contains the Total ASU Capacity, was 1,960.13 GB. The Total ASU Capacity utilized 100% of the Addressable Storage Capacity. The actual Configured Storage Capacity was 3,920.25 GB, which included the multiple copies of user data required by a Data Protection Level of Mirroring. The Configured Storage Capacity utilized 64.09% of the priced Physical Storage Capacity of 6,116.98.456 GB.

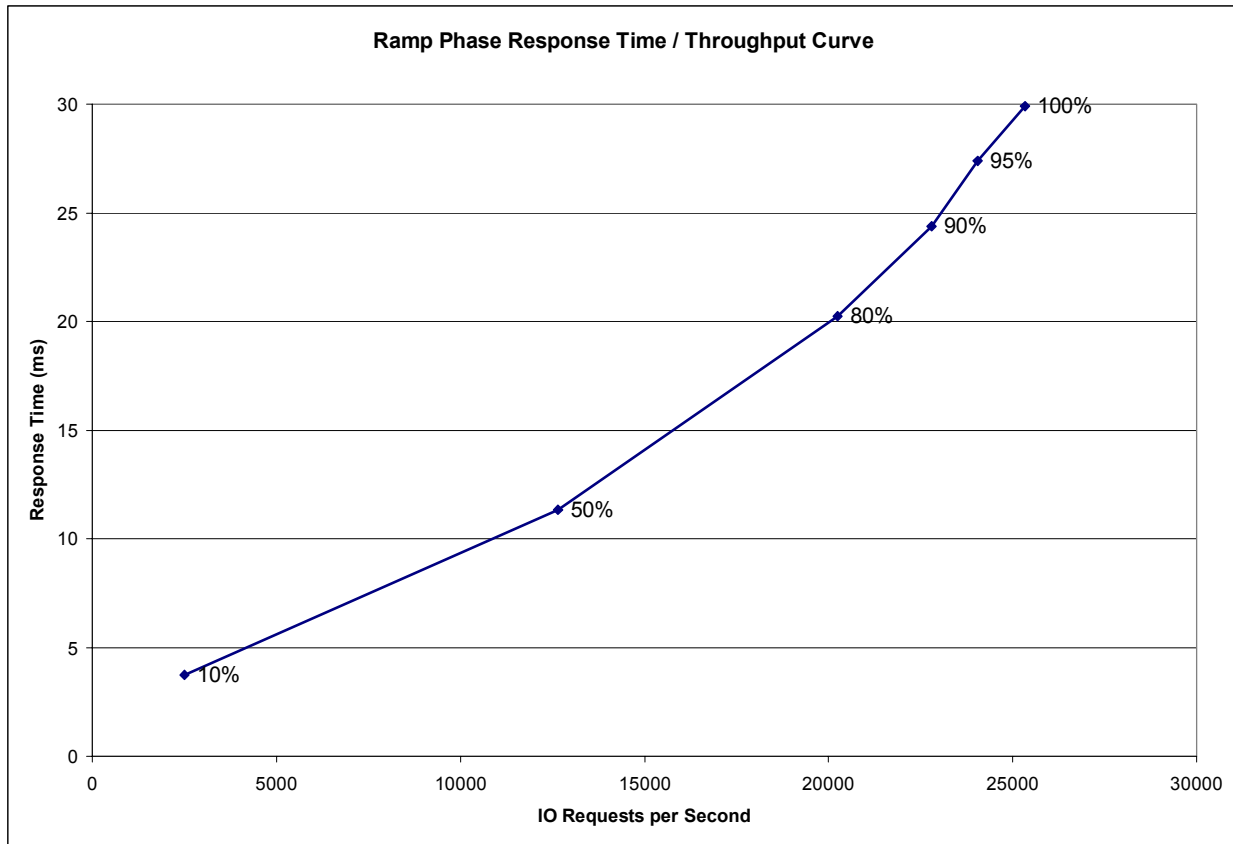
A **Data Protection Level** of Mirroring configures two or more identical copies of user data, maintained on separate disks.

The **SPC-1 LRT™** metric is the Average Response Time measured at the 10% load point, as illustrated on the next page. SPC-1 LRT™ represents the Average Response Time measured on a lightly loaded Tested Storage Configuration (TSC).

### 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 the 100% load point cannot exceed 30 milliseconds or the benchmark measurement is invalid.



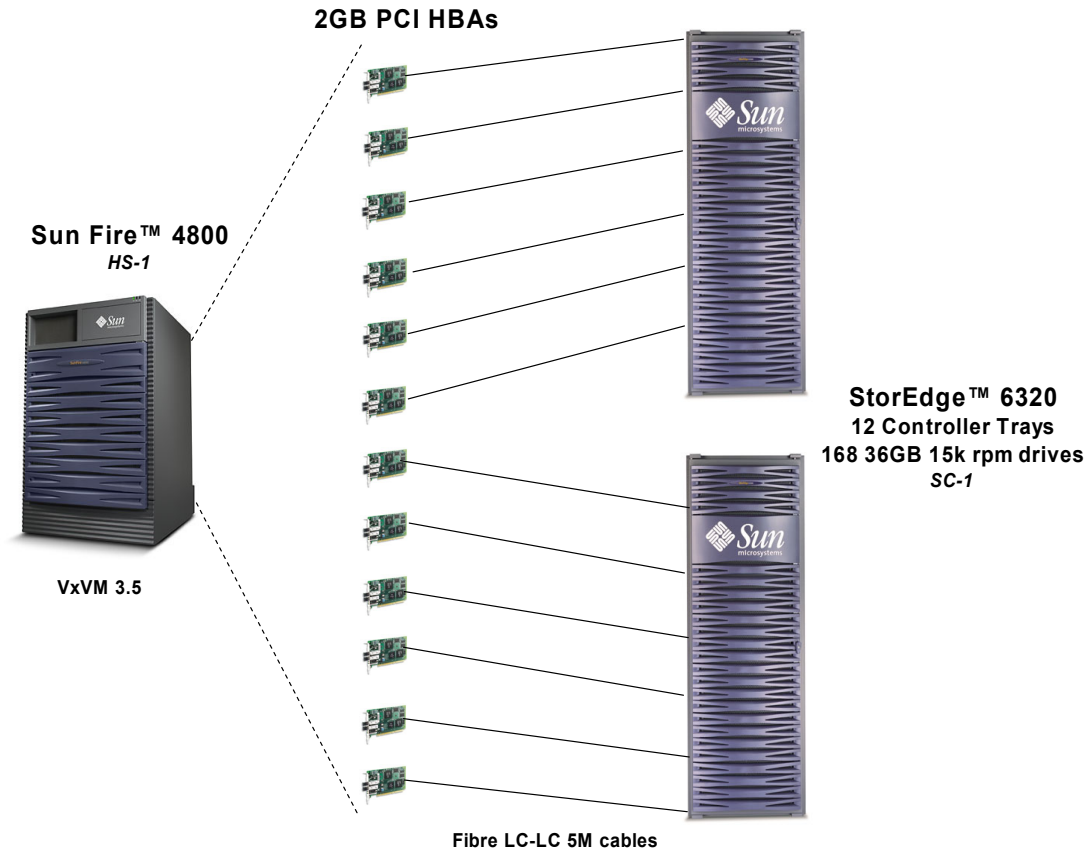
### Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
<b>I/O Request Throughput</b>	2,499.14	12,649.72	20,239.34	22,799.07	24,050.58	25,340.29
<b>Average Response Time (ms):</b>						
<b>All ASUs</b>	3.75	11.33	20.24	24.39	27.38	29.91
<b>ASU-1</b>	4.18	11.29	19.78	23.76	26.64	29.06
<b>ASU-2</b>	3.97	11.57	20.25	24.29	27.03	29.59
<b>ASU-3</b>	2.75	11.33	21.23	25.77	29.09	31.85
<b>Reads</b>	5.64	12.35	20.27	23.99	26.67	28.91
<b>Writes</b>	2.53	10.67	20.23	24.65	27.83	30.56

**Tested Storage Configuration Pricing**

Part Number	Description	Quantity	US List	Disc.	Ave. Price
XTA6320-00-1226T06	Sun StorEdge 6320 System	1	\$365,500	15%	\$310,675
	2 cabinets				
	12 Controller Trays				
	12GB Cache Memory				
	36GB/15K Drives	168			
NAVIS-310-1FNS	Sun StorEdge Availability Suite 3.1 (1TB Lic.)	1			
NEMIS-120-3FN9	Sun Enterprise Storage Manager 2.1 (6TB Lic.)	1			
NCSSS-210-9FN9	Sun StorEdge 6000 Family Host Installation CD	1			
W9D-632N12-3G	3-Year Maintenance Agreement	1	\$51,084	50%	\$25,542
VVMGS-999-3A99	VxVM 3.5 License Tier 3A	1	\$14,895	35%	\$9,682
VVMGS-3A99-LIC	VxVM 3.5 Maintenance Agreement (3 years)	1	\$15,300	0%	\$15,300
X6767A	2Gb PCI Single FC Network Adapter	6	\$14,400	35%	\$9,360
X6768A	2Gb PCI Dual FC Network Adapter	6	\$29,400	35%	\$19,110
X9733A	5M LC to LC FC Optical Cable	10	\$800	35%	\$520
<b>Total</b>			<b>\$491,379</b>		<b>\$390,189</b>

**Benchmark Configuration/Tested Storage Configuration Diagram**



Host System:	Storage System:
Sun Fire™ 4800	Sun StorEdge™ 6320
UID=HS-1	UID=SC-1
12 UltraSPARC™ III 900MHz CPU each 8MB EEC external cache per CPU	12 Controller Trays with 12 Controllers in 6 redundant pairs Each controller has: 1 GB of memory (12 GB total) 400MHZ PowerPC 750 with 1MB L2 cache 2 GB fibre channel interface – front-end 1GB fibre channel interface – back-end with 3 fibre channel loops
12 GB Main Memory	168 – 36.4 GB 15K RPM disk drives 14 disk drives per Controller Tray
Solaris™ 9 update 2	
Veritas Volume Manager 3.5	
6 – 2Gb PCI Single FC Network Adapters 6 – 2Gb PCI Dual FC Network Adapters	
WG	

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

## 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 13 (*Benchmark Configuration/Tested Storage Configuration Diagram*).

## Customer Tuning 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.

The following settings were made in the Solaris "etc/system" control file on the Sun Fire™ 4800 Host System for the execution of SPC-1:

```
* Memory allocation parameters
set vxio:voliomem_chunk_size = 1048576
set vxio:voliomem_maxpool_sz = 134217728
* I/O related parameters
set vxio:vol_default_iodelay = 10
set vxio:vol_maxkiocount = 32768
set vxio:vol_maxioctl = 131072
set vxio:vol_maxio = 8192
set vxio:vol_maxspecialio = 10240

* VM related
* scanner I/Os per second page-outs.(default 65536 for E10000)
* set maxpgio = 16384
* # of pages the scanned when freelist falls below lotsfree.
* set to 1/16 to 1/4 RAM up to 1Gb/sec (131072)
*set fastscan = 65536
**Fri Mar 31 16:07:32 PST 2000
* R. McDougall: increase maxpgio to prevent the scanner from limiting writes
set maxpgio = 65536
* R. McDougall: increase fastscan to limit the effect the page scanner
* has on file system throughput
set fastscan = 65536

* increase capability to do 1Mb IOs to *raw* devices, 32MB max.
*set maxphys = 1048576
set maxphys = 4194304

* TCP related
* decrease potential connection backlog by:
* 1. increase connection hash table size, increase if connections are high.
set tcp:tcp_conn_hash_size = 32768
* 2. depth of destination queue (# of messages outbound streams can hold)
```

```
* NOTE: sq_max_size = 0 is unlimited, but uses more kernel memory.  
set sq_max_size = 10
```

```
* vxvm_START (do not remove)  
forceload: drv/vxdmp  
forceload: drv/vxio  
forceload: drv/vxspec  
* vxvm_END (do not remove)
```

The 'blocksize' parameter for the storage controllers was changed from the default of 16K to a value of 64K. That parameter change was done using the Logical Volume creation script found in the next section of this document.



