SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

IBM CORPORATION
IBM TOTALSTORAGE ENTERPRISE STORAGE SERVER MODEL 800

SPC-1 V1.6

Submitted for Review: December 7, 2002
Accepted: February 5, 2003

First Edition – December 2002

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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

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

December 7, 2002

The SPC Benchmark 1™ results listed below for the IBM TotalStorage Enterprise Storage Server Model 800 were produced in compliance with the SPC Benchmark 1™ Remote Audit requirements.

SPC Benchmark 1™ Results	
Tested Storage Configuration (TSC) Name: IBM TotalStorage Enterprise Storage Server Model 800	
Metric	**Reported Result**
SPC-1 IOPS™	22,999.27
SPC-1 Price-Performance	$34.88/SPC-1 IOPS™
Total ASU Capacity	3,206.66 GB
Data Protection Level	RAID5
SPC-1 LRT™	2.53 ms
Total TSC Price (including three-year maintenance)	$802,116

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.

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- 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 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

Walter E. Baker
SPC Auditor

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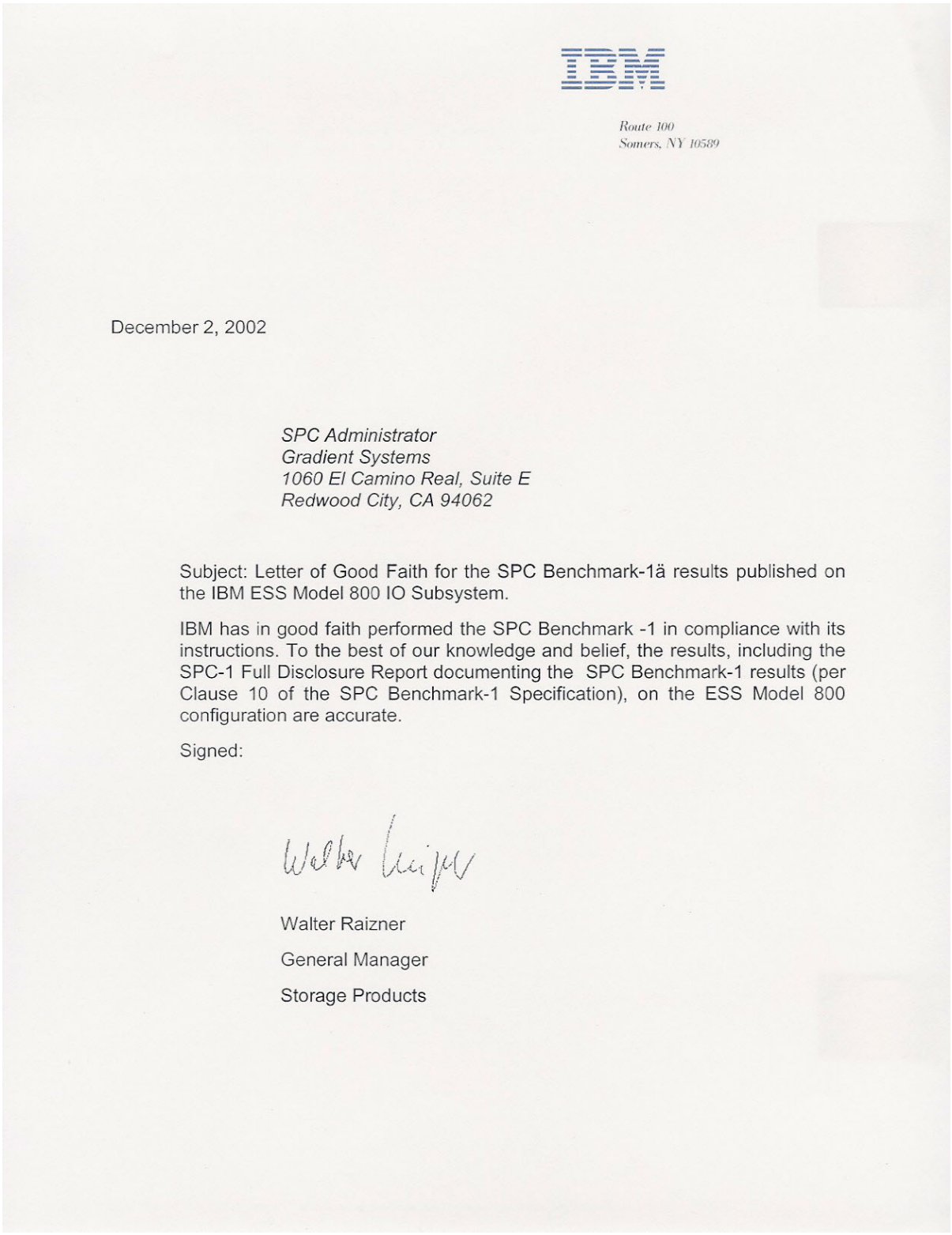
LETTER OF GOOD FAITH



IBM

Route 100
Somers, NY 10589

December 2, 2002

SPC Administrator
Gradient Systems
1060 El Camino Real, Suite E
Redwood City, CA 94062

Subject: Letter of Good Faith for the SPC Benchmark-1ä results published on the IBM ESS Model 800 IO Subsystem.

IBM has in good faith performed the SPC Benchmark -1 in compliance with its instructions. To the best of our knowledge and belief, the results, including the SPC-1 Full Disclosure Report documenting the SPC Benchmark-1 results (per Clause 10 of the SPC Benchmark-1 Specification), on the ESS Model 800 configuration are accurate.

Signed:

Walter Raizner

General Manager

Storage Products

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	IBM Corporation www.ibm.com Bruce McNutt bmcnutt@us.ibm.com KBV/9062-2 9000 South Rita Road Tucson, AZ 85744 Phone: (520) 799-2460 FAX: (520) 799-5530
Test Sponsor Alternate Contact	IBM Corporation www.ibm.com John Ponder ponder@us.ibm.com KBV/9062-2 9000 South Rita Road Tucson, AZ 85744 Phone: (520) 799-4388 FAX: (520) 799-5530
Auditor	Storage Performance Council www.storageperformance.org Walter E. Baker AuditService@storageperformance.org 1060 El Camino Real, Suite F Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-1 Specification revision number	V1.6
SPC-1 Workload Generator revision number	V1.1
Date Results were first used publicly	December 6, 2002
Date FDR was submitted to the SPC	December 7, 2002
Date the TSC is/was available for shipment to customers	November 22, 2002
Date the TSC completed audit certification	December 7, 2002

Summary of Results

SPC-1 Results	
Tested Storage Configuration (TSC) Name: IBM TotalStorage Enterprise Storage Server Model 800	
Metric	**Reported Result**
SPC-1 IOPS™	22,999.27
SPC-1 Price-Performance	$34.88/SPC-1 IOPS™
Total ASU Capacity	3,206.66 GB
Data Protection Level	RAID5
SPC-1 LRT™	2.53ms
Total TSC Price (including three-year maintenance)	$802,116

SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point. The SPC-1 IOP™ metric reported was achieved while also ensuring full data integrity of all data written to cache, through the use of non-volatile storage to record a redundant copy of the written data.

Total ASU (Application Storage Unit) **Capacity** represents the total storage capacity read and written in the course of executing the SPC-1 benchmark. The actual Configured Storage Capacity was 4,211.2 GB, which included the parity required by a Data Protection Level of RAID5. The Configured Storage Capacity utilized 89.40% of the priced Physical Storage Capacity of 4,710.4 GB.

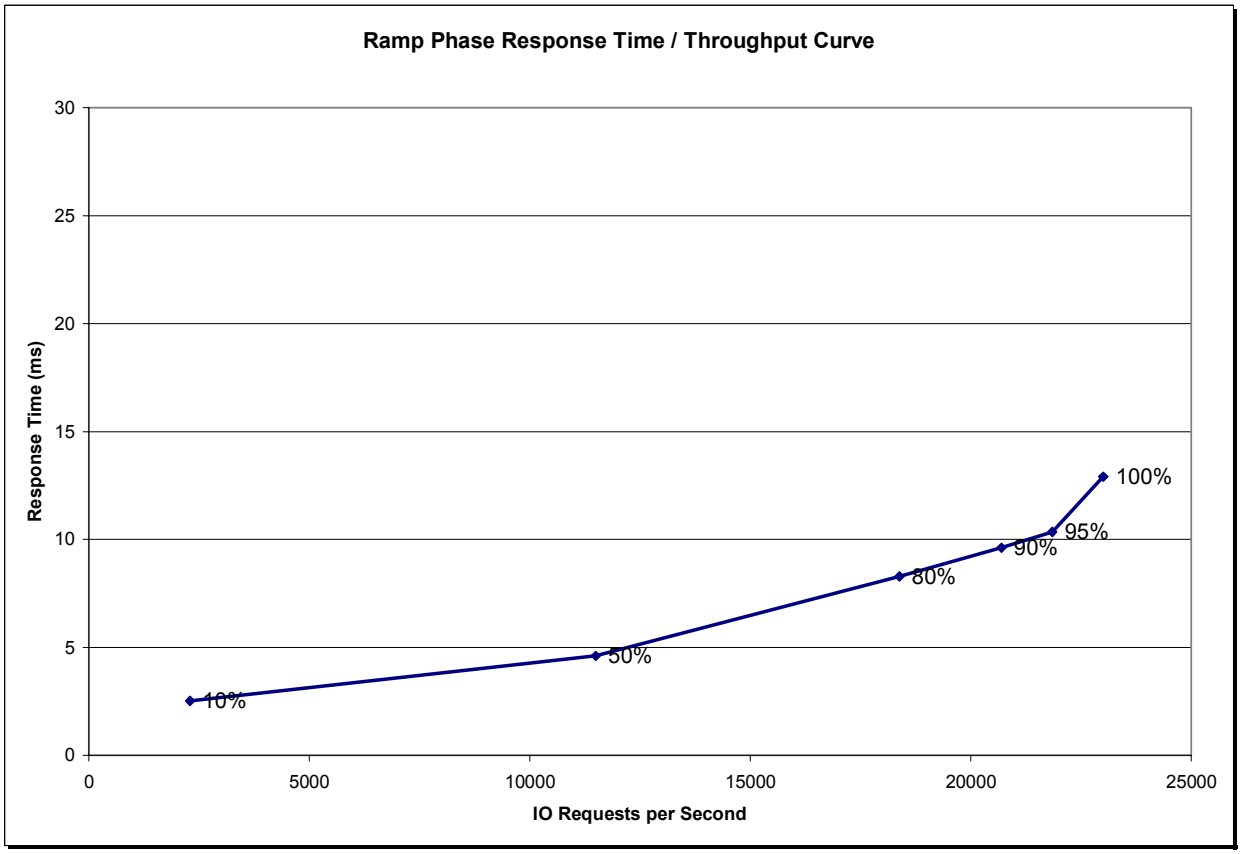
A **Data Protection Level** of RAID5 has user data distributed across disks in an array. Check data corresponding to user data is distributed across multiple disks in the form of bit-by-bit parity.

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

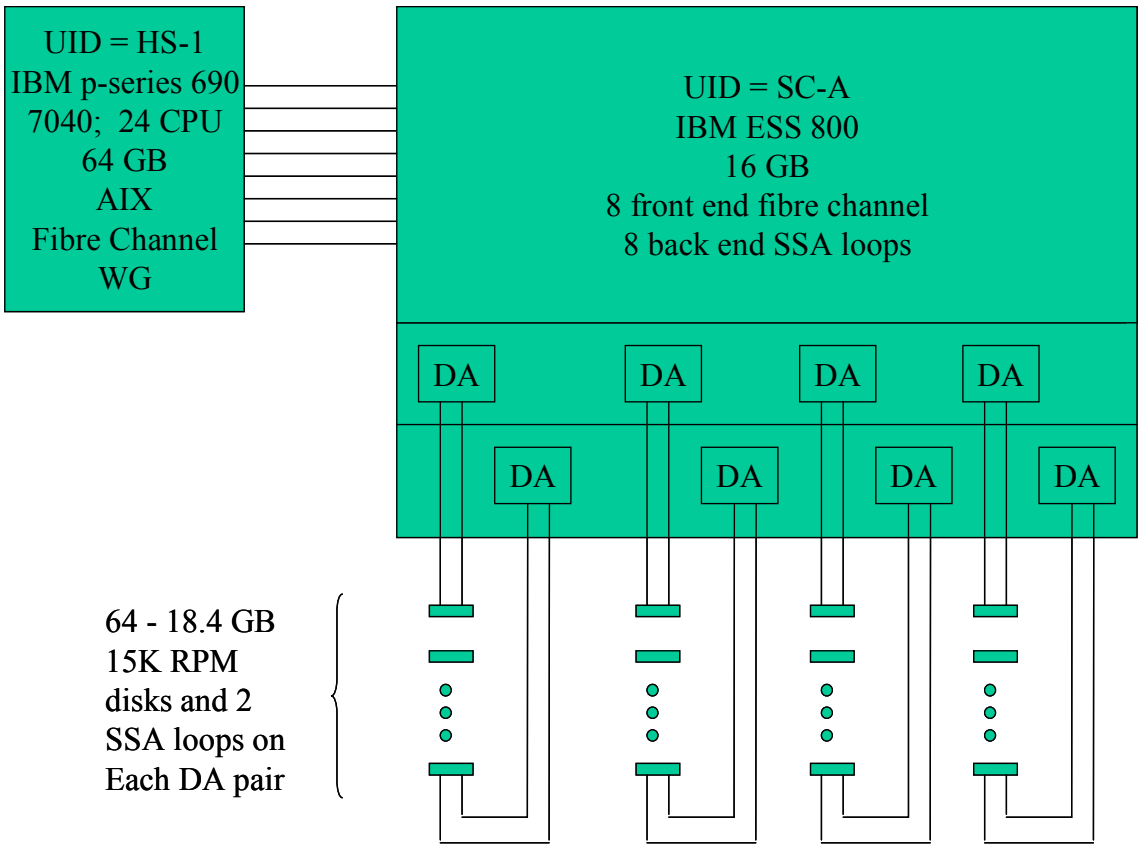
	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	2,299.68	11,500.51	18,388.14	20,702.48	21,844.60	22,999.27
Average Response Time (ms):						
All ASUs	2.53	4.60	8.28	9.62	10.34	12.89
ASU-1	3.36	6.15	11.27	13.01	13.90	17.02
ASU-2	2.30	4.88	8.89	10.29	11.03	13.72
ASU-3	0.85	1.17	1.69	2.11	2.48	3.79
Reads	5.33	10.08	18.71	21.49	22.79	27.31
Writes	0.70	1.02	1.49	1.88	2.23	3.51

Tested Storage Configuration Pricing

Product No.	Description	Unit List Price	Quantity	Quantity List Price	Quantity Field Delegation Price
2105-800	ENTERPRISE STORAGE SERVER	208,000.00	1	208,000.00	87,360.00
2142	DISK EIGHT PACK 18.4 GB	38,000.00	32	1,216,000.00	510,720.00
2110	EXPANSION RACK	40,000.00	1	40,000.00	16,800.00
3025	2 GB FC SHORT WAVE ADAPTER	16,000.00	8	128,000.00	53,760.00
3606	TURBO PROCESSOR	208,000.00	1	208,000.00	87,360.00
2717	ESS MASTER CONSOLE	5,000.00	1	5,000.00	2,100.00
4014	16 GB CACHE	80,000.00	1	80,000.00	33,600.00
6228	EMULEX 9000 Adapter for p-series 7040	3,100.00	8	24,800.00	10,416.00
Tested Storage Configuration (TSC) Cost					**802,116.00**

The above pricing includes 3 year, 24x7 maintenance

Benchmark Configuration/Tested Storage Configuration Diagram



Host System:	Storage System:
IBM p-series 690 7040	IBM TotalStorage ESS 800
UID=HS-1	UID=SC-A
24 1.30GHz POWER4 CPUs 2 CPUs per chip ~1.5 MB L2 cache/chip 32 MB L3 cache/chip	16 GB Cache
64 GB Main Memory	8 – front-end fibre channels
AIX 5.1	8 – back-end SSA loops
Fibre Channel	256 – 18.4 GB 15K RPM disks
WG	Fibre Channel

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.

