SPC Benchmark 1™

Full Disclosure Report

Inspur Electronic Information Industry Co. Ltd.

Inspur HF18000G5-I

SPC-1™ v3.10.0

Submission Identifier: A32023

Submitted For Review: August 16, 2021

First Edition – August 2021

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Benchmark Specification and Glossary

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

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

Table of Contents

AUDIT CERTIFICATION

InfoSizing
The Right Metric For Sizing IT

Storage Performance Council
Certified Auditor

Xudong Wang
Inspur Electronic Information Industry Co. Ltd.
NO.1036, Inspur Road, Jinan
People's Republic of China

August 16, 2021

I verified the SPC Benchmark 1™ (SPC-1™ v3.10.0) test execution and performance results of the following Tested Storage Product:

Inspur HF18000G5-I

The results were:

SPC-1 IOPS™	**23,001,502**
SPC-1 Price-Performance	**$375.56/SPC-1 KIOPS™**
SPC-1 Total System Price	8,638,347.84
SPC-1 IOPS Response Time	0.294 ms
SPC-1 Overall Response Time	0.246 ms
SPC-1 ASU Capacity	343,597 GB
SPC-1 ASU Price	$25.15/GB

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

The testing was executed using the SPC-1 Toolkit Version v3.0.2-1-g823a. The audit process was conducted in accordance with the SPC Policies and met the requirements for the benchmark.

A Letter of Good Faith was issued by Inspur Electronic Information Industry Co. Ltd., stating the accuracy and completeness of the documentation and testing data provided in support of the audit of this result.

A Full Disclosure Report for this result was prepared by InfoSizing, reviewed and approved by Inspur Electronic Information Industry Co. Ltd., and can be found at www.spcresults.org under the Submission Identifier A32023.

Page **1** of **2**

63 Lourdes Dr. | Leominster, MA 01453 | 978-343-6562 | www.sizing.com

The independent audit process conducted by InfoSizing included the verifications of the following items:

- The physical capacity of the data repository (957,600 GB).
- The total capacity of the Application Storage Unit (343,597 GB).
- The accuracy of the Benchmark Configuration diagram.
- The tuning parameters used to configure the Benchmark Configuration.
- The Workload Generator commands used to execute the testing.
- The validity and integrity of the test result files.
- The compliance of the results from each performance test.
- The compliance of the results from each persistence test.
- The compliance of the submitted pricing model.
- The differences between the tested and the priced configuration, if any.

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

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

The SPC-1 Specification requires PERSIST1 to be run with the following settings:

- 3-minute ramp up
- 10-minute measurement interval
- 1-minute ramp down
- 25% of the workload level of RAMPD_100

At sufficiently high IOPs levels and when run for the required times, the SPC-1 toolkit exhibits anomalous behavior which prevents the PERSIST1 test from completing properly.

The SPC Compliance Review Committee has reviewed this situation and granted permission for the test sponsor to run at reduced settings so that the PERSIST1 test can complete properly.

The following setting were used for this result.

- 3-minute ramp up
- 10-minute measurement interval
- 1-minute ramp down
- 8% of the workload level of RAMPD_100

Respectfully Yours,

Doug Johnson, Certified SPC Auditor

63 Lourdes Dr. | Leominster, MA 01453 | 978-343-6562 | www.sizing.com

LETTER OF GOOD FAITH

Aug 12, 2021

To: Doug Johnson, SPC Auditor
        PerfLabs, Inc. DBA InfoSizing
        63 Lourdes Drive
        Leominster, MA 01453-6709
        USA

Subject: SPC-1 Letter of Good Faith for the HF18000G5-I

Inspur Electronic Information Industry Co. Ltd is the SPC-1 test sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 results and materials we have submitted for that product are complete, accurate, and in full compliance with version 3.10 of the SPC-1 benchmark specification.

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

Sincerely,

2021. 8.12

Lay Sun   Date: Aug 12, 2021
PDTM of Storage Product Department
Inspur Electronic Information Industry Co. Ltd.

Inspur HF18000G5-I

SPC-1 IOPS™	**23,001,502**	SPC-1 Price Performance	**$375.56/SPC-1 KIOPS™**
SPC-1 IOPS Response Time	**0.294 ms**	SPC-1 Total System Price	**$8,638,347.84**
SPC-1 Overall Response Time	0.246 ms	SPC-1 Overall Discount	74.95%
		Currency / Target Country	USD / China
		Availability Date	July 25, 2021

Extensions		*Storage Metrics*	
☆ SPC-1 Data Reduction	NA	SPC-1 Data Protection Level	Protected 2
☆ SPC-1 Encryption	NA	SPC-1 Physical Storage Capacity	957,600 GB
☆ SPC-1 NDU	NA	SPC-1 ASU Capacity	343,597 GB
☆ SPC-1 Synchronous Replication	NA	SPC-1 ASU Price	$25.15/GB
☆ SPC-1 Snapshot	NA		

Priced Storage Configuration Summary

122	Emulex 31002 2-port 16 Gb FC HBAs
16	Inspur HF18000G5 Storage Nodes
32	Controllers (2 per node)
49,152	GB Total Cache (1,536 per controller)
384	Total Front-End Ports (320 used)
480	1.92 TB NVMe SSDs
96	375 GB NVMe Optane SSDs
2	FS9620 32 Gb FC Switches
144	Total RUs

RAMPD Average Response Time (ms) vs. IOPS
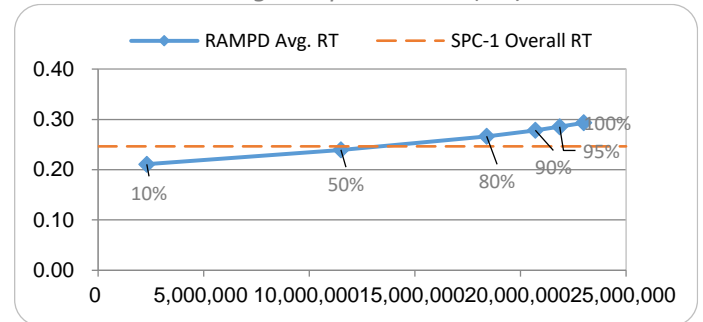
SUSTAIN Response Time (ms)

RAMPD_100 Response Time (ms)

SPC Benchmark 1™ Specification Revision	v3.10.0	Submitted for Review	August 16, 2021
SPC Benchmark 1™ Workload Generator Revision	v3.0.2-1-g823a	Submission Details	www.storageperformance.org/r/A32023
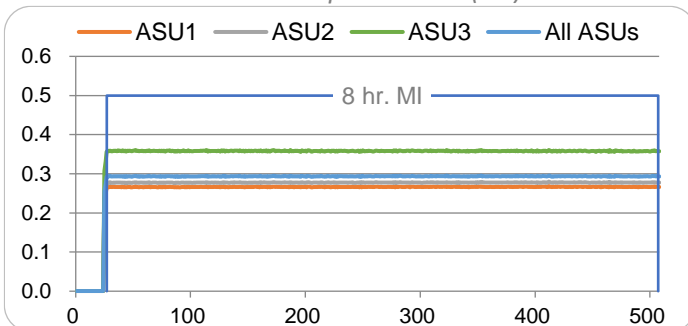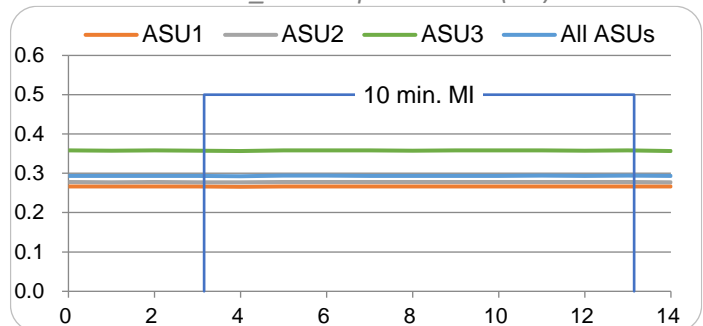
PRICING DETAILS

Part No.	Description	Source	Qty	Unit Price	Ext. Price	Disc.	Disc. Price
	Hardware & Software						
UHF180G5I000	Inspur HF18000G5 Storage System Base Unit (4U,Dual Controllers,BBU+Flash,3Y 5x10xND Basic Svc&Warranty)	1	16	409,856.74	6,557,707.84	75%	1,639,426.96
EGW-0230VL	Inspur 1.92TB NVMe SSD Enterprise Drive(2.5"), For HF18000G5 JBOF	1	480	12,965.62	6,223,497.60	75%	1,555,874.40
EGW-0230VS	Inspur 375GB NVMe Optane SSD Enterprise Drive(2.5"), For HF18000G5 JBOF	1	96	114,204.16	10,963,599.36	75%	2,740,899.84
UHFJ25NF1000	Inspur J025SG5 JBOF （2U, 25*2.5" NVMe SSD)	1	32	9,899.72	316,791.04	75%	79,197.76
EGW-06901G	Inpsur HF18000G5 4*16Gbps FC Ports +SFP	1	96	10,157.60	975,129.60	75%	243,782.40
EGW-08906G	Inpsur HF18000G5 4*NVMe	1	64	1,117.48	71,518.72	75%	17,879.68
THS550	Inspur HF18000G5 Basic Software(InThin,InSnapshot,InClone,InBackup,InVdiskMirror,InQos,InRAID,InPath)	1	16	3,979.66	63,674.56	75%	15,918.64
THS18000	HF18000 Series Rack	1	4	11,934.10	47,736.40	75%	11,934.10
NA	Inspur 3M LC-LC OM4 Fibre Channel Cable	1	320	42.98	13,753.60	75%	3,438.40
NA	Inspur 5M LC-LC OM4 Fibre Channel Cable	1	244	28.66	6,993.04	75%	1,748.26
TSJ203	Inspur 2*Port 16Gbps Fibre Channel Adapter	1	122	5,114.62	623,983.64	75%	155,995.91
NA	Inspur FS9620 SAN switch director， Enable 16Gbps	1	2	681,696.28	1,363,392.56	75%	340,848.14
NA	Inspur FS9620 48 FC IO port board	1	14	516,260.75	7,227,650.50	75%	1,806,912.63
					Hardware & Software Subtotal		**8,613,857.12**
	Support & Maintenance						
F2HII04	Installation Service - Engineering	1	16	1,027.94	16,447.04	0%	16,447.04
F2GD0030AS55G525	UPgrade TO Onsite Premier 24x7x4H Engineer Onsite Service - 36Month(s)	1	16	502.73	8,043.68	0%	8,043.68
					Support & Maintenance Subtotal		**24,490.72**
	SPC-1 Total System Price						**8,638,347.84**
	SPC-1 IOPS™						23,001,502
	SPC-1 Price-Performance™ ($/SPC-1 KIOPS™)						**375.56**
	SPC-1 ASU Capacity (GB)						343,597
	SPC-1 ASU Price ($/GB)						**25.15**

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

Warranty: Provides 7x24x4H arrival service within designated city and distance. The service includes 7x24 contact to the Inspur call center with 4-hours on-site hardware replacement or troubleshooting, and online software support with access to all new software updates or troubleshooting.