## 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.

The following Perl script, invoked as **T4-Setup-raid1-spc-201unsperPP.pl <name of Partner Pair>**, was used to create the volumes and luns used in this SPC-1 measurement. Those luns were used by the Veritas Volume Manager to instantiate the Application Storage Units (ASUs) accessed by the SPC-1 Workload Generator. A description of the process used to instantiate the ASUs follows this script.

```
#!/opt/cbe/SUPPORT-PKGS/perl/bin/perl
# @(#)T4-Setup_Luns.pl 1.1 02/08/16
# Copyright 2002, Sun Microsystems, Inc. All rights reserved.

#####
#
# Sun Proprietary/Confidential Code
#
# Author:      Kris Houghton 77166
#
# File:        T4-Setup_Luns.pl
#
# Description: Setup T4's to have 2 new volumes and 4 new volumes T4 pair.
#              Create luns with read/write permissions for all wwn's.
#
#              Syntax: T4-Setup_Luns <T4name>
#
#              Open T4 telnet session
#              Check for 2.01.00 version
#              Check for enable_volslice
#              Unmount all volumes
#              Remove all volumes
#              Create new volumes
#              Mount all volumes
#              Create 2 25gb luns for each volume with rw permissions
#
#              History: 08/13/02 - hkris - Created Script
#                      10/04/02 - hkris - Commented out OUT lines and cleaned up
#                      12/04/02 - hkris - Added version test for 2.01.03
#                      01/15/03 - hkris - Added version test for 3.0.0
#
# Copyright 2002, Sun Microsystems, Inc. All rights reserved.
#####

@dt = `date`;
```

```

print @dt;

# Check for Arguments ( t4 disk array ) & die if none

if ( $ARGV[0] eq "" ) { print "You need a name of a T4 disk array \n"; exit; }

# Set username & password for telnet

use Net::Telnet ();

$username = "root";
$password = "";
# $adminname = "sun";
# $adminpasswd = "arrayservice";

print "Opening $ARGV[0] telnet session ... \n";

$t = new Net::Telnet (Timeout => 7200, Prompt => '/:\/:|\[N\]:|Continue ?
\[N\]:/');
$t->open("$ARGV[0]");
$t->login($username, $password);

# open(OUT, ">T4-Setup.out");

# Get T4 version

@tx = $t->cmd("ver");
#$sz = @tx; print "Size of Array = $sz \n";
print "$tx[2]";
@chk = split(/\s+/, $tx[2]);
$verchk = $chk[2];

if ( $verchk eq "2\.01\.00" ) { print "version = 2.01.00 \n";
} elsif ( $verchk eq "2\.01\.03" ) { print "version = 2.01.03 \n";
} elsif ( $verchk eq "3\.0\.2" ) { print "version = 3.0.2 \n";
} else {
print " This firmware version $verchk Can't create luns \n";
exit;
}

# Check to see if T4 enable_volslice is on / off

# @tx = $t->cmd("sys list");
# for $u ( @tx ) {
#   if ( $u =~ /enable_volslice/ ) {
#     if ( $u =~ /off/ ) { print "$u";
#       print " Can't create luns with this feature off \n";
#       exit; }
#     print "$u";
#   }
# }

# vol list; vol unmount; vol remove

@tx = $t->cmd("vol list");
#$sz = @tx; print "Size of Array = $sz \n";
for $line ( @tx ) {
@chk = split(/\s+/, $line);
if ( $chk[1] >= 1 ) {
print "vol unmount $chk[0] \n";
@unm = $t->cmd("vol unmount $chk[0]");
print "vol remove $chk[0] \n";
# @rmv = $t->cmd("vol remove $chk[0]");
if ( $verchk eq "2\.01\.00" ) { @rmv = $t->cmd("vol -y remove $chk[0]"); }
}
}

```

```

        if ( $verchk eq "3\.0\.2" ) { @rmv = $t->cmd("vol -y remove $chk[0]"); }
    }
} # end for

# Check to see if T4 partner pair

@tx = $t->cmd("port list");
$pp = "single";
for $u ( @tx ) {
    #print "$u\n";
    if ( $u =~ /u2p1/ ) { $pp = "pair"; }
}

# Create volumes for t4's and Luns
#
    print "Changing Blocksize to 64K \n";
    @tx = $t->cmd("sys blocksize 64k");

    print "vol add v0 data uld1-7 raid 1 \n";
    @tx = $t->cmd("vol add v0 data uld1-7 raid 1");
    #print "Create v0 @tx\n";
    @tx = $t->cmd("vol list");
    print "vol init v0 sysarea \n";
    @tx = $t->cmd("vol init v0 sysarea");
    print "vol init v0 data \n";
    if ( $verchk eq "2\.01\.00" ) { @tx = $t->cmd(".vol init v0 fast"); @answer =
$t->cmd("y"); }
    if ( $verchk eq "3\.0\.2" ) { @tx = $t->cmd("vol init v0 data rate 16");
@answer = $t->cmd("y"); }
    print "vol mount v0\n";
    @tx = $t->cmd("vol mount v0");
    print "vol list v0\n";
    @tx = $t->cmd("vol list v0");
    print "$tx[2]";
    @v1 = split(/\s+/, $tx[2]);
#    print OUT "vol add v0 data uld1-7 raid 1 Capacity = $v1[1]$v1[2]\n";
    @tx = $t->cmd("volslice create s0 -z 17.1gb v0");
    @tx = $t->cmd("volslice create s1 -z 17.1gb v0");
    @tx = $t->cmd("volslice create s2 -z 17.1gb v0");
    @tx = $t->cmd("volslice create s3 -z 17.1gb v0");
    @tx = $t->cmd("volslice create s4 -z 7.7gb v0");
    @tx = $t->cmd("lun perm all_lun rw all_wnw");
#
    print "vol add v1 data uld8-14 raid 1 \n";
    @tx = $t->cmd("vol add v1 data uld8-14 raid 1");
    #print "Create v1 @tx\n";
    @tx = $t->cmd("vol list");
    print "vol init v1 sysarea \n";
    @tx = $t->cmd("vol init v1 sysarea");
    print "vol init v1 data \n";
    if ( $verchk eq "2\.01\.00" ) { @tx = $t->cmd(".vol init v1 fast"); @answer =
$t->cmd("y"); }
    if ( $verchk eq "3\.0\.2" ) { @tx = $t->cmd("vol init v1 data rate 16");
@answer = $t->cmd("y"); }
    print "vol mount v1\n";
    @tx = $t->cmd("vol mount v1");
    print "vol list v1\n";
    @tx = $t->cmd("vol list v1");
    print "$tx[2]";
    @v1 = split(/\s+/, $tx[2]);
#    print OUT "vol add v1 data uld5-8 raid 5 standby uld9 Capacity =
$v1[1]$v1[2]\n";
    @tx = $t->cmd("volslice create s5 -z 17.1gb v1");

```

```

        @tx = $t->cmd("volslice create s6 -z 17.1gb v1");
        @tx = $t->cmd("volslice create s7 -z 17.1gb v1");
        @tx = $t->cmd("volslice create s8 -z 17.1gb v1");
        @tx = $t->cmd("volslice create s9 -z 7.7gb v1");
        @tx = $t->cmd("lun perm all_lun rw all_wnw");
#
if ( $pp eq "pair" ) { # Partner Pair Only

    print "vol add v2 data u2d1-7 raid 1 \n";
    @tx = $t->cmd("vol add v2 data u2d1-7 raid 1");
    #print "Create v2 @tx\n";
    @tx = $t->cmd("vol list");
    print "vol init v2 sysarea \n";
    @tx = $t->cmd("vol init v2 sysarea");
    print "vol init v2 data \n";
#    @tx = $t->cmd("vol init v2 data"); @answer = $t->cmd("y");
    if ( $verchk eq "2\.01\.00" ) { @tx = $t->cmd(".vol init v2 fast"); @answer =
    $t->cmd("y"); }
    if ( $verchk eq "3\.0\.2" ) { @tx = $t->cmd("vol init v2 data rate 16");
@answer = $t->cmd("y"); }
    print "vol mount v2\n";
    @tx = $t->cmd("vol mount v2");
    print "vol list v2\n";
    @tx = $t->cmd("vol list v2");
    print "$tx[2]";
    @vl = split(/\s+/, $tx[2]);
#    print OUT "vol add v2 data u2d1-4 raid 5 standby u2d9    Capacity =
    $vl[1]$vl[2]\n";
    @tx = $t->cmd("volslice create s10 -z 17.1gb v2");
    @tx = $t->cmd("volslice create s11 -z 17.1gb v2");
    @tx = $t->cmd("volslice create s12 -z 17.1gb v2");
    @tx = $t->cmd("volslice create s13 -z 17.1gb v2");
    @tx = $t->cmd("volslice create s14 -z 7.7gb v2");
    @tx = $t->cmd("lun perm all_lun rw all_wnw");
#
    print "vol add v3 data u2d8-14 raid 1 \n";
    @tx = $t->cmd("vol add v3 data u2d8-14 raid 1");
    #print "Create v3 @tx\n";
    @tx = $t->cmd("vol list");
    print "vol init v3 sysarea \n";
    @tx = $t->cmd("vol init v3 sysarea");
    print "vol init v3 data \n";
    if ( $verchk eq "2\.01\.00" ) { @tx = $t->cmd(".vol init v3 fast"); @answer =
    $t->cmd("y"); }
    if ( $verchk eq "3\.0\.2" ) { @tx = $t->cmd("vol init v3 data rate 16");
@answer = $t->cmd("y
    "); }
    print "vol mount v3\n";
    @tx = $t->cmd("vol mount v3");
    print "vol list v3\n";
    @tx = $t->cmd("vol list v3");
    print "$tx[2]";
    @vl = split(/\s+/, $tx[2]);
#    print OUT "vol add v3 data u2d5-8 raid 5 standby u2d9    Capacity =
    $vl[1]$vl[2]\n";
    @tx = $t->cmd("volslice create s15 -z 17.1gb v3");
    @tx = $t->cmd("volslice create s16 -z 17.1gb v3");
    @tx = $t->cmd("volslice create s17 -z 17.1gb v3");
    @tx = $t->cmd("volslice create s18 -z 17.1gb v3");
    @tx = $t->cmd("volslice create s19 -z 7.7gb v3");
    @tx = $t->cmd("lun perm all_lun rw all_wnw");

} # End of Partner Pair Only

```

```
@tx = $t->cmd("vol stat");
$sz=@tx;
for ( $i=0; $i < $sz; $i++ ) {
    if ( $i > 0 ) { print "$tx[$i]"; }
}

@tx = $t->cmd("volslice list");
$sz=@tx;
for ( $i=0; $i < $sz; $i++ ) {
    if ( $i > 0 ) { print "$tx[$i]"; }
}

# close(OUT);

@dt = `date`;
print @dt;

exit
```

The Veritas volumes were created using the VxVM graphical interface. There were three (3) disk pools created, which were labeled 'asu1', 'asu2', and 'asu3'. Both 'asu1' and 'asu2' were each allocated forty-eight (48) disks (luns from the controller). Twenty-four (24) disks (luns) were allocated to 'asu3'. The default 128k stripe size was used with 48 columns for 'asu1' and 'asu2' and 24 columns for 'asu3'.

One (1) volume per disk pool was created to utilize the entire capacity of each disk pool to create the following three (3) volumes: 'asu1-vol1', 'asu2-vol1', and 'asu3-volu1'. Those volumes were used in the SPC-1 configuration file to implement ASU1, ASU2, and ASU3 for the benchmark measurement.

## DATA REPOSITORY

### Definitions

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

**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.

**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.

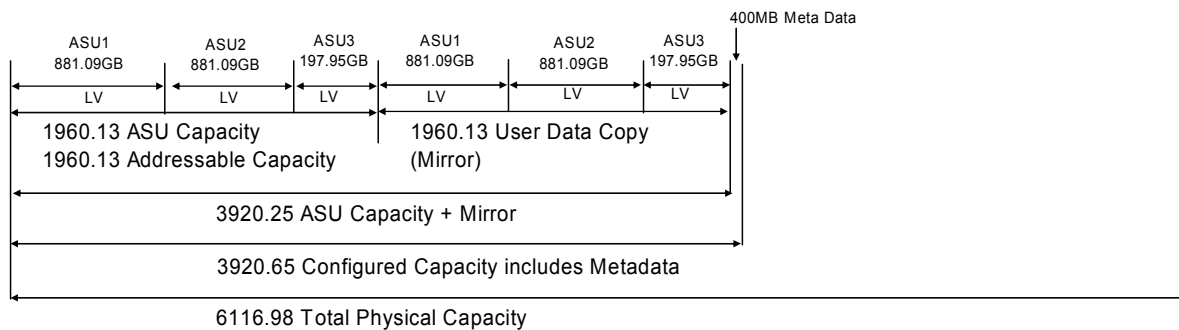
**Logical Volume:** The division of Addressable Storage Capacity into individually addressable logical units of storage used in the SPC-1 benchmark. Each Logical Volume is implemented as a single, contiguous address space.