There were no customer tunable parameters or options that were altered from their default values.

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 scripts (Master Script, mkvg512.sh, and mkrawlv512.sh) were used to create the logical representation of the TSC used in the benchmark measurement.

Master Script

```
./mkvg512.sh
./mkrawlv512.sh spclv
```

mkvg512.sh

```
#!/bin/ksh
# mkvg4vp.script
# Adds volume group
#   Change ' vpathx ' to the desired vpaths
#
display_usage()
{
  echo "\nUSAGE: $0 <volume group name>"
  exit -1
}

mkvg4vp -f -y ess512vg0 -s'64'    vpath0 vpath16 vpath32 vpath48 vpath64 vpath80
vpath96 vpath112 vpath128 vpath144 vpath160 vpath176 vpath192 vpath208 vpath224
vpath240 vpath256 vpath272 vpath288 vpath304 vpath320 vpath336 vpath352 vpath368
vpath384 vpath400 vpath416 vpath432 vpath448 vpath464 vpath480 vpath496

mkvg4vp -f -y ess512vg1 -s'64'    vpath1 vpath17 vpath33 vpath49 vpath65 vpath81
vpath97 vpath113 vpath129 vpath145 vpath161 vpath177 vpath193 vpath209 vpath225
vpath241 vpath257 vpath273 vpath289 vpath305 vpath321 vpath337 vpath353 vpath369
vpath385 vpath401 vpath417 vpath433 vpath449 vpath465 vpath481 vpath497

mkvg4vp -f -y ess512vg2 -s'64'    vpath2 vpath18 vpath34 vpath50 vpath66 vpath82
vpath98 vpath114 vpath130 vpath146 vpath162 vpath178 vpath194 vpath210 vpath226
vpath242 vpath258 vpath274 vpath290 vpath306 vpath322 vpath338 vpath354 vpath370
vpath386 vpath402 vpath418 vpath434 vpath450 vpath466 vpath482 vpath498

mkvg4vp -f -y ess512vg3 -s'64'    vpath3 vpath19 vpath35 vpath51 vpath67 vpath83
vpath99 vpath115 vpath131 vpath147 vpath163 vpath179 vpath195 vpath211 vpath227
vpath243 vpath259 vpath275 vpath291 vpath307 vpath323 vpath339 vpath355 vpath371
vpath387 vpath403 vpath419 vpath435 vpath451 vpath467 vpath483 vpath499

mkvg4vp -f -y ess512vg4 -s'64'    vpath4 vpath20 vpath36 vpath52 vpath68 vpath84
vpath100 vpath116 vpath132 vpath148 vpath164 vpath180 vpath196 vpath212 vpath228
vpath244 vpath260 vpath276 vpath292 vpath308 vpath324 vpath340 vpath356 vpath372
vpath388 vpath404 vpath420 vpath436 vpath452 vpath468 vpath484 vpath500

mkvg4vp -f -y ess512vg5 -s'64'    vpath5 vpath21 vpath37 vpath53 vpath69 vpath85
vpath101 vpath117 vpath133 vpath149 vpath165 vpath181 vpath197 vpath213 vpath229
vpath245 vpath261 vpath277 vpath293 vpath309 vpath325 vpath341 vpath357 vpath373
vpath389 vpath405 vpath421 vpath437 vpath453 vpath469 vpath485 vpath501

mkvg4vp -f -y ess512vg6 -s'64'    vpath6 vpath22 vpath38 vpath54 vpath70 vpath86
vpath102 vpath118 vpath134 vpath150 vpath166 vpath182 vpath198 vpath214 vpath230
vpath246 vpath262 vpath278 vpath294 vpath310 vpath326 vpath342 vpath358 vpath374
vpath390 vpath406 vpath422 vpath438 vpath454 vpath470 vpath486 vpath502

mkvg4vp -f -y ess512vg7 -s'64'    vpath7 vpath23 vpath39 vpath55 vpath71 vpath87
vpath103 vpath119 vpath135 vpath151 vpath167 vpath183 vpath199 vpath215 vpath231
vpath247 vpath263 vpath279 vpath295 vpath311 vpath327 vpath343 vpath359 vpath375
vpath391 vpath407 vpath423 vpath439 vpath455 vpath471 vpath487 vpath503

mkvg4vp -f -y ess512vg8 -s'64'    vpath8 vpath24 vpath40 vpath56 vpath72 vpath88
vpath104 vpath120 vpath136 vpath152 vpath168 vpath184 vpath200 vpath216 vpath232
```

```
vpath248 vpath264 vpath280 vpath296 vpath312 vpath328 vpath344 vpath360 vpath376
vpath392 vpath408 vpath424 vpath440 vpath456 vpath472 vpath488 vpath504

mkvg4vp -f -y ess512vg9 -s'64'    vpath9 vpath25 vpath41 vpath57 vpath73 vpath89
vpath105 vpath121 vpath137 vpath153 vpath169 vpath185 vpath201 vpath217 vpath233
vpath249 vpath265 vpath281 vpath297 vpath313 vpath329 vpath345 vpath361 vpath377
vpath393 vpath409 vpath425 vpath441 vpath457 vpath473 vpath489 vpath505

mkvg4vp -f -y ess512vg10 -s'64' vpath10 vpath26 vpath42 vpath58 vpath74 vpath90
vpath106 vpath122 vpath138 vpath154 vpath170 vpath186 vpath202 vpath218 vpath234
vpath250 vpath266 vpath282 vpath298 vpath314 vpath330 vpath346 vpath362 vpath378
vpath394 vpath410 vpath426 vpath442 vpath458 vpath474 vpath490 vpath506

mkvg4vp -f -y ess512vg11 -s'64' vpath11 vpath27 vpath43 vpath59 vpath75 vpath91
vpath107 vpath123 vpath139 vpath155 vpath171 vpath187 vpath203 vpath219 vpath235
vpath251 vpath267 vpath283 vpath299 vpath315 vpath331 vpath347 vpath363 vpath379
vpath395 vpath411 vpath427 vpath443 vpath459 vpath475 vpath491 vpath507

mkvg4vp -f -y ess512vg12 -s'64' vpath12 vpath28 vpath44 vpath60 vpath76 vpath92
vpath108 vpath124 vpath140 vpath156 vpath172 vpath188 vpath204 vpath220 vpath236
vpath252 vpath268 vpath284 vpath300 vpath316 vpath332 vpath348 vpath364 vpath380
vpath396 vpath412 vpath428 vpath444 vpath460 vpath476 vpath492 vpath508

mkvg4vp -f -y ess512vg13 -s'64' vpath13 vpath29 vpath45 vpath61 vpath77 vpath93
vpath109 vpath125 vpath141 vpath157 vpath173 vpath189 vpath205 vpath221 vpath237
vpath253 vpath269 vpath285 vpath301 vpath317 vpath333 vpath349 vpath365 vpath381
vpath397 vpath413 vpath429 vpath445 vpath461 vpath477 vpath493 vpath509

mkvg4vp -f -y ess512vg14 -s'64' vpath14 vpath30 vpath46 vpath62 vpath78 vpath94
vpath110 vpath126 vpath142 vpath158 vpath174 vpath190 vpath206 vpath222 vpath238
vpath254 vpath270 vpath286 vpath302 vpath318 vpath334 vpath350 vpath366 vpath382
vpath398 vpath414 vpath430 vpath446 vpath462 vpath478 vpath494 vpath510

mkvg4vp -f -y ess512vg15 -s'64' vpath15 vpath31 vpath47 vpath63 vpath79 vpath95
vpath111 vpath127 vpath143 vpath159 vpath175 vpath191 vpath207 vpath223 vpath239
vpath255 vpath271 vpath287 vpath303 vpath319 vpath335 vpath351 vpath367 vpath383
vpath399 vpath415 vpath431 vpath447 vpath463 vpath479 vpath495 vpath511
```

mkrawlv512.sh:

```
#!/bin/ksh
#
# mkrawlv.script
#
# Creates logical volumes
#     Change 'vpath8' to the desired vpath
#     Change 'ess512vg1' to the appropriate volume group
#      Change ' 128 '  to the desired number of partitions (Note: the size of the
physical partition is
#                     decided when the volume group is created )
#

display_usage()
{
  echo "\nUSAGE: $0 <logical volume>"
  echo "  logical volume  is the prefix for the logical volume name (required)"
  exit -1
}
```

```
# check parameters
if [ $# -lt 1 ]
then
  display_usage
fi

let count=0
let vgnum=0
while [ $vgnum -lt 14 ]
do
let i=1
while [ $i -lt 17 ]
do
let count=count+1
LV=${1}${count}
VG=ess512vg${vgnum}
let num1=vgnum
let num2=vgnum+16
let num3=vgnum+32
let num4=vgnum+48
let num5=vgnum+64
let num6=vgnum+80
let num7=vgnum+96
let num8=vgnum+112
let num9=vgnum+128
let num10=vgnum+144
let num11=vgnum+160
let num12=vgnum+176
let num13=vgnum+192
let num14=vgnum+208
let num15=vgnum+224
let num16=vgnum+240
let num17=vgnum+256
let num18=vgnum+272
let num19=vgnum+288
let num20=vgnum+304
let num21=vgnum+320
let num22=vgnum+336
let num23=vgnum+352
let num24=vgnum+368
let num25=vgnum+384
let num26=vgnum+400
let num27=vgnum+416
let num28=vgnum+432
let num29=vgnum+448
let num30=vgnum+464
let num31=vgnum+480
let num32=vgnum+496
LUN1=vpath${num1}
LUN2=vpath${num2}
LUN3=vpath${num3}
LUN4=vpath${num4}
LUN5=vpath${num5}
LUN6=vpath${num6}
LUN7=vpath${num7}
LUN8=vpath${num8}
LUN9=vpath${num9}
LUN10=vpath${num10}
LUN11=vpath${num11}
LUN12=vpath${num12}
LUN13=vpath${num13}
LUN14=vpath${num14}
LUN15=vpath${num15}
```

```
LUN16=vpath${num16}
LUN17=vpath${num17}
LUN18=vpath${num18}
LUN19=vpath${num19}
LUN20=vpath${num20}
LUN21=vpath${num21}
LUN22=vpath${num22}
LUN23=vpath${num23}
LUN24=vpath${num24}
LUN25=vpath${num25}
LUN26=vpath${num26}
LUN27=vpath${num27}
LUN28=vpath${num28}
LUN29=vpath${num29}
LUN30=vpath${num30}
LUN31=vpath${num31}
LUN32=vpath${num32}
mklv -S 128K -y $LV  -t'rawio' $VG 192  $LUN1 $LUN2 $LUN3 $LUN4 $LUN5 $LUN6 $LUN7
$LUN8 $LUN9 $LUN10 $LUN11 $LUN12 $LUN13 $LUN14 $LUN15 $LUN16 $LUN17 $LUN18 $LUN19
$LUN20 $LUN21 $LUN22 $LUN23 $LUN24 $LUN25 $LUN26 $LUN27 $LUN28 $LUN29 $LUN30 $LUN31
$LUN32
echo "Logical volume $LV has been created"
let i=i+1
echo $i
done
let vgnum=vgnum+1
echo $vgnum
done
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath14
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath30
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath46
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath62
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath78
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath94
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath110
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath126
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath142
```

```
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath158
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath174
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath190
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath206
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath222
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath238
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath254
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath270
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath286
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath302
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath318
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath334
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath350
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath366
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath382
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
```

```
mklv -y $LV  -t'rawio' ess512vg14 96 vpath398
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath414
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath430
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath446
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath462
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath478
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath494
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg14 96 vpath510
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath15
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath31
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath47
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath63
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath79
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath95
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath111
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath127
echo "Logical volume $LV has been created"
let count=count+1
```

```
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath143
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath159
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath175
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath191
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath207
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath223
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath239
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath255
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath271
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath287
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath303
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath319
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath335
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath351
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath367
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath383
echo "Logical volume $LV has been created"
```

```
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath399
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath415
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath431
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath447
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath463
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath479
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath495
echo "Logical volume $LV has been created"
let count=count+1
LV=${1}${count}
mklv -y $LV  -t'rawio' ess512vg15 96 vpath511
echo "Logical volume $LV has been created"
```

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.

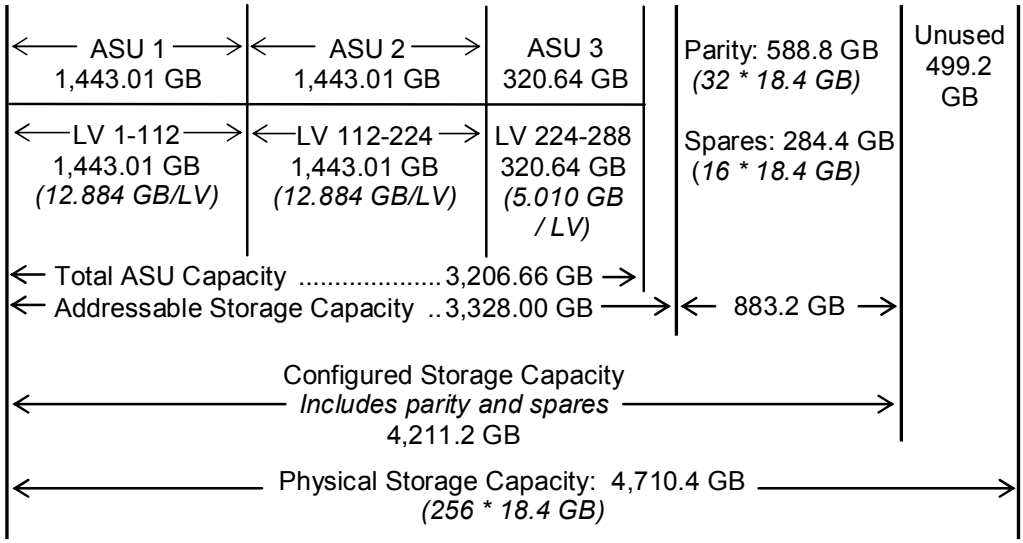
Logical Volume: The division of Addressable Storage Capacity into individually addressable logical units of storage used in the SPC-1 benchmark. Each Logical Volume is implemented as a single, contiguous address space.

