SPC BENCHMARK 2C™
FULL DISCLOSURE REPORT

SEAGATE TECHNOLOGY LLC
SEAGATE BARRACUDA ES.2 ST31000640SS

SPC-2C™ V1.1

Submitted for Review: October 15, 2008
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AUDIT CERTIFICATION

Craig Paris
Seagate Technology LLC
1280 Disc Drive
Shakopee, MN 55372

October 6, 2008

The SPC Benchmark 2C™ results listed below for the Seagate Barracuda ES.2 ST31000640SS were produced in compliance with the SPC Benchmark 2C™ V1.1 Onsite Audit requirements.

SPC Benchmark 2C™ V1.1 Results	
Tested Storage Product: Seagate Barracuda ES.2 ST31000640SS	
Metric	**Reported Result**
SPC-2C MBPS™	65.53
ASU Capacity	500.103 GB
Data Protection Level	Unprotected
Total Price – Priced Storage Configuration	$508.26

The following SPC Benchmark 2C™ Audit requirements were reviewed and found compliant with V1.1 of the SPC Benchmark 2C™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by physical inspection and documentation supplied by Seagate Technology LLC:
  - ✓ Physical Storage Capacity and related requirements.
  - ✓ Configured Storage Capacity and related requirements.
  - ✓ Addressable Storage Capacity and related requirements.
  - ✓ Capacity of each Logical Volume and related requirements.
  - ✓ Capacity of the Application Storage Unit (ASU) and related requirements.
- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Physical verification of the components to match the above diagram.
- Listings and commands used to create and configure the Benchmark Configuration/Tested Storage Configuration.
- Documentation of each customer tunable parameter or option that was changed from its default value.

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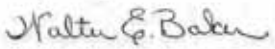
AUDIT CERTIFICATION *(CONT.)*

- The following Host System items were verified by physical inspection and documentation supplied by Seagate Technology LLC:
  - ✓ Required Host System configuration information.
  - ✓ The TSC boundary within each Host System.
- The following SPC-2C Workload Generator information was verified by physical inspection and documentation supplied by Seagate Technology LLC:
  - ✓ The presence and version number of the SPC-2C Workload Generator on each Host System.
  - ✓ Commands and parameters used to configure the SPC-2C Workload Generator.
- The Test Results Files and resultant Summary Results Files received for each of the following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 5 and 6 of the SPC-2C Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Large File Processing Test
  - ✓ Large Database Query Test
  - ✓ Video on Demand Delivery Test
- There were no differences between the Tested Storage Configuration (TSC) used for the benchmark and the Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 9 of the SPC-2C Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 10 of the SPC-2C Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,



Walter E. Baker
SPC Auditor

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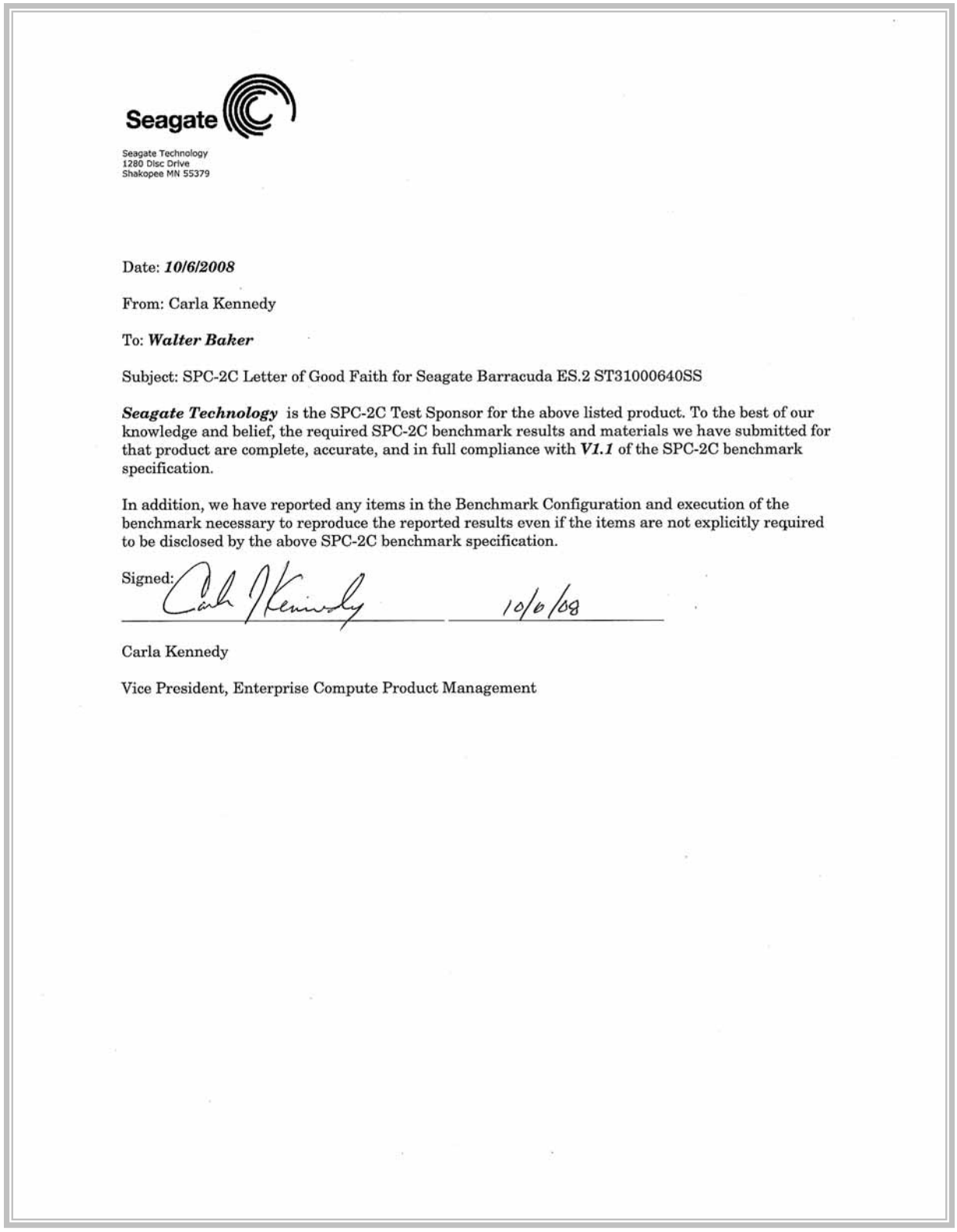
LETTER OF GOOD FAITH



Seagate

Seagate Technology
1280 Disc Drive
Shakopee MN 55379

Date: ***10/6/2008***

From: Carla Kennedy

To: ***Walter Baker***

Subject: SPC-2C Letter of Good Faith for Seagate Barracuda ES.2 ST31000640SS

Seagate Technology is the SPC-2C Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-2C benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with ***V1.1*** of the SPC-2C benchmark specification.

In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark necessary to reproduce the reported results even if the items are not explicitly required to be disclosed by the above SPC-2C benchmark specification.

Signed: Carla Kennedy 10/6/08

Carla Kennedy

Vice President, Enterprise Compute Product Management

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Seagate Technology LLC – http://www.seagate.com Craig Parris – Craig.Parris@seagate.com 1280 Disc Drive Shakopee, MN 55372 Phone: (952) 402-2418 FAX: (952) 402-2695
Test Sponsor Alternate Contact	Seagate Technology LLC – http://www.seagate.com Jeff Crist – Jeff.Crist@seagate.com 1280 Disc Drive Shakopee, MN 55372 Phone: (952) 402-2840 FAX: (952) 402-2840
Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-2C Specification revision number	V1.1
SPC-2C Workload Generator revision number	V1.0
Date Results were first used publicly	October 15, 2008
Date FDR was submitted to the SPC	October 15, 2008
Date the TSC will be available for shipment to customers	currently available
Date the TSC completed audit certification	October 6, 2008

Tested Storage Product (TSP) Description

The Seagate® Barracuda® ES.2 drive uses second-generation Seagate perpendicular recording technology to provide up to one terabyte of storage in a single, 4-platter hard drive. This 7200-RPM drive with best-in-class reliability and rotational vibration tolerance was developed for 24x7 availability in high-density, Tier 2 storage applications. The drive's integrated workload management feature aids in drive cooling during periods of prolonged activity. The integrated PowerTrim™ technology optimizes power consumption during operation and idle without any host interaction or performance loss. The Barracuda ES.2 drive comes with in-drive data integrity protection guaranteed through Seagate IOEDC/IOECC* technology and is available with a choice of system initiators. SAS offers improved performance over SATA due in part to the dual processors, hardware sequential streaming, the 2.4 GHz SAS ASIC data rate and the SAS clock rate of 75 MHz.The SAS interface allows Barracuda ES.2 drives to be freely attached to any SAS host in single or dual-ported configurations and provides full-duplex support, with two active data channels, to as many as 16 concurrent initiators.

SPC-2C Reported Data

SPC-2C Reported Data consists of three groups of information:

- The following SPC-2C Primary Metrics, which characterize the overall benchmark result:
  - SPC-2C MBPS™
  - Application Storage Unit (ASU) Capacity
- Supplemental data to the SPC-2C Primary Metrics.
  - Total Price
  - Data Protection Level
- Reported Data for each SPC Test: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand Delivery (VOD) Test.

SPC-2C Reported Data			
Seagate Barracuda ES.2 ST31000640SS			
SPC-2C MBPS™	**ASU Capacity (GB)**	**Total Price**	**Data Protection Level**
65.53	500.103	$508.26	Unprotected
The above SPC-2C MBPS™ value represents the aggregate data rate of all three SPC-2C workloads: Large File Processing, Large Database Query, and Video On Demand			
SPC-2 Large File Processing (LFP) Reported Data			
	Data Rate *(MB/second)*	**Number of Streams**	**Data Rate per Stream**
LFP Composite	79.47		
Write Only:			
1024 KiB Transfer	109.80	5	21.96
256 KiB Transfer	105.63	5	21.13
Read-Write:			
1024 KiB Transfer	59.45	5	11.89
256 KiB Transfer	38.24	5	7.65
Read Only:			
1024 KiB Transfer	53.02	5	10.60
256 KiB Transfer	110.67	5	22.13
The above SPC-2C Data Rate value for LFP Composite represents the aggregate performance of all three LFP Test Phases: (Write Only, Read-Write, and Read Only).			
SPC-2 Large Database Query (LDQ) Reported Data			
	Data Rate *(MB/second)*	**Number of Streams**	**Data Rate per Stream**
LDQ Composite	82.52		
1024 KiB Transfer Size			
4 I/Os Outstanding	107.32	5	21.46
1 I/O Outstanding	53.78	5	10.76
64 KiB Transfer Size			
4 I/Os Outstanding	94.64	5	18.93
1 I/O Outstanding	74.35	5	14.87
The above SPC-2C Data Rate value for LDQ Composite represents the aggregate performance of the two LDQ Test Phases: (1024 KiB and 64 KiB Transfer Sizes).			
SPC-2 Video On Demand (VOD) Reported Data			
	Data Rate *(MB/second)*	**Number of Streams**	**Data Rate per Stream**
	34.60	44	0.79

SPC-2C MBPS™ represents the aggregate data rate, in megabytes per second, of all three SPC-2C workloads: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand (VOD).

ASU (Application Storage Unit) **Capacity** represents the total storage capacity read and written in the course of executing the SPC-2C benchmark.

A **Data Protection Level** of "Unprotected" makes no claim of data protection in the event of a single point of failure.

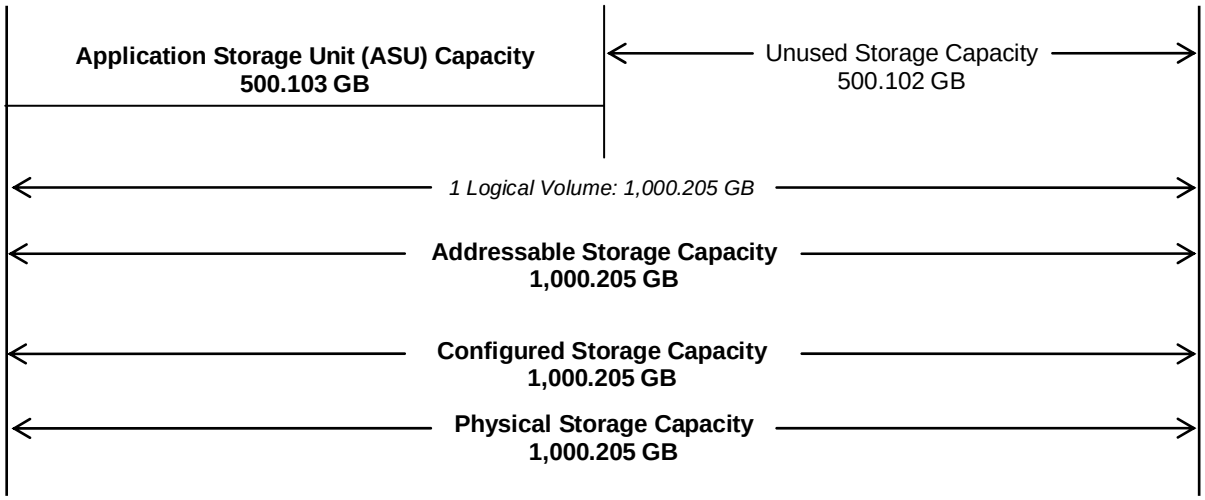
Storage Capacities and Relationships

The Tested Storage Configuration (TSC) must be configured so that there is either no Unused Storage or that the sum of ASU Capacity and storage required for data protection equals 50% (+-1 GiB) of the Physical Storage Capacity. This configuration meets the 50% requirement as documented below:

1,000.205 GB *(Physical Storage Capacity)* * 0.5 = 500.102 GB

500.103 GB (*ASU Capacity)* + 0.000 GB *(data protection)* = 500.103 GB

The following diagram *(not to scale)* documents the various storage capacities and their relationships, used in this SPC-2C benchmark measurement.