**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.

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

### Storage Capacities and Relationships

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



## Storage Hierarchy Capacity

### Clause 9.2.4.6.1

A table illustrating the size of key components of the Storage Hierarchy shall be included in the FDR.

Storage Hierarchy Capacity		
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	1,960.13
Addressable Storage Capacity	Gigabytes (GB)	1,960.13
Configured Storage Capacity	Gigabytes (GB)	3,920.25
Physical Storage Capacity	Gigabytes (GB)	6,116.98

The Total ASU Capacity of 1,960.13 GB utilized 100% of the Addressable Storage Capacity. The Configured Storage Capacity of 3,920.25 GB, which included the multiple copies of user data required by a Data Protection Level of Mirroring, utilized 64.09% of the priced Physical Storage Capacity of 6,116.98 GB.

## 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 (881.09 GB)	ASU-2 (881.09 GB)	ASU-3 (197.95 GB)
1 Logical Volume 881.09GB per Logical Volume (881.09 GB used/Logical Volume)	1 Logical Volume 881.09 GB per Logical Volume (881.09 GB used/Logical Volume)	1 Logical Volume 197.95 GB per Logical Volume (197.95 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.*

### **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 SPC-1 Workload Generator input parameters for the Sustainability, IOPS, and Response Time Ramp Test Runs are listed below.

```
java -Xmx2048m -Xss1024k metrics -b 507 -s 240
```

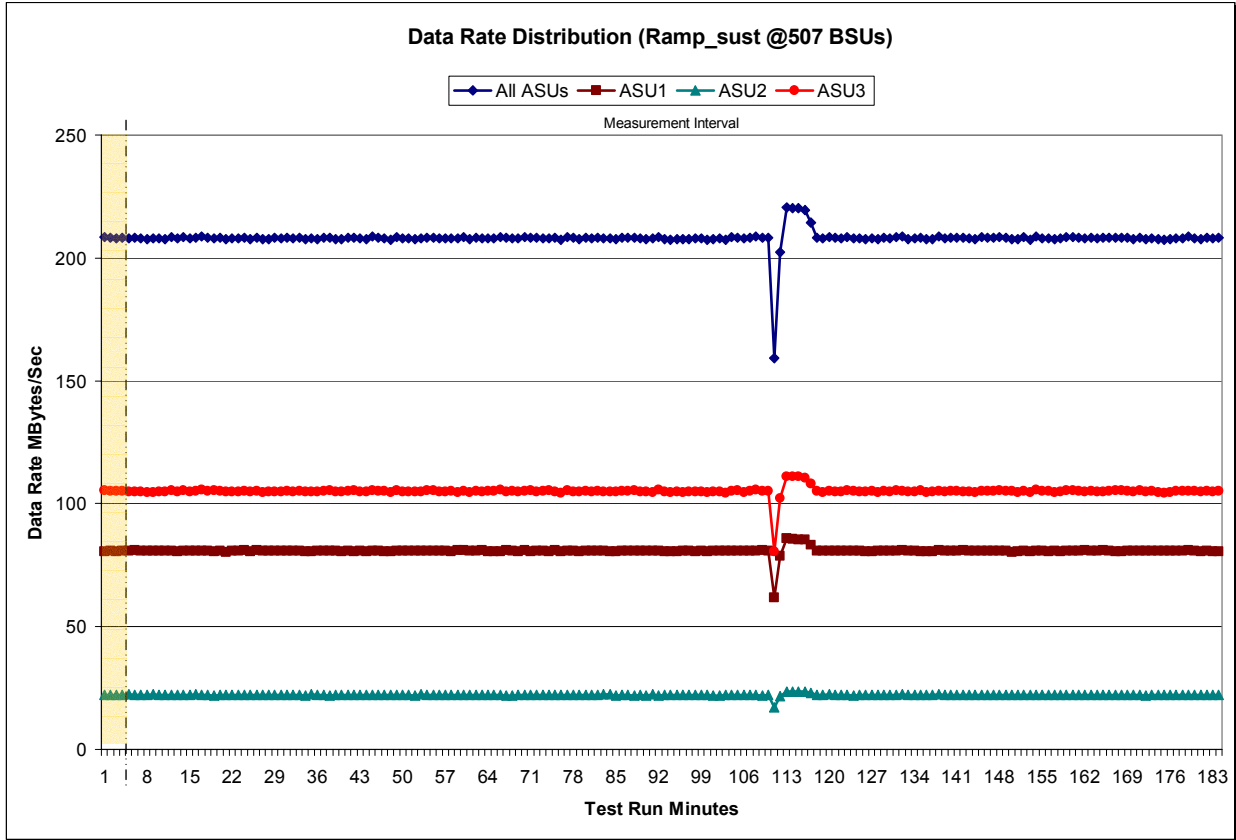
### **Sustainability Test Results File**

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

[Sustainability Test Results File](#)

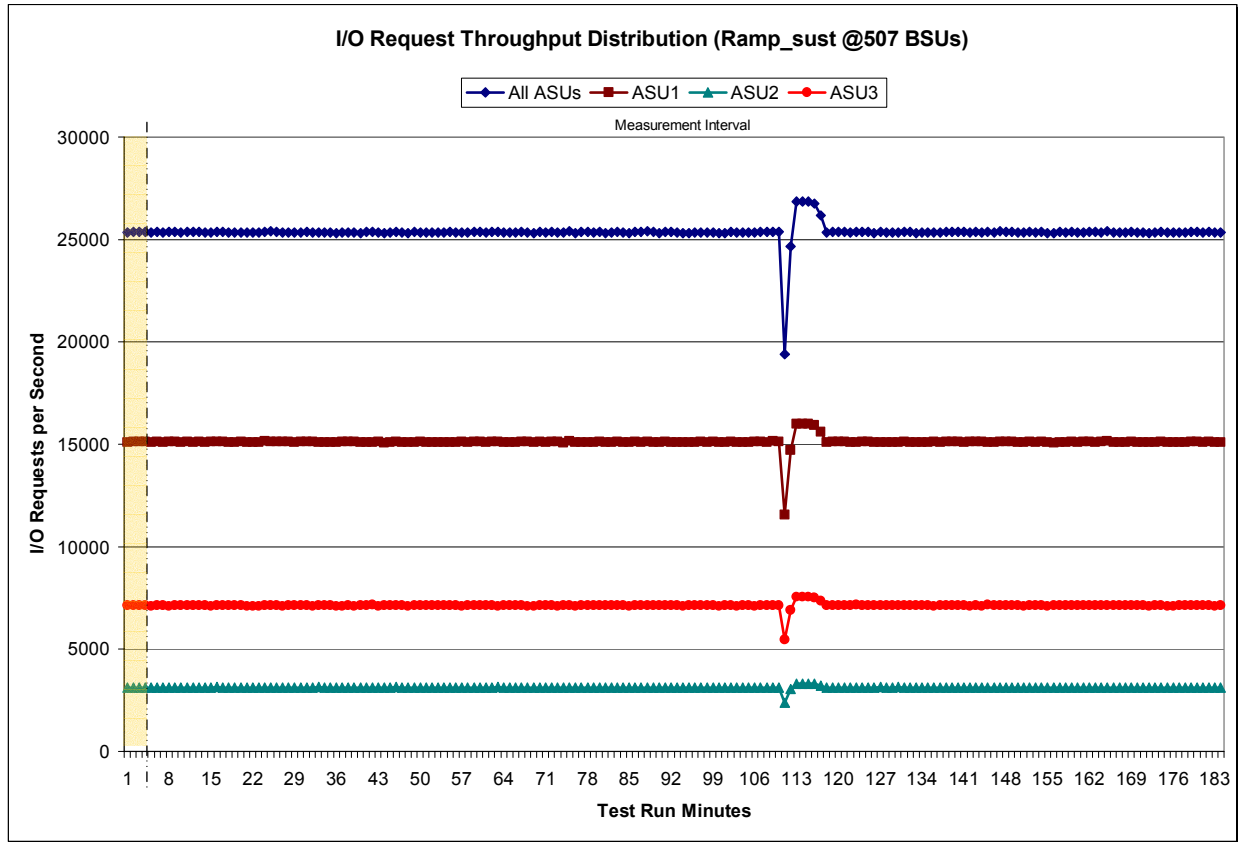


### Sustainability - Data Rate Distribution Graph





### 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	0.035	0.2810
COV	0.004	0.001	0.003	0.002	0.007	0.003	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.

## **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 SPC-1 Workload Generator input parameters for the Sustainability, IOPS, and Response Time Ramp Test Runs are listed below.

```
java -Xmx2048m -Xss1024k metrics -b 507 -s 240
```

## **IOPS Test Results File**

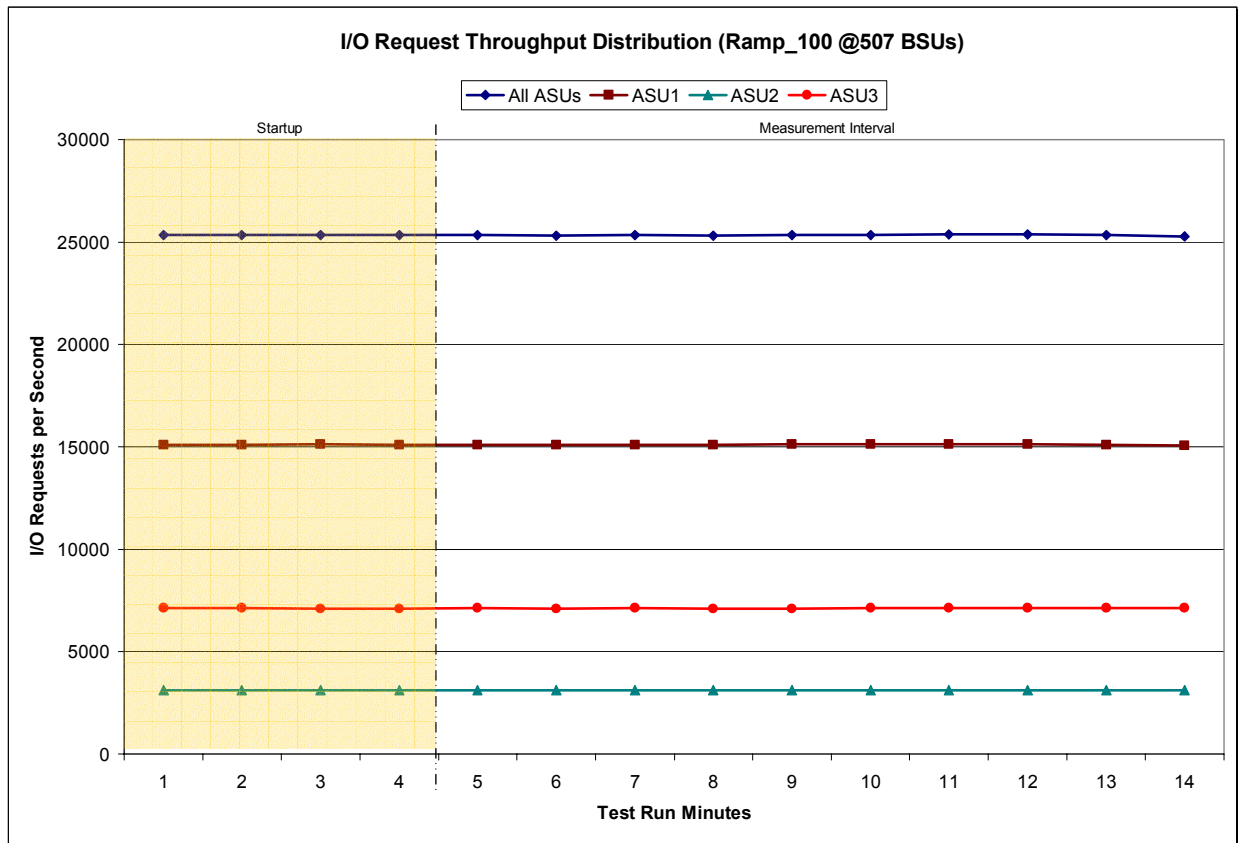
A link to the test results file generated from the IOPS Test Run is listed below.

