SPC BENCHMARK-3BR™ (SPC-3BR)

PUBLIC REVIEW DRAFT SPECIFICATION

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Document History

Release Date	Version	Description
December 3, 2007	0.0.11	Public Review Draft

Table of Contents

SPC BENCHMARK-3BR™ (SPC-3BR) ..... **II**
SPC MEMBERSHIP II
DOCUMENT HISTORY II
TABLE OF CONTENTS II
TABLE OF FIGURES IV
TABLE OF TABLES V

CLAUSE 0 INTRODUCTION **0-1**
0.1 PREAMBLE 0-1
0.2 GENERAL GUIDELINES 0-2
0.3 MEASUREMENT GUIDELINES 0-4
0.4 READERS GUIDE 0-4
0.5 TYPOGRAPHIC CONVENTIONS 0-4
0.6 DISCLAIMER 0-4
0.7 SPC BENCHMARK SERIES 0-5

CLAUSE 1 WORKLOAD ENVIRONMENT 1-1
1.1 BUSINESS AND APPLICATION ENVIRONMENT 1-1
1.2 HIGH-LEVEL WORKLOAD MODEL 1-1
1.3 HIGH-LEVEL STORAGE MODEL 1-2

CLAUSE 2 DATA REPOSITORY 2-1
2.1 OVERVIEW 2-1
2.2 GENERIC STORAGE LAYER (GSL) 2-1
2.3 TRANSFORMATION 2-3
2.4 SPC-3BR STORAGE HIERARCHY 2-4

CLAUSE 3 DATA MODEL 3-1
3.1 OVERVIEW 3-1
3.2 DATA MODEL 3-1
3.3 FILE AGING 3-6

CLAUSE 4 BENCHMARK CONFIGURATION (BC), TESTED STORAGE CONFIGURATION (TSC), AND TESTED STORAGE PRODUCT (TSP) 4-1
4.1 OVERVIEW 4-1
4.2 BENCHMARK CONFIGURATION (BC) 4-2
4.3 THE TESTED STORAGE CONFIGURATION (TSC) 4-5
4.4 THE TESTED STORAGE PRODUCT (TSP) 4-11

CLAUSE 5 BENCHMARK TOOLS 5-1
5.1 OVERVIEW 5-1
5.2 HOSTS 5-1

CLAUSE 6 TEST MEASUREMENT REQUIREMENTS (EXECUTION RULES) 6-1
6.1 OVERVIEW 6-1
6.2 GENERAL REQUIREMENTS 6-1
6.3 STORAGE CONFIGURATION REQUIREMENTS 6-1
6.4 DATA SET SCALING REQUIREMENTS 6-2
6.5 FILESET GENERATION REQUIREMENTS 6-2
6.6 DATA GATHERING REQUIREMENTS 6-3
6.7 TEST EXECUTION 6-3

CLAUSE 7 REPORTED METRICS 7-1
7.1 OVERVIEW 7-1
7.2 PRIMARY METRICS 7-1
7.3 SECONDARY METRICS 7-2
7.4 USAGE REQUIREMENTS 7-2

CLAUSE 8 PRICING 8-1
8.1 OVERVIEW 8-1
8.2 DEFINITIONS 8-1

CLAUSE 9 FULL DISCLOSURE 9-1
9.1 GENERAL REQUIREMENTS 9-1
9.2 FRONT MATTER 9-1
9.3 STORAGE HIERARCHY ITEMS 9-5
9.4 DATA MODEL ITEMS 9-8
9.5 BENCHMARK CONFIGURATION AND TSP 9-13
9.6 BENCHMARK TOOLS 9-17
9.7 TEST MEASUREMENT AND EXECUTION RULES 9-17
9.8 REPORTED METRICS 9-20
9.9 PRICING 9-20
9.10 EXECUTIVE SUMMARY 9-21