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)	3,206.66
Addressable Storage Capacity	Gigabytes (GB)	3,328.0
Configured Storage Capacity	Gigabytes (GB)	4,211.2
Physical Storage Capacity	Gigabytes (GB)	4,710.4

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 (1,443.01 GB)	**ASU-2 (1,443.01 GB)**	**ASU-3 (320.64 GB)**
112 Logical Volumes 12.884 GB per Logical Volume (12.884 GB used/Logical Volume)	112 Logical Volumes 12.884 GB per Logical Volume (12.884 GB used/Logical Volume)	64 Logical Volumes 5.010 GB per Logical Volume (5.010 GB used/Logical Volume)

The Data Protection Level used for all Logical Volumes was RAID5 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 –Xmx512m metrics –b 460
```

Sustainability Test Results File

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

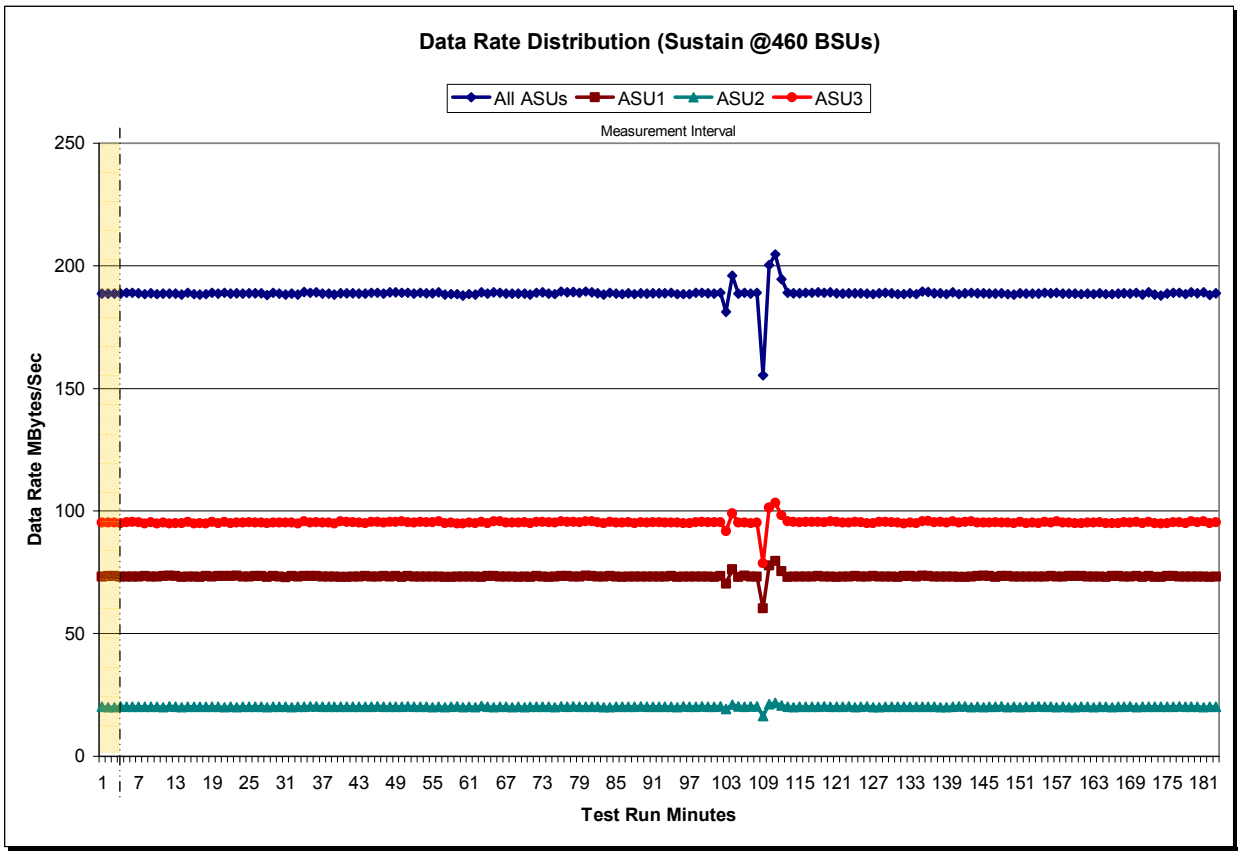
Sustainability Test Results File

Sustainability – Data Rate Distribution Data *(MB / second)*

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	17:08:01	17:11:01	0-2	0:03:00
Measurement Interval	17:11:01	20:11:01	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	188.65	73.34	20.15	95.16	60	188.49	73.17	20.13	95.19	120	188.86	73.05	20.20	95.61
1	188.65	73.49	20.01	95.16	61	188.33	73.22	20.05	95.06	121	188.64	73.18	20.23	95.23
2	188.71	73.36	20.07	95.28	62	189.14	73.10	20.45	95.59	122	188.81	73.23	20.39	95.19
3	188.55	73.17	20.32	95.06	63	188.69	73.41	20.17	95.11	123	188.82	73.35	19.95	95.53
4	188.94	73.26	20.20	95.48	64	189.19	73.35	20.05	95.79	124	188.87	73.31	20.15	95.41
5	189.00	73.24	20.12	95.64	65	189.03	73.28	20.07	95.68	125	188.65	73.26	20.26	95.12
6	188.79	73.27	20.10	95.42	66	188.65	73.24	20.17	95.24	126	188.45	73.41	20.02	95.02
7	188.42	73.47	20.13	94.82	67	188.56	73.23	20.06	95.26	127	188.84	73.28	20.06	95.50
8	188.82	73.34	20.07	95.40	68	188.57	73.16	20.20	95.21	128	188.95	73.19	20.20	95.56
9	188.41	73.30	20.19	94.93	69	188.67	73.32	19.97	95.39	129	188.84	73.32	20.19	95.33
10	188.64	73.40	20.06	95.18	70	188.26	73.07	20.15	95.04	130	188.53	73.08	20.18	95.27
11	188.71	73.53	20.33	94.85	71	189.03	73.38	20.14	95.51	131	188.39	73.48	20.14	94.77
12	188.59	73.39	20.16	95.03	72	189.18	73.34	20.19	95.66	132	188.82	73.48	20.11	95.23
13	188.23	73.13	20.04	95.06	73	188.55	73.10	20.10	95.35	133	188.46	73.18	20.18	95.09
14	188.92	73.28	20.15	95.49	74	188.48	73.22	20.03	95.23	134	189.61	73.62	20.23	95.76
15	188.47	73.32	20.23	94.92	75	189.44	73.37	20.28	95.80	135	189.37	73.42	20.11	95.84
16	188.25	73.13	20.17	94.95	76	189.24	73.40	20.25	95.59	136	188.82	73.24	20.21	95.37
17	188.40	73.37	20.13	94.90	77	189.26	73.32	20.29	95.65	137	188.75	73.22	19.98	95.55
18	189.05	73.23	20.23	95.60	78	188.90	73.24	20.22	95.45	138	188.42	73.22	20.07	95.14
19	188.55	73.38	20.12	95.04	79	189.44	73.56	20.20	95.68	139	189.20	73.26	20.20	95.74
20	188.94	73.40	19.99	95.55	80	189.23	73.37	20.19	95.68	140	188.48	73.10	20.25	95.13
21	188.60	73.38	20.18	95.03	81	188.87	73.27	20.22	95.38	141	188.84	72.99	20.28	95.57
22	188.84	73.55	20.04	95.25	82	188.23	73.19	20.05	94.99	142	189.01	73.26	20.02	95.74
23	188.60	73.31	20.09	95.21	83	189.02	73.46	20.03	95.53	143	188.80	73.39	20.14	95.28
24	188.89	73.28	20.18	95.43	84	188.71	73.34	20.16	95.21	144	188.77	73.59	20.01	95.17
25	188.78	73.41	20.15	95.22	85	188.53	73.04	20.23	95.26	145	188.70	73.37	20.11	95.21
26	188.75	73.49	20.11	95.15	86	188.74	73.33	20.09	95.33	146	188.62	73.02	20.18	95.42
27	188.16	73.07	20.03	95.05	87	188.39	73.27	20.13	94.99	147	188.86	73.40	20.27	95.19
28	188.90	73.48	20.13	95.29	88	188.81	73.17	20.29	95.35	148	188.53	73.40	20.00	95.12
29	188.63	73.30	20.08	95.25	89	188.69	73.27	20.24	95.19	149	188.31	73.21	20.07	95.02
30	188.34	72.97	20.18	95.19	90	188.85	73.30	20.24	95.31	150	188.89	73.18	20.06	95.65
31	188.60	73.38	20.02	95.20	91	188.75	73.17	20.24	95.34	151	188.57	73.31	20.17	95.08
32	188.25	73.26	20.19	94.80	92	188.77	73.26	20.22	95.29	152	188.60	73.19	20.14	95.28
33	189.29	73.44	20.08	95.77	93	188.94	73.42	20.25	95.27	153	188.65	73.32	20.27	95.06
34	188.92	73.37	20.28	95.27	94	188.43	73.14	20.01	95.28	154	188.91	73.18	20.07	95.65
35	189.08	73.44	20.30	95.33	95	188.53	73.26	20.25	95.02	155	188.78	73.36	20.17	95.25
36	188.61	73.23	20.21	95.17	96	188.46	73.26	20.19	95.01	156	189.06	73.25	19.99	95.82
37	188.62	73.19	20.13	95.30	97	188.92	73.34	20.22	95.36	157	188.61	73.23	20.22	95.16
38	188.31	73.20	20.18	94.93	98	189.06	73.18	20.28	95.59	158	188.69	73.37	20.06	95.26
39	188.84	73.02	20.11	95.71	99	188.84	73.31	20.19	95.34	159	188.62	73.45	20.06	95.11
40	188.85	73.14	20.17	95.55	100	188.67	73.14	20.10	95.43	160	188.52	73.42	20.08	95.01
41	188.89	73.31	20.15	95.42	101	189.07	73.36	20.38	95.32	161	188.71	73.22	20.21	95.28
42	188.60	73.27	20.13	95.20	102	181.33	70.39	19.20	91.75	162	188.47	73.17	20.04	95.26
43	188.59	73.35	20.18	95.07	103	196.09	76.16	21.01	98.92	163	188.85	73.27	20.21	95.37
44	189.05	73.31	20.14	95.59	104	188.58	73.16	20.25	95.17	164	188.43	73.11	20.23	95.09
45	189.01	73.24	20.26	95.52	105	189.03	73.55	20.25	95.24	165	188.45	73.38	20.05	95.02
46	188.67	73.35	20.14	95.18	106	188.60	73.34	20.25	95.01	166	188.65	73.41	20.21	95.03
47	189.10	73.32	20.15	95.64	107	188.93	73.32	20.41	95.20	167	188.77	73.24	20.11	95.42
48	189.13	73.40	20.18	95.56	108	155.29	60.29	16.43	78.58	168	188.71	73.17	20.27	95.26