[IOPS Test Results File](#)

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

507 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	8:14:31	8:18:32	0-3	0:04:01
<i>Measurement Interval</i>	8:18:32	8:28:32	4-13	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	25,349.50	15,087.93	3,115.07	7,146.50
1	25,343.40	15,100.05	3,105.07	7,138.28
2	25,342.73	15,116.72	3,125.37	7,100.65
3	25,340.83	15,110.68	3,118.22	7,111.93
4	25,357.63	15,112.30	3,130.57	7,114.77
5	25,325.57	15,104.75	3,111.98	7,108.83
6	25,346.50	15,104.53	3,112.32	7,129.65
7	25,307.68	15,091.73	3,113.92	7,102.03
8	25,350.02	15,113.88	3,122.90	7,113.23
9	25,355.98	15,114.28	3,117.67	7,124.03
10	25,363.65	15,127.55	3,117.15	7,118.95
11	25,374.83	15,124.53	3,120.67	7,129.63
12	25,326.77	15,087.92	3,115.33	7,123.52
13	25,294.27	15,061.80	3,116.82	7,115.65
<b>Average</b>	25,340.29	15,104.33	3,117.93	7,118.03

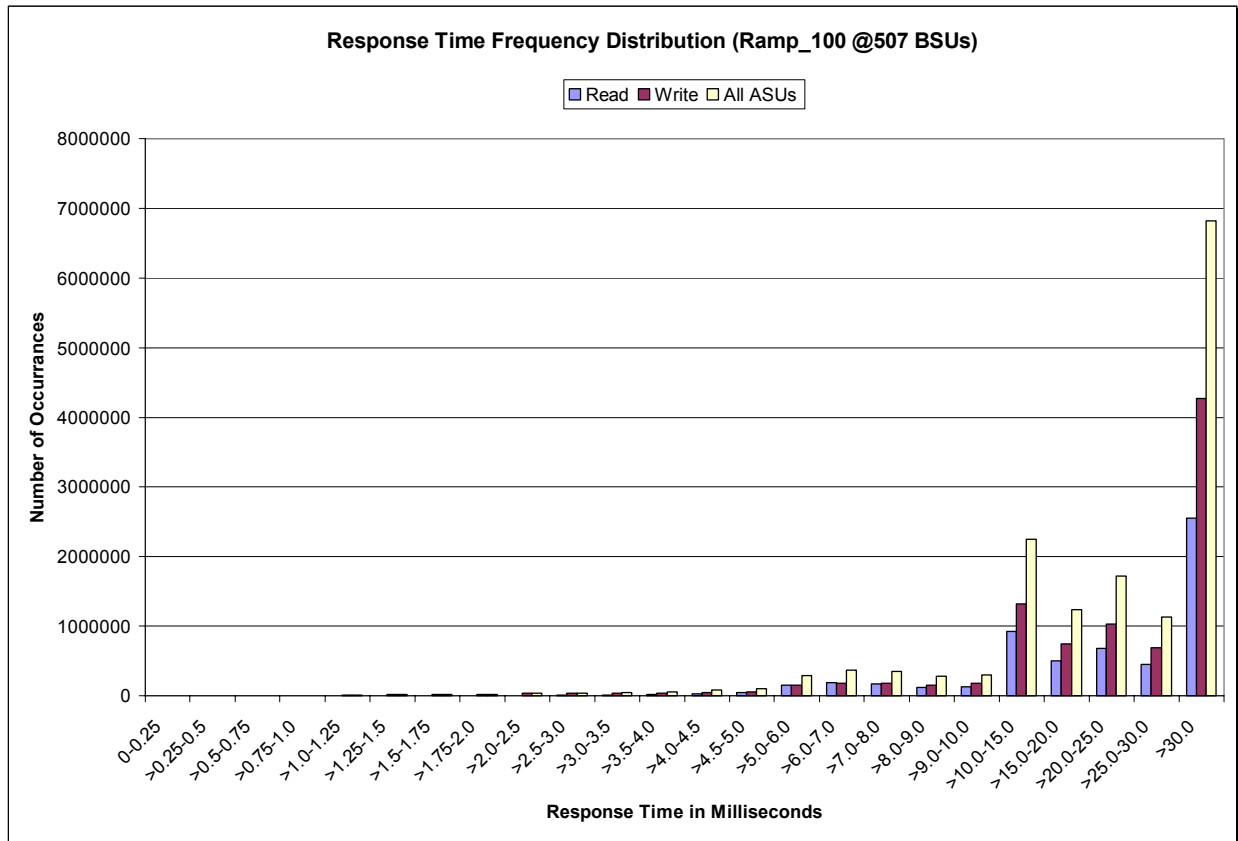
### IOPS Test Run - I/O Request Throughput Distribution Graph



**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	-	1,049	4,271	2,619	1,732	1,364	1,366	1,639
Write	-	-	-	444	12,143	17,061	16,527	16,904
All ASUs	-	1,049	4,271	3,063	13,875	18,425	17,893	18,543
ASU1	-	843	3,215	2,300	8,091	9,319	8,900	9,477
ASU2	-	206	1,056	666	1,995	2,366	2,139	2,218
ASU3	-	-	-	97	3,789	6,740	6,854	6,848
Response Time (ms)	>2.0-2.5	>2.5-3.0	>3.0-3.5	>3.5-4.0	>4.0-4.5	>4.5-5.0	>5.0-6.0	>6.0-7.0
Read	4,032	5,914	9,915	18,813	32,114	48,283	146,806	188,948
Write	35,107	35,575	37,361	41,191	48,440	57,533	147,072	178,760
All ASUs	39,139	41,489	47,276	60,004	80,554	105,816	293,878	367,708
ASU1	20,263	22,095	26,758	36,931	52,636	71,043	199,430	248,681
ASU2	4,636	4,731	5,216	6,365	8,462	11,685	34,793	46,034
ASU3	14,240	14,663	15,302	16,708	19,456	23,088	59,655	72,993
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	171,609	127,380	128,278	922,556	495,938	682,298	449,198	2,552,557
Write	177,021	155,521	174,880	1,325,810	744,520	1,032,213	686,404	4,264,546
All ASUs	348,630	282,901	303,158	2,248,366	1,240,458	1,714,511	1,135,602	6,817,103
ASU1	229,561	179,239	190,298	1,392,574	752,997	1,034,050	675,533	3,888,090
ASU2	45,692	38,465	39,603	284,715	155,246	210,290	138,954	825,161
ASU3	73,377	65,197	73,257	571,077	332,215	470,171	321,115	2,103,852

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

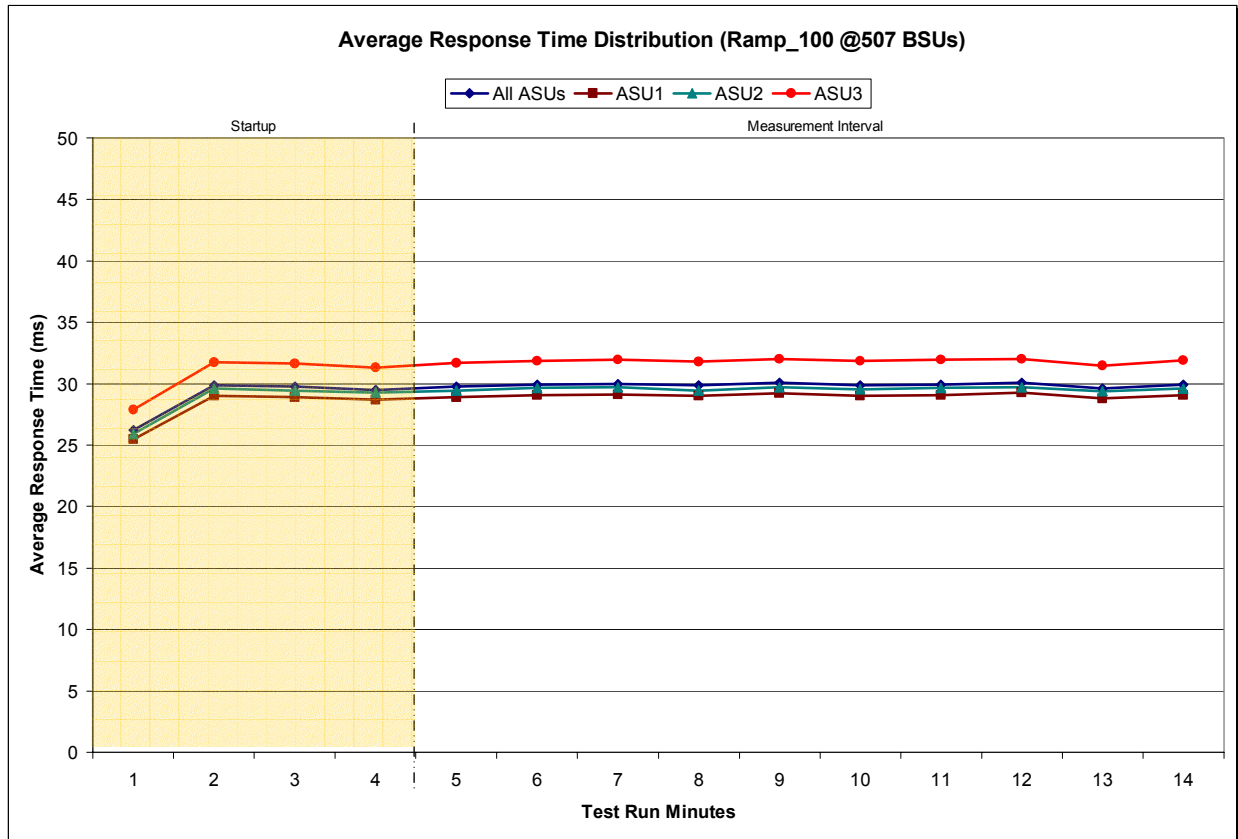




**IOPS Test Run – Average Response Time (ms) Distribution Data**

507 BSUs	Start	Stop	Interval	Duration
<i>Start-Up/Ramp-Up</i>	8:14:31	8:18:32	0-3	0:04:01
<i>Measurement Interval</i>	8:18:32	8:28:32	4-13	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	26.21	25.48	25.91	27.87
1	29.86	29.02	29.59	31.75
2	29.75	28.93	29.43	31.62
3	29.52	28.72	29.28	31.33
4	29.77	28.93	29.45	31.71
5	29.93	29.09	29.66	31.83
6	30.00	29.14	29.71	31.93
7	29.86	29.03	29.44	31.80
8	30.07	29.21	29.73	32.02
9	29.86	29.00	29.57	31.83
10	29.95	29.06	29.67	31.96
11	30.10	29.26	29.70	32.03
12	29.63	28.81	29.38	31.46
13	29.92	29.06	29.60	31.89
<b>Average</b>	29.91	29.06	29.59	31.85

**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
15,203,712	8,386,609	6,817,103

**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	0.0352	0.2809	0.0700	0.2100	0.0180	0.0700	0.0350	0.2809
COV	0.004	0.001	0.002	0.001	0.009	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.