Tested Storage Configuration Pricing *(Priced Storage Configuration)*

Description	Part Numbers	Qty	Price	Extended Price
1TB GB SAS 3.5" HDD	ST31000640SS	1	295.18	295.18
SAS HBA	LSI00033-F	1	213.08	213.08
(incl 4 SAS/SATA -1M Cables)				
			Total	$508.26

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

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

Benchmark Configuration/Tested Storage Configuration Diagram

Host System(s) and Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):
HS-1	1 – LSI SAS3041X-R HBA
"White Box" server: Supermicro X6DH*-XG2 motherboard 2 – 2.8 GHz Intel® Xeon™ CPUs 16 KB L1 cache per CPU 1024 KB L2 cache per CPU 2 GB main memory	1 – Seagate Barracuda ES.2 ST31000640SS SAS disk drive
	Point-to-point cable connection
Windows 2003 Enterprise Edition	
PCIe	

CONFIGURATION INFORMATION

This portion of the Full Disclosure Report documents and illustrates the detailed information necessary to recreate the Benchmark Configuration (BC), including the Tested Storage Configuration (TSC), so that the SPC-2C benchmark result produced by the BC may be independently reproduced.

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-2C benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

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

Clause 10.4.5.9

The Executive Summary will contain a one page BC/TSC diagram that illustrates all major components of the BC/TSC.

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

Host System and Tested Storage Configuration Table

Clause 10.4.5.10

The Executive Summary will contain a table that lists the major components of each Host System and the Tested Storage Configuration.

The components that comprise each Host System and the Tested Storage Configuration are listed in the table that appears on page 13 *(Host System(s) and Tested Storage Configuration Components).*

Customer Tunable Parameters and Options

Clause 10.4.6.1

All Benchmark Configuration (BC) components with customer tunable parameter and options that have been altered from their default values must be listed in the FDR. The FDR entry for each of those components must include both the name of the component and the altered value of the parameter or option. If the parameter name is not self-explanatory to a knowledgeable practitioner, a brief description of the parameter's use must also be included in the FDR entry.

"Appendix B: Customer Tunable Parameters and Options" on page 52 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

Tested Storage Configuration (TSC) Creation and Configuration

Clause 10.4.6.2

The Full Disclosure Report must include sufficient information to recreate the logical representation of the Tested Storage Configuration (TSC). In addition to customer tunable parameters and options (Clause10.6.6.1), that information must include, at a minimum:

- *A diagram and/or description of the following:*
  - *All physical components that comprise the TSC. Those components are also illustrated in the BC Configuration Diagram in Clause 10.6.5.7 and the Storage Network Configuration Diagram in Clause 10.4.5.9.*
  - *The logical representation of the TSC, configured from the above components that will be presented to the SPC-2C Workload Generator.*
- *Listings of scripts used to create the logical representation of the TSC.*
- *If scripts were not used, a description of the process used with sufficient detail to recreate the logical representation of the TSC.*

"Appendix C: Tested Storage Configuration (TSC) Creation" on page 53 contains the detailed information that describes how to create and configure the logical TSC.

SPC-2C Workload Generator Storage Configuration

Clause 10.4.6.3

The Full Disclosure Report will include all SPC-2C Workload Generator storage configuration commands and parameters used in the SPC-2C benchmark measurement.

The SPC-2C Workload Generator storage configuration commands and parameters for this measurement appear in "Appendix D: SPC-2C Workload Generator Storage Commands and Parameters" on page 53.

SPC-2C DATA REPOSITORY

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-2C storage capacities and mappings used in the Tested Storage Configuration. "SPC-2C Data Repository Definitions" on page 47 contains definitions of terms specific to the SPC-2C Data Repository.

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-2C benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

SPC-2C Storage Capacities and Relationships

Clause 10.4.7.1

Two tables and an illustration documenting the storage capacities and relationships of the SPC-2C Storage Hierarchy (Clause 2.1) shall be included in the FDR.

SPC-2C Storage Capacities

SPC-2C Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	500.103
Addressable Storage Capacity	Gigabytes (GB)	1,000.205
Configured Storage Capacity	Gigabytes (GB)	1,000.205
Physical Storage Capacity	Gigabytes (GB)	1,000.205
Data Protection *(Unprotected)*	Gigabytes (GB)	0.000
Required Storage	Gigabytes (GB)	0.000
Global Storage Overhead	Gigabytes (GB)	0.000
Total Unused Storage	Gigabytes (GB)	500.102

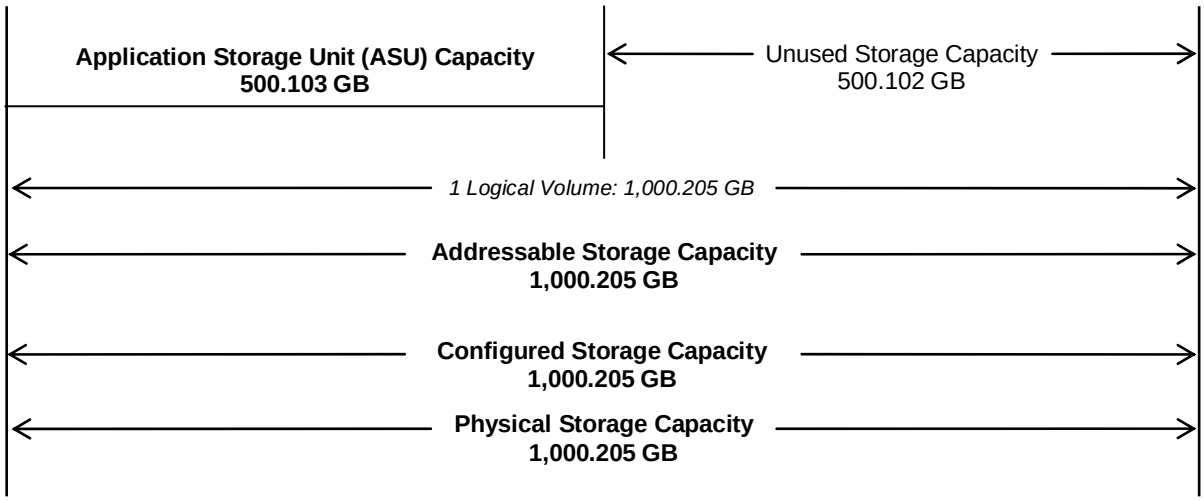
SPC-2C Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	50.00%	50.00%	50.00%
Data Protection *(Unprotected)*		0.00%	0.00%
Addressable Storage Capacity		100.00%	100.00%
Required Storage		0.00%	0.00%
Configured Storage Capacity			100.00%
Global Storage Overhead			0.00%
Unused Storage:			
Addressable	50.00%		
Configured		50.00%	
Physical			50.00%

The Physical Storage Capacity consisted of 1,000.205 GB distributed over 1 disk drive with a formatted capacity of 1,000.205 GB. There was 500.102 GB (50.00%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0.000 GB (0.00%) of Physical Storage Capacity. There was 500.102 GB (50.00%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 50.00% of the Addressable Storage Capacity resulting in 500.102 GB (0.00%) of Unused Storage within the Addressable Storage Capacity.

SPC-2C Storage Capacities and Relationships Illustration

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



Logical Volume Capacity and ASU Mapping

Clause 10.4.7.2

A table illustrating the capacity of the Application Storage Unit (ASU) and the mapping of Logical Volumes to ASU will be provided in the FDR. Capacity must be stated in gigabytes (GB) as a value with a minimum of two digits to the right of the decimal point. Each Logical Volume will be sequenced in the table from top to bottom per its position in the contiguous address space of the ASU. Each Logical Volume entry will list its total capacity, the portion of that capacity used for the ASU, and any unused capacity.

Logical Volume (LV) Capacity and Mapping			
ASU (500.103 GB)			
	Total Capacity *(GB)*	Capacity Used *(GB)*	Capacity Unused *(GB)*
Logical Volumes 1	1,000.205 per LV	500.103 per LV	500.102 per LV

See the Storage Definition (sd) entries in "Appendix D: SPC-2C Workload Generator Storage Commands and Parameters" on page 53 for more detailed configuration information.

SPC-2C TEST EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-2C Test, Test Phases, Test Run Sequences, and Test Runs. "SPC-2C Test Execution Definitions" on page 48 contains definitions of terms specific to the SPC-2C Data Repository.

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-2C benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

SPC-2C Tests, Test Phases, Test Run Sequences, and Test Runs

The SPC-2C benchmark consists of the following Tests, Test Phases, Test Run Sequences, and Test Runs:

- **Large File Processing Test**
  - WRITE ONLY Test Phase
    - Test Run Sequence 1
      - ✓ Test Run 1 – 1024 KiB Transfer – maximum number of Streams
      - ✓ Test Run 2 – 1024 KiB Transfer – 50% of Test Run 1's Streams value
      - ✓ Test Run 3 – 1024 KiB Transfer – 25% of Test Run 1's Streams value
      - ✓ Test Run 4 – 1024 KiB Transfer – 12.5% of Test Run 1's Streams value
      - ✓ Test Run 5 – 1024 KiB Transfer – single (1) Stream
    - Test Run Sequence 2
      - ✓ Test Run 6 – 256 KiB Transfer – maximum number of Streams
      - ✓ Test Run 7 – 256 KiB Transfer – 50% of Test Run 6's Streams value
      - ✓ Test Run 8 – 256 KiB Transfer – 25% of Test Run 6's Streams value
      - ✓ Test Run 9 – 256 KiB Transfer – 12.5% of Test Run 6's Streams value
      - ✓ Test Run 10 – 256 KiB Transfer – single (1) Stream
  - READ-WRITE Test Phase
    - Test Run Sequence 3
      - ✓ Test Run 11 – 1024 KiB Transfer – maximum number of Streams
      - ✓ Test Run 12 – 1024 KiB Transfer – 50% of Test Run 11's Streams value
      - ✓ Test Run 13 – 1024 KiB Transfer – 25% of Test Run 11's Streams value
      - ✓ Test Run 14 – 1024 KiB Transfer – 12.5% of Test Run 11's Streams value
      - ✓ Test Run 15 – 1024 KiB Transfer – single (1) Stream
    - Test Run Sequence 4
      - ✓ Test Run 16 – 256 KiB Transfer – maximum number of Streams
      - ✓ Test Run 17 – 256 KiB Transfer – 50% of Test Run 16's Streams value
      - ✓ Test Run 18 – 256 KiB Transfer – 25% of Test Run 16's Streams value
      - ✓ Test Run 19 – 256 KiB Transfer – 12.5% of Test Run 16's Streams value
      - ✓ Test Run 20 – 256 KiB Transfer – single (1) Stream

- **Large File Processing Test *(continued)***
  - READ ONLY Test Phase
    - Test Run Sequence 5
      - ✓ Test Run 21 – 1024 KiB Transfer – maximum number of Streams
      - ✓ Test Run 22 – 1024 KiB Transfer – 50% of Test Run 21's Streams value
      - ✓ Test Run 23 – 1024 KiB Transfer – 25% of Test Run 21's Streams value
      - ✓ Test Run 24 – 1024 KiB Transfer – 12.5% of Test Run 21's Streams value
      - ✓ Test Run 25 – 1024 KiB Transfer – single (1) Stream
    - Test Run Sequence 6
      - ✓ Test Run 26 – 256 KiB Transfer – maximum number of Streams
      - ✓ Test Run 27 – 256 KiB Transfer – 50% of Test Run 26's Streams value
      - ✓ Test Run 28 – 256 KiB Transfer – 25% of Test Run 26's Streams value
      - ✓ Test Run 29 – 256 KiB Transfer – 12.5% of Test Run 26's Streams value
      - ✓ Test Run 30 – 256 KiB Transfer – single (1) Stream

- **Large Database Query Test**
  - 1024 KIB TRANSFER SIZE Test Phase
    - Test Run Sequence 1
      - ✓ Test Run 1 – 4 I/O Requests Outstanding – maximum number of Streams
      - ✓ Test Run 2 – 4 I/O Requests Outstanding – 50% of Test Run 1's Streams value
      - ✓ Test Run 3 – 4 I/O Requests Outstanding – 25% of Test Run 1's Streams value
      - ✓ Test Run 4 – 4 I/O Requests Outstanding – 12.5% of Test Run 1's Streams value
      - ✓ Test Run 5 – 4 I/O Requests Outstanding – single (1) Stream
    - Test Run Sequence 2
      - ✓ Test Run 6 – 1 I/O Request Outstanding – maximum number of Streams
      - ✓ Test Run 7 – 1 I/O Request Outstanding – 50% of Test Run 6's Streams value
      - ✓ Test Run 8 – 1 I/O Request Outstanding – 25% of Test Run 6's Streams value
      - ✓ Test Run 9 – 1 I/O Request Outstanding – 12.5% of Test Run 6's Streams value
      - ✓ Test Run 10 – 1 I/O Request Outstanding – single (1) Stream
  - 64 KIB TRANSFER SIZE Test Phase
    - Test Run Sequence 3
      - ✓ Test Run 11 – 4 I/O Requests Outstanding – maximum number of Streams
      - ✓ Test Run 12 – 4 I/O Requests Outstanding – 50% of Test Run 11's Streams value
      - ✓ Test Run 13 – 4 I/O Requests Outstanding – 25% of Test Run 11's Streams value
      - ✓ Test Run 14 – 4 I/O Requests Outstanding – 12.5% of Test Run 11's Streams value
      - ✓ Test Run 15 – 4 I/O Requests Outstanding – single (1) Stream
    - Test Run Sequence 4
      - ✓ Test Run 16 – 1 I/O Request Outstanding – maximum number of Streams
      - ✓ Test Run 17 – 1 I/O Request Outstanding – 50% of Test Run 16's Streams value
      - ✓ Test Run 18 – 1 I/O Request Outstanding – 25% of Test Run 16's Streams value
      - ✓ Test Run 19 – 1 I/O Request Outstanding – 12.5% of Test Run 16's Streams value
      - ✓ Test Run 20 – 1 I/O Request Outstanding – single (1) Stream

- **Video on Demand Delivery Test**
  - Video on Demand Delivery Test Run

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

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

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

Large File Processing Test

Clause 6.4.3.1

The Large File Processing Test consists of the I/O operations associated with the type of applications, in a wide range of fields, which require simple sequential processing of one or more large files. Specific examples of those types of applications include scientific computing and large-scale financial processing

Clause 6.4.3.2

The Large File Processing Test has three Test Phases, which shall be executed in the following uninterrupted sequence:

1. *WRITE ONLY*
2. *READ-WRITE*
3. *READ ONLY*

The BC shall not be restarted or manually disturbed, altered, or adjusted during the execution of the Large File Processing Test. If power is lost to the BC during this Test all results shall be rendered invalid and the Test re-run in its entirety.