49	189.03	73.11	20.24	95.69	109	200.37	77.73	21.28	101.36	169	189.04	73.40	20.01	95.64
50	188.97	73.37	20.28	95.33	110	204.62	79.56	21.76	103.30	170	188.20	73.11	20.11	94.98
51	188.67	73.32	20.08	95.28	111	194.48	75.42	20.73	98.33	171	189.19	73.46	20.10	95.63
52	188.92	73.22	20.21	95.49	112	188.96	73.12	20.17	95.68	172	188.26	73.08	20.09	95.09
53	188.74	73.24	20.12	95.38	113	188.82	73.33	20.00	95.49	173	187.97	73.01	20.14	94.83
54	188.77	73.32	20.06	95.39	114	188.87	73.26	20.18	95.42	174	188.69	73.36	20.21	95.12
55	189.23	73.30	20.24	95.69	115	188.90	73.26	20.15	95.49	175	188.98	73.35	20.22	95.42
56	188.30	73.14	20.05	95.11	116	188.94	73.26	20.12	95.56	176	189.05	73.32	20.28	95.45
57	188.44	73.07	20.09	95.27	117	189.17	73.48	20.19	95.50	177	188.43	73.26	20.15	95.02
58	188.38	73.22	20.32	94.83	118	188.92	73.25	20.32	95.35	178	189.21	73.34	20.17	95.70
59	187.95	73.17	19.98	94.80	119	189.09	73.18	20.20	95.72	179	188.72	73.33	20.08	95.31
										180	189.18	73.29	20.05	95.84
										181	188.15	73.07	20.10	94.98
										182	188.73	73.27	20.12	95.33

Sustainability – Data Rate Distribution Graph

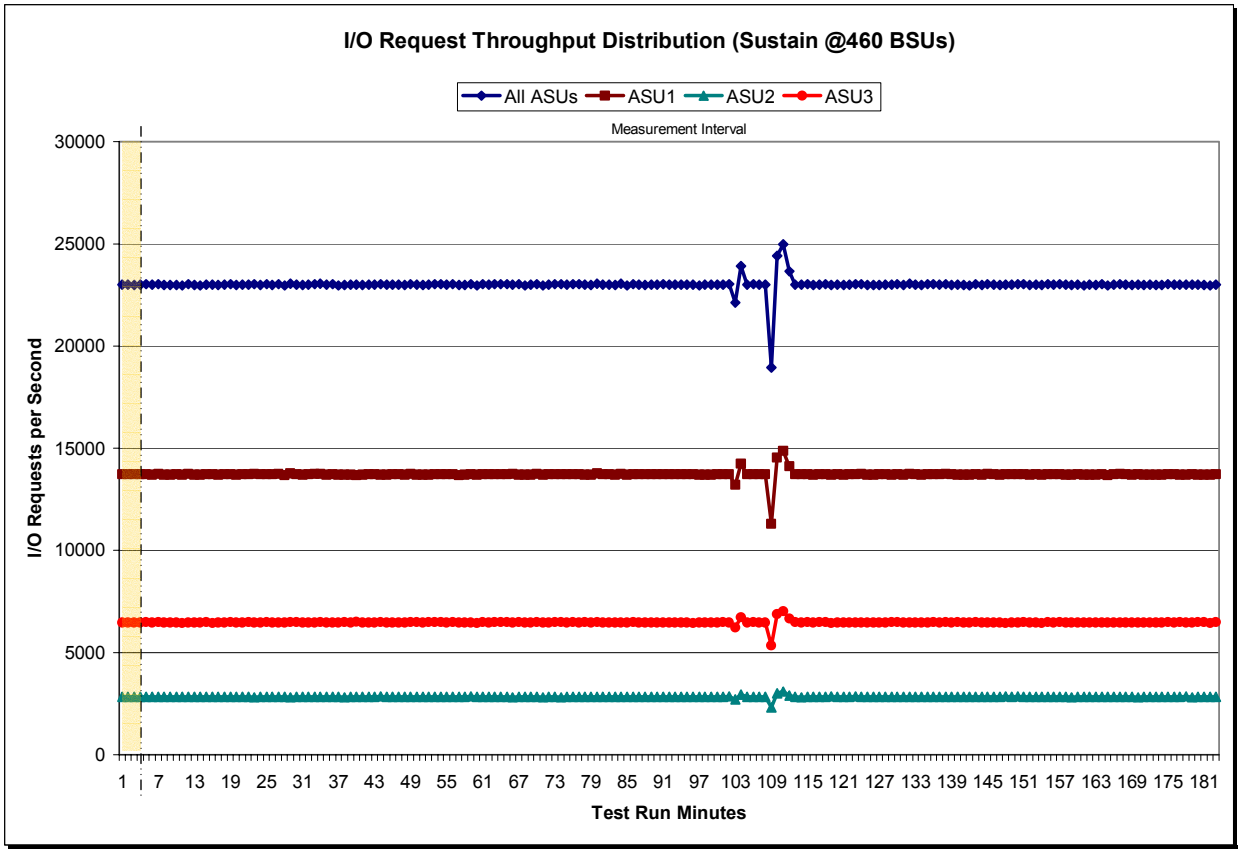


Sustainability – I/O Request Throughput Distribution Data

	Start	Stop	Interval	Duration
Ramp-Up/Start-Up	17:08:01	17:11:01	0-2	0:03:00
Measurement Interval	17:11:01	20:11:01	3-182	3:00:00

Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3	Interval	All ASUs	ASU1	ASU2	ASU3
0	23,007.73	13,721.17	2,823.10	6,463.47	60	23,033.90	13,722.68	2,832.57	6,478.65	120	22,985.23	13,694.67	2,826.57	6,464.00
1	23,000.00	13,710.32	2,824.53	6,465.15	61	23,003.15	13,716.10	2,822.13	6,464.92	121	23,000.97	13,711.82	2,829.95	6,459.20
2	22,984.85	13,707.42	2,822.77	6,454.67	62	23,020.00	13,707.57	2,837.95	6,474.48	122	23,018.75	13,710.17	2,844.35	6,464.23
3	22,996.20	13,705.30	2,831.43	6,459.47	63	23,014.13	13,706.20	2,838.12	6,469.82	123	23,018.02	13,735.42	2,824.83	6,457.77
4	23,019.02	13,725.27	2,824.33	6,469.42	64	23,013.35	13,719.78	2,824.03	6,469.53	124	22,973.97	13,694.07	2,826.98	6,452.92
5	22,996.75	13,697.57	2,832.93	6,466.25	65	23,002.98	13,728.67	2,812.63	6,461.68	125	22,983.40	13,698.83	2,832.97	6,451.60
6	23,032.62	13,729.95	2,824.93	6,477.73	66	23,019.47	13,700.55	2,836.32	6,482.60	126	22,989.78	13,711.42	2,821.35	6,457.02
7	22,988.07	13,699.88	2,832.37	6,455.82	67	22,959.45	13,685.13	2,820.35	6,453.97	127	22,994.20	13,709.90	2,827.82	6,456.48
8	22,990.95	13,701.78	2,828.28	6,460.88	68	22,996.58	13,699.95	2,834.72	6,461.92	128	22,997.20	13,698.47	2,823.67	6,475.07
9	22,981.25	13,708.67	2,824.55	6,448.03	69	23,029.75	13,730.22	2,819.75	6,479.78	129	23,013.67	13,715.50	2,828.38	6,469.78
10	22,956.63	13,696.70	2,819.37	6,440.57	70	22,965.27	13,691.63	2,818.07	6,455.57	130	22,980.15	13,691.53	2,824.42	6,464.20
11	23,020.62	13,728.53	2,835.05	6,457.03	71	23,004.35	13,712.32	2,825.57	6,466.47	131	23,036.10	13,742.52	2,833.47	6,460.12
12	22,970.28	13,690.27	2,823.28	6,456.73	72	23,028.85	13,723.40	2,827.08	6,478.37	132	22,993.15	13,707.23	2,821.17	6,464.75
13	22,967.52	13,692.13	2,818.88	6,456.50	73	23,022.37	13,717.98	2,817.12	6,487.27	133	22,973.25	13,689.95	2,824.38	6,458.92
14	23,008.00	13,713.47	2,824.55	6,469.98	74	22,997.90	13,711.10	2,822.07	6,464.73	134	23,023.65	13,723.45	2,836.85	6,463.35
15	23,001.13	13,723.30	2,831.63	6,446.20	75	23,024.32	13,717.75	2,827.60	6,478.97	135	23,013.87	13,714.38	2,825.47	6,474.02
16	22,989.85	13,700.45	2,829.53	6,459.87	76	23,013.80	13,719.65	2,825.83	6,468.32	136	23,000.92	13,706.08	2,829.95	6,464.88
17	23,008.83	13,723.97	2,831.50	6,453.37	77	22,999.18	13,693.75	2,836.15	6,469.28	137	23,032.68	13,726.27	2,832.57	6,473.85
18	23,015.55	13,710.15	2,826.50	6,478.90	78	22,976.40	13,698.40	2,822.13	6,455.87	138	22,985.92	13,707.80	2,820.97	6,457.15
19	22,981.25	13,698.05	2,829.27	6,453.93	79	23,054.60	13,749.07	2,828.22	6,477.32	139	23,002.05	13,694.50	2,831.97	6,475.58
20	22,993.10	13,707.83	2,821.30	6,463.97	80	23,006.88	13,709.18	2,832.67	6,465.03	140	22,973.58	13,688.17	2,832.32	6,453.10
21	23,012.77	13,711.90	2,825.00	6,475.87	81	22,995.18	13,706.58	2,831.60	6,457.00	141	22,965.68	13,683.20	2,832.35	6,450.13
22	23,015.43	13,736.17	2,817.02	6,462.25	82	22,972.45	13,692.27	2,827.20	6,452.98	142	23,024.13	13,710.83	2,826.02	6,487.28
23	22,991.25	13,708.32	2,823.72	6,459.22	83	23,045.12	13,746.95	2,839.27	6,458.90	143	22,975.22	13,693.50	2,823.40	6,458.32
24	23,019.77	13,714.13	2,830.40	6,475.23	84	22,967.08	13,688.00	2,825.55	6,453.53	144	23,013.07	13,727.05	2,827.43	6,458.58
25	22,989.60	13,713.72	2,824.08	6,451.80	85	23,015.30	13,714.53	2,831.80	6,468.97	145	23,006.23	13,723.15	2,826.52	6,456.57
26	23,025.65	13,734.17	2,827.72	6,463.77	86	22,997.17	13,712.82	2,820.70	6,463.65	146	22,986.57	13,689.53	2,833.05	6,463.98
27	22,952.42	13,678.50	2,820.05	6,453.87	87	22,985.25	13,704.63	2,828.75	6,451.87	147	22,992.60	13,707.15	2,840.80	6,444.65
28	23,041.75	13,750.32	2,816.90	6,474.53	88	23,006.92	13,719.05	2,829.85	6,458.02	148	22,995.10	13,708.32	2,832.35	6,454.43
29	23,001.82	13,704.75	2,824.95	6,472.12	89	23,002.27	13,706.05	2,831.85	6,464.37	149	23,021.10	13,718.33	2,843.90	6,458.87
30	22,978.88	13,689.63	2,828.67	6,460.58	90	23,013.58	13,721.13	2,825.88	6,466.57	150	23,020.17	13,706.25	2,827.63	6,486.28