Differences Between Tested and Priced Storage Configurations

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

PUBLICATION DETAILS

This section provides contact information for the test sponsor and auditor, a revision history of this document, and a description of any exceptions or waivers associated with this publication.

Contact Information

Role	Name	Details
Test Sponsor Primary Contact	Inspur Electronic Information Industry Co. Ltd. Xudong Wang	http://en.inspur.com/ wangxudong02@inspur.com
SPC Auditor	InfoSizing Doug Johnson	www.sizing.com doug@sizing.com

Revision Information

Date	FDR Revision	Details
August 16, 2021	First Edition	Initial Publication

Anomalies, Exceptions, Waivers

The SPC-1 Specification requires PERSIST1 to be run with the following settings:

- 3-minute ramp up
- 10-minute measurement interval
- 1-minute ramp down
- 25% of the workload level of RAMPD_100

At sufficiently high IOPs levels and when run for the required times, the SPC-1 toolkit exhibits anomalous behavior which prevents the PERSIST1 test from completing properly.

The SPC Compliance Review Committee has reviewed this situation and granted permission for the test sponsor to run at reduced settings so that the PERSIST1 test can complete properly.

The following setting were used for this result.

- 3-minute ramp up
- 10-minute measurement interval
- 1-minute ramp down
- 8% of the workload level of RAMPD_100

CONFIGURATION INFORMATION

Tested Storage Product Description

HF18000G5-I is an enterprise-level high-end all-flash storage system for enterprise core applications and provides both SAN and NAS. It adopts a new NVMe architecture, all-flash optimization algorithm and intelligent InView management platform, bringing lower latency, higher performance, and greater flexibility. Expand capacity and simplify management. HF18000G5-I is optimized in terms of performance, function, reliability, and ease of use, which satisfies data storage, disaster recovery, and active-active under various applications such as OLTP/OLAP, virtualization, and file sharing for large and medium-sized databases, backup and other needs, and are widely used in finance, communications, energy, media, medical, education, SMB and other industries.

Host System and Tested Storage Configuration Components

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

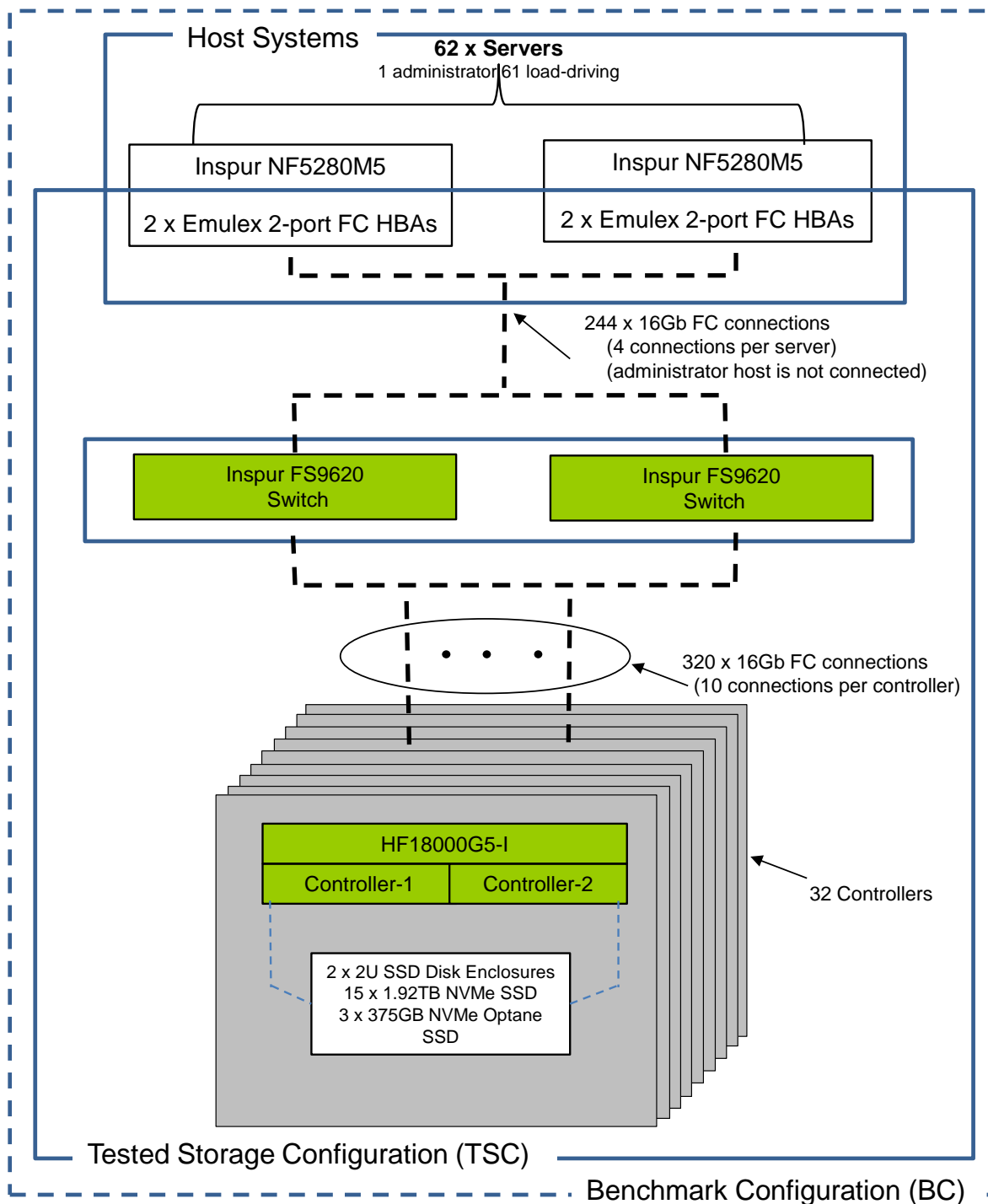| Host Systems |
|---|
| 62 x Inspur NF5280M5 Servers (1 Admin ; 61 Load Driving), each with: |
| 2 x Intel® Xeon® Gold 6230 CPU (2.1 GHz, 26-Core, 36 MB L3) |
| 128 GB Main Memory |
| CentOS Linux Release 7.4 |
| **Tested Storage Configuration** |
| 122 x Emulex 31002 2-port 16 Gb FC HBAs |
| 16 x HF18000G5-I, each with: |
| 2 x Controllers, each with: |
| 1,536 GB cache (49,152 GB total) |
| 3 x 4-port 16 Gbps FC Front End Ports |
| 32 x Disk Enclosures, each with: |
| 15 x 1.92 TB NVMe SSD |
| 3 x 375 GB NVMe Optane SSD |
| 576 x NVMe Storage Devices Total |
| 2 x FS9620 32Gb Switches |

Component Changes in Revised Full Disclosure Report

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

Original Component	Revised Component	Description of Change
n/a	n/a	Initial submission

Configuration Diagrams

BC/TSC Configuration Diagram

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

Host Systems

62 x Servers
1 administrator 61 load-driving

Inspur NF5280M5

2 x Emulex 2-port FC HBAs

Inspur NF5280M5

2 x Emulex 2-port FC HBAs

244 x 16Gb FC connections
(4 connections per server)
(administrator host is not connected)

Inspur FS9620
Switch

Inspur FS9620
Switch

320 x 16Gb FC connections
(10 connections per controller)

HF18000G5-I

Controller-1   Controller-2

2 x 2U SSD Disk Enclosures
15 x 1.92TB NVMe SSD
3 x 375GB NVMe Optane
SSD

32 Controllers

Tested Storage Configuration (TSC)

Benchmark Configuration (BC)

Storage Network Configuration

The Tested Storage Configuration (TSC) comprised 16 HF18000G5-I storage nodes driven by one administrative server and 61 load-driving host systems (Inspur NF5280M5). Each load-driving host was connected to each FS9620 switch using the four ports of the two Emulex 31002s. This was a total of 244 16Gb connections between the hosts and the switches. Each HF18000G5-I storage node had 10 connections (5 per controller) to each FS9620 switch. This was a total of 320 16 Gb connections between the storage nodes and the switches.

Benchmark Configuration Creation Process

Customer Tuning Parameters and Options

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

Tested Storage Configuration Creation

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

Tested Storage Configuration Inventory

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

Workload Generator Storage Configuration

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

Logical Volume Capacity and Application Storage Unit Mapping

The following table details the capacity of the Application Storage Units (ASUs) and how they are mapped to logical volumes (LVs). All capacities are reported in GB.

	LV per ASU	LV Capacity	Used per LV	Total per ASU	% ASU Capacity	Optimized*
ASU-1	18	8,589.9	8,589.9	154,618.8	45.0%	No
ASU-2	18	8,589.9	8,589.9	154,618.8	45.0%	No
ASU-3	4	8,589.9	8,589.9	34,359.7	10.0%	No
SPC-1 ASU Capacity				343,597	*See Space Optimization Techniques	

Physical Storage Capacity and Utilization

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

Devices	Count	Physical Capacity	Total Capacity
NVMe SSD	480	1,920.0	921,600.0
NVMe Optane SSD	96	375	36,000.0
	Total Physical Capacity		**957,600**
	Physical Capacity Utilization		**35.88%**

Data Protection

The data protection level used for all LVs was **Protected 2 (RAID10)**, which was accomplished by providing fully redundant pathways from each host to the storage cluster where all drives were protected via RAID10.

Space Optimization Information

Description of Utilized Techniques

The TSC did not use any space optimization techniques.

Physical Free Space Metrics

The following table lists the Physical Free Space as measured at each of the required points during test execution. If space optimization techniques were not used, "NA" is reported.

Physical Free Space Measurement	Free Space (GB)
After Logical Volume Creation	NA
After ASU Pre-Fill	NA
After Repeatability Test Phase	NA

Space Optimization Metrics

The following table lists the required space optimization metrics. If space optimization techniques were not used, "NA" is reported.