## 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 SPC-1 Workload Generator input parameters for the Sustainability, IOPS, and Response Time Ramp Test Runs are listed below.

```
java -Xmx2048m -Xss1024k metrics -b 507 -s 240
```

## 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](#)

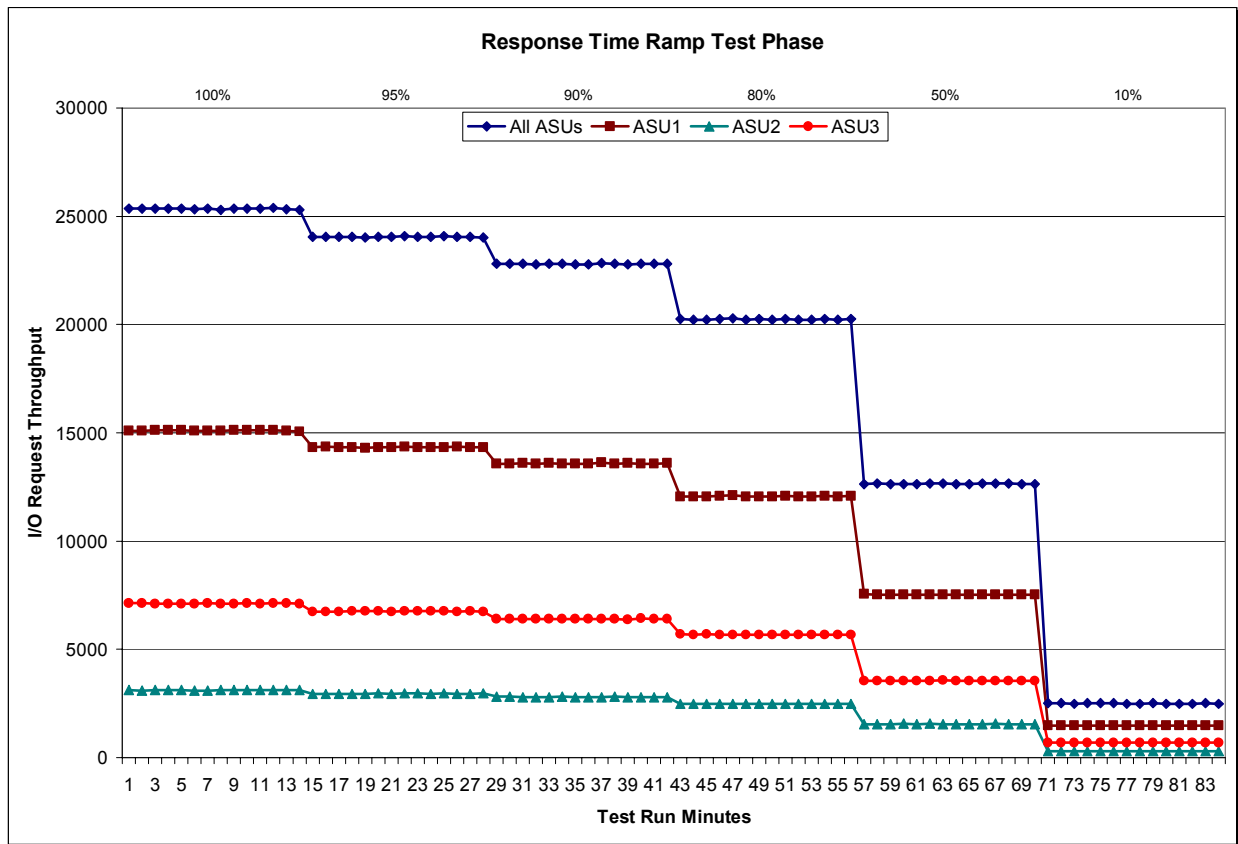
[10% Load Level](#)

**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 - 507 BSUs					95% Load Level - 481 BSUs				
Start-Up/Ramp-Up	Start	Stop	Interval	Duration	Start-Up/Ramp-Up	Start	Stop	Interval	Duration
Measurement Interval	8:18:32	8:18:32	0-2	0:04:01	Measurement Interval	8:32:50	8:32:50	0-2	0:04:01
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	25,349.50	15,087.93	3,115.07	7,146.50	0	24,045.57	14,335.18	2,955.72	6,754.67
1	25,343.40	15,100.05	3,105.07	7,138.28	1	24,059.68	14,354.03	2,950.95	6,754.70
2	25,342.73	15,116.72	3,125.37	7,100.65	2	24,039.40	14,331.05	2,956.63	6,751.72
3	25,340.83	15,110.68	3,118.22	7,111.93	3	24,050.68	14,335.38	2,951.33	6,763.97
4	25,357.63	15,112.30	3,130.57	7,114.77	4	24,021.82	14,298.53	2,949.10	6,774.18
5	25,325.57	15,104.75	3,111.98	7,108.83	5	24,061.47	14,330.08	2,964.95	6,766.43
6	25,346.50	15,104.53	3,112.32	7,129.65	6	24,052.13	14,342.55	2,954.03	6,755.55
7	25,307.68	15,091.73	3,113.92	7,102.03	7	24,073.98	14,349.30	2,964.20	6,760.48
8	25,350.02	15,113.88	3,122.90	7,113.23	8	24,056.83	14,333.62	2,964.00	6,759.22
9	25,355.98	15,114.28	3,117.67	7,124.03	9	24,045.58	14,327.00	2,955.38	6,763.20
10	25,363.65	15,127.55	3,117.15	7,118.95	10	24,065.58	14,328.33	2,965.67	6,771.58
11	25,374.83	15,124.53	3,120.67	7,129.63	11	24,053.57	14,352.93	2,946.45	6,754.18
12	25,326.77	15,087.92	3,115.33	7,123.52	12	24,053.63	14,340.78	2,944.87	6,767.98
13	25,294.27	15,061.80	3,116.82	7,115.65	13	24,021.20	14,323.38	2,963.25	6,734.57
Average	25,340.29	15,104.33	3,117.93	7,118.03	Average	24,050.58	14,332.65	2,957.19	6,760.74
90% Load Level - 456 BSUs					80% Load Level - 405 BSUs				
Start-Up/Ramp-Up	Start	Stop	Interval	Duration	Start-Up/Ramp-Up	Start	Stop	Interval	Duration
Measurement Interval	8:47:06	8:47:06	0-2	0:04:01	Measurement Interval	9:01:23	9:01:23	0-2	0:04:01
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	22,795.72	13,586.85	2,813.58	6,395.28	0	20,267.70	12,068.33	2,501.03	5,698.33
1	22,798.63	13,568.15	2,813.48	6,417.00	1	20,232.77	12,058.40	2,484.42	5,689.95
2	22,800.92	13,606.55	2,794.18	6,400.18	2	20,233.15	12,061.22	2,477.13	5,694.80
3	22,786.28	13,578.13	2,806.82	6,401.33	3	20,259.77	12,076.85	2,495.27	5,687.65
4	22,802.87	13,593.55	2,805.75	6,403.57	4	20,285.23	12,102.07	2,491.25	5,691.92
5	22,796.67	13,575.30	2,811.47	6,409.90	5	20,228.80	12,064.67	2,486.82	5,677.32
6	22,781.68	13,584.40	2,800.42	6,396.87	6	20,249.42	12,063.97	2,495.15	5,690.30
7	22,777.18	13,581.68	2,794.75	6,400.75	7	20,220.38	12,052.55	2,485.15	5,682.68
8	22,823.67	13,621.28	2,807.30	6,395.08	8	20,246.17	12,078.30	2,484.70	5,683.17
9	22,806.22	13,578.28	2,809.53	6,418.40	9	20,226.95	12,066.18	2,484.25	5,676.52
10	22,783.82	13,594.38	2,808.45	6,380.98	10	20,216.83	12,050.12	2,498.17	5,668.55
11	22,813.58	13,586.27	2,801.05	6,426.27	11	20,238.62	12,077.73	2,484.50	5,676.38
12	22,790.55	13,587.53	2,802.95	6,400.07	12	20,224.18	12,058.40	2,485.92	5,679.87
13	22,814.50	13,599.53	2,800.78	6,414.18	13	20,256.85	12,075.55	2,491.87	5,689.43
Average	22,799.07	13,590.22	2,804.25	6,404.61	Average	20,239.34	12,068.95	2,488.78	5,681.61
50% Load Level - 253 BSUs					10% Load Level - 50 BSUs				
Start-Up/Ramp-Up	Start	Stop	Interval	Duration	Start-Up/Ramp-Up	Start	Stop	Interval	Duration
Measurement Interval	9:15:36	9:15:36	0-2	0:04:01	Measurement Interval	9:29:47	9:29:47	0-2	0:04:01
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	12,642.98	7,547.98	1,547.20	3,547.80	0	2,506.12	1,496.58	307.47	702.07
1	12,650.08	7,539.55	1,551.78	3,558.75	1	2,514.03	1,499.75	313.47	700.82
2	12,629.67	7,529.52	1,550.92	3,549.23	2	2,501.25	1,496.62	305.47	699.17
3	12,638.87	7,525.92	1,564.77	3,548.18	3	2,507.23	1,494.07	308.88	704.28
4	12,641.18	7,535.78	1,549.38	3,556.02	4	2,506.88	1,489.03	307.60	710.25
5	12,657.10	7,540.17	1,565.23	3,551.70	5	2,508.67	1,500.28	307.32	701.07
6	12,669.82	7,538.67	1,555.63	3,575.52	6	2,501.12	1,490.88	309.50	700.73
7	12,639.97	7,531.88	1,549.25	3,558.83	7	2,498.87	1,484.82	306.70	707.35
8	12,644.08	7,537.57	1,554.67	3,551.85	8	2,507.78	1,494.85	304.27	708.67
9	12,655.77	7,537.00	1,556.17	3,562.60	9	2,487.92	1,482.78	309.52	695.62
10	12,673.10	7,542.47	1,564.43	3,566.20	10	2,493.90	1,484.10	305.38	704.42
11	12,648.27	7,532.15	1,551.95	3,564.17	11	2,482.67	1,482.50	303.88	696.28
12	12,638.02	7,534.10	1,554.75	3,549.17	12	2,507.22	1,490.47	311.23	705.52
13	12,629.90	7,521.47	1,557.33	3,551.10	13	2,496.38	1,487.62	309.15	699.62
Average	12,649.72	7,535.13	1,555.88	3,558.72	Average	2,499.14	1,488.73	307.46	702.95

### Response Time Ramp Distribution (IOPS) Graph



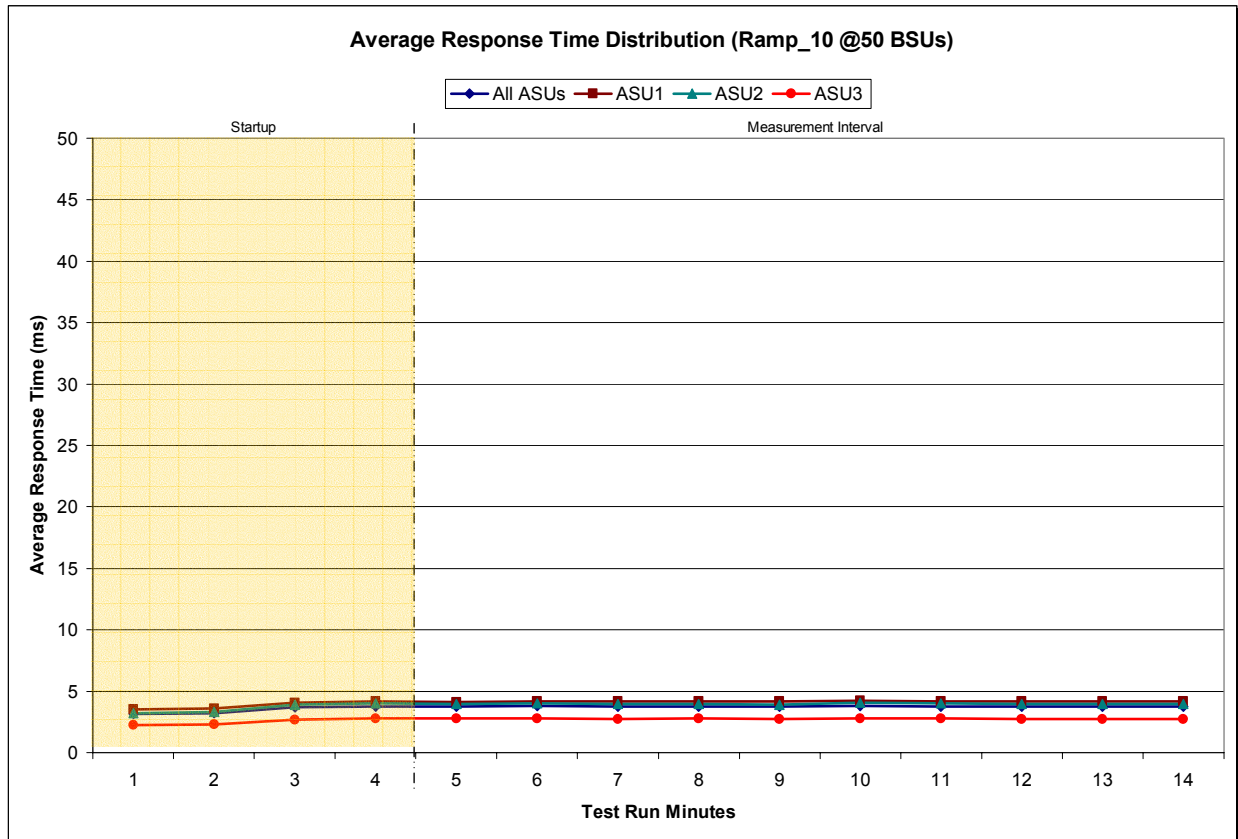
**SPC-1 LRT™ Average Response Time (ms) Distribution Data**