Clause 10.4.8.1

The Full Disclosure Report will contain the following content for the Large File Processing Test:

1. *A listing of the SPC-2C Workload Generator commands and parameters used to execute each of the Test Runs in the Large File Processing Test.*
2. *The human readable SPC-2C Test Results File for each of the Test Runs in the Large File Processing Test.*
3. *A table that contains the following information for each Test Run in all three Test Phases of the Large File Processing Test:*
    - *The number Streams specified.*
    - *The Ramp-Up duration in seconds.*
    - *The Measurement Interval duration in seconds.*
    - *The average data rate, in MB per second, for the Measurement Interval.*
    - *The average data rate, in MB per second, per Stream for the Measurement Interval.*
4. *Average Data Rate and Average Data Rate per Stream graphs as defined in Clauses 10.1.1 and 10.1.2.*

SPC-2C Workload Generator Commands and Parameters

The SPC-2C Workload Generator commands and parameters for the Large File Processing Test Runs are documented in "Appendix E: SPC-2C Workload Generator Execution Commands and Parameters" on Page 57.

SPC-2C Test Results File

A link to the SPC-2C Test Results file generated from the Large File Processing Test Runs is listed below.

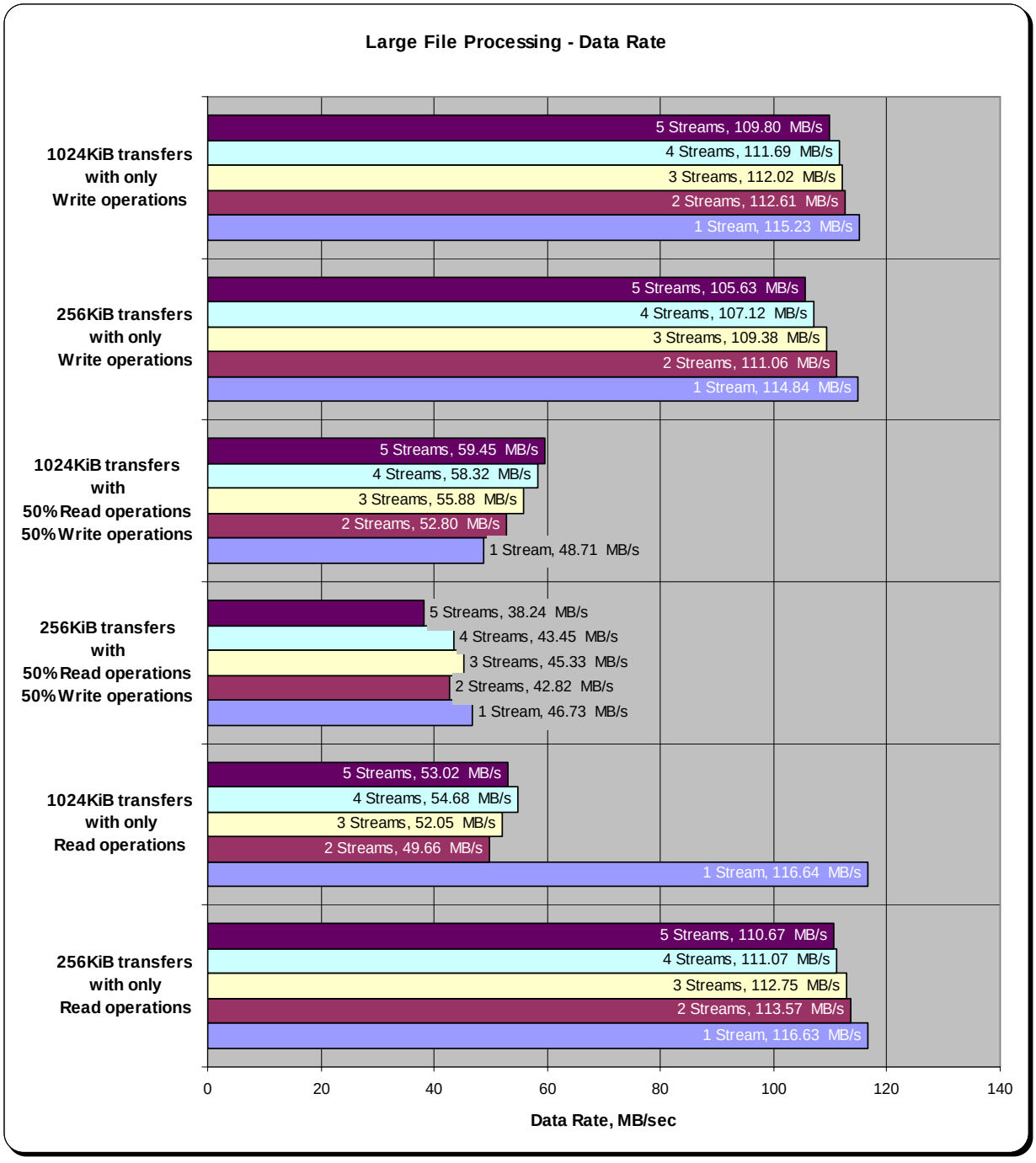
SPC-2C Large File Processing Test Results File

SPC-2C Large File Processing Average Data Rates (MB/s)

The average Data Rate (MB/s) for each Test Run in the three Test Phases of the SPC-2C Large File Processing Test is listed in the table below as well as illustrated in the following graph.

Test Run Sequence	1 Stream	2 Streams	3 Streams	4 Streams	5 Streams
Write 1024KiB	115.23	112.61	112.02	111.69	109.80
Write 256KiB	114.84	111.06	109.38	107.12	105.63
Read/Write 1024KiB	48.71	52.80	55.88	58.32	59.45
Read/Write 256KiB	46.73	42.82	45.33	43.45	38.24
Read 1024KiB	116.64	49.66	52.05	54.68	53.02
Read 256KiB	116.63	113.57	112.75	111.07	110.67

SPC-2C Large File Processing Average Data Rates Graph

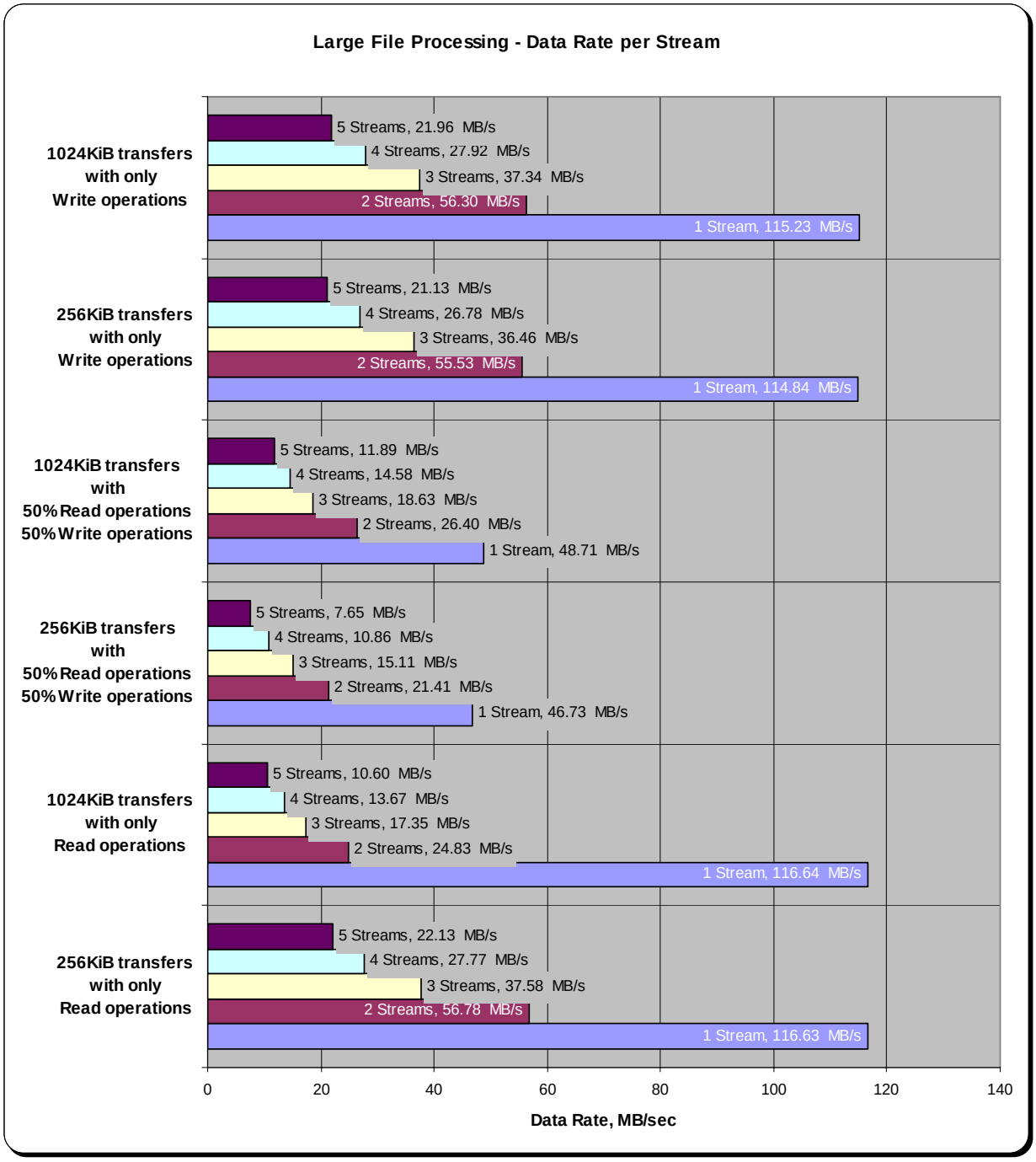


SPC-2C Large File Processing Average Data Rate per Stream

The average Data Rate per Stream for each Test Run in the three Test Phases of the SPC-2C Large File Processing Test is listed in the table below as well as illustrated in the following graph.

Test Run Sequence	1 Stream	2 Streams	3 Streams	4 Streams	5 Streams
Write 1024KiB	115.23	56.30	37.34	27.92	21.96
Write 256KiB	114.84	55.53	36.46	26.78	21.13
Read/Write 1024KiB	48.71	26.40	18.63	14.58	11.89
Read/Write 256KiB	46.73	21.41	15.11	10.86	7.65
Read 1024KiB	116.64	24.83	17.35	13.67	10.60
Read 256KiB	116.63	56.78	37.58	27.77	22.13

SPC-2C Large File Processing Average Data Rate per Stream Graph

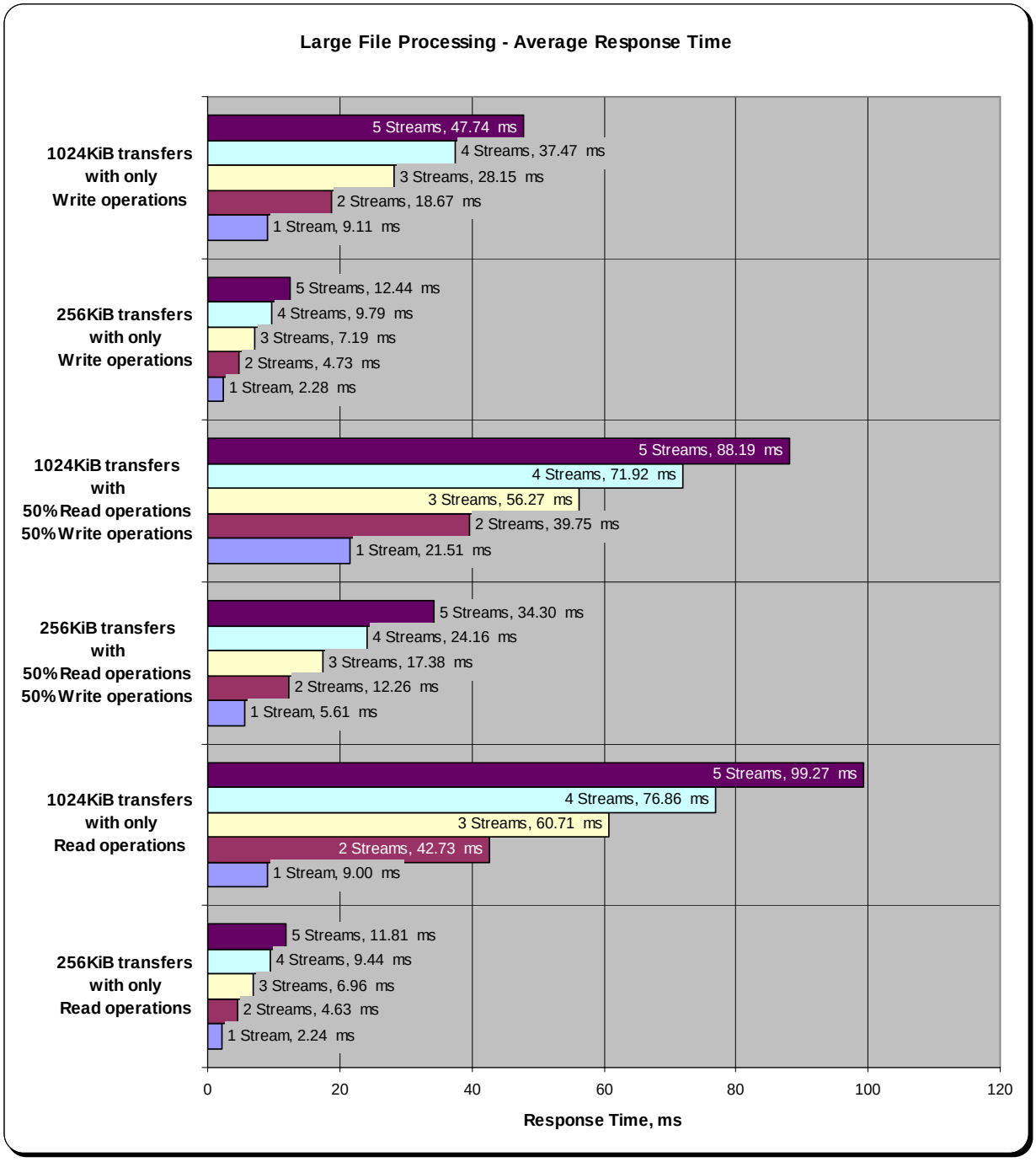


SPC-2C Large File Processing Average Response Time

The average Response Time, milliseconds (ms), for each Test Run in the three Test Phases of the SPC-2C Large File Processing Test is listed in the table below as well as illustrated in the following graph.