CLAUSE 10 MEASUREMENT, AUDIT, AND RESULTS SUBMISSION 10-1
10.1 INTRODUCTION 10-1
10.2 ORIGINAL SPC-3BR RESULT 10-1
10.3 SPC-3BR AUDIT 10-1
10.4 SPC-3BR AUDIT CERTIFICATION 10-6
10.5 SPC-3BR MEASUREMENT SUBMISSION 10-6
10.6 SPC PEER REVIEW 10-7
10.7 CREATING A NEW SPC-3BR RESULT BASED ON AN EXISTING SPC-3BR RESULT 10-7
10.8 SPC-3BR RESULT REVISIONS 10-8

Table of Figures

Figure 2-1: GSL Components 2-2

Figure 2-2 GSL Relationships 2-2

Figure 2-3SPC-BR Storage Hierarchy 2-4

Figure 4-1 Generic Benchmark Configuration 4-1

Figure 4-2 Direct Attached Configurations 4-3

Figure 4-3 Network Attached Configurations 4-4

Figure 4-4 Target and Source TSC on a Single Storage System 4-6

Figure 4-5 Embedded Configurations 4-8

Figure 5-1 Measurement Boundary 5-2

Table of Tables

Table 3-1 File Size Distribution 3-2

Table 3-2 File Modification Date Distribution 3-2

Table 3-3 File Services File Name Length Distribution 3-3

Table 3-4 Directory Depth Distribution 3-4

Table 3-5 Directory Fanout Distribution 3-4

Table 3-6 Directory Entries Distribution 3-5

Table 3-7 Compressibility Values 3-6

Table 3-8 Typical Free Space 3-7

Table 3-9: File Aging Process Outline 3-8

Table 6-1 Data Set Creation Concurrency Requirements 6-5

Table 6-2 Initial Aging Concurrency Requirements 6-5

Table 9-1: Test Sponsor and Contact Information 9-3

Table 9-2: Revision Information and Key Dates 9-4

Table 9-3: Basis SPC-3BR Result Information 9-5

Table 9-4 Storage Component Inventory 9-5

Table 9-5 TSC-Source Capacity Allocation Summary 9-6

Table 9-6 TSC-Source Protection Summary 9-6

Table 9-7 TSC-Target Capacity Allocation Summary 9-6

Table 9-8 TSC-Target Hierarchy Summary 9-7

Table 9-9 TSC-SOURCE Storage Subsystem Mapping 9-8

Table 9-10 TSC-TARGET Storage Subsystem Mapping 9-8

Table 9-11 File Size Distribution Comparison **9-9**

Table 9-12 File Modification Date Distribution Comparison **9-10**

Table 9-13 File Name Length Distribution Comparison **9-10**

Table 9-14 Directory Depth Distribution Comparison **9-11**

Table 9-15 Directory Fanout Distribution Comparison **9-12**

Table 9-16 Directory Entries Distribution Comparison **9-13**

Table 9-17 Physical Storage Inventory **9-15**

Table 9-18 Parameter Changes **9-16**

Table 9-19 Data Load Test Timing **9-17**

Table 9-20 Backup Test Timing **9-18**

Table 9-21 Recovery Test Timing **9-19**

Table 9-22 Primary Metrics **9-20**

Table 9-23 Result Identification **9-22**

Table 9-24 Metrics Summary **9-23**

Table 9-25 Tool Identification **9-23**

Table 9-26 Test Timing **9-24**

Table 9-27 TSC Overview **9-24**

Table 9-28 Pricing Header **9-25**

Table 9-29 Audit Identifier **9-25**

Clause 0 Introduction

0.1 Preamble

The purpose of this specification is:

- to define a common content model that can be used to characterize a broad range of file operations run against a selected data repository, (e.g., a file system built around the POSIX interface standard, a policy-driven storage system that relies on a hierarchical storage system and a lifecycle management approach);
- to define the first performance test based upon the foundation provided by the content model.