Metric	Value
SPC-1 Space Optimization Ratio	NA
SPC-1 Space Effectiveness Ratio	NA

BENCHMARK EXECUTION RESULTS

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

Benchmark Execution Overview

Workload Generator Input Parameters

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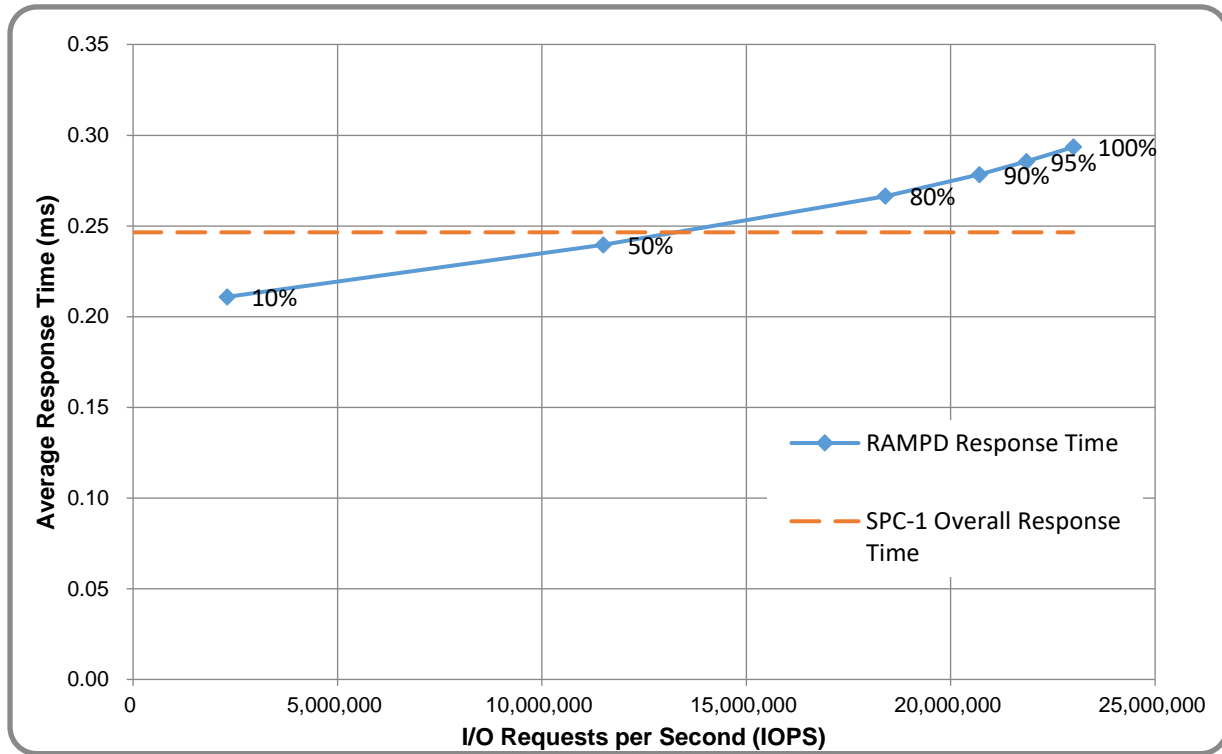
Measurement Intervals by Test Phase Graph

The following graph presents the average IOPS and the average Response Times measured over the MI of each Test Phase.
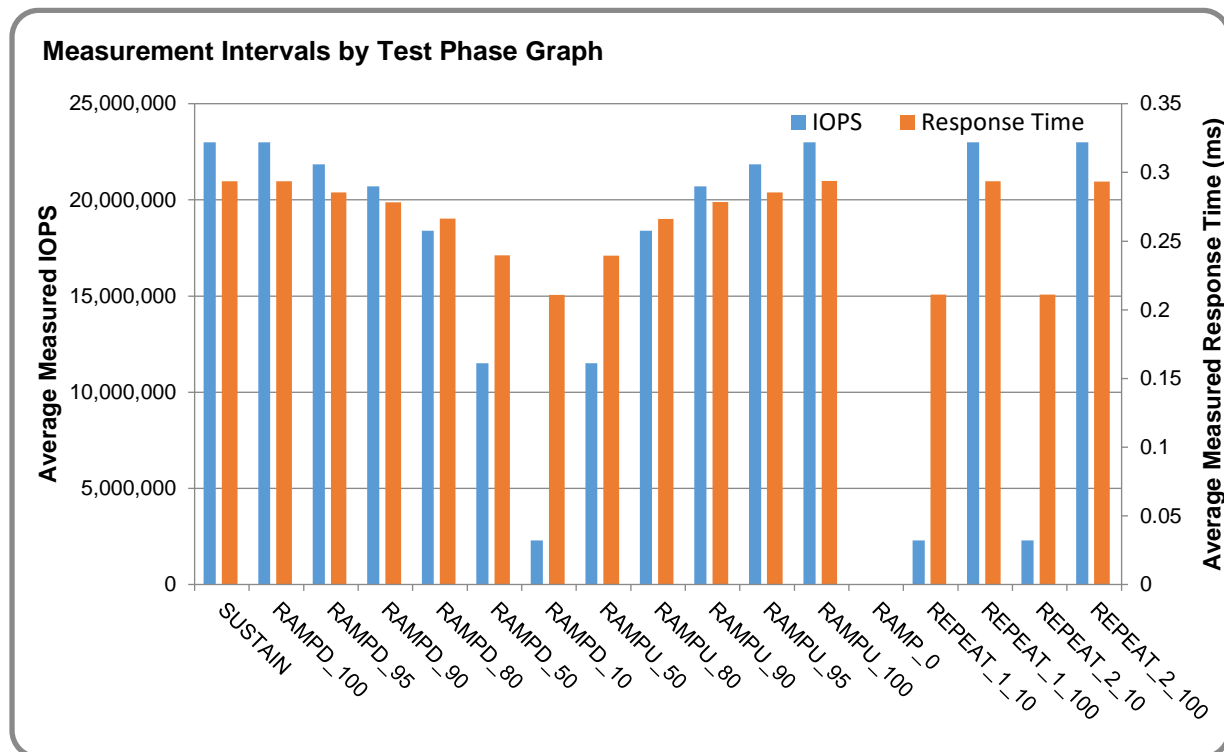
Response Time vs. Throughput Graph

The following graph presents the average Response Times versus the average IOPS for RAMPD_100 to RAMPD_10.

ASU Pre-Fill

The following table provides a summary of the Pre-Fill performed on the ASU prior to testing.

| ASU Pre-Fill Summary			
Start Time	22-Jul-21 15:32:09	**Requested IOP Level**	10,000 MB/sec
End Time	23-Jul-21 00:49:14	**Observed IOP Level**	10,280 MB/sec
Duration	9:17:05	For additional details see the Supporting Files.	

SUSTAIN Test Phase

SUSTAIN – Results File

The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:
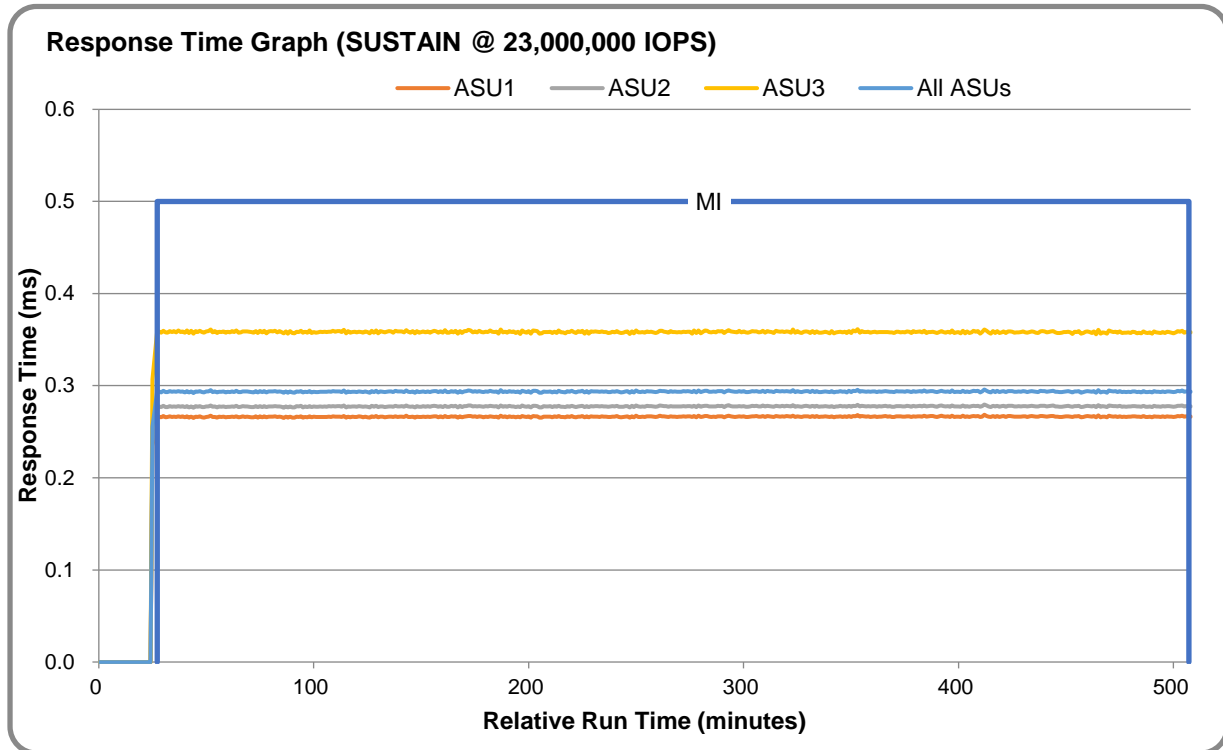
- **SPC1_METRICS_0_Raw_Results.xlsx**

SUSTAIN – Execution Times

| Interval	Start Date & Time	End Date & Time	Duration
Transition Period	23-Jul-21 01:47:28	23-Jul-21 01:50:28	0:03:00
Measurement Interval	23-Jul-21 01:50:28	23-Jul-21 09:50:29	8:00:01