Test Run Sequence	1 Stream	2 Streams	3 Streams	4 Streams	5 Streams
Write 1024KiB	9.11	18.67	28.15	37.47	47.74
Write 256KiB	2.28	4.73	7.19	9.79	12.44
Read/Write 1024KiB	21.51	39.75	56.27	71.92	88.19
Read/Write 256KiB	5.61	12.26	17.38	24.16	34.30
Read 1024KiB	9.00	42.73	60.71	76.86	99.27
Read 256KiB	2.24	4.63	6.96	9.44	11.81

SPC-2C Large File Processing Average Response Time Graph



Large File Processing Test – WRITE ONLY Test Phase

Clause 10.4.8.1.1

1. *A table that will contain the following information for each "WRITE ONLY, 1024 KiB Transfer Size" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
2. *Average Data Rate (intervals), Average Data Rate per Stream (intervals), and Average Response Time (intervals) graphs for the "WRITE ONLY, 1024 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*
3. *A table that will contain the following information for each "WRITE ONLY, 256 KiB Transfer Size" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
4. *Average Data Rate (intervals), Average Data Rate per Stream (intervals), and Average Response Time (intervals) graphs for the "WRITE ONLY, 256 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*

The tables and graphs for the SPC-2C Large File Processing WRITE ONLY Test Phase are available via the link listed below.

SPC-2C Large File Processing WRITE ONLY Test Phase – Data Tables and Graphs

Large File Processing Test – READ-WRITE Test Phase

Clause 10.4.8.1.2

1. *A table that will contain the following information for each "READ-WRITE, 1024 KiB Transfer Size" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
2. *Average Data Rate (intervals), Average Data Rate per Stream (intervals), and Average Response Time (intervals) graphs for the "READ-WRITE, 1024 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*
3. *A table that will contain the following information for each " READ-WRITE, 256 KiB Transfer Size" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
4. *Average Data Rate (intervals), Average Data Rate per Stream (intervals), and Average Response Time (intervals) graphs for the "READ-WRITE, 256 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*

The tables and graphs for the SPC-2C Large File Processing READ-WRITE Test Phase are available via the link listed below.

SPC-2C Large File Processing READ-WRITE Test Phase – Data Tables and Graphs

Large File Processing Test – READ ONLY Test Phase

Clause 10.4.8.1.3

1. *A table that will contain the following information for each "READ ONLY, 1024 KiB Transfer Size" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
2. *Average Data Rate (intervals), Average Data Rate per Stream (intervals), and Average Response Time (intervals) graphs for the "READ ONLY, 1024 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*
3. *A table that will contain the following information for each "READ ONLY, 256 KiB Transfer Size" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
4. *Average Data Rate (intervals), Average Data Rate per Stream (intervals), and Average Response Time (intervals) graphs for the "READ ONLY, 256 KiB Transfer Size" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*

The tables and graphs for the SPC-2C Large File Processing READ ONLY Test Phase are available via the link listed below.

SPC-2C Large File Processing READ ONLY Test Phase – Data Tables and Graphs

Large Database Query Test

Clause 6.4.4.1

The Large Database Query Test is comprised of a set of I/O operations representative of scans or joins of large relational tables such as those performed for data mining or business intelligence.

Clause 6.4.4.2

The Large Database Query Test has two Test Phases, which shall be executed in the following uninterrupted sequence:

1. *1024 KIB TRANSFER SIZE*
2. *64 KIB TRANSFER SIZE*

The BC shall not be restarted or manually disturbed, altered, or adjusted during the execution of the Large File Processing Test. If power is lost to the BC during this Test all results shall be rendered invalid and the Test re-run in its entirety.

Clause 10.4.8.2

The Full Disclosure Report will contain the following content for the Large Database Query Test:

1. *A listing of the SPC-2C Workload Generator commands and parameters used to execute each of the Test Runs in the Large Database Query Test.*
2. *The human readable SPC-2C Test Results File for each of the Test Runs in the Large Database Query Test.*
3. *The following three tables, defined in Clauses 10.1.1 – 10.1.3.:*
   - *Average Data Rate: This table will will contain the average Data Rate, in MB per second, for the Measurement Interval of each Test Run in the Large Database Query Test.*
   - *Average Data Rate per Stream: This table will will contain the average Data Rate per Stream, in MB per second, for the Measurement Interval of each Test Run in the Large Database Query Test.*
   - *Average Response Time: This table will contain the average Response Time, in milliseconds (ms), for the Measurement Interval of each Test Run in the Large Database Query Test.*

   Each table will also include the following information for each Test Run:
   - *The number of Streams specified.*
   - *The Ramp-Up duration in seconds.*
   - *The Measurement Interval duration in seconds.*
4. *Average Data Rate, Average Data Rate per Stream, and Average Response Time graphs as defined in Clauses 10.1.1, 10.1.2, and 10.1.3.*

SPC-2C Workload Generator Commands and Parameters

The SPC-2C Workload Generator commands and parameters for the Large Database Query Test Runs are documented in "Appendix E: SPC-2C Workload Generator Execution Commands and Parameters" on Page 57.

SPC-2C Test Results File

A link to the SPC-2C Test Results file generated from the Large Database Query Test Runs is listed below.

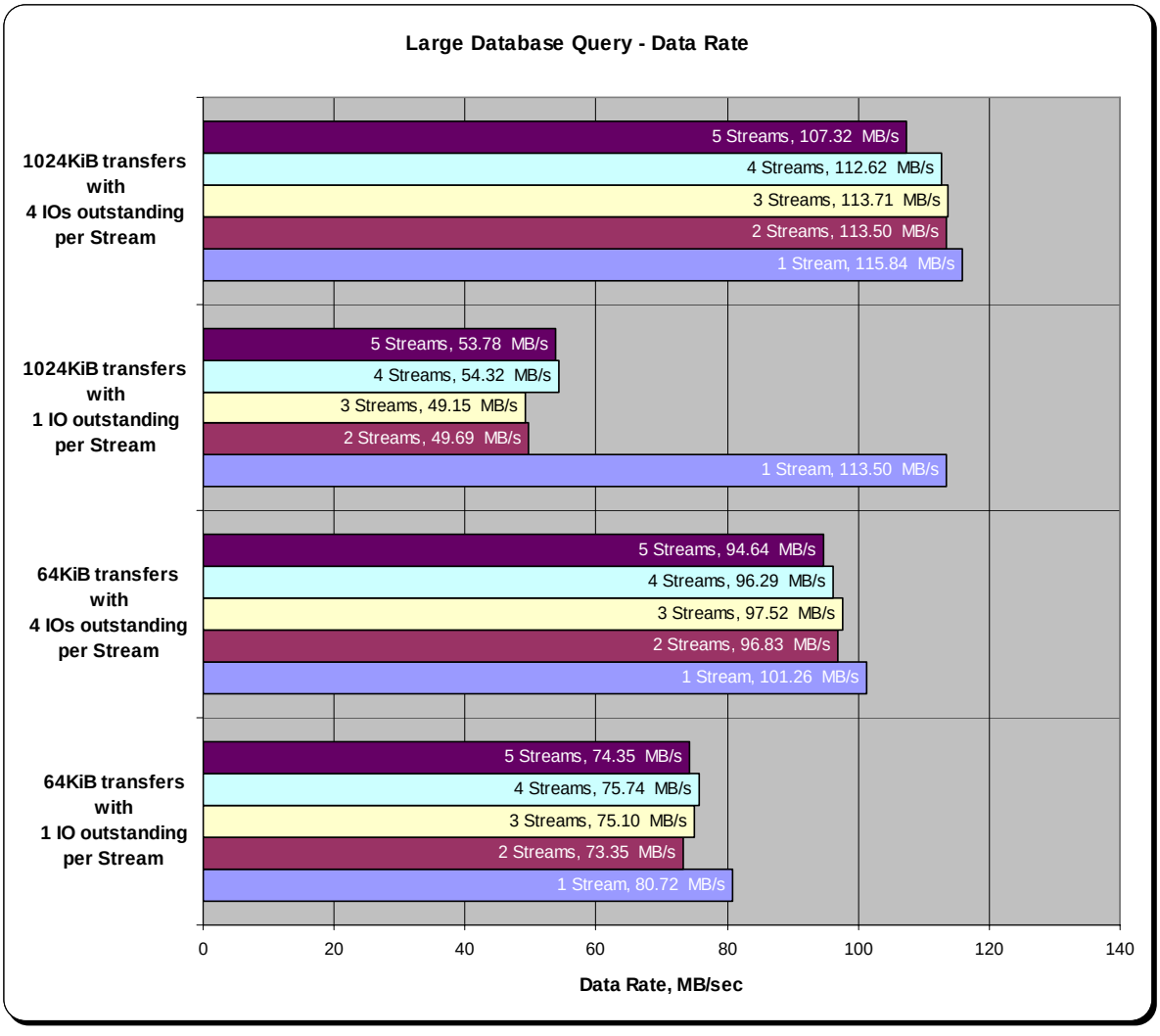
SPC-2C Large Database Query Test Results File

SPC-2C Large Database Query Average Data Rates (MB/s)

The average Data Rate (MB/s) for each Test Run in the two Test Phases of the SPC-2C Large Database Query Test is listed in the table below as well as illustrated in the following graph.

Test Run Sequence	1 Stream	2 Streams	3 Streams	4 Streams	5 Streams
1024KiB w/ 4 IOs/Stream	115.84	113.50	113.71	112.62	107.32
1024KiB w/ 1 IO/Stream	113.50	49.69	49.15	54.32	53.78
64KiB w/ 4 IOs/Stream	101.26	96.83	97.52	96.29	94.64
64KiB w/ 1 IO/Stream	80.72	73.35	75.10	75.74	74.35

SPC-2C Large Database Query Average Data Rates Graph

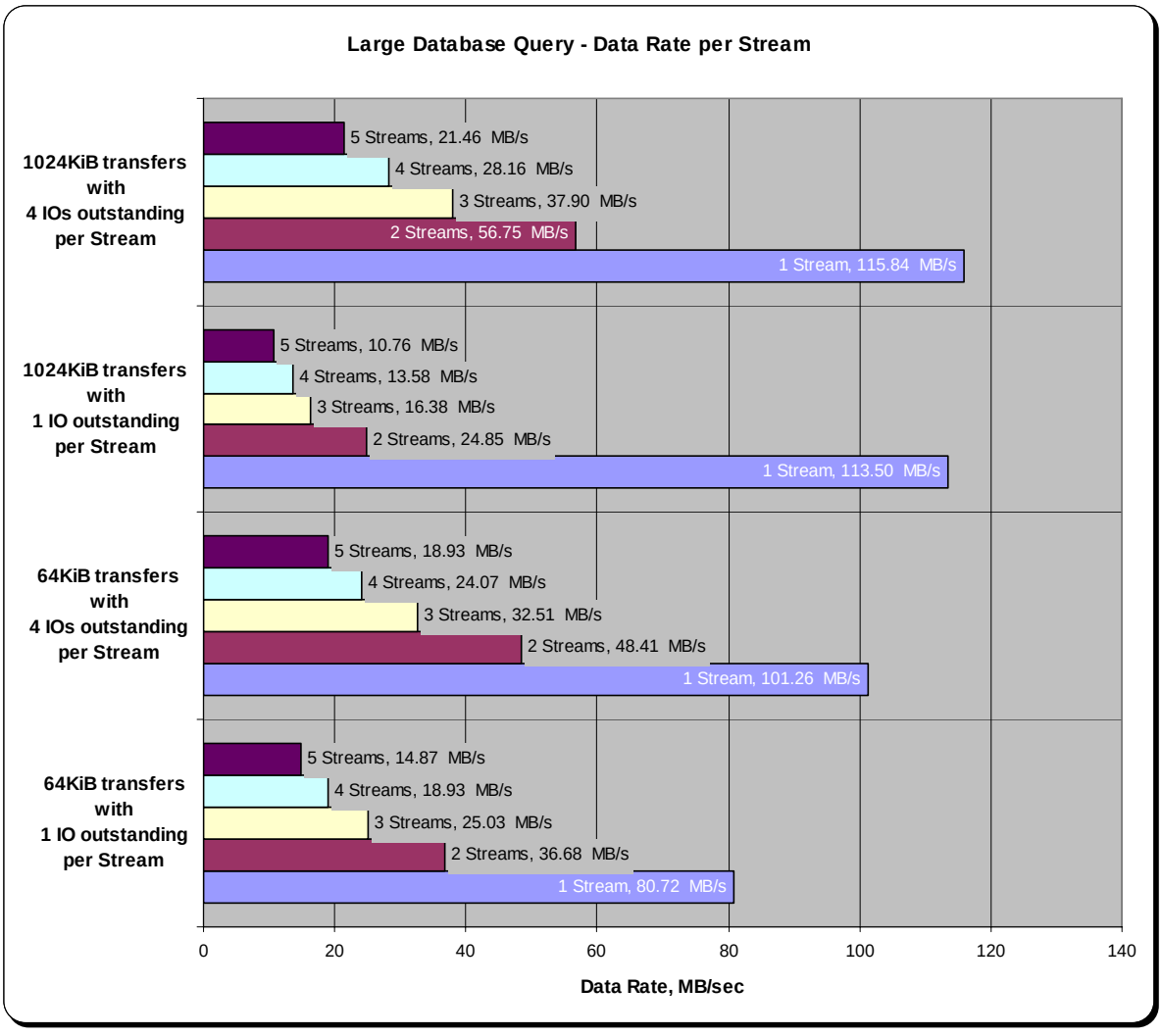


SPC-2C Large Database Query Average Data Rate per Stream

The average Data Rate per Stream for each Test Run in the two Test Phases of the SPC-2C Large Database Query Test is listed in the table below as well as illustrated in the following graph.