This clause gives an overview of both the SPC Benchmark-3™ (SPC-3) foundation model and the SPC-3 backup and restore benchmark (SPC-3BR)

The SPC-3 content model is designed to permit the construction of a scalable and complex set of data objects, whose structure reflects the evolution of files or other content over time. An approach that tests against a newly created file system fails to assess the impact of prior user activity. The SPC-3 content model accounts for the effects of concurrent requests for content creation, deletion, and expansion made within a diverse community of end users and applications. The SPC-3 content model also provides for a realistic distribution of content attributes including size, naming, compressibility, directory organization, and date/time stamps.

By providing a common, extensible and realistic environment to gather performance measurements, the SPC-3 content model provides a foundation for a broad range of benchmarks and evaluations in the areas of storage management, hierarchical storage management, content management, information lifecycle management, and/or disaster recovery. However, performance tests other than SPC-3BR are outside the scope of this specification.

A performance evaluation using the SPC-3BR benchmark is a two step process. First, a repository is populated using a utility that implements the SPC-3 content model. Then, the performance of the test sponsor's backup and restore solution is evaluated by running against the repository.

The SPC-3BR test is intended to realistically exercise the capabilities of the benchmarked backup and restore solution in several dimensions, including:

- Scalable storage capacity requirements,
- Modern, realistic and complex file and directory attributes,
- Realistic levels of storage fragmentation,
- Scalable numbers of individual files ranging from a few bytes to many gigabytes, and
- Verification that content is reliably preserved through the backup/restore process.

The purpose of the SPC-3BR benchmark test is to provide comparative performance information that adds value throughout the product lifecycle (e.g., development of product requirements, product implementation, performance tuning, capacity planning, market positioning and purchase evaluation.

The SPC-3BR specification is vendor and platform independent. Any vendor should be able to sponsor and publish an SPC-3BR benchmark, provided their tested configuration satisfies the performance, integrity, and availability requirements of the specification.

SPC-3BR allows benchmark sponsor to produce meaningful, comparable performance data without requiring the use any particular product, topology or protocol. Benchmark sponsors are free to configure virtually any storage configuration, including using:

- Different solution components: the specification allows virtually any combination of storage and server technologies, software, and operational strategies for backup processing. Implementers are free to use any combination of storage and server types and to select the level of redundancy and reliability that best showcases their solution.
- Different interconnect topologies: the benchmark has been designed to allow for all forms of system and network interconnection. Network-based solutions (i.e., NAS or SAN) and more traditional host-based systems can both produce accurate, meaningful and comparable benchmark results.
- Different communications protocols: the specification makes no assumptions about the communications mechanism used in a storage configuration. Since all benchmark stimuli are defined at the application level, SPC-3BR can provide head-to-head comparisons between systems that employ any number of protocols, including NFS, iSCSI or CIFS.
- Different File Systems: Different file systems provide a wide array of features and functionalities. By defining a user-based, application level workload, SPC-3BR allows the direct comparison of content repository or file system performance measured where it matters most, by the end user.

Rather than requiring or favoring a particular implementation, it is the goal of the SPC-3BR benchmark specification to provide a robust, verifiable, reproducible environment within which the relative strengths of differing design and configuration approaches can be evaluated.

0.2 General Guidelines

The purpose of SPC-3BR benchmark is to provide objective, relevant, and verifiable data to purchasers of computer based solutions. To that end, the SPC-3BR specification requires that sponsored benchmark tests be implemented with system platforms and products that:

1. Are generally available to users.
2. A significant percentage of the users in the target market segment (server class systems) would implement.
3. Are relevant to the market segment that the SPC-3 benchmark represents.

In addition, all SPC-3BR benchmark results are required to be sponsored by a distinctly identifiable entity, which is referred to as the Test Sponsor. The Test Sponsor is responsible for the submission of all required SPC-3BR benchmark results and materials. The Test Sponsor is responsible for the completeness, accuracy, and authenticity of those submitted results and materials as attested to in the required Letter of Good Faith (see Appendix A). A Test Sponsor is not required to be a SPC member and may be an individual, company, or organization.