SUSTAIN – Throughput Graph

Throughput Graph (SUSTAIN @ 23,000,000 IOPS)
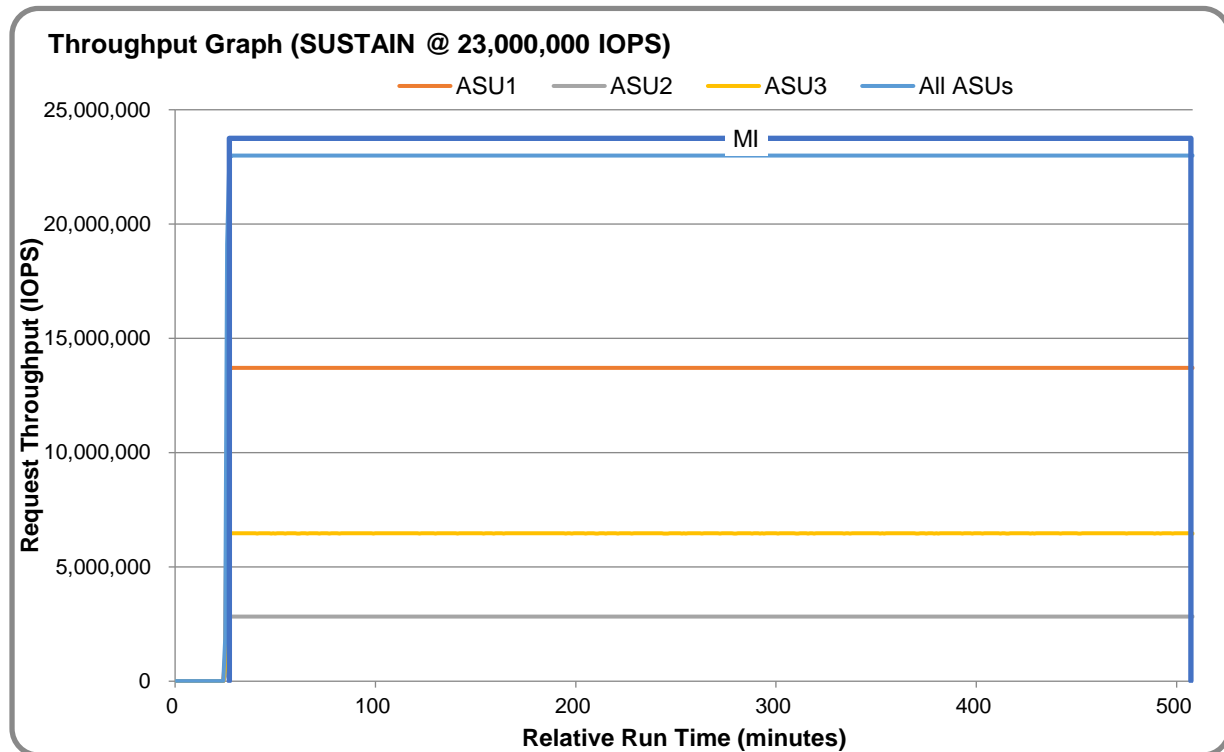
SUSTAIN – Response Time Graph

Response Time Graph (SUSTAIN @ 23,000,000 IOPS)

SUSTAIN – Data Rate Graph

Data Rate Graph (SUSTAIN @ 23,000,000 IOPS)
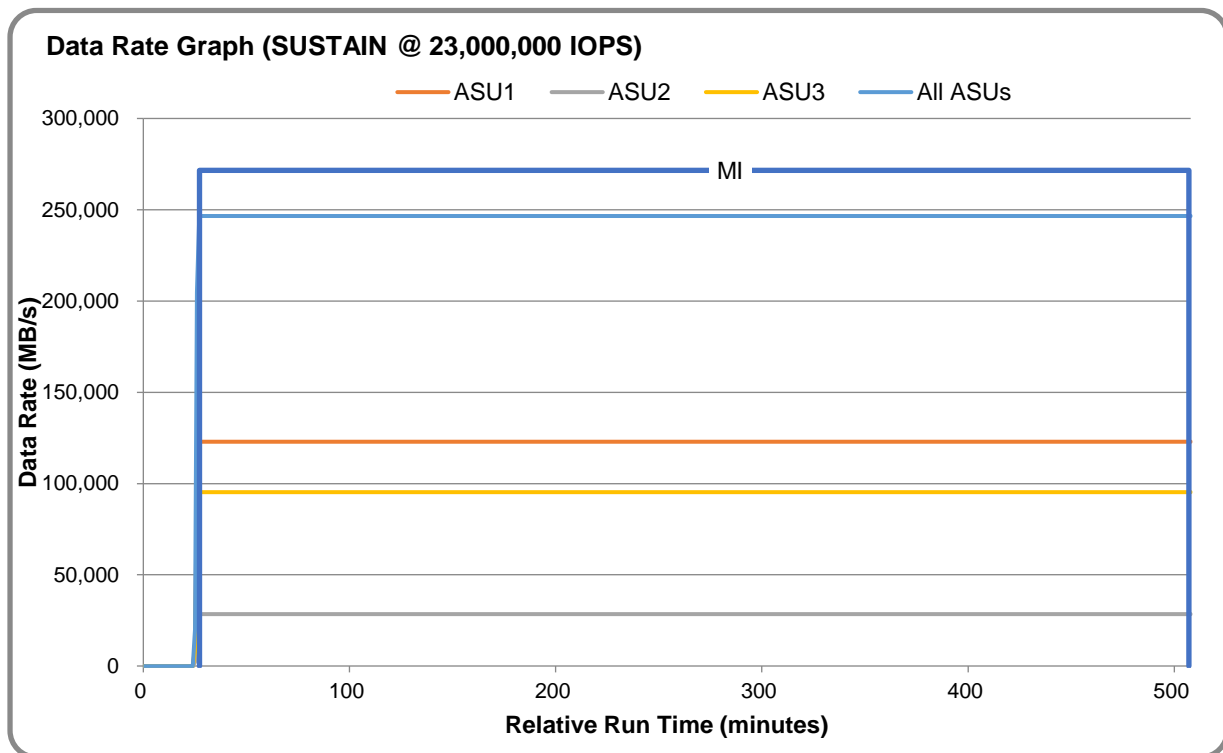
SUSTAIN – Response Time Frequency Graph
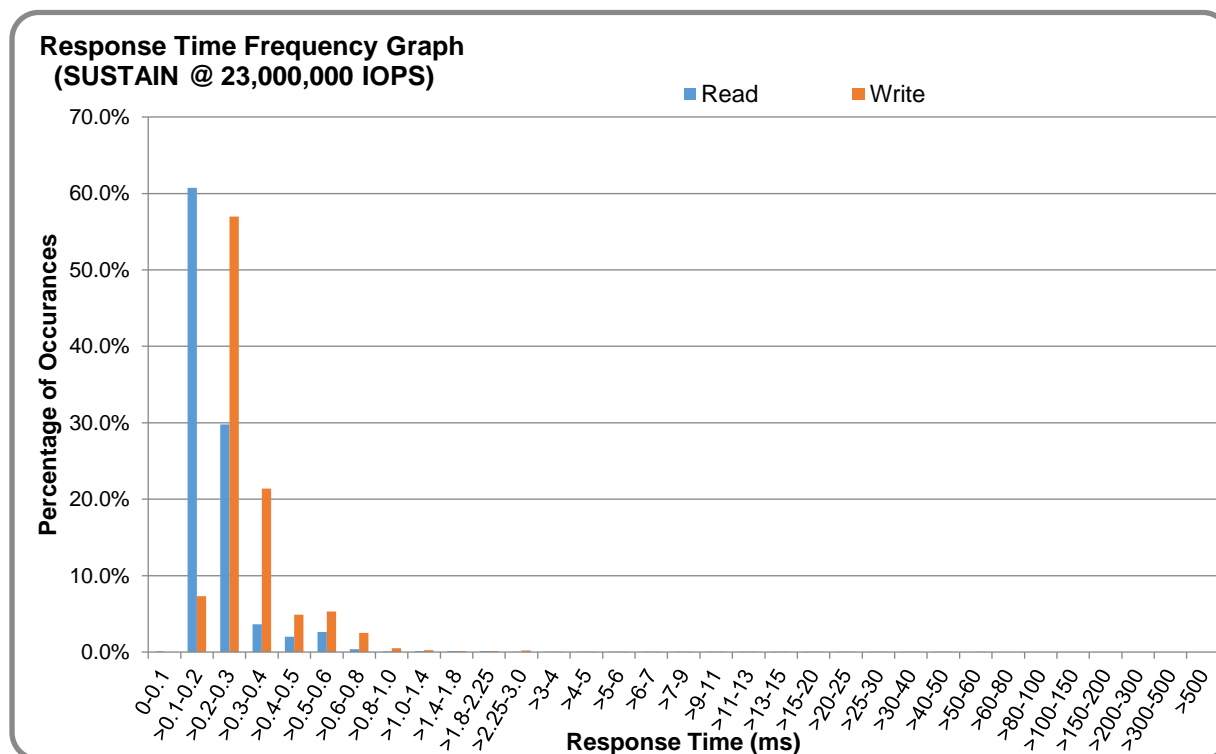
SUSTAIN – Intensity Multiplier