50 BSUs Start-Up/Ramp-Up Measurement Interval	Start	Stop	Interval	Duration
	9:25:46	9:29:47	0-3	0:04:01
	9:29:47	9:39:47	4-13	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	3.15	3.55	3.24	2.27
1	3.19	3.59	3.30	2.29
2	3.67	4.09	3.89	2.68
3	3.76	4.17	4.00	2.79
4	3.73	4.14	3.97	2.78
5	3.78	4.20	4.03	2.77
6	3.73	4.15	3.95	2.74
7	3.76	4.19	3.96	2.78
8	3.74	4.19	3.91	2.72
9	3.81	4.26	4.04	2.76
10	3.76	4.18	4.00	2.76
11	3.76	4.18	3.98	2.75
12	3.74	4.18	3.94	2.74
13	3.73	4.16	3.94	2.71
Average	3.75	4.18	3.97	2.75

**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>	0.0351	0.2806	0.0701	0.2100	0.0180	0.0702	0.0349	0.2813
<i>COV</i>	0.012	0.004	0.008	0.004	0.014	0.011	0.013	0.005

***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 SPC-1 Workload Generator input parameters for the Repeatability Test Runs are listed below.

```
java -Xmx2048m -Xss1024k repeat1 -b 507 -s 240
java -Xmx2048m -Xss1024k repeat1 -b 507 -s 240
```

## 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>	25,340.29	3.75
<b>Repeatability Test Phase 1</b>	25,344.39	3.77
<b>Repeatability Test Phase 2</b>	25,341.95	3.76



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 \(IOPS\)](#)

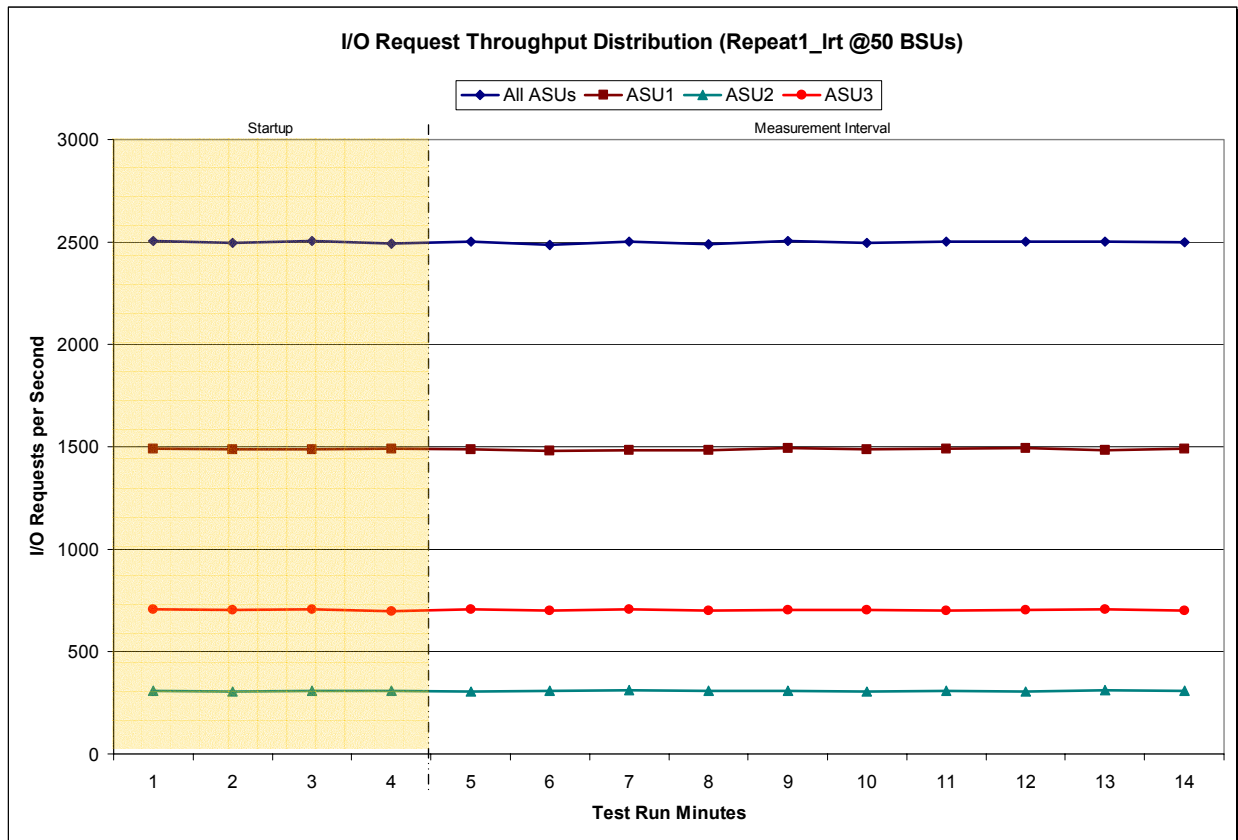
**Repeatability 1 LRT - I/O Request Throughput Distribution Data**

50 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:41:42	10:45:42	0-3	0:04:00
Measurement Interval	10:45:42	10:55:42	4-13	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2,504.27	1,491.82	307.23	705.22
1	2,497.03	1,487.35	306.55	703.13
2	2,503.75	1,488.57	307.23	707.95
3	2,493.58	1,489.55	306.83	697.20
4	2,500.58	1,488.28	306.67	705.63
5	2,487.57	1,480.07	308.15	699.35
6	2,503.30	1,484.48	310.88	707.93
7	2,490.83	1,483.88	307.17	699.78
8	2,506.35	1,494.88	307.57	703.90
9	2,495.40	1,486.62	304.67	704.12
10	2,501.07	1,491.35	308.58	701.13
11	2,503.52	1,493.95	306.10	703.47
12	2,501.57	1,482.68	312.97	705.92
13	2,500.03	1,490.43	308.55	701.05
Average	2,499.02	1,487.66	308.13	703.23

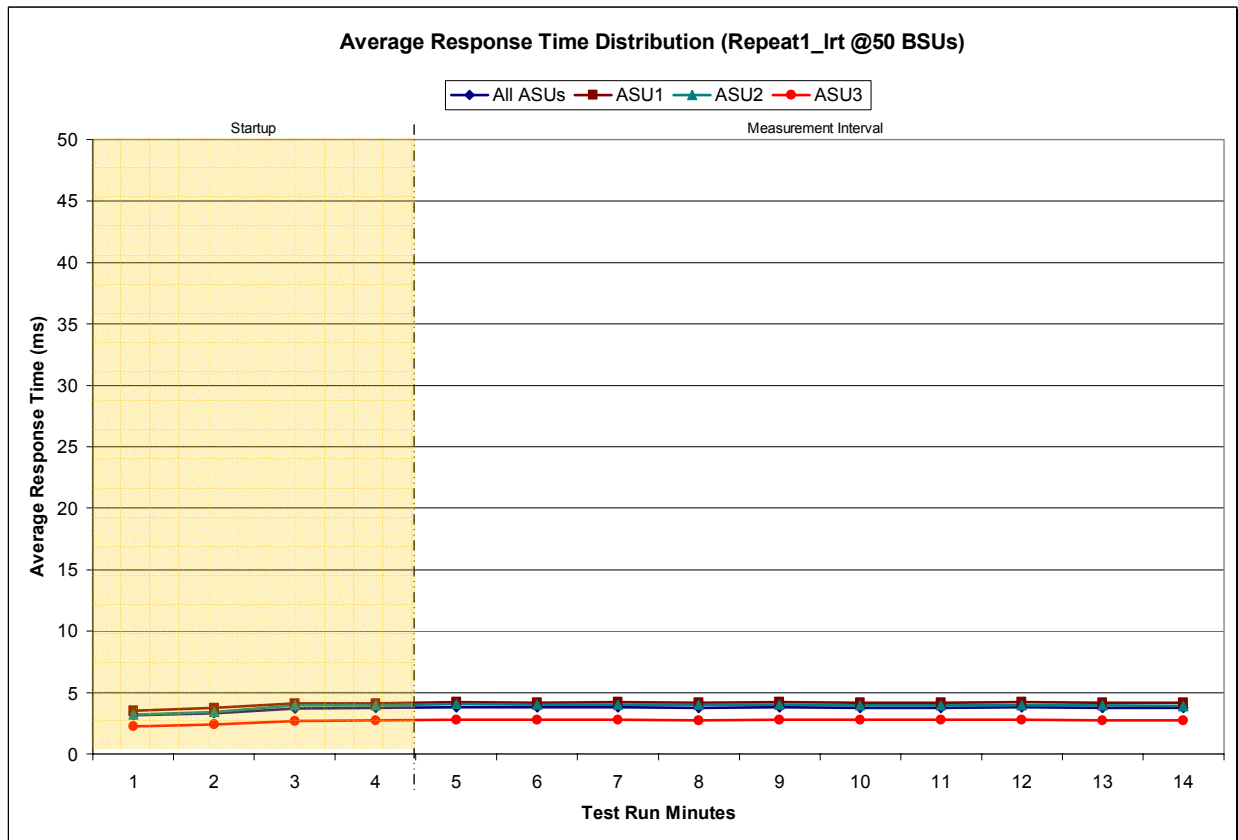
**Repeatability 1 LRT - I/O Request Throughput Distribution Graph**



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

50 BSUs Start-Up/Ramp-Up Measurement Interval	Start 10:41:42 10:45:42	Stop 10:45:42 10:55:42	Interval 0-3 4-13	Duration 0:04:00 0:10:00
<b>60 second intervals</b>	<b>All ASUs</b>	<b>ASU1</b>	<b>ASU2</b>	<b>ASU3</b>
0	3.14	3.55	3.21	2.25
1	3.32	3.73	3.42	2.43
2	3.71	4.15	3.97	2.67
3	3.73	4.15	3.98	2.73
4	3.78	4.21	4.04	2.78
5	3.78	4.19	4.03	2.78
6	3.80	4.24	4.00	2.77
7	3.73	4.16	3.99	2.71
8	3.81	4.24	4.01	2.81
9	3.77	4.19	3.94	2.80
10	3.74	4.15	3.95	2.78
11	3.78	4.21	3.98	2.77
12	3.75	4.19	3.97	2.74
13	3.74	4.18	3.89	2.74
<b>Average</b>	<b>3.77</b>	<b>4.20</b>	<b>3.98</b>	<b>2.77</b>

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



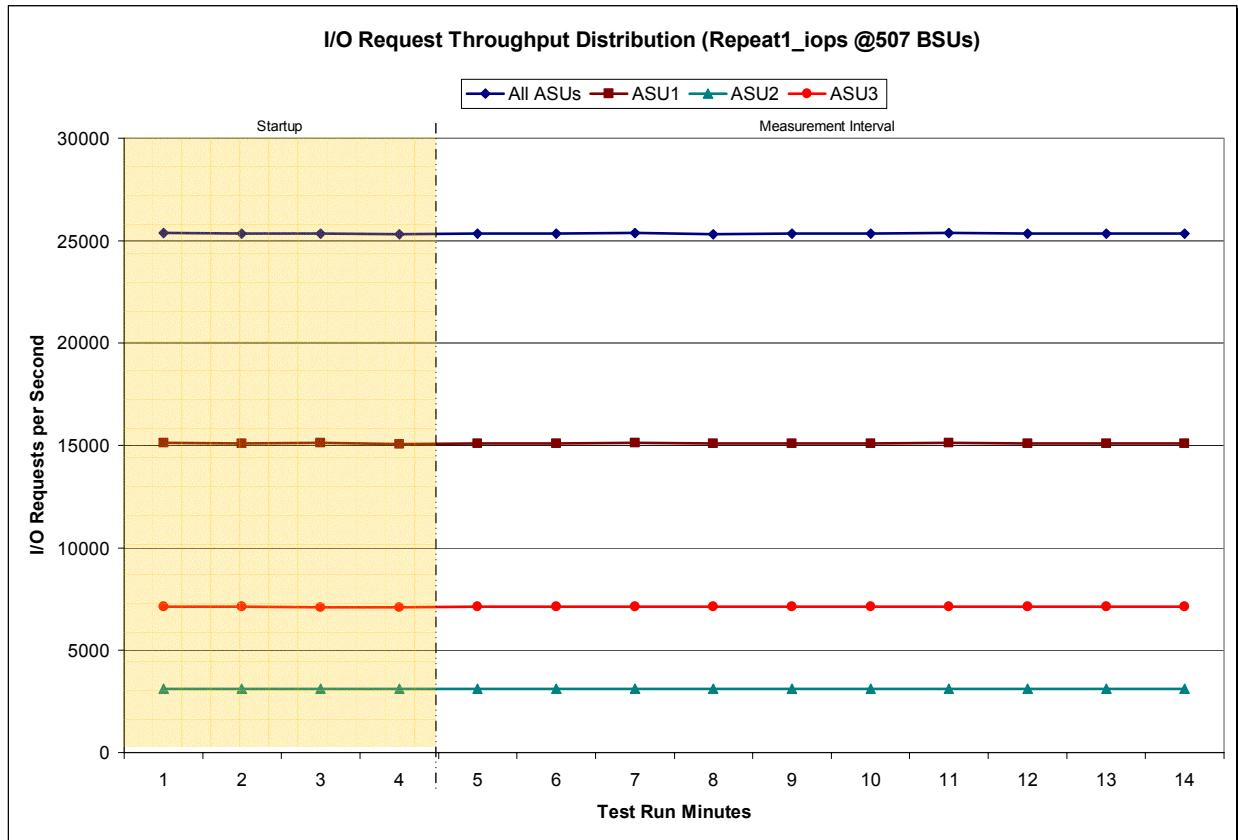
**Repeatability 1 IOPS - I/O Request Throughput Distribution Data**