31	22,999.45	13,721.08	2,826.58	6,451.78	91	23,003.63	13,710.28	2,831.17	6,462.18	151	22,988.12	13,693.73	2,835.38	6,459.00
32	23,018.77	13,736.90	2,834.12	6,447.75	92	23,010.28	13,706.48	2,835.95	6,467.85	152	22,999.40	13,719.63	2,818.58	6,461.18
33	23,034.92	13,726.62	2,822.42	6,485.88	93	23,006.62	13,723.43	2,822.50	6,460.68	153	22,970.85	13,696.48	2,834.30	6,440.07
34	23,000.97	13,704.10	2,837.38	6,459.48	94	22,997.90	13,706.02	2,826.78	6,465.10	154	23,025.35	13,712.30	2,826.27	6,486.78
35	23,021.25	13,724.87	2,833.88	6,462.50	95	22,994.83	13,712.92	2,836.08	6,445.83	155	22,998.98	13,719.65	2,831.65	6,447.68
36	22,964.43	13,685.35	2,818.77	6,460.32	96	22,968.98	13,688.87	2,823.43	6,456.68	156	23,026.98	13,722.63	2,818.83	6,485.52
37	22,982.97	13,695.83	2,816.47	6,470.67	97	22,997.08	13,704.05	2,825.33	6,467.70	157	22,995.78	13,698.30	2,838.68	6,458.80
38	23,000.45	13,702.30	2,836.20	6,461.95	98	23,000.87	13,702.27	2,837.10	6,461.50	158	22,976.05	13,700.80	2,817.27	6,457.98
39	23,001.12	13,670.98	2,832.83	6,497.30	99	22,998.50	13,705.97	2,834.02	6,458.52	159	22,994.05	13,707.85	2,827.58	6,458.62
40	22,987.18	13,690.82	2,827.95	6,468.42	100	23,007.53	13,715.08	2,821.98	6,470.47	160	22,962.25	13,689.60	2,823.80	6,448.85
41	23,012.17	13,714.70	2,835.45	6,462.02	101	23,028.32	13,723.03	2,841.52	6,463.77	161	22,997.97	13,702.05	2,828.35	6,467.57
42	22,991.82	13,708.15	2,822.00	6,461.67	102	22,109.72	13,188.97	2,705.97	6,214.78	162	22,981.25	13,697.18	2,823.07	6,461.00
43	23,013.95	13,702.72	2,841.60	6,469.63	103	23,909.07	14,240.57	2,944.25	6,724.25	163	23,013.88	13,721.53	2,831.58	6,460.77
44	23,001.38	13,697.70	2,839.25	6,464.43	104	23,004.20	13,714.48	2,835.05	6,454.67	164	22,964.10	13,681.63	2,826.63	6,455.83
45	23,010.82	13,709.62	2,836.38	6,464.82	105	23,016.60	13,714.87	2,831.58	6,470.15	165	23,004.48	13,718.60	2,830.50	6,455.38
46	22,991.80	13,713.72	2,828.15	6,449.93	106	22,997.43	13,712.23	2,824.40	6,460.80	166	23,026.85	13,727.25	2,838.15	6,461.45
47	22,983.10	13,684.03	2,832.35	6,466.72	107	23,004.48	13,708.37	2,840.03	6,456.08	167	22,999.95	13,708.37	2,826.77	6,464.82
48	23,034.50	13,736.08	2,828.22	6,470.20	108	18,939.18	11,292.02	2,314.08	5,333.08	168	22,985.10	13,694.40	2,827.38	6,463.32
49	23,005.97	13,697.72	2,836.03	6,472.22	109	24,409.40	14,536.93	2,997.98	6,874.48	169	22,999.23	13,717.68	2,816.57	6,464.98
50	22,991.05	13,702.48	2,836.68	6,451.88	110	24,961.33	14,867.38	3,078.28	7,015.67	170	22,973.98	13,694.83	2,826.80	6,452.35
51	22,994.25	13,690.63	2,833.27	6,470.35	111	23,651.28	14,094.05	2,903.85	6,653.38	171	22,996.33	13,698.73	2,831.42	6,466.18
52	23,016.30	13,722.70	2,821.85	6,471.75	112	23,010.00	13,713.23	2,822.00	6,474.77	172	22,983.15	13,692.33	2,828.30	6,462.52
53	23,013.40	13,710.63	2,832.18	6,470.58	113	22,995.58	13,721.90	2,818.32	6,455.37	173	22,971.87	13,683.23	2,824.47	6,464.17
54	22,998.92	13,706.77	2,828.88	6,463.27	114	23,029.55	13,724.03	2,831.68	6,473.83	174	23,026.10	13,721.83	2,833.05	6,471.22
55	23,031.18	13,719.50	2,837.43	6,474.25	115	22,981.77	13,690.92	2,833.12	6,457.73	175	23,001.58	13,711.67	2,831.87	6,458.05
56	22,970.02	13,681.53	2,824.77	6,463.72	116	22,999.80	13,706.35	2,823.90	6,469.55	176	22,996.90	13,693.55	2,833.50	6,469.85
57	22,979.38	13,695.03	2,824.30	6,460.05	117	23,028.60	13,720.83	2,827.83	6,479.93	177	22,992.75	13,695.75	2,844.87	6,452.13
58	23,013.50	13,710.45	2,841.52	6,461.53	118	22,978.72	13,696.57	2,841.90	6,440.25	178	23,004.35	13,721.17	2,816.47	6,466.72
59	22,956.33	13,692.88	2,823.45	6,440.00	119	22,998.82	13,705.70	2,834.97	6,458.15	179	22,997.53	13,699.00	2,826.43	6,472.10
										180	22,991.22	13,695.47	2,819.92	6,475.83
										181	22,964.12	13,684.72	2,833.12	6,446.28
										182	23,011.37	13,710.13	2,826.62	6,474.62
										Average	23,000.04	13,708.02	2,828.50	6,463.53

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	0.018	0.0700	0.0350	0.2810
COV	0.0045	0.0013	0.0030	0.0015	0.0059	0.0031	0.0046	0.0012

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 t 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 –Xmx512m metrics –b 460

IOPS Test Results File

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

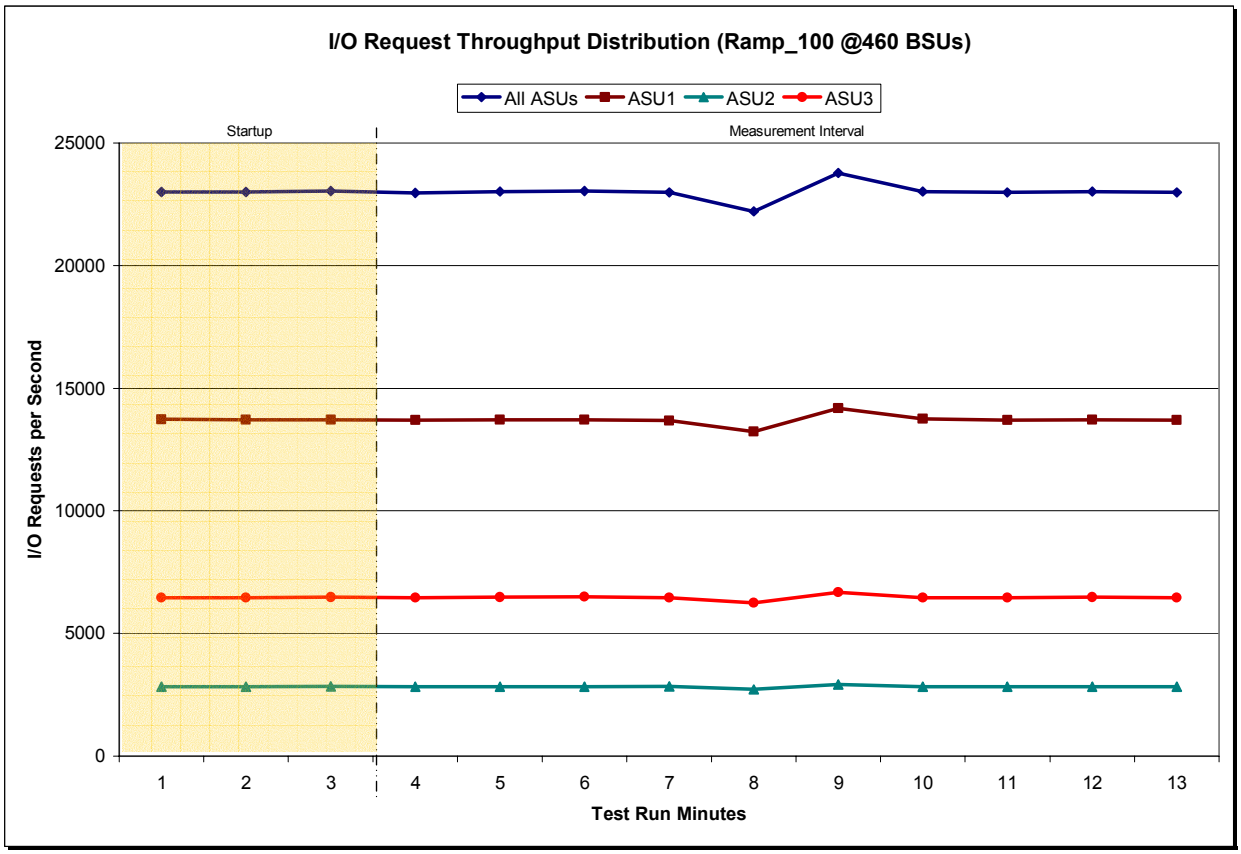
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution Data

460 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:11:36	20:14:37	0-2	0:03:01
Measurement Interval	20:14:37	20:24:37	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	23,009.93	13,724.75	2,820.80	6,464.38
1	23,003.10	13,709.58	2,830.40	6,463.12
2	23,030.62	13,710.57	2,845.05	6,475.00
3	22,970.87	13,692.05	2,822.97	6,455.85
4	23,019.30	13,707.47	2,832.83	6,479.00
5	23,034.18	13,712.92	2,828.13	6,493.13
6	22,986.67	13,682.18	2,836.63	6,467.85
7	22,204.33	13,230.50	2,723.95	6,249.88
8	23,776.02	14,189.47	2,915.15	6,671.40
9	23,026.10	13,742.77	2,827.77	6,455.57
10	22,980.00	13,690.10	2,826.17	6,463.73
11	23,016.85	13,716.27	2,826.22	6,474.37
12	22,978.33	13,696.22	2,828.65	6,453.47
Average	22,999.27	13,705.99	2,826.85	6,466.43

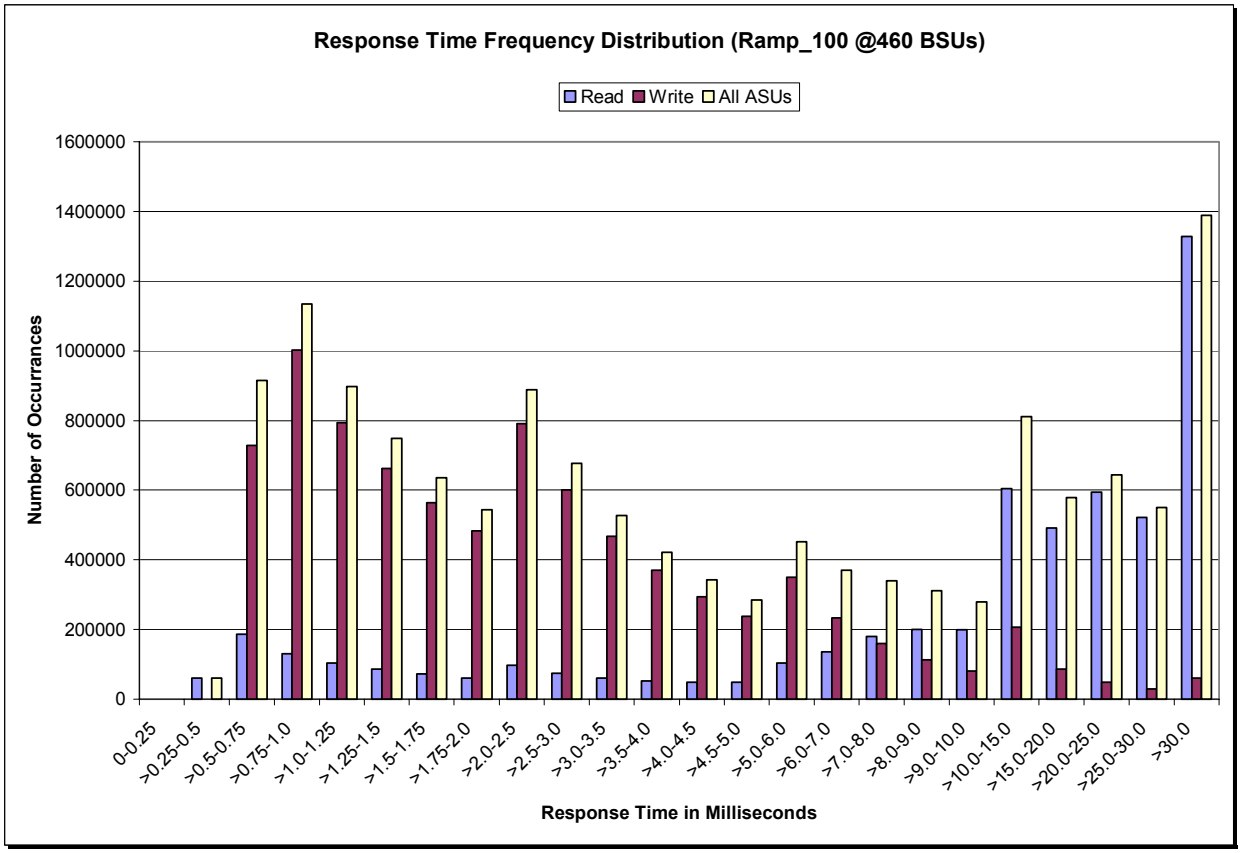
IOPS Test Run – I/O Request Throughput Distribution Graph



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	0	60,543	185,895	131,053	103,759	86,279	72,733	61,407