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

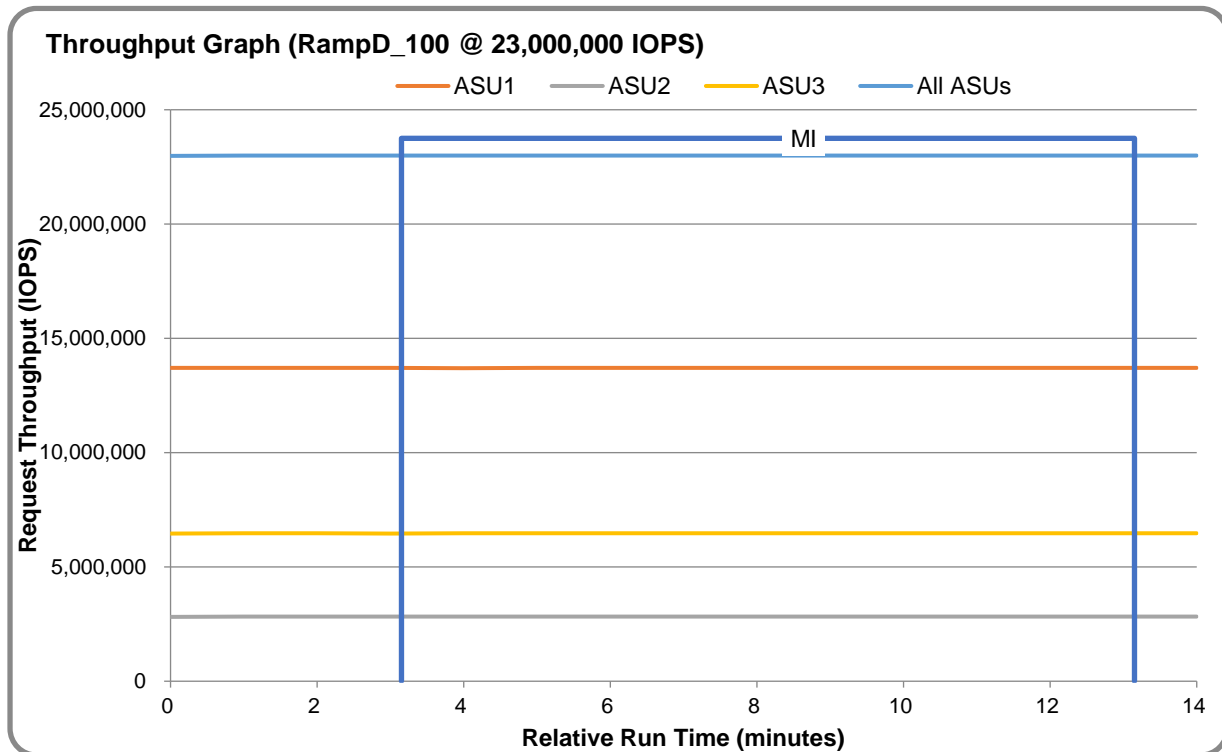|	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0001	0.0000	0.0001	0.0001	0.0002	0.0001	0.0001	0.0000
Difference	0.004%	0.002%	0.004%	0.000%	0.006%	0.003%	0.005%	0.002%

RAMPD_100 Test Phase

RAMPD_100 – Results File

The results file generated during the execution of the RAMPD_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:
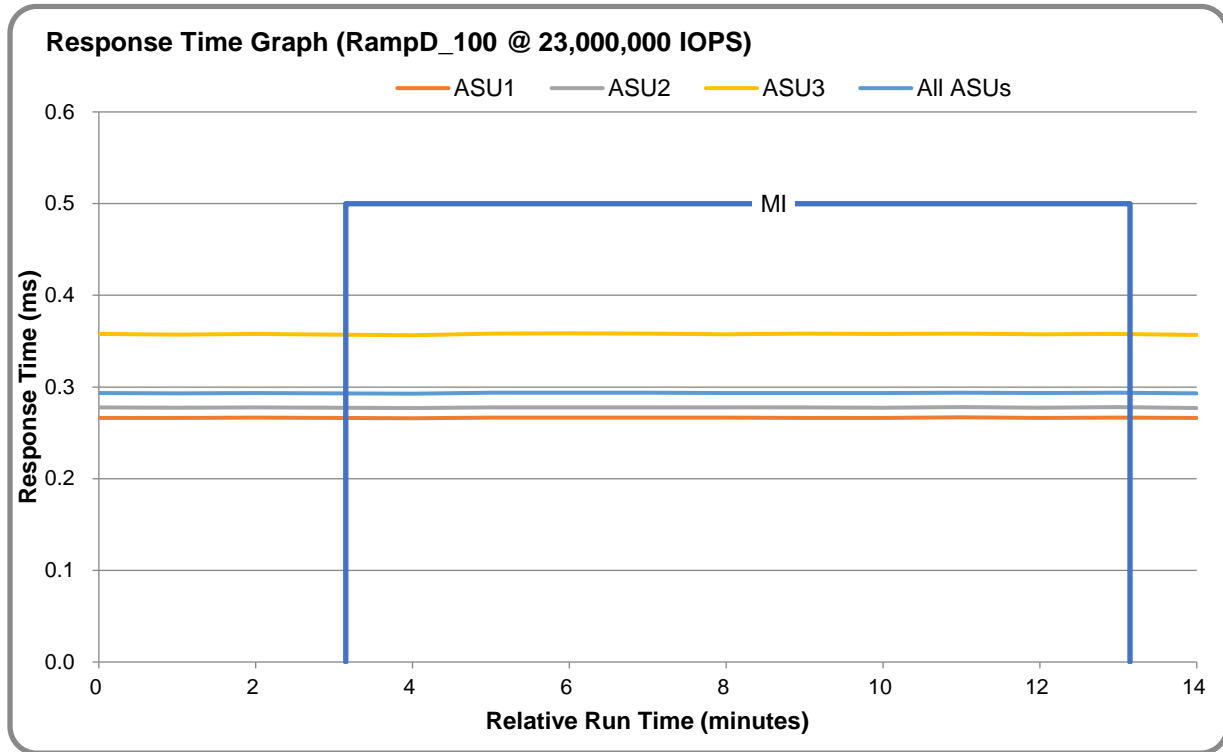
- **SPC1_METRICS_0_Raw_Results.xlsx**

RAMPD_100 – Execution Times

| Interval	Start Date & Time	End Date & Time	Duration
Transition Period	23-Jul-21 09:51:28	23-Jul-21 09:54:29	0:03:01
Measurement Interval	23-Jul-21 09:54:29	23-Jul-21 10:04:29	0:10:00

RAMPD_100 – Throughput Graph

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SPC Benchmark 1™ v3.10.0Inspur Electronic Information Industry Co. Ltd.

Inspur HF18000G5-I

Submission ID: A32023
Submitted: August 16, 2021

RAMPD_100 – Response Time Graph

Response Time Graph (RampD_100 @ 23,000,000 IOPS)

RAMPD_100 – Data Rate Graph

Data Rate Graph (RampD_100 @ 23,000,000 IOPS)

RAMPD_100 – Response Time Frequency Graph
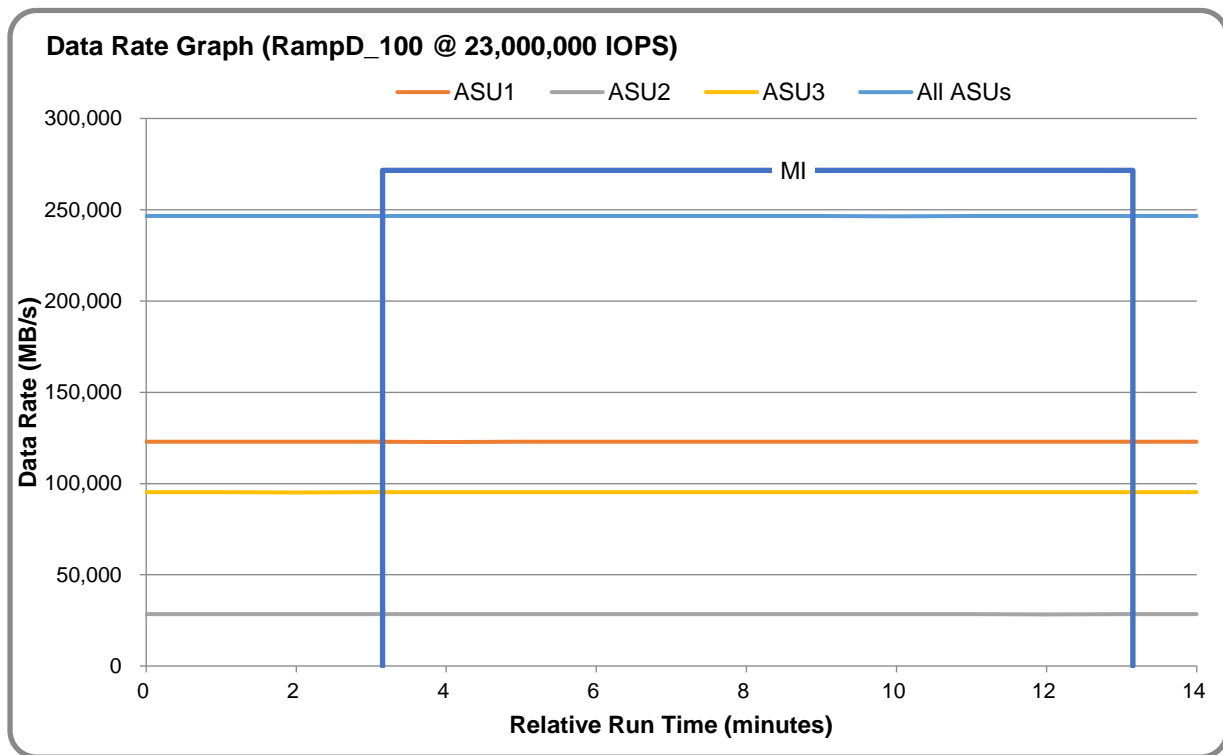
Response Time Frequency Graph
(RampD_100 @ 23,000,000 IOPS)
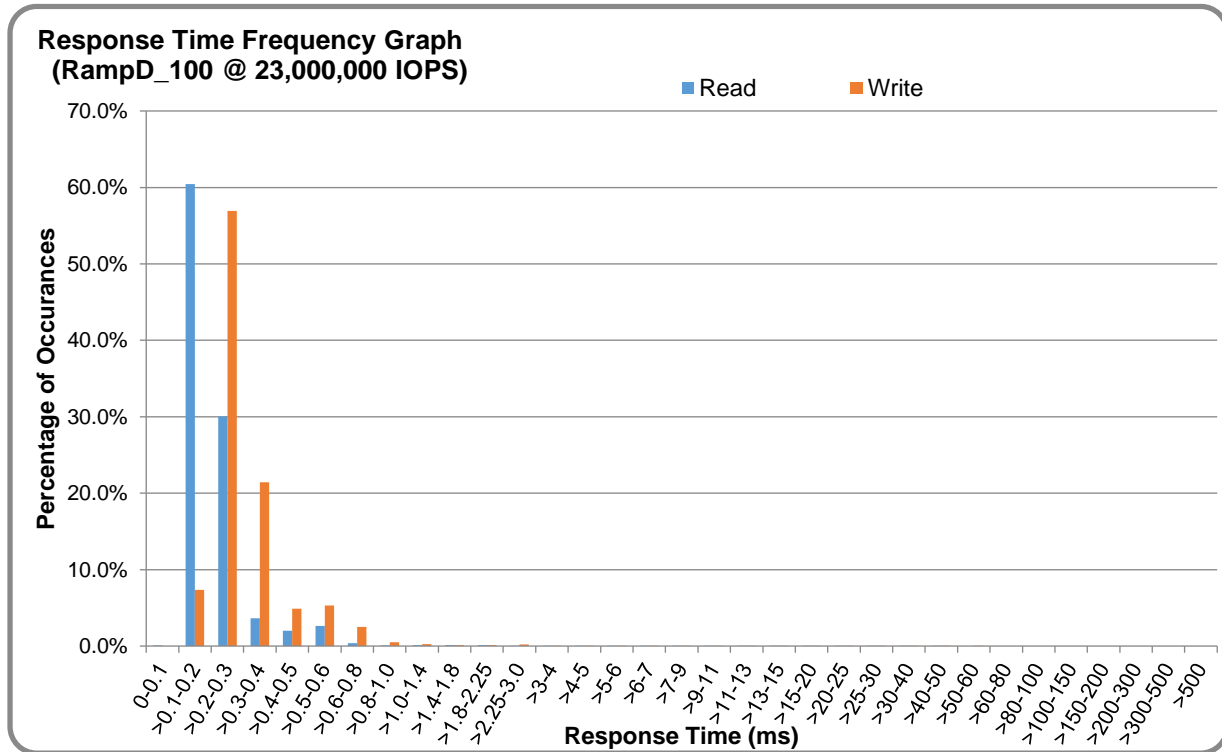
RAMPD_100 – Intensity Multiplier