507 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:56:00	11:00:01	0-3	0:04:01
Measurement Interval	11:00:01	11:10:01	4-13	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	25,372.78	15,128.62	3,122.48	7,121.68
1	25,349.20	15,106.27	3,116.72	7,126.22
2	25,345.32	15,127.45	3,117.53	7,100.33
3	25,302.77	15,076.23	3,115.15	7,111.38
4	25,330.97	15,086.77	3,120.87	7,123.33
5	25,353.30	15,111.12	3,116.75	7,125.43
6	25,360.28	15,130.82	3,111.88	7,117.58
7	25,308.03	15,084.78	3,107.78	7,115.47
8	25,350.53	15,106.57	3,118.97	7,125.00
9	25,335.87	15,095.07	3,122.05	7,118.75
10	25,366.60	15,116.12	3,121.27	7,129.22
11	25,353.62	15,111.75	3,119.83	7,122.03
12	25,345.02	15,097.02	3,113.52	7,134.48
13	25,339.68	15,095.13	3,106.53	7,138.02
Average	25,344.39	15,103.51	3,115.95	7,124.93

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



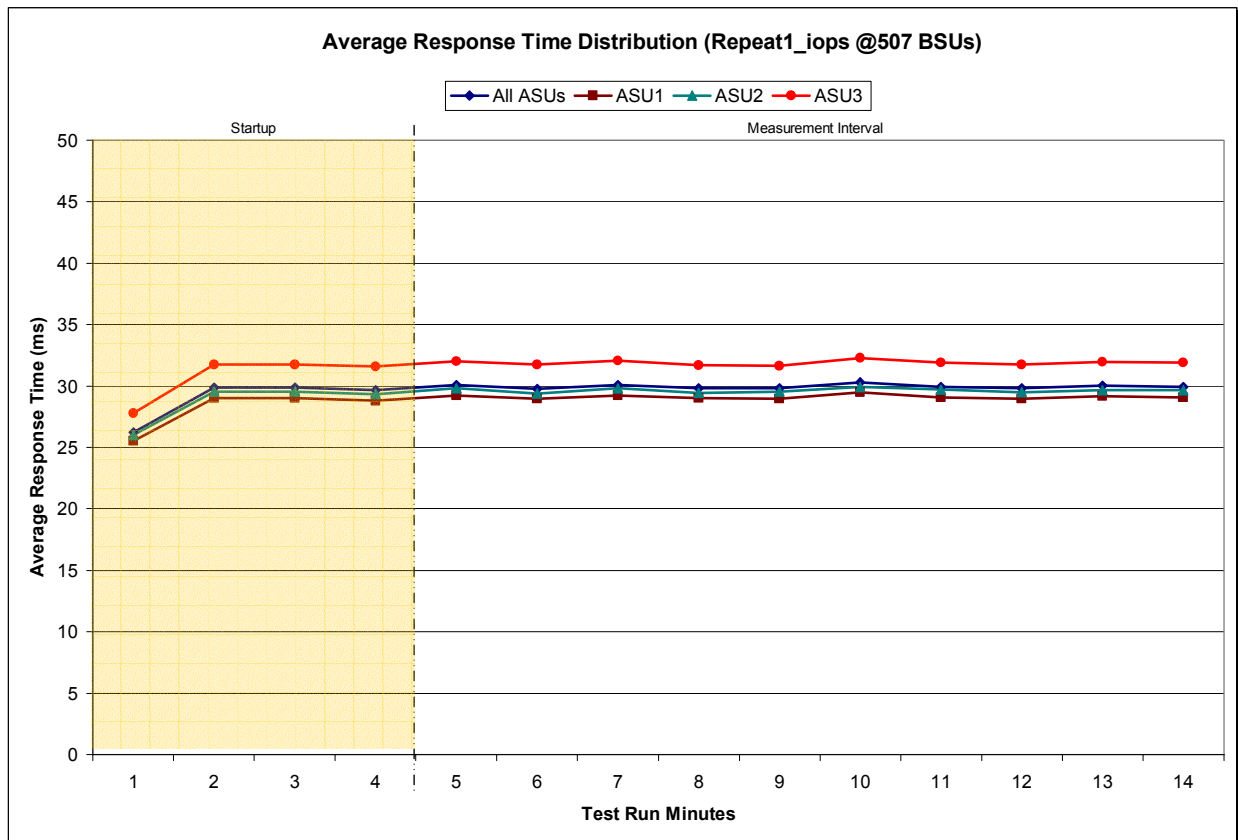
**Repeatability 1 IOPS –Average Response Time (ms) Distribution Data**

507 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	10:56:00	11:00:01	0-3	0:04:01
Measurement Interval	11:00:01	11:10:01	4-13	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	26.23	25.54	26.04	27.78
1	29.85	29.01	29.57	31.75
2	29.86	29.04	29.54	31.76
3	29.64	28.79	29.35	31.57
4	30.10	29.26	29.81	32.01
5	29.78	28.95	29.41	31.72
6	30.09	29.21	29.80	32.08
7	29.82	29.01	29.45	31.69
8	29.80	28.98	29.55	31.64
9	30.32	29.47	29.95	32.27
10	29.94	29.05	29.71	31.92
11	29.83	28.98	29.51	31.76
12	30.02	29.19	29.64	31.94
13	29.94	29.07	29.67	31.89
Average	29.96	29.12	29.65	31.89

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



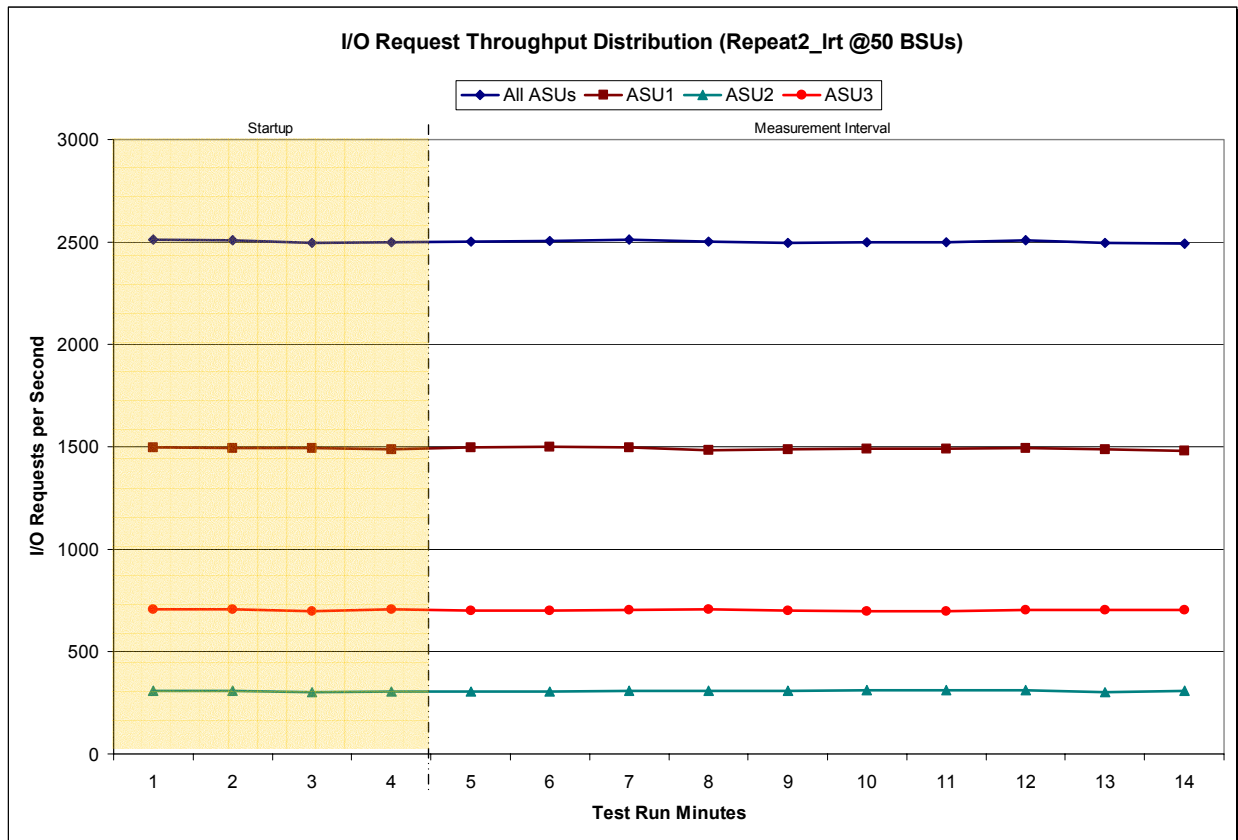
**Repeatability 2 LRT - I/O Request Throughput Distribution Data**

50 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:10:20	11:14:20	0-3	0:04:00
Measurement Interval	11:14:20	11:24:20	4-13	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2,510.48	1,496.07	309.20	705.22
1	2,507.17	1,493.65	307.93	705.58
2	2,494.42	1,492.82	303.23	698.37
3	2,498.60	1,486.05	305.90	706.65
4	2,501.73	1,496.53	304.13	701.07
5	2,505.15	1,499.75	305.73	699.67
6	2,510.97	1,497.17	309.22	704.58
7	2,500.83	1,485.07	308.38	707.38
8	2,495.22	1,487.82	308.55	698.85
9	2,498.75	1,489.33	311.13	698.28
10	2,498.55	1,489.98	310.40	698.17
11	2,508.58	1,494.80	310.02	703.77
12	2,495.08	1,488.62	303.03	703.43
13	2,492.38	1,480.83	307.98	703.57
Average	2,500.73	1,490.99	307.86	701.88

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



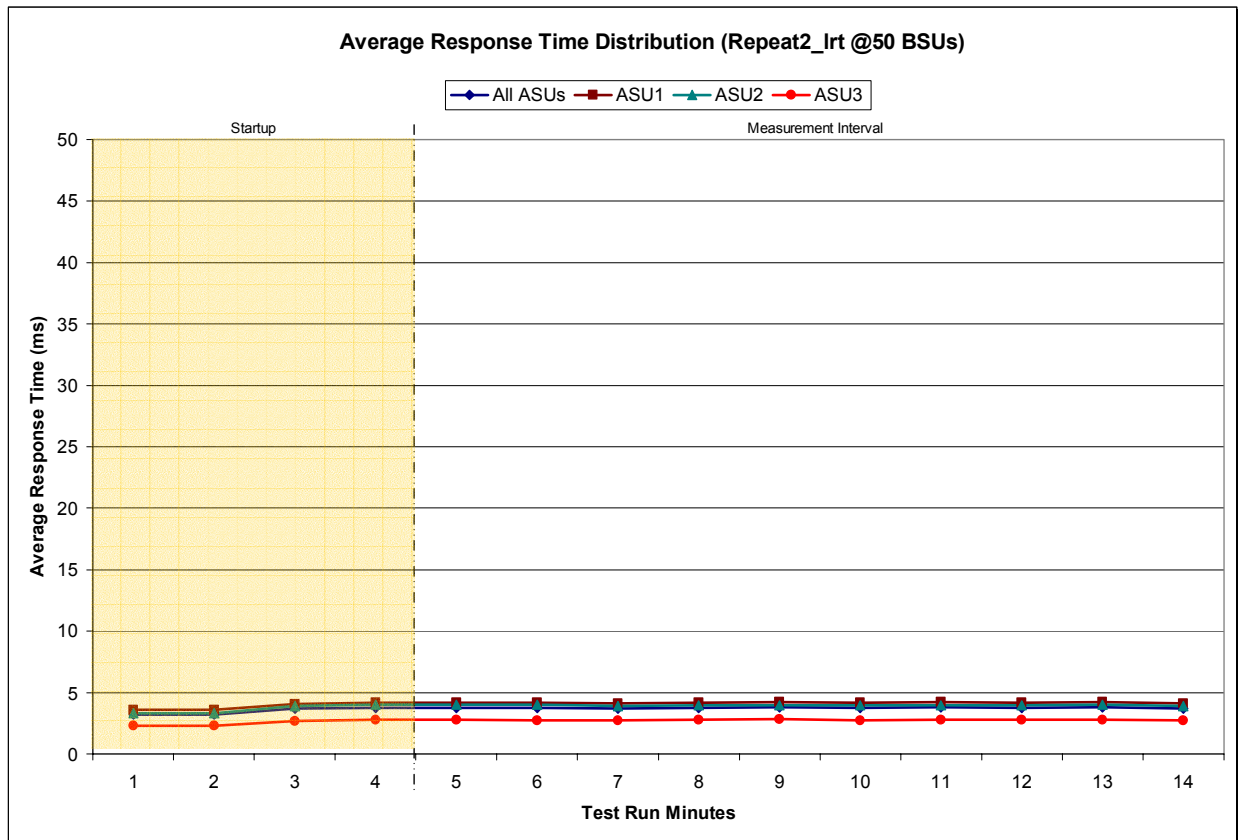
**Repeatability 2 LRT –Average Response Time (ms) Distribution Data**