Write	0	42	728,382	1,002,541	793,562	662,103	563,530	482,631
All ASUs	0	60,585	914,277	1,133,594	897,321	748,382	636,263	544,038
ASU1	0	49,237	552,946	599,580	439,101	356,183	296,849	249,730
ASU2	0	11,324	137,797	150,823	109,528	89,669	74,365	62,864
ASU3	0	24	223,534	383,191	348,692	302,530	265,049	231,444
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	97,781	75,184	60,640	52,166	48,123	47,590	103,666	135,944
Write	790,499	600,957	466,896	370,127	294,207	237,907	349,142	233,683
All ASUs	888,280	676,141	527,536	422,293	342,330	285,497	452,808	369,627
ASU1	394,774	297,025	231,757	187,142	154,554	132,929	224,208	206,454
ASU2	98,772	73,836	58,211	45,971	36,411	30,085	47,249	40,424
ASU3	394,734	305,280	237,568	189,180	151,365	122,483	181,351	122,749
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	179,905	199,948	198,335	603,973	492,028	594,541	521,307	1,327,465
Write	159,448	112,133	80,858	206,666	86,397	48,403	28,718	60,394
All ASUs	339,353	312,081	279,193	810,639	578,425	642,944	550,025	1,387,859
ASU1	215,192	213,098	199,810	598,947	462,681	537,227	462,430	1,161,681
ASU2	39,481	38,708	35,667	100,138	70,301	80,716	72,625	191,137
ASU3	84,680	60,275	43,716	111,554	45,443	25,001	14,970	35,041

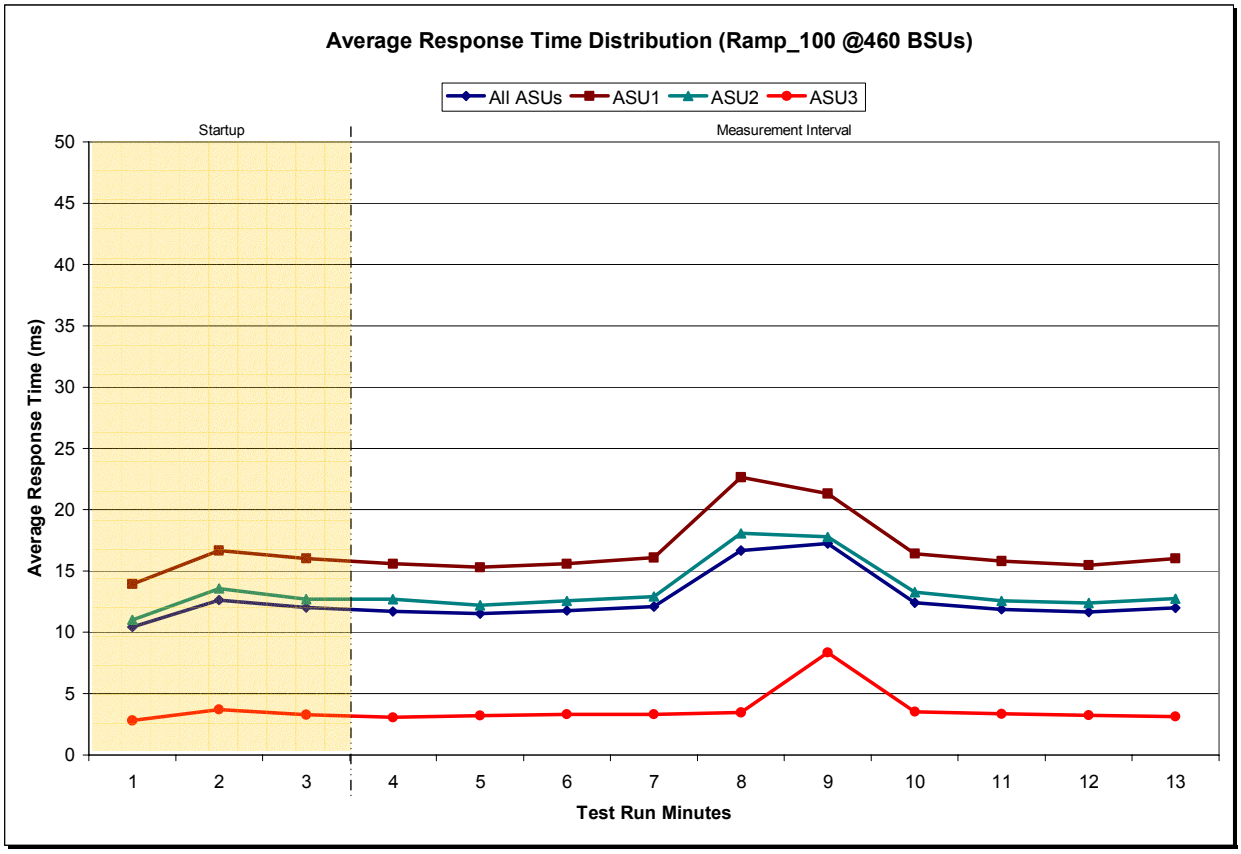
IOPS Test Run –Response Time Frequency Distribution Graph



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

460 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:11:36	20:14:37	0-2	0:03:01
Measurement Interval	20:14:37	20:24:37	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	10.44	13.92	11.02	2.80
1	12.65	16.68	13.58	3.69
2	12.03	16.04	12.71	3.26
3	11.71	15.58	12.69	3.06
4	11.50	15.28	12.22	3.19
5	11.76	15.58	12.56	3.33
6	12.11	16.09	12.91	3.33
7	16.68	22.63	18.08	3.46
8	17.24	21.31	17.78	8.34
9	12.41	16.42	13.28	3.51
10	11.89	15.79	12.56	3.33
11	11.67	15.49	12.39	3.25
12	11.99	16.00	12.74	3.13
Average	12.89	17.02	13.72	3.79

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
13,799,491	12,411,632	1,387,859

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	0.0179	0.0700	0.0349	0.2812
COV	0.0028	0.0012	0.0025	0.0019	0.0069	0.0026	0.0059	0.0016

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, Response Time Ramp, and Repeatability Test Runs are listed below.

Java –Xmx512m metrics –b 460

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 - 460 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:11:36	20:14:37	0-2	0:03:01
Measurement Interval	20:14:37	20:24:37	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	23,009.93	13,724.75	2,820.80	6,464.38
1	23,003.10	13,709.58	2,830.40	6,463.12
2	23,030.62	13,710.57	2,845.05	6,475.00
3	22,970.87	13,692.05	2,822.97	6,455.85
4	23,019.30	13,707.47	2,832.83	6,479.00
5	23,034.18	13,712.92	2,828.13	6,493.13
6	22,986.67	13,682.18	2,836.63	6,467.85
7	22,204.33	13,230.50	2,723.95	6,249.88
8	23,776.02	14,189.47	2,915.15	6,671.40
9	23,026.10	13,742.77	2,827.77	6,455.57
10	22,980.00	13,690.10	2,826.17	6,463.73
11	23,016.85	13,716.27	2,826.22	6,474.37
12	22,978.33	13,696.22	2,828.65	6,453.47
Average	22,999.27	13,705.99	2,826.85	6,466.43

95% Load Level - 437 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:24:50	20:27:51	0-2	0:03:01
Measurement Interval	20:27:51	20:37:51	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	21,878.55	13,025.65	2,702.08	6,150.82
1	21,831.27	13,000.47	2,692.35	6,138.45
2	21,855.72	13,022.87	2,685.15	6,147.70
3	21,813.47	13,000.92	2,687.75	6,124.80
4	21,849.15	13,019.12	2,694.15	6,135.88
5	21,858.73	13,016.83	2,693.03	6,148.87
6	21,835.07	13,016.20	2,692.80	6,126.07
7	21,867.28	13,021.37	2,690.82	6,155.10
8	21,860.83	13,030.37	2,685.40	6,145.07
9	21,835.23	13,023.03	2,683.23	6,128.97
10	21,832.83	12,996.52	2,693.87	6,142.45
11	21,836.00	13,026.78	2,685.67	6,123.55
12	21,857.37	13,046.20	2,691.07	6,120.10
Average	21,844.60	13,019.73	2,689.78	6,135.09

90% Load Level - 414 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:38:01	20:41:02	0-2	0:03:01
Measurement Interval	20:41:02	20:51:02	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	20,705.72	12,346.30	2,539.97	5,819.45
1	20,669.48	12,319.85	2,539.62	5,810.02
2	20,710.58	12,334.10	2,548.68	5,827.80
3	20,675.98	12,312.63	2,546.10	5,817.25
4	20,688.10	12,336.68	2,541.98	5,809.43
5	20,684.03	12,330.22	2,540.65	5,813.17
6	20,716.92	12,362.75	2,554.43	5,799.73
7	20,719.17	12,347.15	2,553.07	5,818.95
8	20,700.27	12,334.48	2,555.48	5,810.30
9	20,717.42	12,342.02	2,558.62	5,816.78
10	20,693.52	12,331.65	2,540.30	5,821.57
11	20,705.97	12,341.88	2,549.62	5,814.47
12	20,723.42	12,350.40	2,552.58	5,820.43
Average	20,702.48	12,338.99	2,549.28	5,814.21

80% Load Level - 368 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	20:51:13	20:54:14	0-2	0:03:01
Measurement Interval	20:54:14	21:04:14	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	18,405.30	10,976.75	2,259.93	5,168.62
1	18,391.23	10,955.60	2,261.47	5,174.17
2	18,408.75	10,977.52	2,258.62	5,172.62
3	18,384.68	10,960.92	2,260.97	5,162.80
4	18,405.67	10,969.57	2,248.72	5,187.38
5	18,381.42	10,963.33	2,249.00	5,169.08
6	18,374.33	10,945.47	2,264.53	5,164.33
7	18,412.60	10,986.30	2,265.30	5,161.00
8	18,370.00	10,932.23	2,261.00	5,176.77
9	18,391.77	10,953.42	2,262.80	5,175.55