Test Run Sequence	1 Stream	2 Streams	3 Streams	4 Streams	5 Streams
1024KiB w/ 4 IOs/Stream	115.84	56.75	37.90	28.16	21.46
1024KiB w/ 1 IO/Stream	113.50	24.85	16.38	13.58	10.76
64KiB w/ 4 IOs/Stream	101.26	48.41	32.51	24.07	18.93
64KiB w/ 1 IO/Stream	80.72	36.68	25.03	18.93	14.87

SPC-2C Large Database Query Average Data Rate per Stream Graph

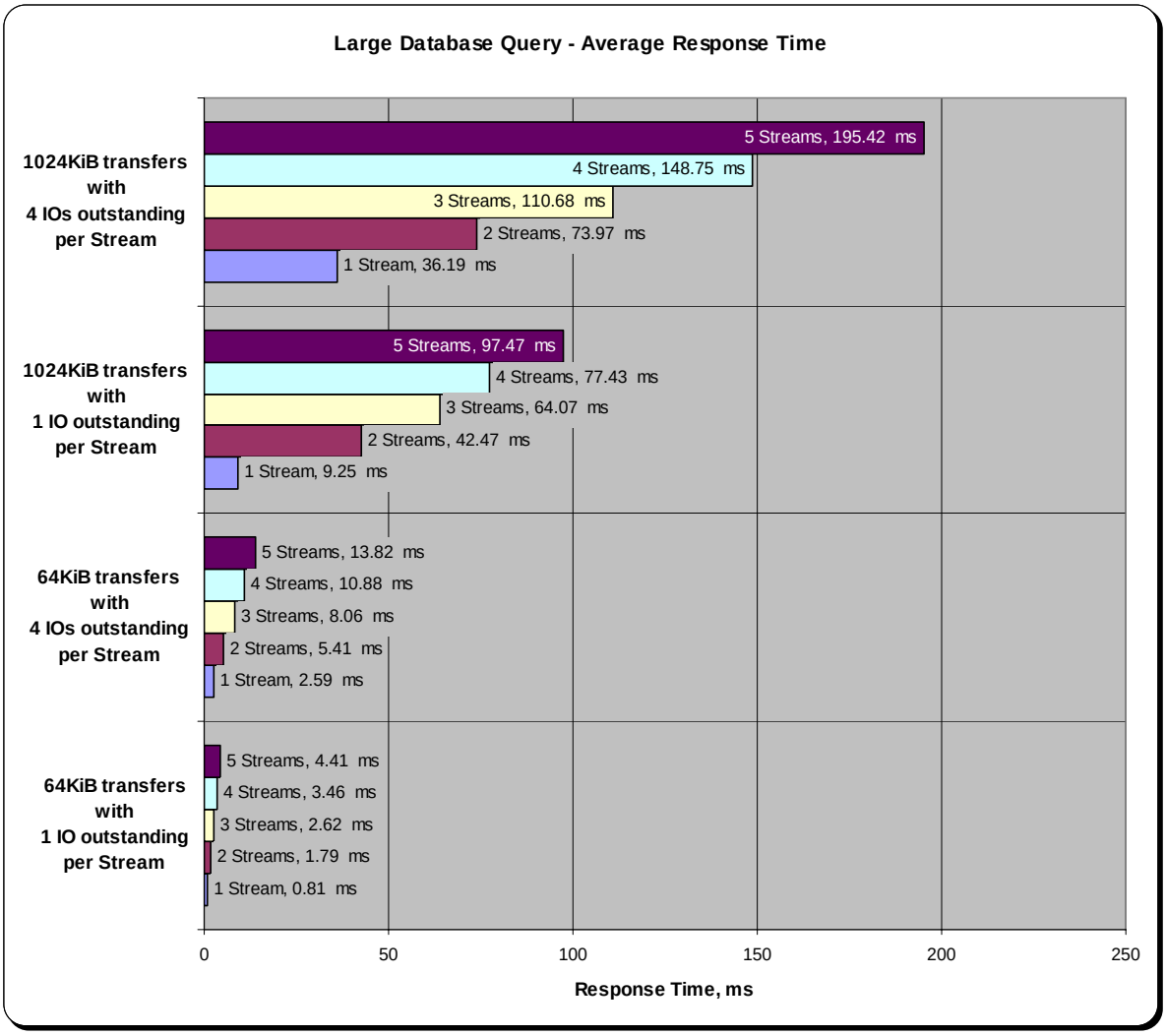


SPC-2C Large Database Query Average Response Time

The average Response Time, in milliseconds, for each Test Run in the two Test Phases of the SPC-2C Large Database Query Test is listed in the table below as well as illustrated in the following graph.

Test Run Sequence	1 Stream	2 Streams	3 Streams	4 Streams	5 Streams
1024KiB w/ 4 IOs/Stream	36.19	73.97	110.68	148.75	195.42
1024KiB w/ 1 IO/Stream	9.25	42.47	64.07	77.43	97.47
64KiB w/ 4 IOs/Stream	2.59	5.41	8.06	10.88	13.82
64KiB w/ 1 IO/Stream	0.81	1.79	2.62	3.46	4.41

SPC-2C Large Database Query Average Response Time Graph



Large Database Query Test – 1024 KIB TRANSFER SIZE Test Phase

Clause 10.4.8.2.1

1. *A table that will contain the following information for each "1024 KiB Transfer Size, 4 Outstanding I/Os" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
2. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "1024 KIB TRANSFER SIZE, 4 Outstanding I/Os" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*
3. *A table that will contain the following information for each "1024 KiB Transfer Size, 1 Outstanding I/O" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
4. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "1024 KIB TRANSFER SIZE, 4 Outstanding I/Os" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*

The tables and graphs for the SPC-2C Large Database Query 1024 KIB TRANSFER Test Phase are available via the link listed below.

SPC-2C Large Database Query 1024 KIB TRANSFER SIZE Test Phase – Data Tables and Graphs

Large Database Query Test – 64 KiB TRANSFER SIZE Test Phase

Clause 10.4.8.2.2

1. *A table that will contain the following information for each "64 KiB Transfer Size, 4 Outstanding I/Os" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
2. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "64 KIB TRANSFER SIZE, 4 Outstanding I/Os" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*
3. *A table that will contain the following information for each "64 KiB Transfer Size, 1 Outstanding I/O" Test Run:*
   - *The number of Streams specified.*
   - *The average data rate, average data rate per stream, and average Response Time reported at five second intervals.*
4. *Average Data Rate by Intervals, Average Data Rate per Stream by Intervals, and Average Response Time by Intervals graphs for the "64 KIB TRANSFER SIZE, 4 Outstanding I/Os" Test Runs as specified in Clauses 10.1.4 – 10.1.6.*

The tables and graphs for the SPC-2C Large Database Query 64 KIB TRANSFER Test Phase are available via the link listed below.

SPC-2C Large Database Query 64 KIB TRANSFER SIZE Test Phase – Data Tables and Graphs

Video on Demand Delivery Test

Clause 6.4.5.1

The Video on Demand Delivery Test represents the I/O operations required to enable individualized video entertainment for a community of subscribers, which draw from a digital film library.

Clause 6.4.5.2

The Video on Demand Delivery Test consists of one (1) Test Run.

The BC shall not be restarted or manually disturbed, altered, or adjusted during the execution of the Video on Demand Delivery Test. If power is lost to the BC during this Test all results shall be rendered invalid and the Test re-run in its entirety.

Clause 10.4.8.3

The Full Disclosure Report will contain the following content for the Video on Demand Delivery Test:

1. *A listing of the SPC-2C Workload Generator commands and parameters used to execute the Test Run in the Video on Demand Delivery Test.*
2. *The human readable SPC-2C Test Results File for the Test Run in the Video on Demand Delivery Test.*
3. *A table that contains the following information for the Test Run in the Video on Demand Delivery Test:*
    - *The number Streams specified.*
    - *The Ramp-Up duration in seconds.*
    - *The Measurement Interval duration in seconds.*
    - *The average data rate, in MB per second, for the Measurement Interval.*
    - *The average data rate, in MB per second, per Stream for the Measurement Interval.*
4. *A table that contains the following information for the single Video on Demand Delivery Test Run:*
    - *The number Streams specified.*
    - *The average data rate, average data rate per stream, average Response Time, and Maximum Response Time reported at 60 second intervals.*
5. *Average Data Rate by Interval and Average Response Time by Interval graphs for the single Video on Demand Delivery Test Run as specified in Clauses 10.1.4-2-10.1.6.*
6. *A Maximum Response Time (intervals) graph as specified in Clause 10.1.9.*

SPC-2C Workload Generator Commands and Parameters

The SPC-2C Workload Generator commands and parameters for the Video on Demand Delivery Test Run are documented in “Appendix E: SPC-2C Workload Generator Execution Commands and Parameters” on Page 57.

SPC-2C Test Results File

A link to the SPC-2C Test Results file generated from the Video on Demand Delivery Test Run is listed below.

SPC-2C Video on Demand Delivery Test Results File

SPC-2C Video on Demand Delivery Test Run Data

The number of Streams specified, Ramp-Up duration in seconds, Measurement Interval duration in seconds, average Data Rate for the Measurement Interval, and average Data Rate per Stream for the Measurement Interval are listed in the following table.

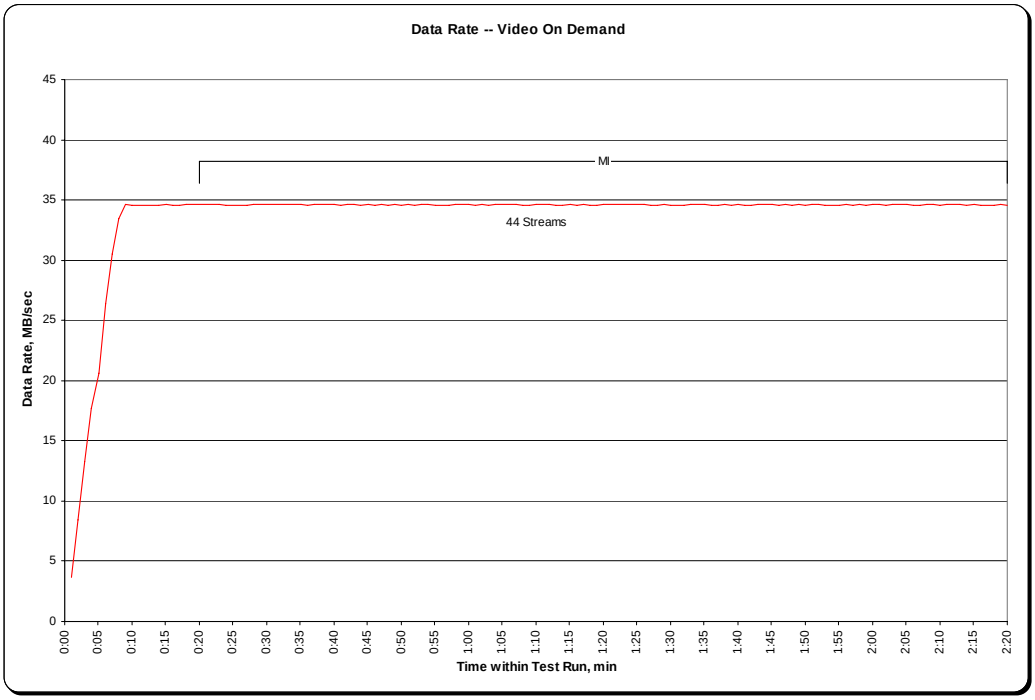
SPC-2-VOD	TR1
Number of Streams	44
Ramp-up Time, sec	1200
Measurement Interval, sec	7200
Average Data Rate, MB/sec	34.60
Per Stream Data Rate, MB/sec	0.79
Average Response Time, ms	158.85
Average Max Response Time, ms	1,017.92

Video on Demand Delivery Test – TEST RUN DATA BY INTERVAL

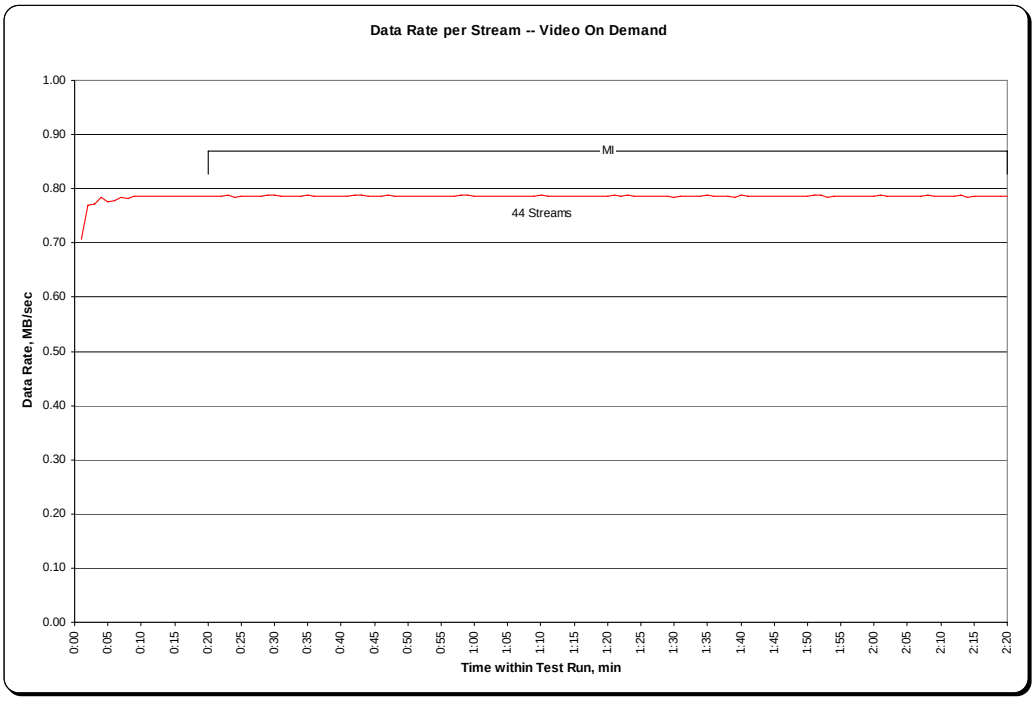
The SPC-2C Video on Demand Delivery Test Run data is contained in the table that appears on the next page. That table is followed by graphs illustrating the average Data Rate and average Data Rate per Stream produced by the same Test Runs. The table and graphs present the data at sixty second intervals.