50 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:10:20	11:14:20	0-3	0:04:00
Measurement Interval	11:14:20	11:24:20	4-13	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	3.19	3.59	3.30	2.30
1	3.20	3.59	3.32	2.32
2	3.68	4.09	3.89	2.69
3	3.77	4.19	4.00	2.77
4	3.76	4.18	4.01	2.78
5	3.76	4.18	4.00	2.75
6	3.71	4.13	3.93	2.72
7	3.77	4.20	3.98	2.77
8	3.81	4.24	3.98	2.82
9	3.76	4.19	3.98	2.75
10	3.79	4.21	3.98	2.81
11	3.75	4.17	3.97	2.77
12	3.80	4.23	4.02	2.78
13	3.71	4.14	3.88	2.71
Average	3.76	4.19	3.97	2.77

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



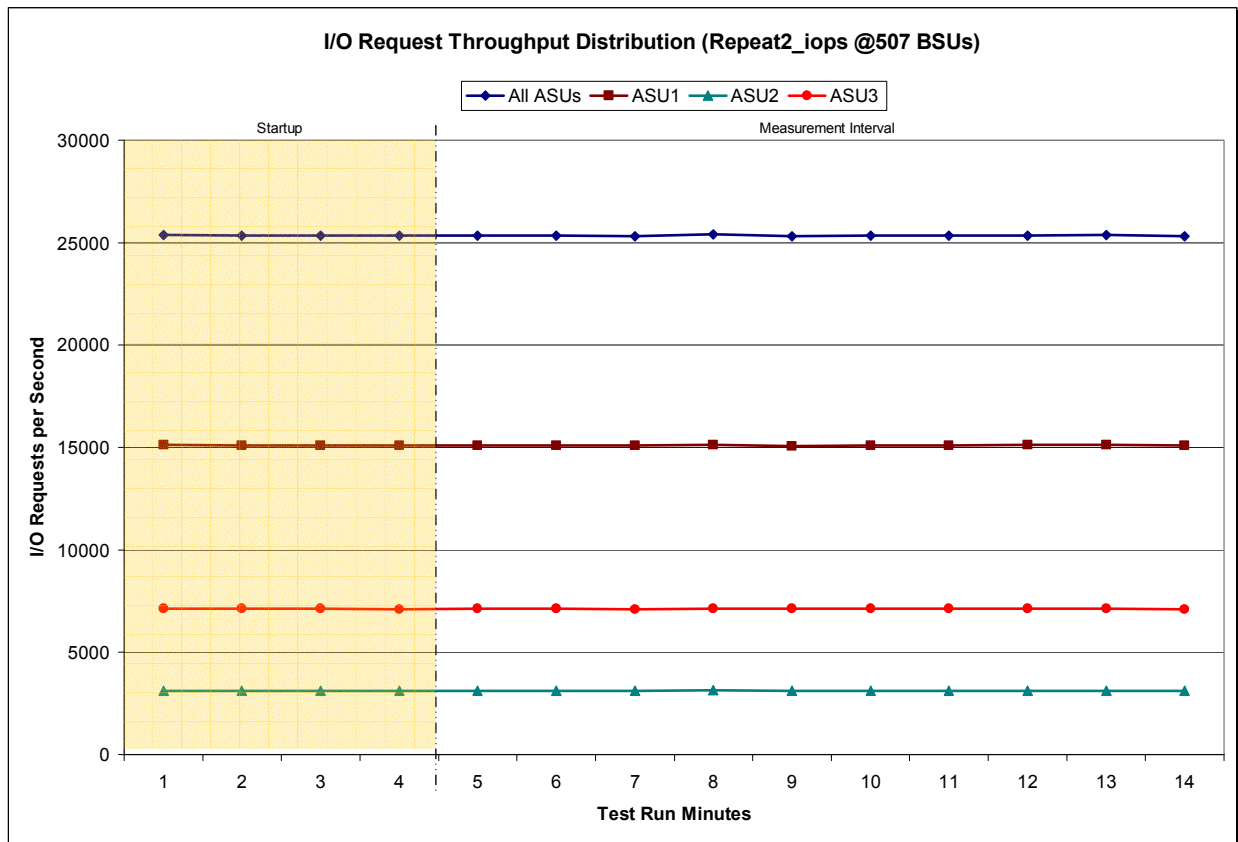
**Repeatability 2 IOPS - I/O Request Throughput Distribution Data**

507 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:24:37	11:28:38	0-3	0:04:01
Measurement Interval	11:28:38	11:38:38	4-13	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	25,361.53	15,113.57	3,114.93	7,133.03
1	25,349.00	15,106.85	3,116.48	7,125.67
2	25,352.88	15,103.20	3,113.37	7,136.32
3	25,347.65	15,109.08	3,124.17	7,114.40
4	25,355.48	15,100.80	3,119.60	7,135.08
5	25,339.03	15,099.77	3,117.32	7,121.95
6	25,297.43	15,085.35	3,109.72	7,102.37
7	25,397.70	15,133.73	3,134.85	7,129.12
8	25,324.95	15,078.85	3,124.18	7,121.92
9	25,328.22	15,098.90	3,111.88	7,117.43
10	25,332.58	15,099.80	3,108.78	7,124.00
11	25,355.48	15,125.50	3,115.35	7,114.63
12	25,387.90	15,142.00	3,125.67	7,120.23
13	25,300.68	15,095.67	3,107.58	7,097.43
Average	25,341.95	15,106.04	3,117.49	7,118.42

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





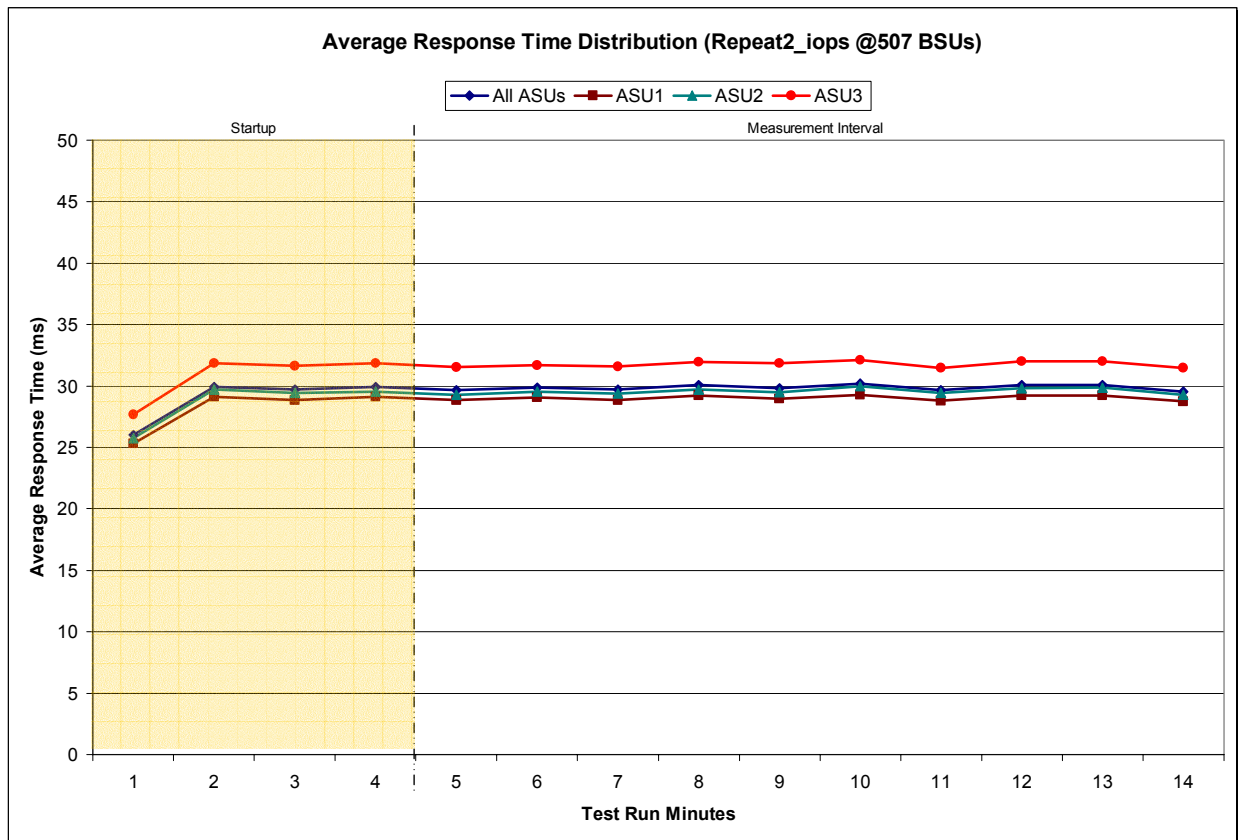
**Repeatability 2 IOPS –Average Response Time (ms) Distribution Data**

507 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:24:37	11:28:38	0-3	0:04:01
Measurement Interval	11:28:38	11:38:38	4-13	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	26.03	25.32	25.74	27.65
1	29.95	29.12	29.69	31.83
2	29.70	28.83	29.45	31.63
3	29.93	29.10	29.57	31.83
4	29.66	28.86	29.28	31.53
5	29.86	29.07	29.54	31.70
6	29.70	28.86	29.41	31.59
7	30.07	29.24	29.73	31.96
8	29.84	28.98	29.51	31.83
9	30.17	29.31	29.95	32.10
10	29.64	28.81	29.45	31.49
11	30.08	29.22	29.80	32.03
12	30.09	29.24	29.87	32.00
13	29.56	28.72	29.28	31.46
Average	29.87	29.03	29.58	31.77

**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	0.0348	0.2801	0.0697	0.2106	0.0180	0.0701	0.0352	0.2814
COV	0.009	0.005	0.009	0.005	0.022	0.009	0.018	0.003

**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	0.0351	0.2810	0.0699	0.2099	0.0179	0.0700	0.0350	0.2811
COV	0.003	0.001	0.003	0.003	0.004	0.003	0.003	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	0.0350	0.2810	0.0702	0.2100	0.0182	0.0701	0.0348	0.2807
COV	0.015	0.003	0.008	0.005	0.019	0.013	0.017	0.005

**Repeatability 2 (IOPS)**

**Measured Intensity Multiplier and Coefficient of Variation**

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2812	0.0700	0.2099	0.0180	0.0700	0.0350	0.2809
COV	0.004	0.001	0.004	0.002	0.006	0.002	0.005	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 SPC-1 Workload Generator input parameters for the Data Persistence Test are listed below.

```
java -Xmx512m persist1 -b 507
```

```
java -Xmx512m persist2
```

## 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

<b>Data Persistence Test Results</b>	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	62,880,144
Total Number of Logical Blocks Verified	54,782,848
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.

## **TESTED STORAGE CONFIGURATION (TSC) AVAILABILITY DATE**

### *Clause 9.2.4.9*

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

The Sun StorEdge™ 6320, as documented in this Full Disclosure Report became available for customer purchase and shipment on April 7, 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 observed during the SPC-1 Remote Audit of the Sun StorEdge™ 6320.