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0002	0.0000	0.0001	0.0000	0.0002	0.0001	0.0001	0.0000
Difference	0.004%	0.001%	0.004%	0.004%	0.008%	0.004%	0.003%	0.004%

RAMPD_100 – I/O Request Summary

I/O Requests Completed in the Measurement Interval	13,801,001,141
I/O Requests Completed with Response Time <= 30 ms	13,800,924,494
I/O Requests Completed with Response Time > 30 ms	76,647

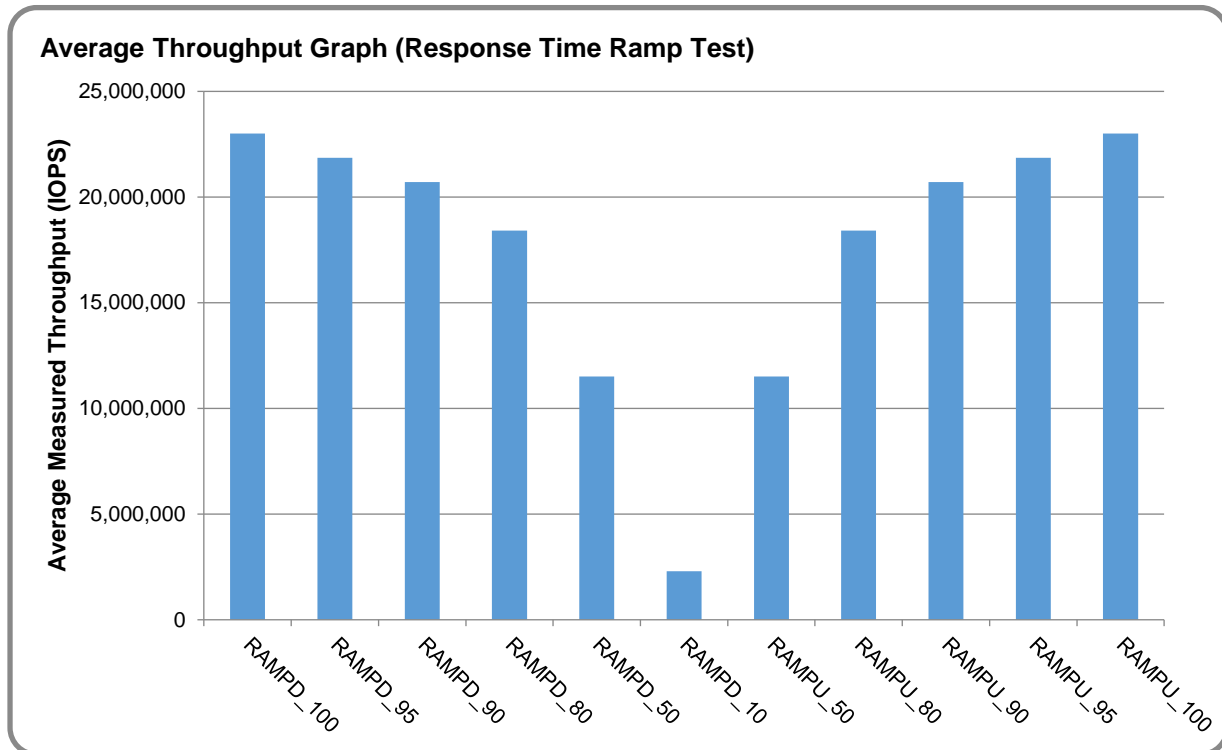# Response Time Ramp Test

Response Time Ramp Test – Results File

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

- **SPC1_METRICS_0_Raw_Results.xlsx**

Response Time Ramp Test – Phases

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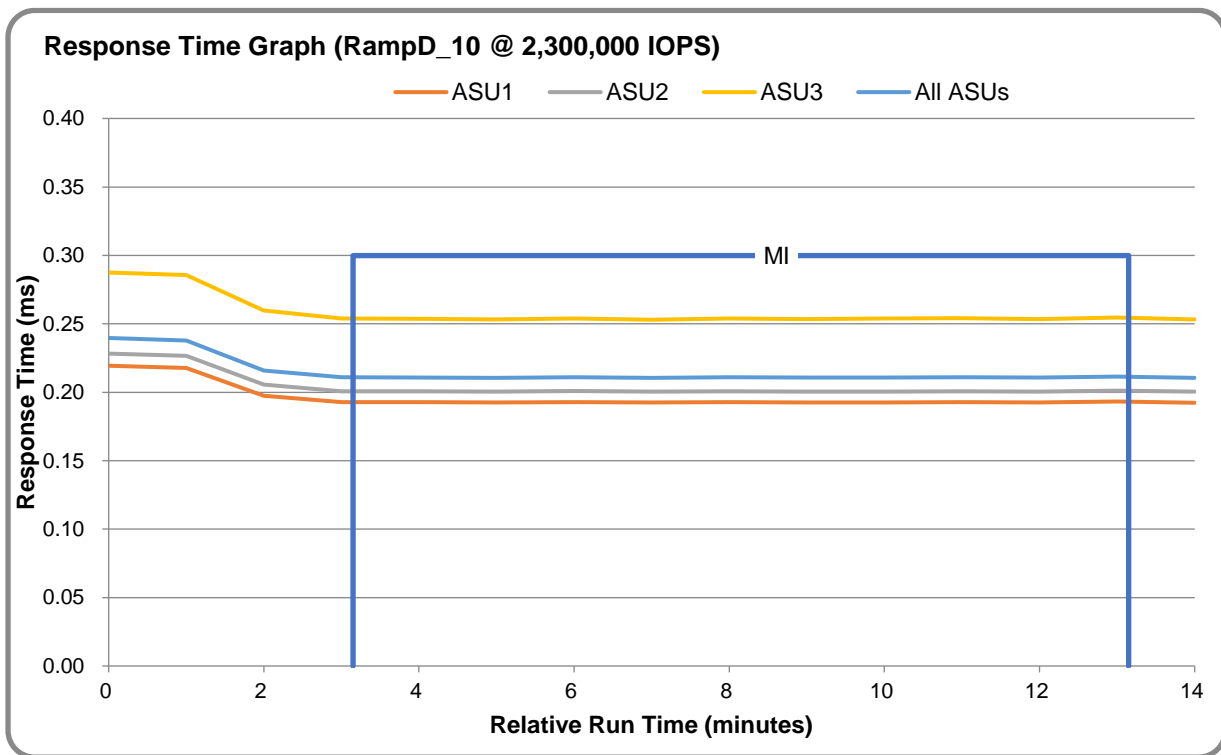
Response Time Ramp Test – Average Throughput Graph

Response Time Ramp Test – Average Response Time Graph

Average Response Time Graph (Response Time Ramp Test)
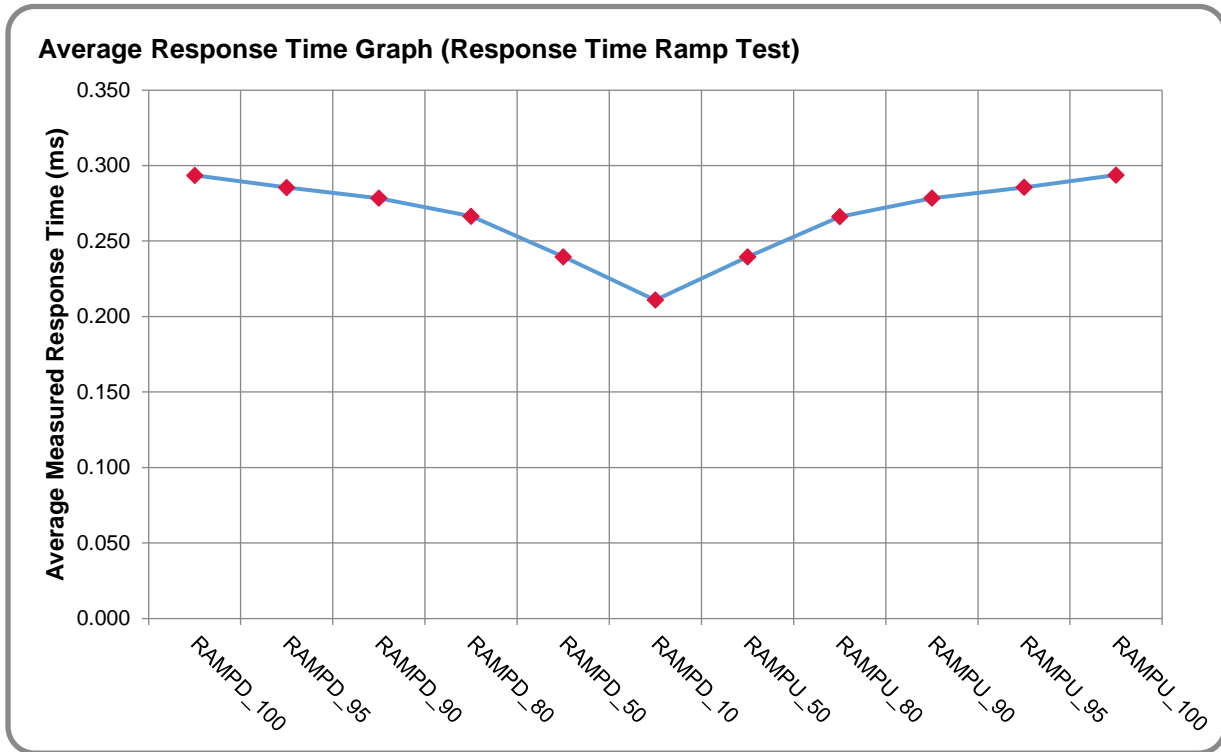
Response Time Ramp Test – RAMPD_10 Response Time Graph