TR1	44 Streams				TR1	44 Streams				TR1	44 Streams			
Test Run Sequence Time	Data Rate, MB/sec	Data Rate / Stream, MB/sec	Response Time, ms	Maximum Response Time, ms	Test Run Sequence Time	Data Rate, MB/sec	Data Rate / Stream, MB/sec	Response Time, ms	Maximum Response Time, ms	Test Run Sequence Time	Data Rate, MB/sec	Data Rate / Stream, MB/sec	Response Time, ms	Maximum Response Time, ms
0:01:00	3.64	0.71	3.54	26.08	0:51:00	34.61	0.79	170.58	1,163.45	1:41:00	34.59	0.79	140.19	901.35
0:02:00	8.46	0.77	7.12	65.89	0:52:00	34.56	0.79	163.35	1,138.36	1:42:00	34.58	0.79	157.40	1,061.83
0:03:00	13.25	0.77	13.32	70.15	0:53:00	34.60	0.79	158.07	1,053.96	1:43:00	34.60	0.79	174.02	1,015.60
0:04:00	17.66	0.78	17.65	65.49	0:54:00	34.61	0.79	156.08	1,052.92	1:44:00	34.63	0.79	171.65	1,122.46
0:05:00	20.58	0.78	20.82	86.02	0:55:00	34.57	0.79	160.19	1,016.01	1:45:00	34.62	0.79	152.27	948.79
0:06:00	26.41	0.78	41.76	204.35	0:56:00	34.56	0.79	160.68	956.36	1:46:00	34.56	0.79	148.84	1,033.24
0:07:00	30.51	0.78	76.59	447.08	0:57:00	34.57	0.79	166.37	1,012.97	1:47:00	34.60	0.79	157.53	1,050.07
0:08:00	33.46	0.78	128.89	796.13	0:58:00	34.65	0.79	177.92	1,108.93	1:48:00	34.58	0.79	172.39	1,134.92
0:09:00	34.62	0.79	150.85	978.89	0:59:00	34.64	0.79	168.94	1,080.32	1:49:00	34.63	0.79	167.72	1,094.40
0:10:00	34.59	0.79	163.16	949.84	1:00:00	34.60	0.79	167.13	1,101.21	1:50:00	34.56	0.79	178.05	1,167.99
0:11:00	34.57	0.79	167.67	1,032.34	1:01:00	34.57	0.79	164.31	1,101.67	1:51:00	34.64	0.79	155.11	1,183.02
0:12:00	34.59	0.79	171.68	1,135.20	1:02:00	34.61	0.79	168.28	1,098.14	1:52:00	34.64	0.79	145.82	936.49
0:13:00	34.59	0.79	187.50	1,249.20	1:03:00	34.58	0.79	156.64	1,014.24	1:53:00	34.53	0.78	162.44	1,005.52
0:14:00	34.59	0.79	172.15	1,057.21	1:04:00	34.60	0.79	155.26	920.30	1:54:00	34.58	0.79	163.81	1,079.93
0:15:00	34.61	0.79	169.88	1,104.02	1:05:00	34.60	0.79	165.34	1,028.41	1:55:00	34.58	0.79	154.07	1,009.95
0:16:00	34.55	0.79	174.92	1,000.95	1:06:00	34.63	0.79	155.28	1,092.49	1:56:00	34.63	0.79	167.84	1,103.03
0:17:00	34.56	0.79	167.39	990.42	1:07:00	34.62	0.79	162.31	1,015.49	1:57:00	34.58	0.79	175.88	1,030.84
0:18:00	34.60	0.79	181.17	1,100.43	1:08:00	34.59	0.79	162.25	929.38	1:58:00	34.60	0.79	152.86	992.75
0:19:00	34.62	0.79	172.85	1,124.34	1:09:00	34.57	0.79	166.05	1,127.69	1:59:00	34.56	0.79	157.28	1,010.80
0:20:00	34.62	0.79	174.18	1,077.27	1:10:00	34.65	0.79	178.36	1,178.60	2:00:00	34.63	0.79	148.40	998.14
0:21:00	34.63	0.79	181.13	1,009.56	1:11:00	34.62	0.79	176.99	1,065.75	2:01:00	34.66	0.79	151.81	1,085.84
0:22:00	34.60	0.79	164.60	977.60	1:12:00	34.62	0.79	152.54	924.07	2:02:00	34.58	0.79	149.61	1,010.38
0:23:00	34.65	0.79	155.08	1,084.81	1:13:00	34.57	0.79	165.82	1,101.87	2:03:00	34.61	0.79	143.82	882.51
0:24:00	34.54	0.79	154.15	995.30	1:14:00	34.56	0.79	161.59	997.87	2:04:00	34.62	0.79	143.01	944.77
0:25:00	34.56	0.79	165.11	1,026.91	1:15:00	34.63	0.79	146.88	1,020.60	2:05:00	34.61	0.79	162.82	1,053.05
0:26:00	34.58	0.79	153.00	971.18	1:16:00	34.59	0.79	167.53	1,112.08	2:06:00	34.59	0.79	144.50	954.12
0:27:00	34.59	0.79	163.64	1,118.17	1:17:00	34.63	0.79	153.92	895.07	2:07:00	34.59	0.79	148.06	862.80
0:28:00	34.60	0.79	156.66	930.84	1:18:00	34.57	0.79	165.45	1,036.18	2:08:00	34.65	0.79	157.67	980.11
0:29:00	34.65	0.79	168.64	1,102.97	1:19:00	34.59	0.79	152.22	951.17	2:09:00	34.61	0.79	155.91	1,140.70
0:30:00	34.65	0.79	161.34	977.79	1:20:00	34.61	0.79	169.09	1,059.64	2:10:00	34.58	0.79	167.33	1,034.83
0:31:00	34.61	0.79	149.63	907.32	1:21:00	34.64	0.79	173.73	1,125.86	2:11:00	34.61	0.79	151.92	992.12
0:32:00	34.60	0.79	146.93	853.07	1:22:00	34.60	0.79	155.71	943.03	2:12:00	34.62	0.79	159.99	976.84
0:33:00	34.62	0.79	168.62	1,011.31	1:23:00	34.65	0.79	154.19	1,141.52	2:13:00	34.64	0.79	157.77	1,003.61
0:34:00	34.60	0.79	148.68	943.40	1:24:00	34.61	0.79	167.85	1,126.88	2:14:00	34.55	0.79	169.15	1,036.13
0:35:00	34.64	0.79	155.11	1,042.61	1:25:00	34.62	0.79	158.49	1,020.46	2:15:00	34.63	0.79	152.25	999.30
0:36:00	34.59	0.79	166.30	1,042.91	1:26:00	34.61	0.79	153.46	957.56	2:16:00	34.59	0.79	149.59	899.53
0:37:00	34.60	0.79	171.10	1,095.23	1:27:00	34.58	0.79	137.17	862.28	2:17:00	34.59	0.79	156.41	1,019.62
0:38:00	34.62	0.79	167.75	1,109.56	1:28:00	34.59	0.79	145.48	960.69	2:18:00	34.55	0.79	153.94	1,030.26
0:39:00	34.60	0.79	155.35	932.51	1:29:00	34.61	0.79	162.36	1,168.33	2:19:00	34.61	0.79	132.29	851.59
0:40:00	34.60	0.79	145.54	1,008.08	1:30:00	34.53	0.78	151.36	922.41	2:20:00	34.57	0.79	145.78	943.59
0:41:00	34.57	0.79	176.16	1,047.46	1:31:00	34.59	0.79	155.28	954.98					
0:42:00	34.65	0.79	166.54	1,066.70	1:32:00	34.59	0.79	177.57	1,124.04					
0:43:00	34.64	0.79	148.10	891.73	1:33:00	34.61	0.79	163.09	996.58					
0:44:00	34.59	0.79	148.79	975.31	1:34:00	34.63	0.79	145.84	971.46					
0:45:00	34.63	0.79	145.87	944.31	1:35:00	34.65	0.79	153.73	952.63					
0:46:00	34.59	0.79	163.51	997.93	1:36:00	34.57	0.79	155.24	973.45					
0:47:00	34.64	0.79	162.36	1,032.56	1:37:00	34.58	0.79	158.68	889.40					
0:48:00	34.57	0.79	150.97	1,004.71	1:38:00	34.62	0.79	149.23	943.99					
0:49:00	34.61	0.79	158.45	1,037.31	1:39:00	34.52	0.78	160.46	1,019.38					
0:50:00	34.57	0.79	168.65	1,150.24	1:40:00	34.64	0.79	169.21	1,114.14					

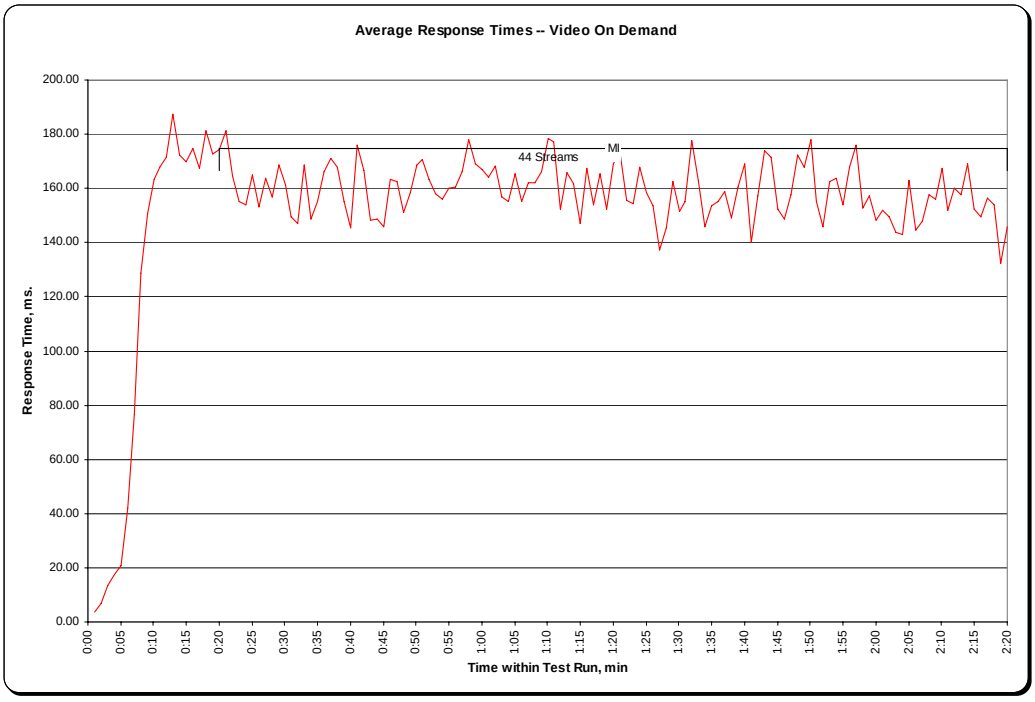
SPC-2C Video on Demand Delivery Average Data Rate Graph



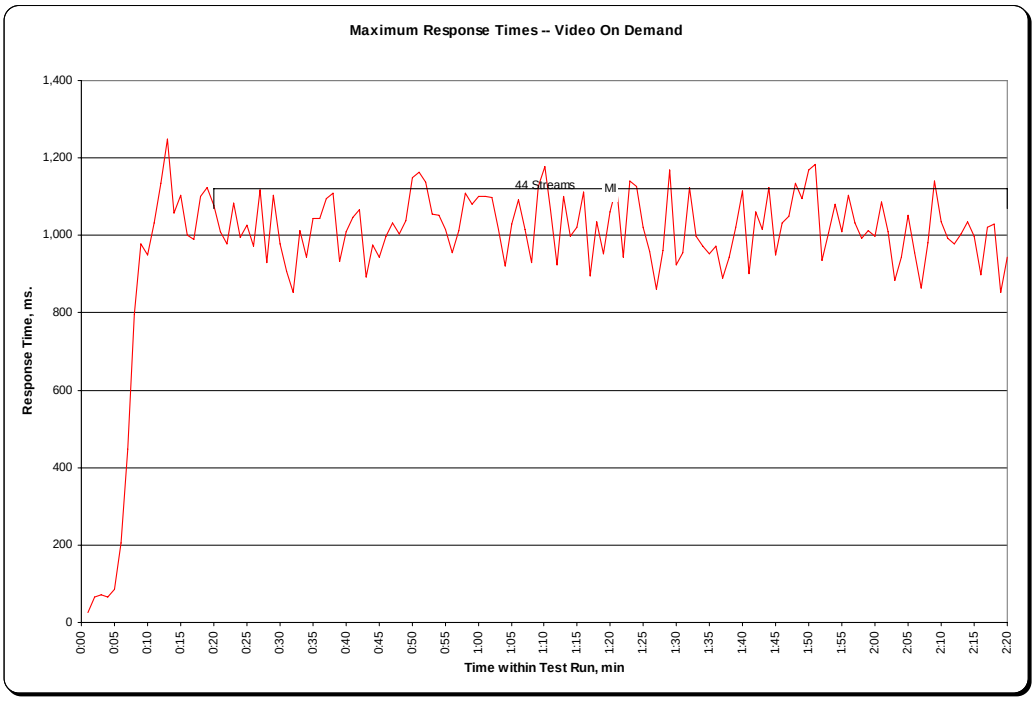
SPC-2C Video on Demand Delivery Average Data Rate per Stream Graph



SPC-2C Video on Demand Delivery Average Response Time Graph



SPC-2C Video on Demand Delivery Maximum Response Time Graph



Data Persistence Test

Clause 7

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-2C Workload Generator will write a specific pattern at randomly selected locations throughout the Total ASU Capacity (Persistence Test Run 1). The SPC-2C Workload Generator will retain the information necessary to later validate the pattern written at each location.

The Tested Storage 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.

Restart the TSC, and if the Host System(s) were shutdown and powered off, restart the Host System(s).

The SPC-2C Workload Generator will utilize the retained data from Persistence Test Run 1 to verify (Persistence Run 2) the bit patterns written in Persistence Test Run 1 and their corresponding location.

Clause 10.4.8.4

The Full Disclosure Report will contain the following content for the Data Persistence Test:

1. *A listing of the SPC-2C Workload Generator commands and parameters used to execute each of the Test Runs in the Persistence Test.*
2. *The human readable SPC-2C Test Results File for each of the Test Runs in the Data Persistence Test.*
3. *A table from the successful Persistence Test, which contains the results from the test.*

SPC-2C Workload Generator Commands and Parameters

The SPC-2C Workload Generator commands and parameters for the Persistence Test Runs are documented in "Appendix E: SPC-2C Workload Generator Execution Commands and Parameters" on Page 57.