10	18,383.10	10,938.52	2,261.07	5,183.52
11	18,394.57	10,972.65	2,266.98	5,154.93
12	18,383.30	10,955.40	2,254.67	5,173.23
Average	18,388.14	10,957.78	2,259.50	5,170.86

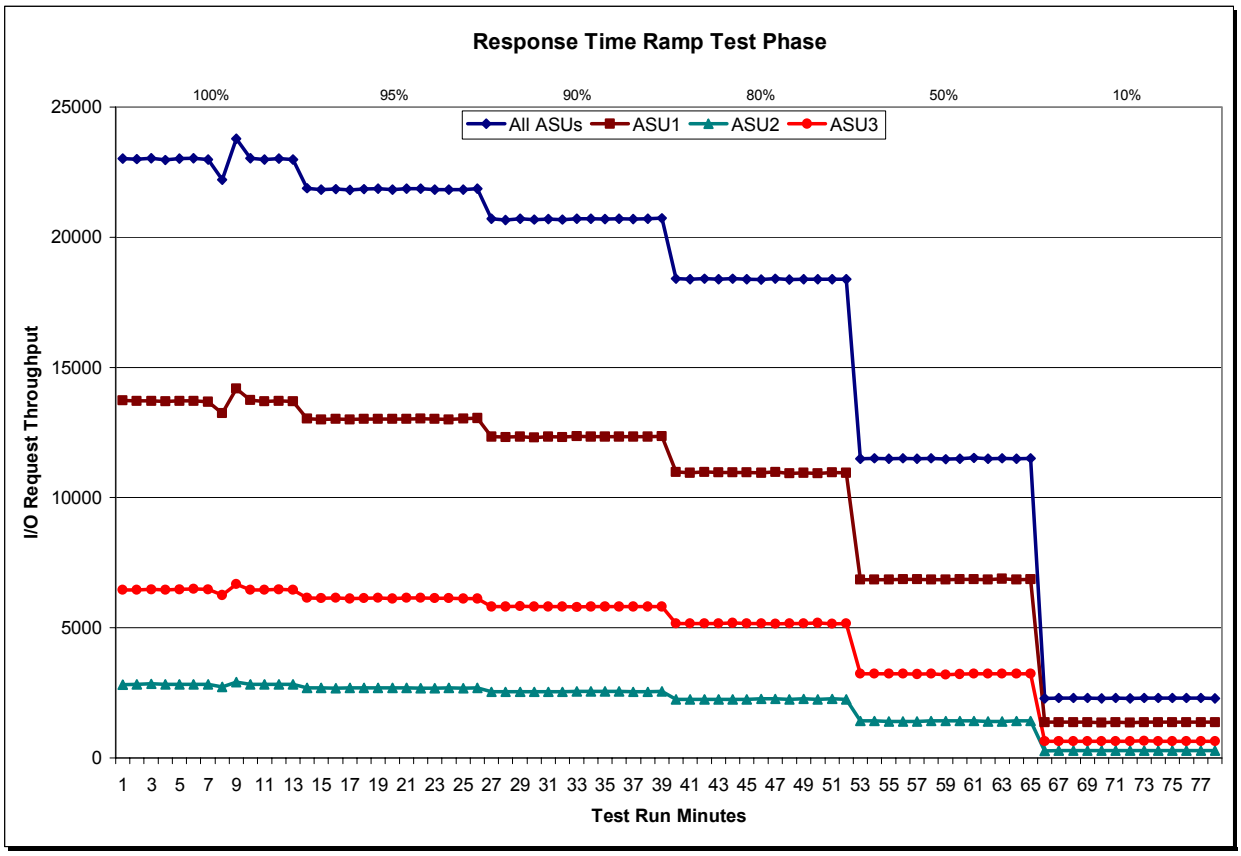
50% Load Level - 230 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:04:24	21:07:25	0-2	0:03:01
Measurement Interval	21:07:25	21:17:25	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	11,491.07	6,841.45	1,416.50	3,233.12
1	11,507.27	6,851.78	1,421.77	3,233.72
2	11,491.25	6,849.35	1,412.92	3,228.98
3	11,502.60	6,860.35	1,410.95	3,231.30
4	11,498.87	6,860.53	1,409.90	3,228.43
5	11,512.37	6,854.60	1,420.40	3,237.37
6	11,468.07	6,839.23	1,418.65	3,210.18
7	11,492.05	6,857.00	1,415.53	3,219.52
8	11,522.38	6,861.60	1,421.58	3,239.20
9	11,490.18	6,853.30	1,404.60	3,232.28
10	11,514.98	6,876.33	1,406.52	3,232.13
11	11,493.85	6,848.93	1,415.70	3,229.22
12	11,509.72	6,859.80	1,417.80	3,232.12
Average	11,500.51	6,857.17	1,414.16	3,229.18

10% Load Level - 46 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:17:34	21:20:35	0-2	0:03:01
Measurement Interval	21:20:35	21:30:35	3-12	0:10:00

(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	2,294.12	1,368.38	279.15	646.58
1	2,299.00	1,366.98	282.20	649.82
2	2,298.80	1,369.87	280.97	647.97
3	2,306.33	1,374.93	282.72	648.68
4	2,290.62	1,362.13	281.13	647.35
5	2,297.72	1,375.28	279.87	642.57
6	2,292.98	1,359.78	284.10	649.10
7	2,303.63	1,365.70	283.32	654.62
8	2,300.95	1,369.73	282.95	648.27
9	2,302.15	1,375.40	281.58	645.17
10	2,303.80	1,372.35	282.83	648.62
11	2,306.90	1,374.68	283.70	648.52
12	2,291.72	1,366.50	283.12	642.10
Average	2,299.68	1,369.65	282.53	647.50

Response Time Ramp Distribution (IOPS) Graph

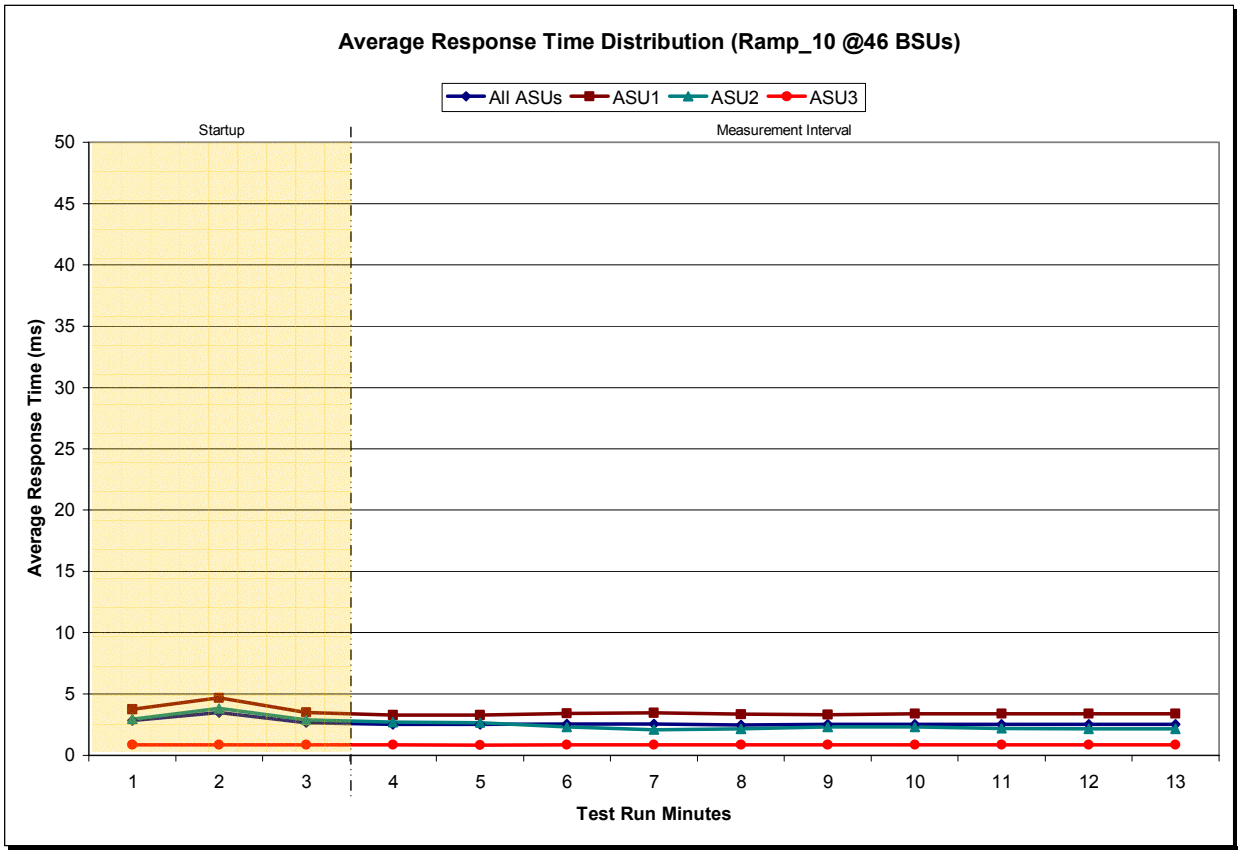


SPC-1 LRT™ Average Response Time (ms) Distribution Data

46 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	21:17:34	21:20:35	0-2	0:03:01
Measurement Interval	21:20:35	21:30:35	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2.83	3.74	2.96	0.85
1	3.49	4.67	3.83	0.85
2	2.66	3.48	2.88	0.85
3	2.53	3.28	2.69	0.85
4	2.52	3.28	2.66	0.84
5	2.56	3.41	2.29	0.85
6	2.55	3.45	2.09	0.86
7	2.48	3.33	2.15	0.85
8	2.50	3.32	2.31	0.85
9	2.54	3.37	2.31	0.85
10	2.53	3.39	2.21	0.85
11	2.53	3.40	2.17	0.85
12	2.53	3.40	2.16	0.85
Average	2.53	3.36	2.30	0.85

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
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0352	0.2802	0.0700	0.2102	0.0180	0.0699	0.0350	0.2816
COV	0.0147	0.0048	0.0087	0.0039	0.0192	0.0060	0.0110	0.0050

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 –Xmx512m repeat1 –b 460

java –Xmx512m repeat2 –b 460

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™
Primary Metrics	*22,999.27*	*2.53*
Repeatability Test Phase 1	23,001.76	2.51
Repeatability Test Phase 2	23,003.74	2.53

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

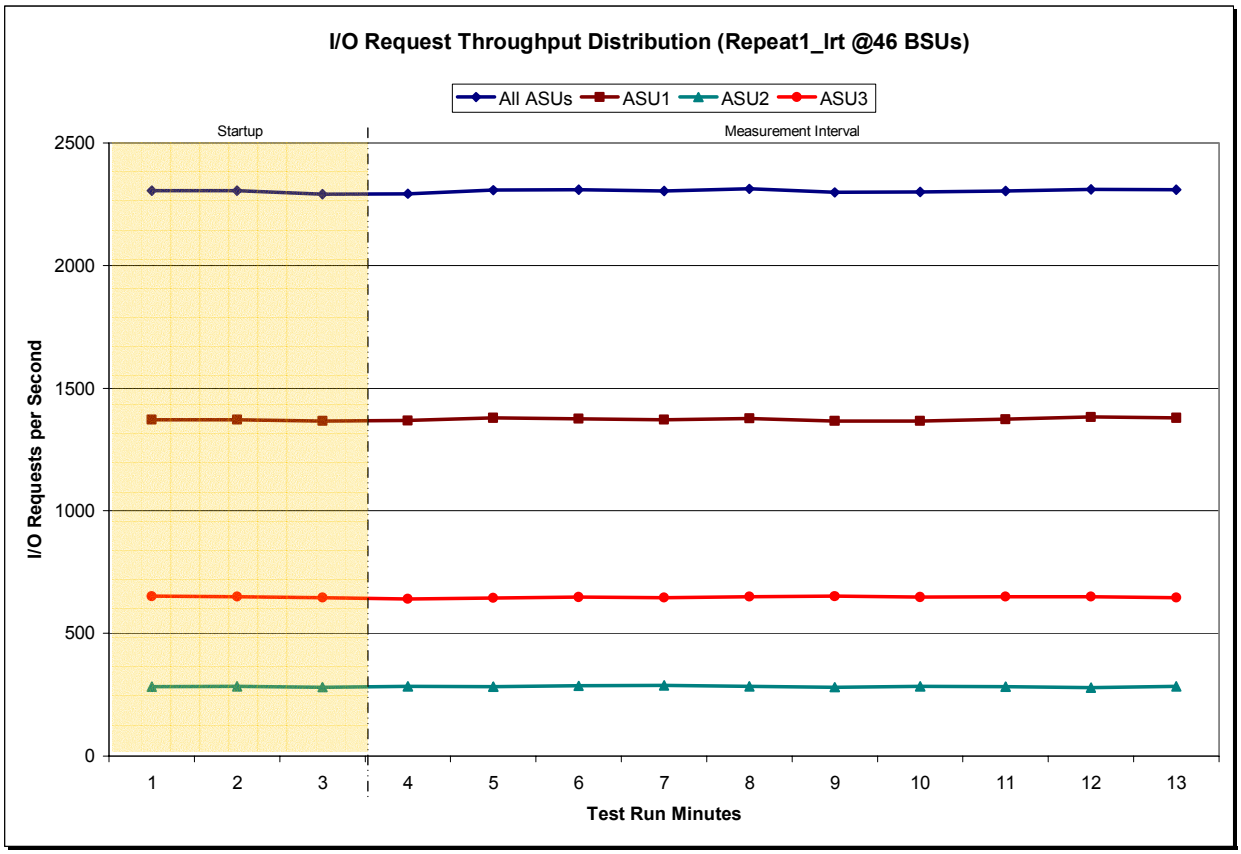
Repeatability Test Phase 1, Test Run 1 (LRT)
Repeatability Test Phase 1, Test Run 2 (IOPS)
Repeatability Test Phase 2, Test Run 1 (LRT)
Repeatability Test Phase 2, Test Run 2 (IOPS)

Repeatability 1 LRT – I/O Request Throughput Distribution Data

46 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:56:04	11:59:04	0-2	0:03:00
Measurement Interval	11:59:04	12:09:04	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2,305.22	1,371.50	282.78	650.93
1	2,304.87	1,370.85	284.88	649.13
2	2,291.72	1,365.30	280.82	645.60
3	2,293.58	1,367.78	284.78	641.02
4	2,306.88	1,379.50	282.40	644.98
5	2,309.07	1,375.57	286.23	647.27
6	2,304.47	1,370.85	287.28	646.33
7	2,312.27	1,377.52	284.33	650.42
8	2,299.28	1,365.48	281.63	652.17
9	2,299.33	1,366.62	283.90	648.82
10	2,303.75	1,372.42	282.43	648.90
11	2,310.58	1,381.85	279.82	648.92
12	2,309.87	1,379.45	284.50	645.92
Average	2,304.91	1,373.70	283.73	647.47

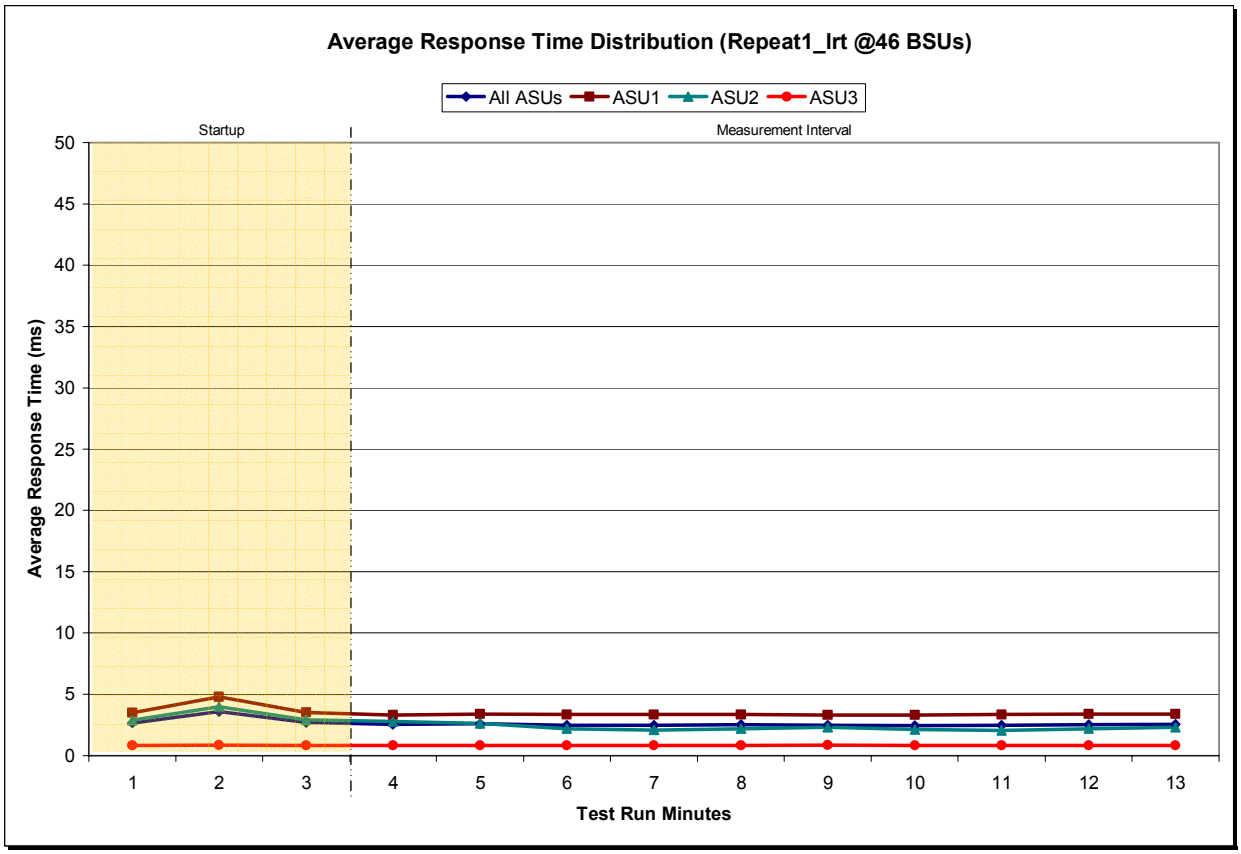
Repeatability 1 LRT – I/O Request Throughput Distribution Graph



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

46 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	11:56:04	11:59:04	0-2	0:03:01
Measurement Interval	11:59:04	12:09:04	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.66	3.48	2.87	0.84
1	3.58	4.79	3.99	0.86
2	2.69	3.51	2.91	0.85
3	2.55	3.31	2.76	0.84
4	2.58	3.39	2.63	0.84
5	2.50	3.34	2.21	0.84
6	2.49	3.36	2.07	0.84
7	2.50	3.35	2.19	0.84
8	2.49	3.31	2.31	0.85
9	2.46	3.30	2.12	0.84
10	2.48	3.35	2.05	0.84
11	2.52	3.37	2.18	0.84
12	2.54	3.38	2.31	0.84
Average	2.51	3.35	2.28	0.84

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

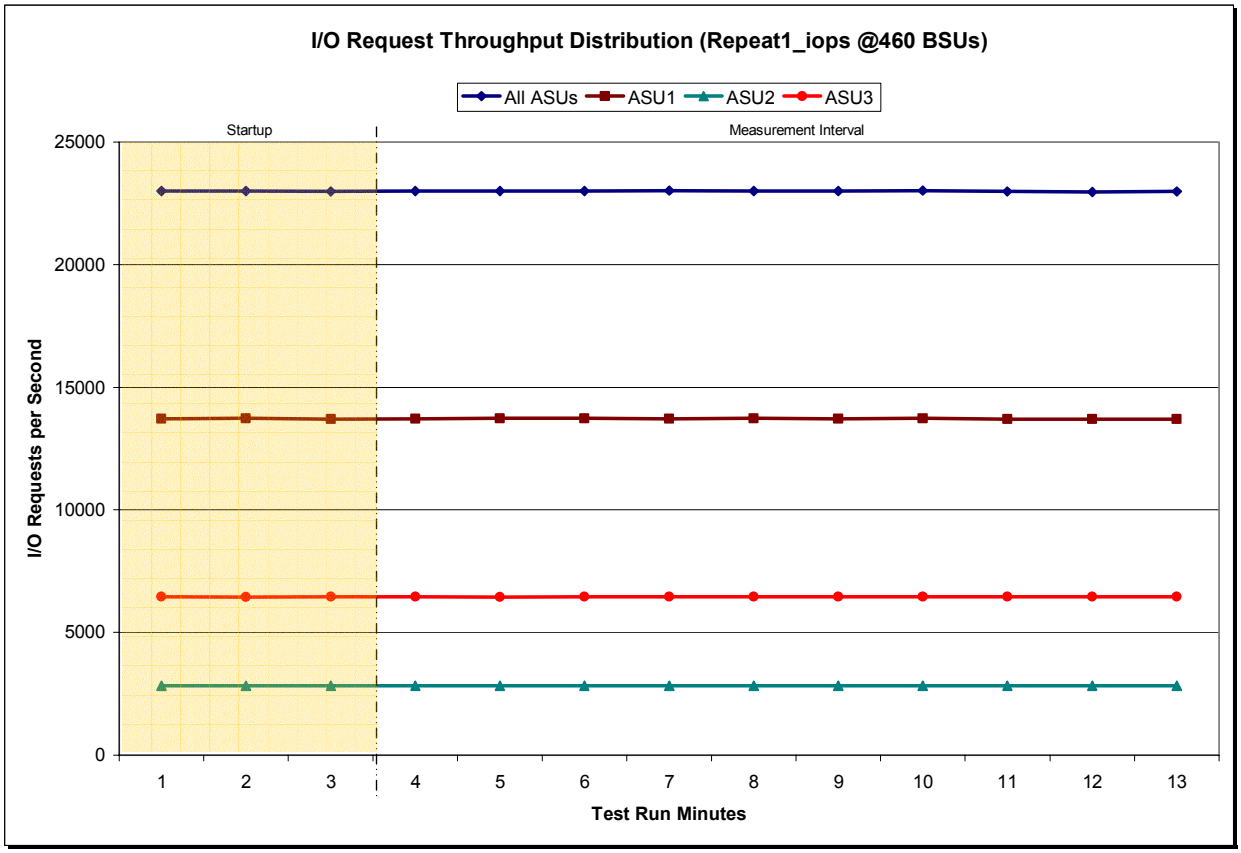


Repeatability 1 IOPS – I/O Request Throughput Distribution Data

460 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:09:15	12:12:16	0-2	0:03:01
Measurement Interval	12:12:16	12:22:16	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	22,996.28	13,713.20	2,829.67	6,453.42
1	23,004.22	13,729.10	2,822.93	6,452.18
2	22,985.13	13,701.65	2,823.58	6,459.90
3	23,009.15	13,717.03	2,830.70	6,461.42
4	23,006.67	13,732.22	2,824.83	6,449.62
5	22,999.77	13,725.47	2,818.23	6,456.07
6	23,020.83	13,723.67	2,828.03	6,469.13
7	23,010.25	13,724.43	2,830.77	6,455.05
8	23,009.38	13,721.28	2,824.18	6,463.92
9	23,028.08	13,734.97	2,825.58	6,467.53
10	22,979.68	13,695.02	2,818.80	6,465.87