Response Time Graph (RampD_10 @ 2,300,000 IOPS)

Repeatability Test

Repeatability Test Results File

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

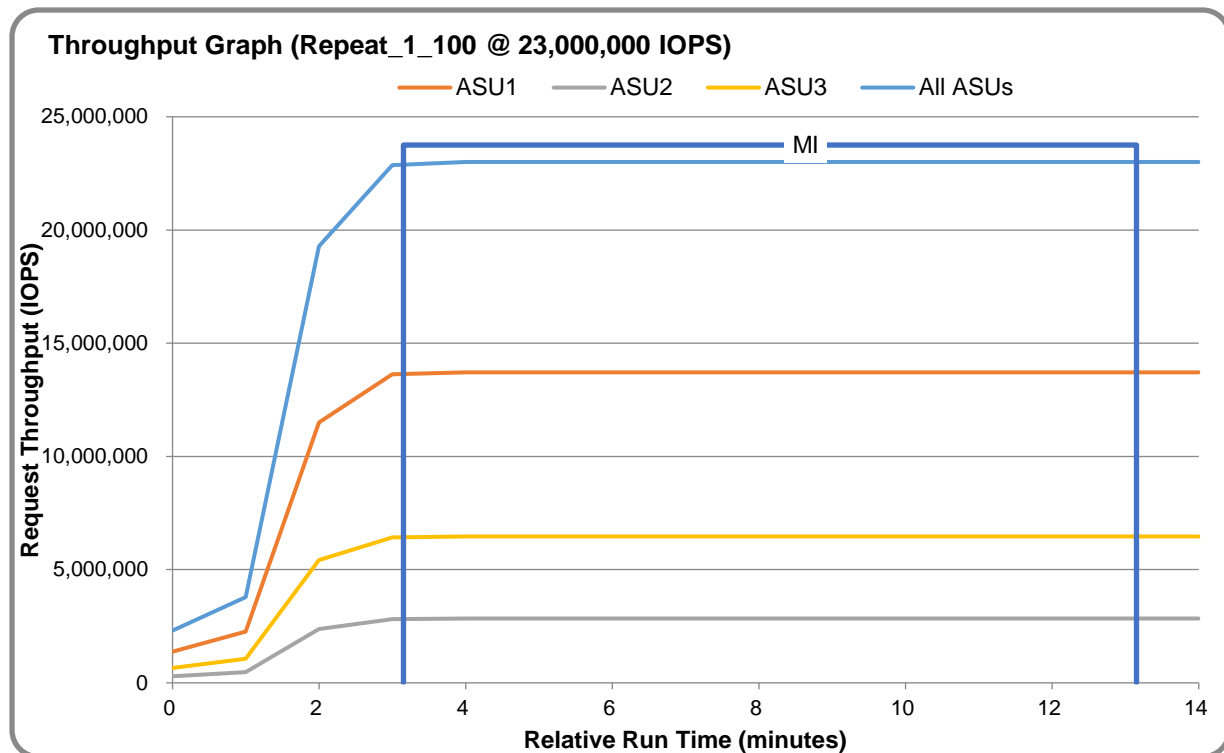- **SPC1_METRICS_0_Raw_Results.xlsx**

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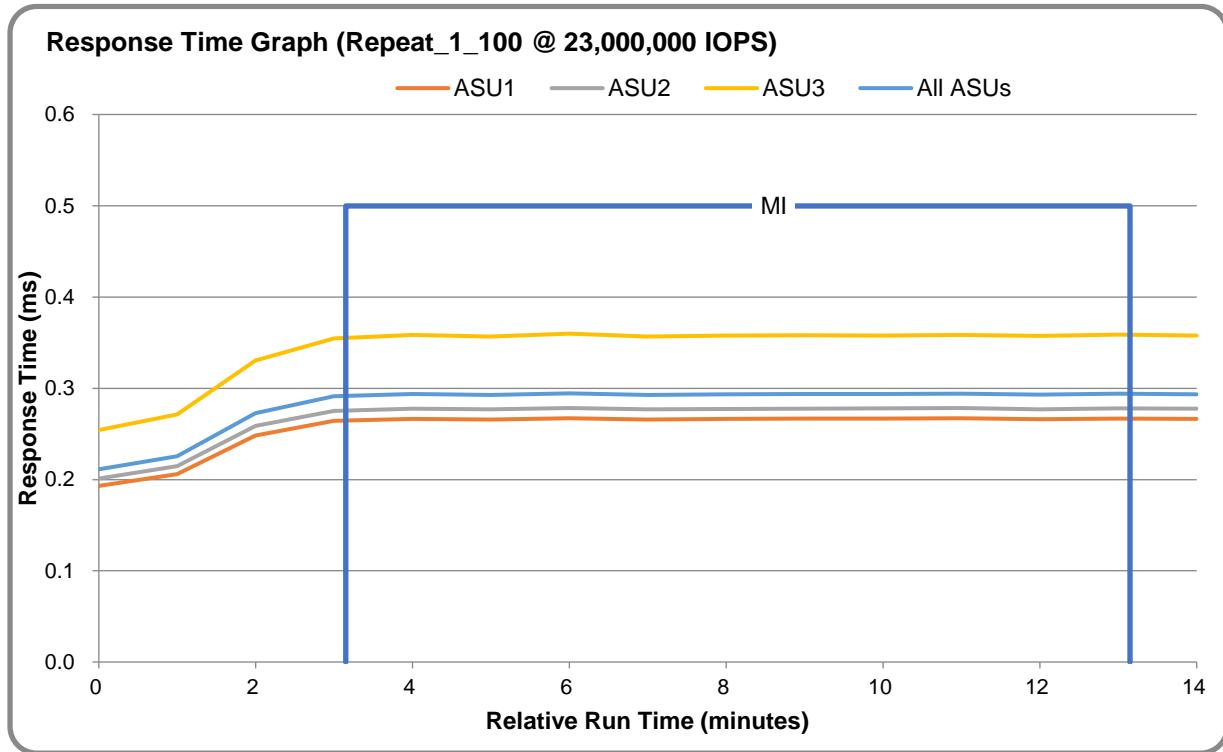
The throughput measurements for the Response Time Ramp Test (RAMPD) and the Repeatability Test Phases (REPEAT_1 and REPEAT_2) are listed in the table below.

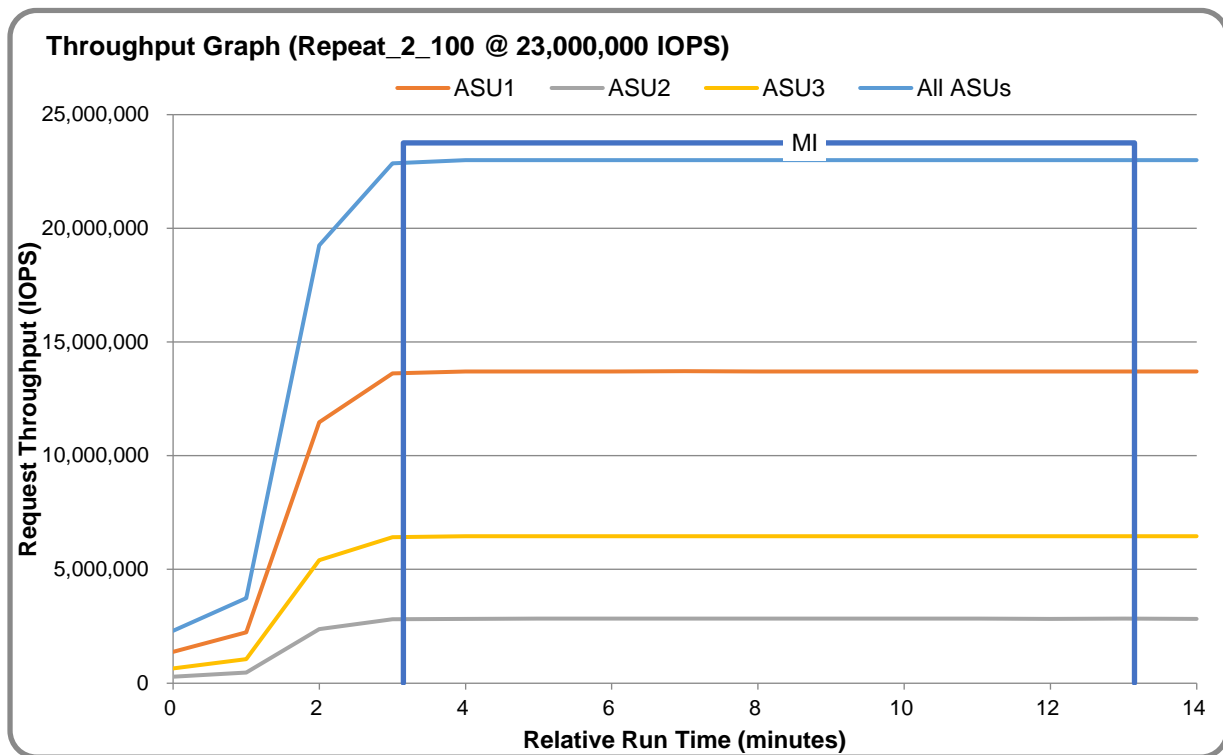| Test Phase	100% IOPS	10% IOPS
RAMPD	23,001,502.1	2,300,192.5
REPEAT_1	23,001,363.3	2,300,346.3
REPEAT_2	23,001,339.6	2,300,024.1