Data Persistence Test Results File

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

Persistence 1 Test Run Results File

Persistence 2 Test Run Results File

Data Persistence Test Results

Data Persistence Test Results	
Data Persistence Test Number: 1	
Total Number of Logical Blocks Written	28,800
Total Number of Logical Blocks Re-referenced	946
Total Number of Logical Blocks Verified	27,854
Total Number of Logical Blocks that Failed Verification	0
Number of Failed I/O Requests in the process of the Test	0

PRICED STORAGE CONFIGURATION AVAILABILITY DATE

Clause 10.4.9

The committed delivery date for general availability (Availability Date) of all products that comprise the Priced Storage Configuration must be reported. When the Priced Storage Configuration includes products or components with different availability dates, the reported Availability Date must be the date at which all components are committed to be available. All availability dates, whether for individual components or for the Priced Storage Configuration as a whole, must be disclosed to a precision of one day.

The Availability Date shall be stated in the FDR by either a combination of specific alphanumeric month, numeric day, and numeric year or as "Currently Available" in the case where all components that comprise the PSC are currently available for customer order and shipment.

The Seagate Barracuda ES.2 *ST31000640SS*, as documented in this SPC-2C Full Disclosure Report, is currently available for customer purchase and shipment.

ANOMALIES OR IRREGULARITIES

Clause 10.4.11

The FDR shall include a clear and complete description of any anomalies or irregularities encountered in the course of executing the SPC-2C benchmark that may in any way call into question the accuracy, verifiability, or authenticity of information published in this FDR.

There were no anomalies or irregularities encountered during the SPC-2C Onsite Audit of the Seagate Barracuda ES.2 ST31000640SS.

APPENDIX A: SPC-2C GLOSSARY

"Decimal" *(powers of ten)* Measurement Units

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

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

"Binary" *(powers of two)* Measurement Units

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

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

SPC-2C Data Repository Definitions

Total ASU Capacity: The total storage capacity read and written in the course of executing the SPC-2C benchmark.

Application Storage Unit (ASU): The logical interface between the storage and SPC-2C Workload Generator. The ASU is implemented on one or more Logical Volume.

Logical Volume: The division of Addressable Storage Capacity into individually addressable logical units of storage used in the SPC-2C benchmark. Each Logical Volume is implemented as a single, contiguous address space.

Addressable Storage Capacity: The total storage (sum of Logical Volumes) that can be read and written by application programs such as the SPC-2C Workload Generator.

Configured Storage Capacity: This capacity includes the Addressable Storage Capacity and any other storage (parity disks, hot spares, etc.) necessary to implement the Addressable Storage Capacity.

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

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

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

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

Total Unused Storage: The sum of unused storage capacity within the Physical Storage Capacity, Configured Storage Capacity, and Addressable Storage Capacity.

SPC-2C Data Protection Levels

Protected: Data protection is provided in the event of a single point of failure of any of the configured storage devices. A brief descripton of the data protection must be included in the FDR.

Unprotected: There is no data protection provided.

SPC-2C Test Execution Definitions

Completed I/O Request: An I/O Request with a Start Time and a Completion Time *(see "I/O Completion Types" illustrated below).*

Completion Time: The time recorded by the Workload Generator when an I/O Request is completed by the Tested Storage Configuration (TSC) as signaled by System Software.

Data Rate: The data volume, in MB, transferred by all Measured I/O Requests in an SPC-2C Test Run divided by the length of the Test Run in seconds.

Failed I/O Request: Any I/O Request issued by the SPC-2C Workload Generator that meets one of the following conditions *(see "I/O Completion Types" illustrated below)*:

- The I/O Request was signaled as failed by System Software.
- The I/O Request started within the Measurement Interval, but did not complete prior to the end of the appropriate Run-Out period..
- The I/O Request started within the Run-Out period, but did not complete prior to the end of the appropriate Ramp-Down period.

I/O Request Throughput: The total number of Measured I/O Requests in an SPC-2C Test Run divided by the duration of the Measurement Interval in seconds.

Measured I/O Request: A Completed I/O Request that begins (Start Time) within a Measurement Interval and completes (Completion Time) prior to the end of the appropriate Ramp Down *(see "I/O Completion Types" illustrated below).*

Measurement Interval: A specified, contiguous period of time, after the TSC has reached Steady State, when data is collected by the Workload Generator to produce the test results for a SPC-2C Test Run *(see "SPC-2C Test Run Components" illustrated below, Test Run 1: T_2-T_3 and Test Run 2: T_7-T_8).*

Outstanding I/O Requests: The Outstanding I/O Requests parameter specifies the maximum number of concurrent I/O Requests, associated with a give Stream, which have been issued but not yet completed. *(Clause 3.4.4 of the SPC-2C Benchmark Specification).*

Ramp-Down: A specified, contiguous period of time in which the TSC is required to complete I/O Requests started but not completed during the preceding Run-Out period. Ramp-Down begins at the end of the preceding Run-Out period *(see "SPC-2C Test Run Components" illustrated below, Test Run 1: T_4-T_5 and Test Run 2: T_9-T_{10}).* The Workload Generator will not submit any I/O Requests during the Ramp-Down.

Ramp-Up: A specified, contiguous period of time required for the Benchmark Configuration (BC) to produce Steady State throughput after the Workload Generator begins submitting I/O Requests to the TSC for execution. The Ramp-Up period ends at the beginning of the Measurement Interval *(see "SPC-2C Test Run Components" illustrated below, Test Run 1: T_0-T_2 and Test Run 2: T_5-T_7).*

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

Run-Out: A specified, contiguous period of time in which the TSC is required to complete I/O Requests started but not completed during the preceding Measurement Interval. The Run-Out period begins at the end of the preceding Measurement Interval and is a component of the Steady State period *(see "SPC-2C Test Run Components" illustrated below, Test Run 1: T_3-T_4 and Test Run 2: T_9-T_{10}).* The Workload Generator will continue to submit I/O Requests at the Test Run's specified rate during the Run-Out period.

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

Steady State: The period during which the workload presented to the TSC by the SPC-2C Workload Generator is constant and the resulting TSC I/O Request Throughput is both consistent and sustainable. The Steady State period includes both the Measurement Interval and Run-Out periods *(see "SPC-2C Test Run Components" illustrated below, Test Run 1: T_1-T_4 and Test Run 2: T_6-T_9).*

Steady State is achieved only after caches in the TSC have filled and as a result the I/O Request Throughput of the TSC has stabilized.

Stream: A collection of Stream Segments that started within a Test Run.

Stream Segment: A sequentially organized pattern of I/O requests, which transfers a contiguous range of data.

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

Test Phase: A collection of one or more SPC-2C Test Runs sharing a common objective and intended to be run in a specific sequence.

Test Run: The execution of SPC-2C that produces specific SPC-2C test results. SPC-2C Test Runs have specified, measured Ramp-Up, Measurement Interval, Run-Out and Ramp-Down periods. "SPC-2C Test Run Components" *(see below)* illustrates the Ramp-Up, Steady State, Measurement Interval, Run-Out, and Ramp-Down components contained in two uninterrupted SPC-2C Test Runs *(Test Run 1: T_0-T_5 and Test Run 2: T_5-T_{10})*.

Test Run Sequence: A related sequence of Large File Processing (LFP) or Large Database Query (LDQ) Test Runs. Each Test Run Sequence will consist of five Test Runs, which vary the number of Streams as follows:

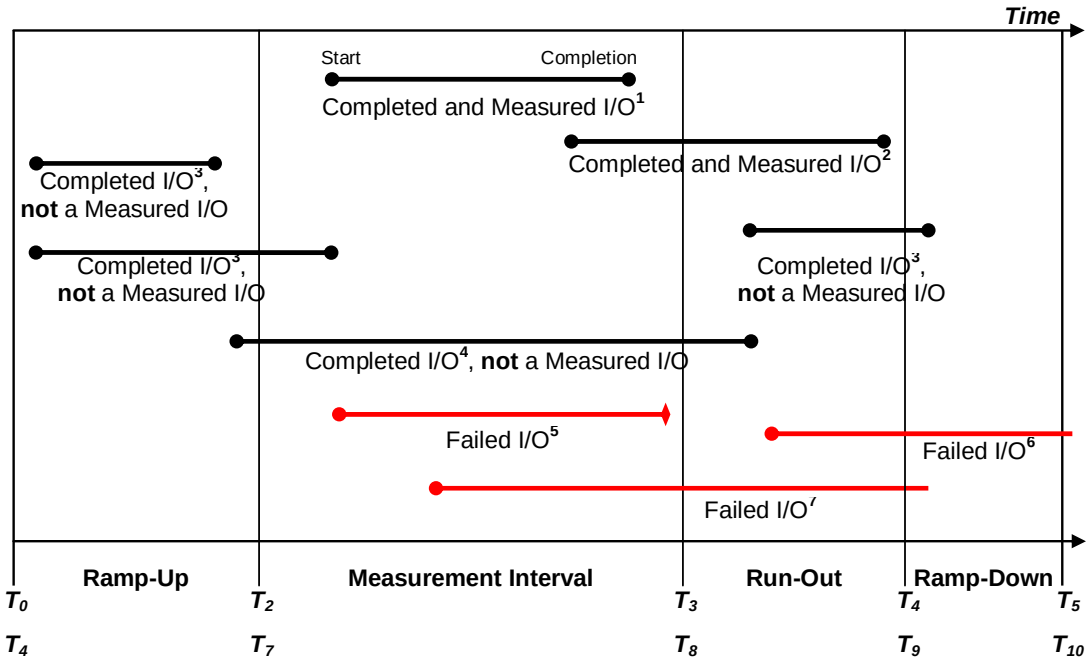
- Test Run 1: Maximum number of Streams, which is selected by the Test Sponsor
- Test Run 2: 50% of the maximum number of Streams used in Test Run 1.
- Test Run 3: 25% of the maximum number of Streams used in Test Run 1.
- Test Run 4: 12.5% of the maximum number of Streams used in Test Run 1.
- Test Run 5: 1 Stream.

Each of the five Test Runs in a Test Run Sequence will share the same attributes with the exception of the number of Streams. For example:

- Large File Processing, Read, 1024 KiB Transfer Size: Maximum Streams
- Large File Processing, Read, 1024 KiB Transfer Size: 50% of Maximum Streams
- Large File Processing, Read, 1024 KiB Transfer Size: 25% of Maximum Streams
- Large File Processing, Read, 1024 KiB Transfer Size: 12.5% of Maximum Streams
- Large File Processing, Read, 1024 KiB Transfer Size: 1 Stream

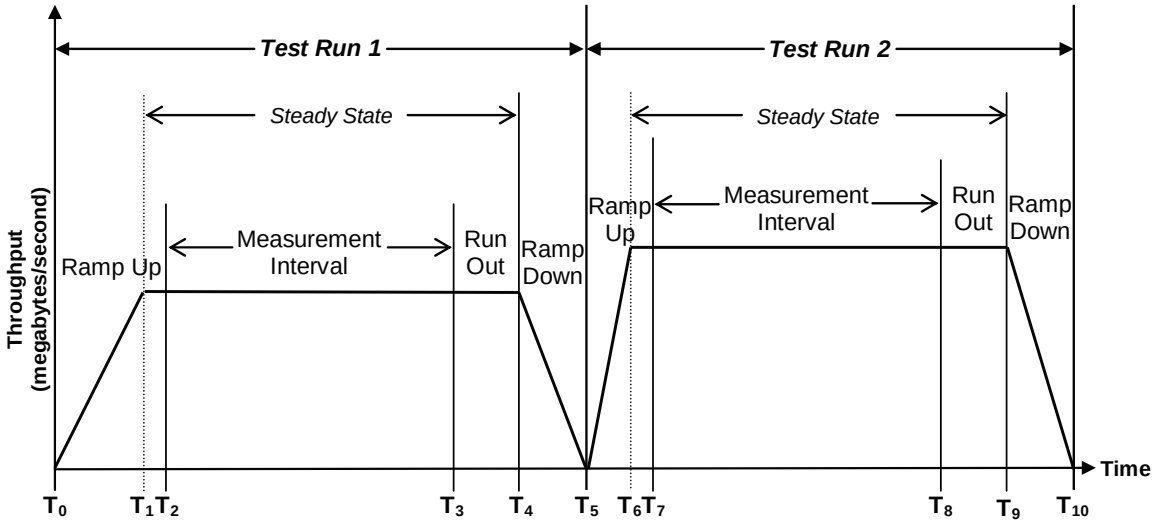
Transfer Size: The Transfer Size parameter specifies the number of bytes in KiB to transfer. *(Clause 3.4.7 of the SPC-2C Benchmark Specification)*

I/O Completion Types



Completed and Measured I/O[1]: *I/O started and completed within the Measurement Interval.*
Completed and Measured I/O[2]: *I/O started within the Measurement Interval and completed within Ramp Down.*
Completed I/O[3]: *I/O started before or after the Measurement Interval – not measured.*
Completed I/O[4]: *I/O started before and completed after the Measurement Interval – not measured.*
Failed I/O[5]: *Signaled as failed by System Software.*
Failed I/O[6]: *I/O did not complete prior to the end of Ramp-Down.*
Failed I/O[7]: *I/O did not complete prior to the end of Run-Out.*

SPC-2C Test Run Components



APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

There were no customer tunables parameters or option changed from their default values.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

The **sd=sd1,lun=\\.\physicaldrive1** entry in each SPC-2C Workload Generator Parameter file provides access to the entire physical disk drive. The **size=476935m** option, used with each **sd**"entry, specifies an SPC-2C ASU with a capacity of 500.103 GB.