11	22,971.57	13,690.40	2,824.95	6,456.22
12	22,982.25	13,698.47	2,825.18	6,458.60
Average	23,001.76	13,716.30	2,825.13	6,460.34

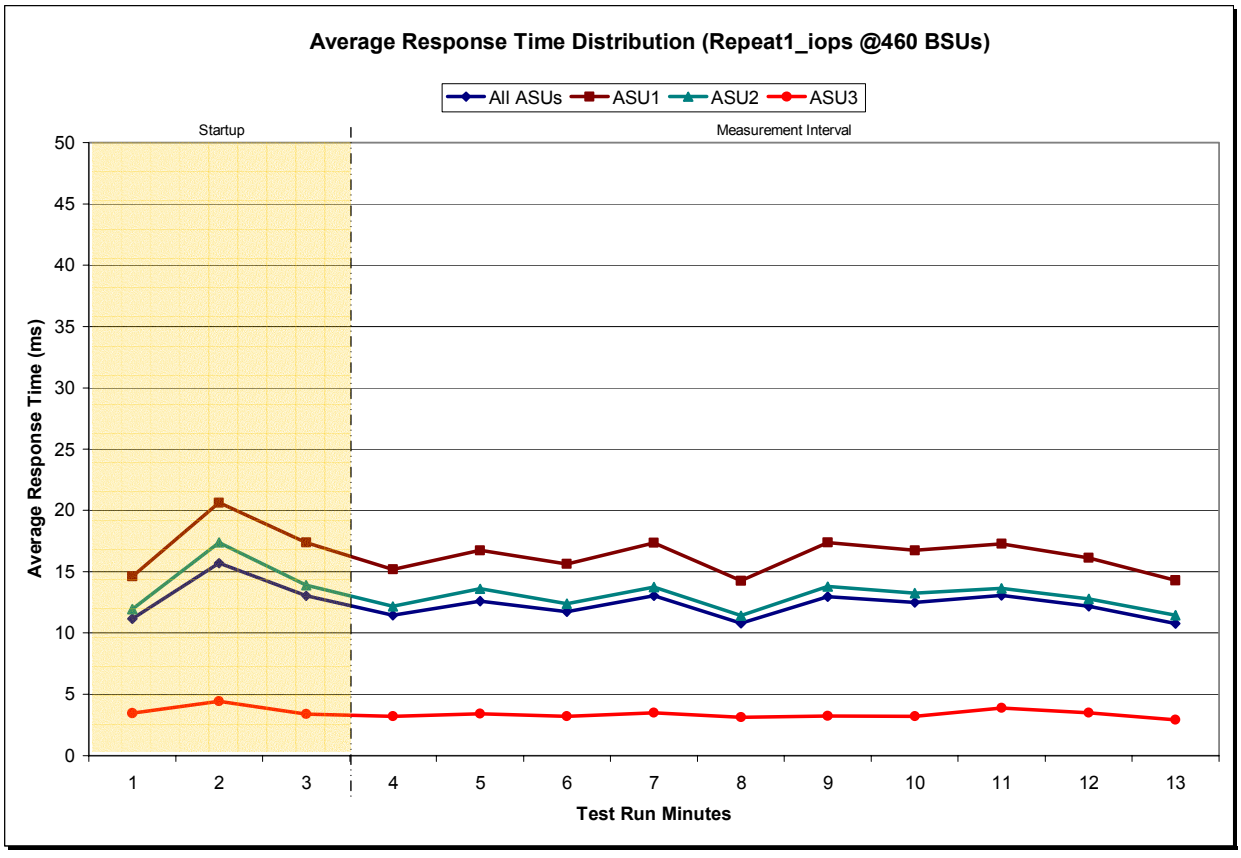
Repeatability 1 IOPS – I/O Request Throughput Distribution Graph



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

460 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:09:15	12:12:16	0-2	0:03:01
Measurement Interval	12:12:16	12:22:16	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	11.15	14.62	11.94	3.44
1	15.69	20.64	17.37	4.44
2	13.02	17.38	13.89	3.39
3	11.45	15.17	12.17	3.21
4	12.62	16.73	13.59	3.43
5	11.75	15.63	12.39	3.20
6	13.02	17.35	13.76	3.49
7	10.78	14.25	11.40	3.13
8	12.97	17.37	13.78	3.26
9	12.50	16.73	13.25	3.19
10	13.07	17.28	13.66	3.88
11	12.16	16.12	12.77	3.49
12	10.76	14.31	11.45	2.93
Average	12.11	16.10	12.82	3.32

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

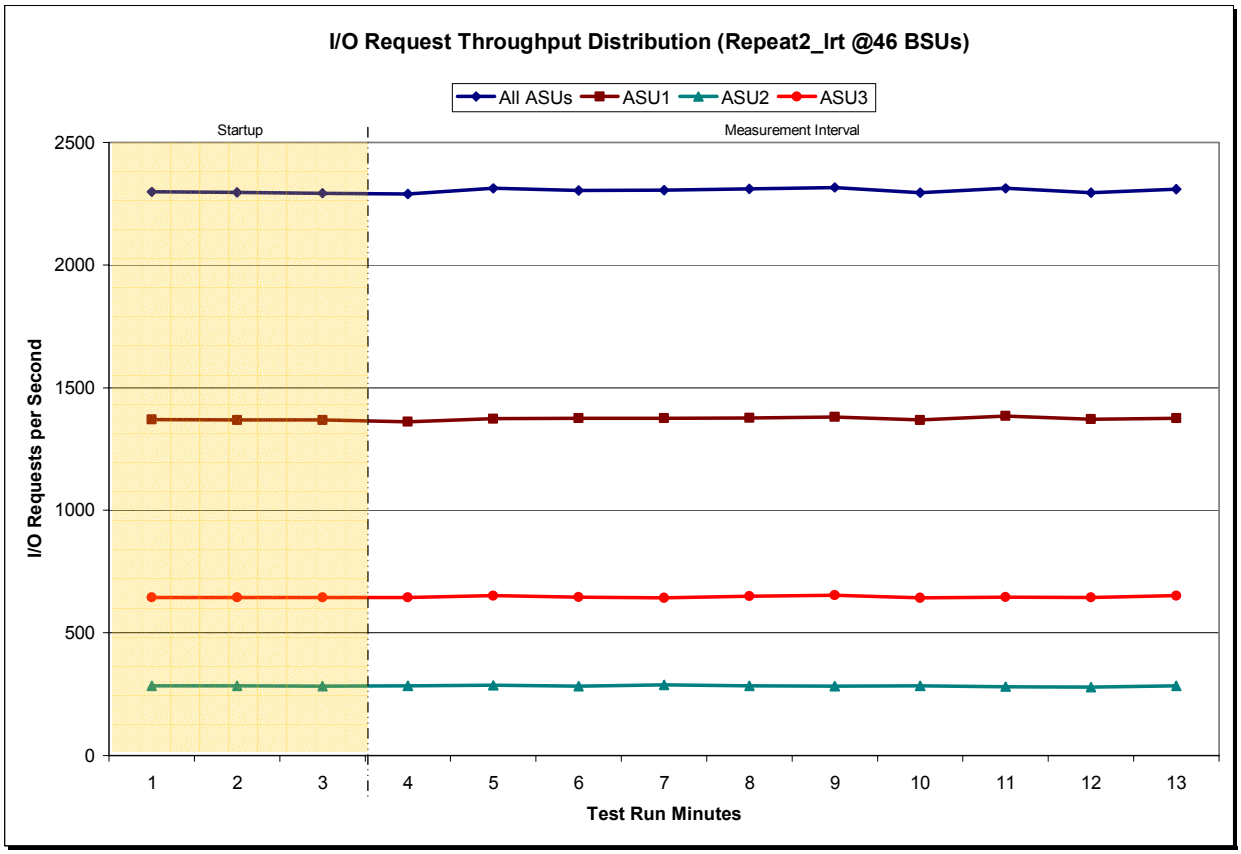


Repeatability 2 LRT – I/O Request Throughput Distribution Data

46 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:22:34	12:25:34	0-2	0:03:00
Measurement Interval	12:25:34	12:35:34	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	2,298.63	1,370.43	284.40	643.80
1	2,296.43	1,367.63	284.32	644.48
2	2,293.80	1,367.42	282.63	643.75
3	2,289.23	1,359.88	284.92	644.43
4	2,311.95	1,373.63	286.63	651.68
5	2,304.10	1,374.38	282.98	646.73
6	2,305.30	1,375.13	287.18	642.98
7	2,310.22	1,376.12	283.62	650.48
8	2,316.70	1,380.98	283.12	652.60
9	2,295.10	1,368.68	284.53	641.88
10	2,312.92	1,384.55	281.60	646.77
11	2,294.42	1,372.35	278.18	643.88
12	2,309.35	1,374.85	283.65	650.85
Average	2,304.93	1,374.06	283.64	647.23

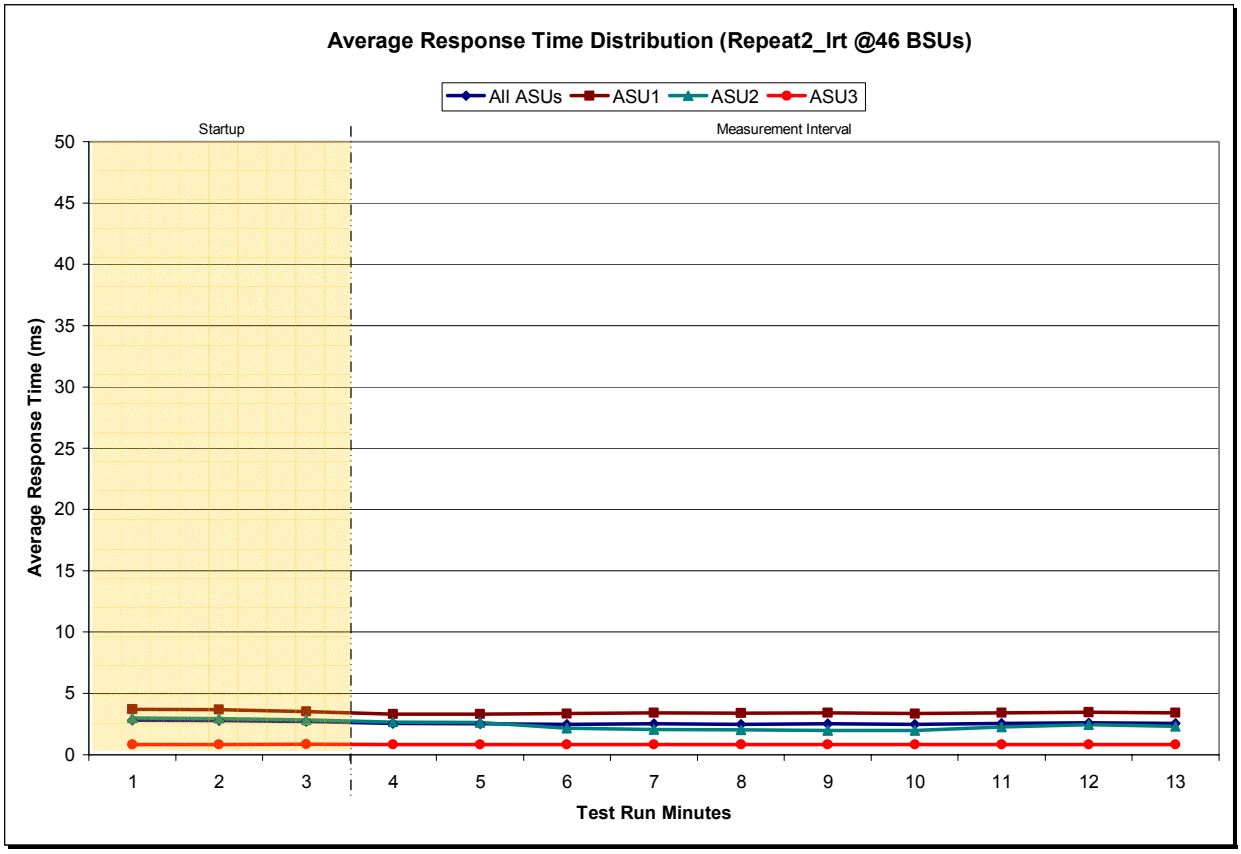
Repeatability 2 LRT – I/O Request Throughput Distribution Graph



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

46 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:22:34	12:25:34	0-2	0:03:01
Measurement Interval	12:25:34	12:35:34	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.81	3.70	2.98	0.85
1	2.79	3.67	2.95	0.84
2	2.69	3.52	2.84	0.85
3	2.54	3.32	2.67	0.84
4	2.53	3.32	2.63	0.84
5	2.50	3.34	2.18	0.84
6	2.52	3.41	2.04	0.84
7	2.49	3.37	2.02	0.84
8	2.51	3.41	1.98	0.84
9	2.47	3.34	2.00	0.84
10	2.55	3.41	2.26	0.84
11	2.59	3.44	2.44	0.84
12	2.56	3.42	2.31	0.84
Average	2.53	3.38	2.25	0.84

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

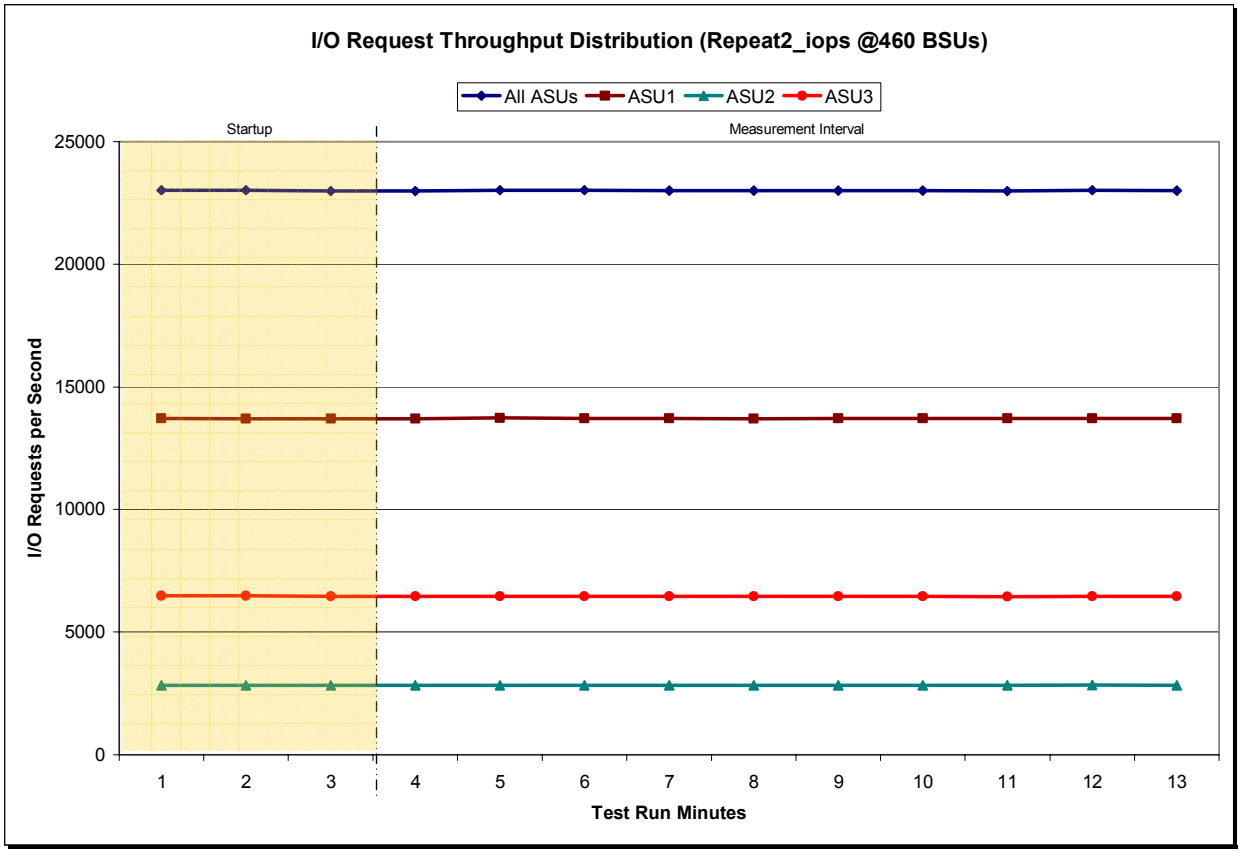


Repeatability 2 IOPS – I/O Request Throughput Distribution Data

460 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:35:45	12:38:46	0-2	0:03:01
Measurement Interval	12:38:46	12:48:46	3-12	0:10:00

60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	23,015.77	13,713.88	2,828.88	6,473.00
1	23,012.02	13,705.68	2,832.83	6,473.50
2	22,990.00	13,705.63	2,823.33	6,461.03
3	22,976.42	13,688.98	2,828.25	6,459.18
4	23,019.80	13,727.38	2,834.52	6,457.90
5	23,021.17	13,720.65	2,831.08	6,469.43
6	22,996.98	13,713.00	2,819.75	6,464.23
7	22,995.00	13,701.82	2,822.88	6,470.30
8	23,009.10	13,716.97	2,822.35	6,469.78
9	23,004.40	13,709.43	2,824.68	6,470.28
10	22,985.15	13,717.75	2,830.82	6,436.58
11	23,019.78	13,714.85	2,836.02	6,468.92
12	23,009.57	13,712.35	2,832.08	6,465.13
Average	23,003.74	13,712.32	2,828.24	6,463.18

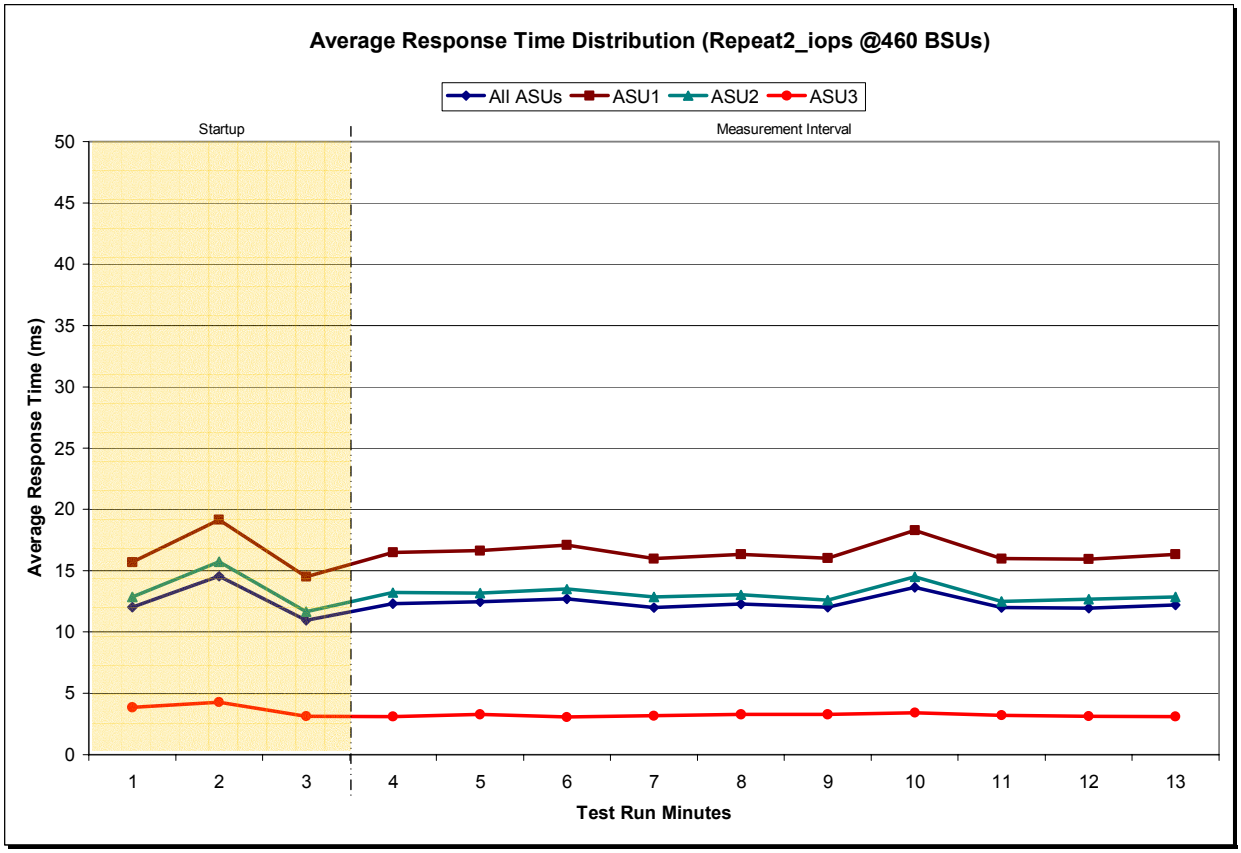
Repeatability 2 IOPS – I/O Request Throughput Distribution Graph



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

460 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	12:35:45	12:38:46	0-2	0:03:01
Measurement Interval	12:38:46	12:48:46	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	12.01	15.68	12.84	3.85
1	14.53	19.13	15.73	4.27
2	10.96	14.51	11.68	3.11
3	12.32	16.49	13.20	3.09
4	12.45	16.63	13.16	3.26
5	12.72	17.11	13.51	3.07
6	12.00	16.00	12.85	3.15
7	12.26	16.35	13.02	3.27
8	12.03	16.03	12.60	3.28
9	13.64	18.28	14.50	3.42
10	11.97	15.98	12.51	3.20
11	11.94	15.94	12.69	3.12
12	12.20	16.36	12.84	3.11
Average	12.35	16.52	13.09	3.20

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	0.2814	0.0703	0.2092	0.0181	0.0700	0.0350	0.2809
COV	0.0153	0.0045	0.0064	0.0059	0.0178	0.0111	0.0115	0.0047

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	0.2811	0.0701	0.2101	0.0209	0.0698	0.0350	0.2809
COV	0.0045	0.0014	0.0026	0.0026	0.0054	0.0029	0.0042	0.0010

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	0.2813	0.0698	0.2100	0.0181	0.0700	0.0350	0.2808
COV	0.0161	0.0048	0.0123	0.0039	0.0242	0.0110	0.0135	0.0038

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	0.2810	0.0700	0.2100	0.0180	0.0699	0.0350	0.2810
COV	0.0045`	0.0017	0.0022	0.0019	0.0049	0.0020	0.0057	0.0014

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 468

java 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

Data Persistence Test Results	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	56,169,600
Total Number of Logical Blocks Verified	49,880,096
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 IBM TotalStorage Enterprise Storage Server Model 800, as documented in this Full Disclosure Report became available for customer purchase and shipment on November 22, 2002.

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 11.

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 Onsite Audit of the IBM TotalStorage Enterprise Storage Server Model 800.