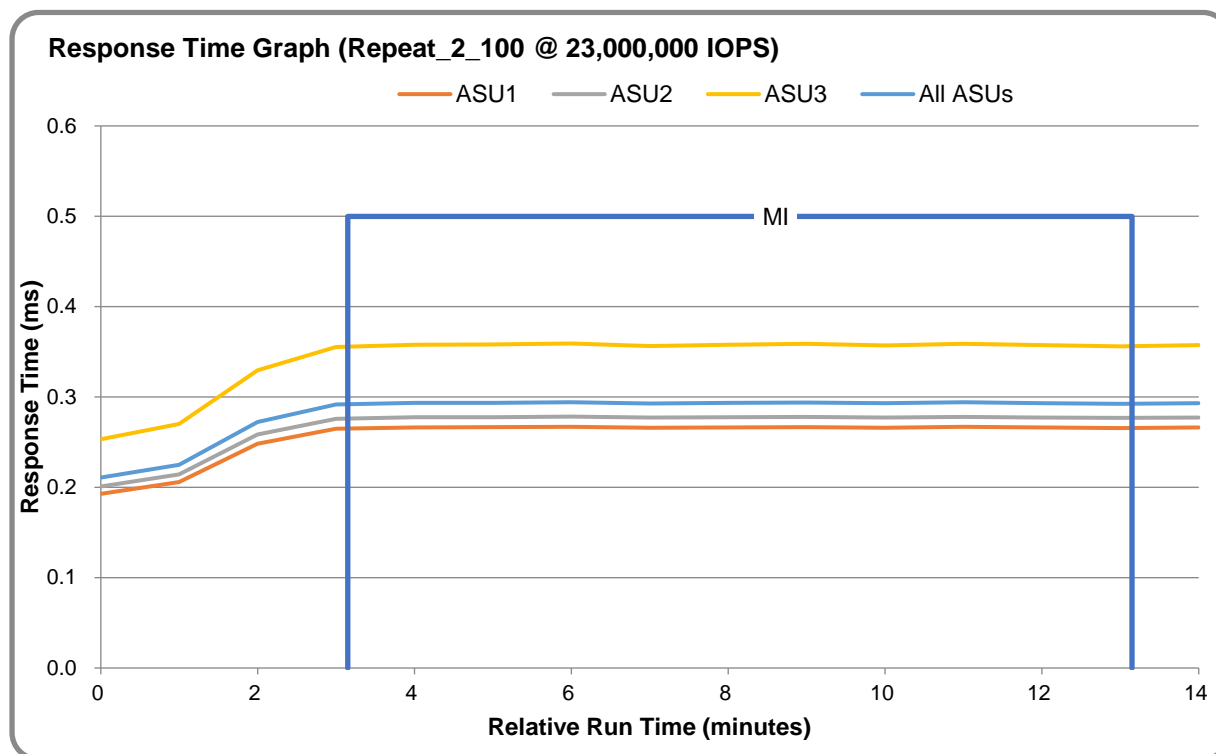## REPEAT_1_100 – Throughput Graph

REPEAT_1_100 – Response Time Graph

REPEAT_2_100 – Throughput Graph

REPEAT_2_100 – Response Time Graph

Repeatability Test – Intensity Multiplier

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

REPEAT_1_100 Test Phase

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0002	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0000
Difference	0.009%	0.003%	0.005%	0.000%	0.009%	0.009%	0.002%	0.002%

REPEAT_2_100 Test Phase

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0001	0.0000	0.0001	0.0001	0.0002	0.0000	0.0001	0.0000
Difference	0.002%	0.003%	0.001%	0.001%	0.004%	0.001%	0.004%	0.002%

Data Persistence Test

Data Persistence Test Results File

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

- **SPC1_PERSIST_1_0_Raw_Results.xlsx**
- **SPC1_PERSIST_2_0_Raw_Results.xlsx**

Data Persistence Test Execution

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

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

Data Persistence Test Results

Data Persistence Test Phase: Persist1	
Total Number of Logical Blocks Written	1,544,664,380
Total Number of Logical Blocks Verified	763,699,635
Total Number of Logical Blocks Overwritten	780,964,745
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks (sec.)	601
Size in bytes of each Logical Block	8,192
Number of Failed I/O Requests in the process of the Test	0

Committed Data Persistence Implementation

TSC uses the BBU power-down protection mechanism, each controller has two batteries and SSD as the system disk. When an unexpected power-down occurs, the controller continues to be powered by the battery and refreshes the cache data to SSD for permanent storage. When the power supply is restored, the data in the system disk SSD is automatically restored.

APPENDIX A: SUPPORTING FILES

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

File Name	Description	Location
/SPC1_RESULTS	**Data reduction worksheets**	**root**
SPC1_INIT_0_Raw_Results.xlsx	Raw results for INIT Test Phase	/SPC1_RESULTS
SPC1_METRICS_0_Quick_Look.xlsx	Quick Look Test Run Overview	/SPC1_RESULTS
SPC1_METRICS_0_Raw_Results.xlsx	Raw results for Primary Metrics Test	/SPC1_RESULTS
SPC1_METRICS_0_Summary_Results.xlsx	Primary Metrics Summary	/SPC1_RESULTS
SPC1_PERSIST_1_0_Raw_Results.xlsx	Raw results for PERSIST1 Test Phase	/SPC1_RESULTS
SPC1_PERSIST_2_0_Raw_Results.xlsx	Raw results for PERSIST2 Test Phase	/SPC1_RESULTS
SPC1_Run_Set_Overview.xlsx	Run Set Overview Worksheet	/SPC1_RESULTS
SPC1_VERIFY_0_Raw_Results.xlsx	Raw results for first VERIFY Test Phase	/SPC1_RESULTS
SPC1_VERIFY_1_Raw_Results.xlsx	Raw results for second VERIFY Test Phase	/SPC1_RESULTS
/C_Tuning	**Tuning parameters and options**	**root**
set_nr_requests.sh	Set queue depth, max AIO and scheduler	/C_Tuning
/D_Creation	**Storage configuration creation**	**root**
init_HF18000G5-I.sh	Create the storage environment	/D_Creation
lv_scan.sh	Scan and activate logical volumes	/D_Creation
lvm.sh	Create logical volumes	/D_Creation
vg.sh	Create volume groups	/D_Creation
/E_Inventory	**Configuration inventory**	**root**
profile.sh	Captures profile of storage environment	/E_Inventory
profile_end_HF18000G5-I.txt	Storage configuration before INIT	/E_Inventory
profile_start_HF18000G5-I.txt	Storage configuration after restart	/E_Inventory
volume_list.sh	Captures list of logical volumes	/E_Inventory
volume_listing_end.txt	List of logical volumes before INIT	/E_Inventory
volume_listing_start.txt	List of logical volumes after restart	/E_Inventory
/F_Generator	**Workload generator**	**Root**
HOST1.HST	Host configuration file (for VERIFY)	/F_generator
HOST61.HST	Host configuration file (all except VERIFY)	/F_generator
SPC1_40.asu	Define LUNs hosting the ASUs	/F_generator
test_init.sh	Execute INIT	/F_generator
test_metrics.sh	Execute METRICS	/F_generator
test_persist1.sh	Execute PERSIST1	/F_generator
test_persist2.sh	Execute PERSIST2	/F_generator
test_verify_0.sh	Execute VERIFY0	/F_generator
test_verify_1.sh	Execute VERIFY1	/F_generator

APPENDIX B: THIRD PARTY QUOTATION

All components are available directly through the Test Sponsor (Inspur Electronic Information Industry Co. Ltd.).

APPENDIX C: TUNING PARAMETERS AND OPTIONS

Change the Scheduler on each Host System. Execute the set_nr_requests.sh script on each Host System to complete the following settings:

- Change the maximum number of AIO operations to 1048576.

- Change the queue depth from 128 to 1024 on each Host System for each device.

- Change the I/O scheduler from cfq to noop on each Host System.

APPENDIX D: STORAGE CONFIGURATION CREATION

Step 1: Create Storage Pools, RAIDs, LUNs, Hosts, Mapping and deploy LUNs.

Execute the init_HF18000G5-I.sh script on a remote server which can login on HF18000G5-I storage system to complete the following:

1. Create 16 storage pools: Pool0, Pool1, Pool2, Pool3, Pool4, Pool5, Pool6, Pool7, Pool8, Pool9, Pool10, Pool11, Pool12, Pool13, Pool14, Pool15
2. Create 64 RAID10
3. Create 256 LUNs(16 LUN per Pool, 1300 GB per LUN)
4. Create 61 Hosts in storage cluster
5. Add the FC port's WWPN to the 61 hosts (4 WWPNs per Host)
6. Map LUNs to the 61 Hosts

Step 2: Create Volumes on the Master Host System

Execute the vg.sh script on the Master Host System to create 2 VGs, and then execute the lvm.sh script to create 40 logical volumes as follows. In addition, the script will make each logical volume available (activate).

1. Create Physical Volumes.

    Create 256 physical volumes using the pvcreate command.

2. Create Volumes Groups

    Create 2 volume groups (spc1vg1 spc1vg2) using the vgcreate command as follows:

    Create spc1vg1 using 128 of 256 physical volumes, and create spc1vg2 using another 128 of 256 physical volumes

3. Create Logical Volumes

   - Create 9 logical volumes, every volume capacity is 8000 GB, on spc1vg1 for ASU-1.
   - Create 9 logical volumes, every volume capacity is 8000 GB, on spc1vg2 for ASU-1
   - Create 9 logical volumes, every volume capacity is 8000 GB, on spc1vg1 for ASU-2.
   - Create 9 logical volumes, every volume capacity is 8000 GB, on spc1vg2 for ASU-2.
   - Create 2 logical volumes, every volume capacity is 8000 GB, on spc1vg1 for ASU-3.
   - Create 2 logical volumes, every volume capacity is 8000 GB, on spc1vg2 for ASU-3.

Step 3: Change the Scheduler on each Host System.

1. Execute the set_nr_requests.sh script on each Host System to complete the following settings:

   - Change the maximum number of AIO operations to 1048576.
   - Change the queue depth from 128 to 1024 on each Host System for each device.
   - Change the I/O scheduler from cfq to noop on each Host System.

APPENDIX E: CONFIGURATION INVENTORY

An inventory of the configuration was collected by running the following scripts.

- profile.sh
- volume_list.sh

The following log files were generated by running the above scripts.

- profile_start_HF18000G5-I.txt
- profile_end_HF18000G5-I.txt
- volume_listing_start.txt
- volume_listing_end.txt

These files are all available in the Supporting Files (see Appendix A).

APPENDIX F: WORKLOAD GENERATOR

The ASUs accessed by the SPC-1 workload generator were defined using the script SPC1_40.asu.

The hosts used to drive the SPC-1 workload were defined using the script HOST61.HST (HOST1.HST was used for VERIFY). The scripts used to execute the benchmark sequence were:

- test_init.sh
- test_metrics.sh
- test_persist1.sh
- test_persist2.sh
- test_verify_0.sh
- test_verify_1.sh

These files are all available in the Supporting Files (see Appendix A).