APPENDIX D: SPC-2C WORKLOAD GENERATOR STORAGE COMMANDS AND PARAMETERS

Large File Processing Test *(LFP)*

```
host=localhost,spc2=c:\spc-
  2C_a,jvms=1,maxstreams=100,java=C:\Java\j2re1.4.2_17\bin\java
sd=default,host=localhost
sd=sd1,lun=\\.\physicaldrive1,size=476935M
maxlatestart=1
reportinginterval=5
segmentlength=512m
rd=default,rampup=180,periods=90,measurement=180,runout=45,rampdown=15,buffers=1
rd=default,rdpct=0,xfersize=1024k
rd=TR1-s5_SPC-2-FP,streams=5
rd=TR2-s4_SPC-2-FP,streams=4
rd=TR3-s3_SPC-2-FP,streams=3
rd=TR4-s2_SPC-2-FP,streams=2
rd=TR5-s1_SPC-2-FP,streams=1
rd=default,xfersize=256k
rd=TR6-s5_SPC-2-FP,streams=5
rd=TR7-s4_SPC-2-FP,streams=4
rd=TR8-s3_SPC-2-FP,streams=3
rd=TR9-s2_SPC-2-FP,streams=2
rd=TR10-s1_SPC-2-FP,streams=1
rd=default,rdpct=50,xfersize=1024k
rd=TR11-s5_SPC-2-FP,streams=5
rd=TR12-s4_SPC-2-FP,streams=4
rd=TR13-s3_SPC-2-FP,streams=3
rd=TR14-s2_SPC-2-FP,streams=2
rd=TR15-s1_SPC-2-FP,streams=1
rd=default,xfersize=256k
rd=TR16-s5_SPC-2-FP,streams=5
rd=TR17-s4_SPC-2-FP,streams=4
rd=TR18-s3_SPC-2-FP,streams=3
rd=TR19-s2_SPC-2-FP,streams=2
rd=TR20-s1_SPC-2-FP,streams=1
rd=default,rdpct=100,xfersize=1024k
rd=TR21-s5_SPC-2-FP,streams=5
rd=TR22-s4_SPC-2-FP,streams=4
rd=TR23-s3_SPC-2-FP,streams=3
rd=TR24-s2_SPC-2-FP,streams=2
rd=TR25-s1_SPC-2-FP,streams=1
rd=default,xfersize=256k
rd=TR26-s5_SPC-2-FP,streams=5
rd=TR27-s4_SPC-2-FP,streams=4
rd=TR28-s3_SPC-2-FP,streams=3
rd=TR29-s2_SPC-2-FP,streams=2
rd=TR30-s1_SPC-2-FP,streams=1
```

Large Database Query Test *(LDQ)*

```
host=localhost,spc2=c:\spc-
  2C_a,jvms=1,maxstreams=100,java=C:\Java\j2re1.4.2_17\bin\java
sd=default,host=localhost
sd=sd1,lun=\\.\physicaldrive1,size=476935M
maxlatestart=1
reportinginterval=5
segmentlength=512m
rd=default,rampup=180,periods=90,measurement=180,runout=45,rampdown=15,buffers=1
```

```
rd=default,rdpct=0,xfersize=1024k
rd=TR1-s5_SPC-2-FP,streams=5
rd=TR2-s4_SPC-2-FP,streams=4
rd=TR3-s3_SPC-2-FP,streams=3
rd=TR4-s2_SPC-2-FP,streams=2
rd=TR5-s1_SPC-2-FP,streams=1
rd=default,xfersize=256k
rd=TR6-s5_SPC-2-FP,streams=5
rd=TR7-s4_SPC-2-FP,streams=4
rd=TR8-s3_SPC-2-FP,streams=3
rd=TR9-s2_SPC-2-FP,streams=2
rd=TR10-s1_SPC-2-FP,streams=1
rd=default,rdpct=50,xfersize=1024k
rd=TR11-s5_SPC-2-FP,streams=5
rd=TR12-s4_SPC-2-FP,streams=4
rd=TR13-s3_SPC-2-FP,streams=3
rd=TR14-s2_SPC-2-FP,streams=2
rd=TR15-s1_SPC-2-FP,streams=1
rd=default,xfersize=256k
rd=TR16-s5_SPC-2-FP,streams=5
rd=TR17-s4_SPC-2-FP,streams=4
rd=TR18-s3_SPC-2-FP,streams=3
rd=TR19-s2_SPC-2-FP,streams=2
rd=TR20-s1_SPC-2-FP,streams=1
rd=default,rdpct=100,xfersize=1024k
rd=TR21-s5_SPC-2-FP,streams=5
rd=TR22-s4_SPC-2-FP,streams=4
rd=TR23-s3_SPC-2-FP,streams=3
rd=TR24-s2_SPC-2-FP,streams=2
rd=TR25-s1_SPC-2-FP,streams=1
rd=default,xfersize=256k
rd=TR26-s5_SPC-2-FP,streams=5
rd=TR27-s4_SPC-2-FP,streams=4
rd=TR28-s3_SPC-2-FP,streams=3
rd=TR29-s2_SPC-2-FP,streams=2
rd=TR30-s1_SPC-2-FP,streams=1
```

Video on Demand Delivery Test *(VOD)*

```
host=localhost,spc2=\spc-
  2C_a,jvms=1,maxstreams=500,java=C:\Java\j2re1.4.2_17\bin\java
sd=default,host=localhost
sd=sd1,lun=\\.\physicaldrive1,size=476935M
maxlatestart=0
videosegmentduration=1200
maxlatevod=0
reportinginterval=5
rd=default,rampup=1200,periods=600,measurement=7200,runout=45,rampdown=15,buffers=8
rd=TR1-s255_SPC-2-VOD,streams=44
```

Persistence Test Run 1 *(write phase)*

```
host=localhost,jvms=1,maxstreams=500
sd=sd1,lun=\\.\physicaldrive1,size=476935M
maxlatestart=1
reportinginterval=5
segmentlength=512m
rd=default,rampup=180,periods=90,measurement=300,runout=0,rampdown=0,buffers=1
rd=default,rdpct=0,xfersize=1024k
rd=TR1-5s_SPC-2-persist-w,streams=5
```

Persistence Test Run 2 *(read phase)*

```
host=localhost,jvms=1,maxstreams=100
sd=sd1,lun=\\.\physicaldrive1,size=476935M
maxlatestart=1
reportinginterval=5
segmentlength=512m
maxpersistenceerrors=10
rd=default,buffers=1,rdpct=100,xfersize=1024k
rd=TR1-5s_SPC-2-persist
```

APPENDIX E: SPC-2C WORKLOAD GENERATOR EXECUTION COMMANDS AND PARAMETERS

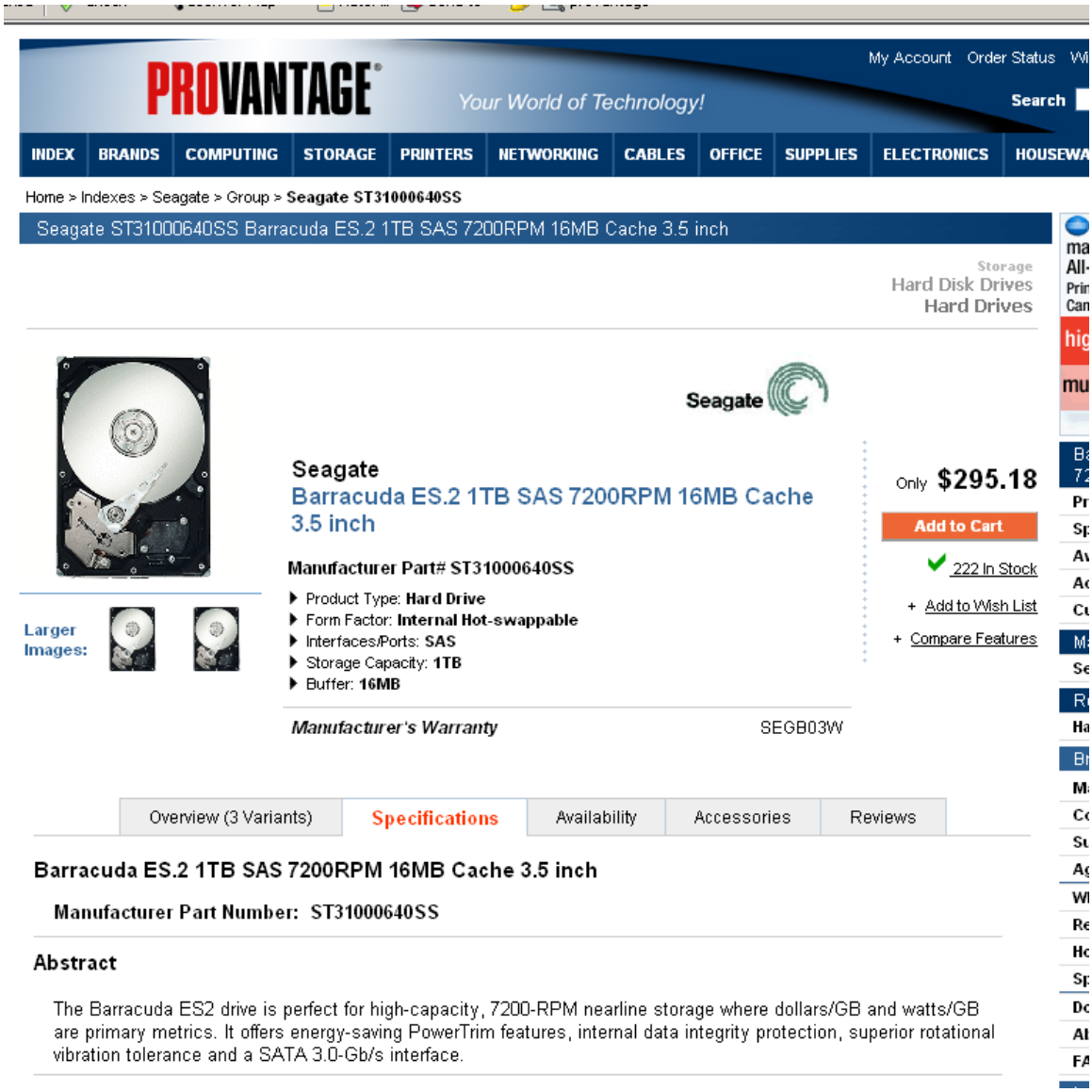
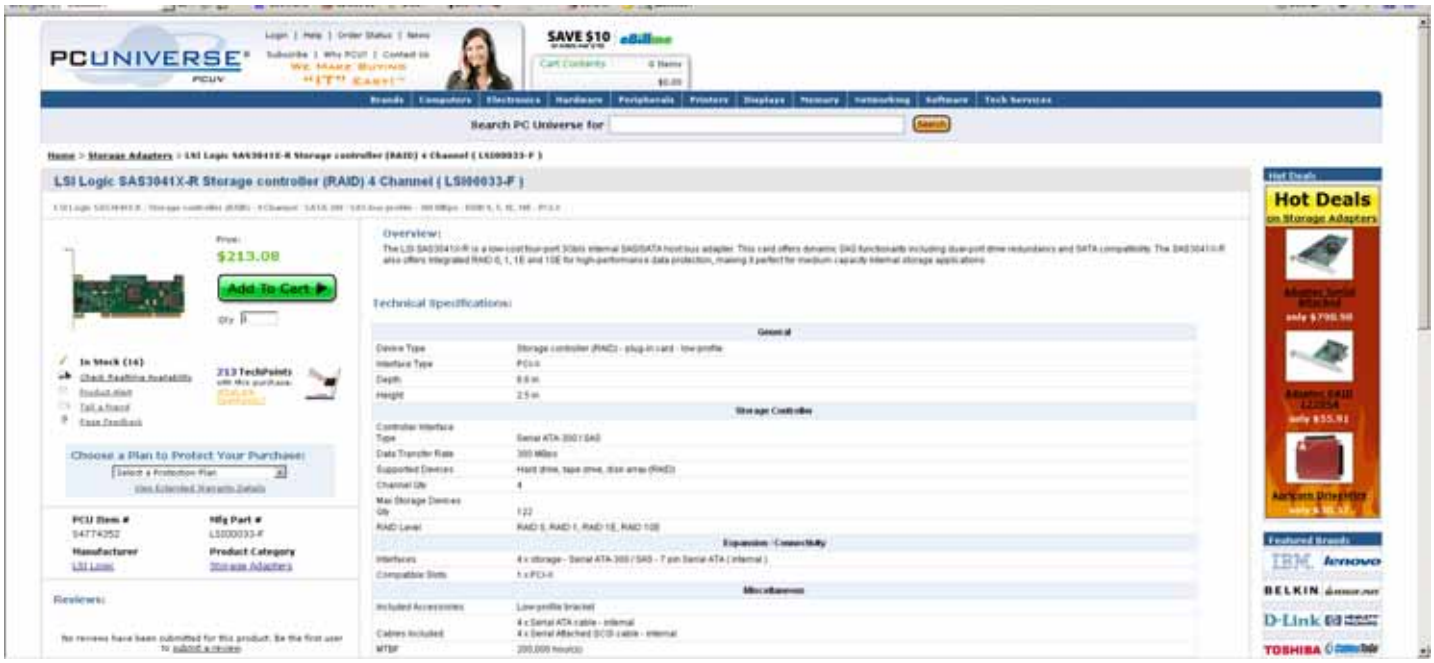
Video on Demand Delivery, Large File Processing Test, Large Database Query Tests, and Persistence Test Run 1

The following script was used to execute the Video on Demand Delivery, Large File Processing and Large Database Query Tests, and Persistence Test Run 1 in an uninterrupted sequence. In addition the script includes a "pause", which allowed the required power cycle step prior to executing Persistence Test Run 2.

```
@echo on

rem Windows: start

rem Directory where this is executed from:
rem set dir=%~dp0

rem set current class path
rem set cp=%~dp0


C:\Java\j2re1.4.2_17\bin\java -Xmx1024m -Xms1024m -Xss48k -cp c:\spc-2c_a vdbench -f
  spc2.vod -o spc2_vod
C:\Java\j2re1.4.2_17\bin\java -Xmx1024m -Xms1024m -Xss48k -cp c:\spc-2c_a vdbench -f
  spc2.lfp -o spc2_lfp
C:\Java\j2re1.4.2_17\bin\java -Xmx1024m -Xms1024m -Xss48k -cp c:\spc-2c_a vdbench -f
  spc2.ldq -o spc2_ldq
C:\Java\j2re1.4.2_17\bin\java -Xmx1024m -Xms1024m -Xss48k -cp c:\spc-2c_a vdbench -f
  spc2-persist1.txt -o spc2_PER1
rem manual power cycle of storage disk
pause
C:\Java\j2re1.4.2_17\bin\java -Xmx1024m -Xms1024m -Xss48k -cp c:\spc-2c_a vdbench -f
  spc2-persist2.txt -o spc2_PER2
```

APPENDIX F: THIRD-PARTY QUOTES

Seagate Barracuda ES.2 ST31000640SS



LSI SAS Storage Controller