The use of new systems, products, technologies (hardware or software) and pricing is encouraged as long as they meet the requirements above. Specifically prohibited are

benchmark systems, products, and pricing (hereafter referred to as "implementations") whose primary purpose is performance optimization of SPC-3BR benchmark results without any corresponding applicability to real-world applications and environments. In other words, all "benchmark specials," those implementations that improve benchmark results but not general, real-world performance are prohibited.

The following characteristics should be used as a guide to judge whether a particular implementation is a “benchmark special”. It is not required that each point below be met, but that the cumulative weight of the evidence be considered to identify an unacceptable implementation. Absolute certainty or certainty beyond a reasonable doubt is not required to make a judgment on this complex issue. The question that must be answered is this: based on the available evidence, does the clear preponderance (the greater share or weight) of evidence indicate that this implementation is a “benchmark special”?

The following characteristics should be used to judge whether a particular implementation is a benchmark special:

- Is the implementation generally available, documented, and supported?
- Does the implementation have significant restrictions on its use or applicability that limits its use beyond the SPC-3BR benchmark?
- Is the implementation or part of the implementation poorly integrated into the larger product?
- Does the implementation take special advantage of the limited nature of the SPC-3BR benchmark (e.g., I/O Request profile, I/O Request mix, I/O Request concurrency and/or resource contention) in a manner that would not be generally applicable to the environment the benchmark represents?
- Is the use of the implementation discouraged by the vendor? (This includes failing to promote the implementation in a manner similar to the Test Sponsor’s other products and technologies.)
- Does the implementation require uncommon sophistication on the part of the end-user, programmer, or system administrator?
- Is the packaging or pricing unusual or non-customary for the vendor or unusual or non-customary to normal business practices? The following pricing practices are suspect:
    - Availability of a discount to a small subset of possible customers.
    - Discounts documented in an unusual or non-customary manner.
    - Pricing featured as a close-out or one-time special.
    - Unusual or non-customary restrictions on transferability of product, warranty or maintenance on discounted items.
- Is the implementation being commonly used or purchased by a majority of end-users in the market area the benchmark represents? If the implementation is not currently being used by end-users, is there any evidence to indicate that it will be used by a significant number of users?

To assure the equitable application of this standard, the SPC has created a robust system of audit and peer review. It is the goal of the SPC to assure that only those results, which represent accurate and meaningful product performance, will be endorsed as official SPC results.

0.3 Measurement Guidelines

SPC-3BR benchmark results are expected to be accurate representations of subsystem performance. Therefore, stringent measurement, auditing, and reporting guidelines are mandated by this specification. In general, fidelity and candor must be maintained in reporting any items necessary to reproduce the reported results even if the items are not explicitly required to be disclosed by the SPC-3BR benchmark specification.

More detailed measurement, evaluation and disclosure requirements can be found in the body of the specification.

0.4 Readers Guide

It is anticipated that some readers of this specification will be mainly interested in the SPC-3 model of a content repository, while others will be interested in the performance test of backup and restore based upon this model. Readers mainly interested in the foundation model should begin with Clause 2, "Data Repository" and Clause 3, "Data Model". Readers interested in the practical requirements for running the SPC-3BR benchmark, on the other hand, should start with Clause 1, "Workload Environment" . and continue on through Clause 6, "Test Measurement Requirements (Execution Rules)". It is recommended that readers who intend to submit SPC-3BRbenchmark results examine the entire specification.

0.5 Typographic Conventions

0.5.1 Defined Terms

In general, SPC-3BR relies on common American English usage for all terms and expressions used in the specification. There are cases where the benchmark relies on a particular, domain-specific meaning for a word or phrase. Whenever the SPC-3BR specific meaning of a term is intended, the word or phrase will appear in SMALLCAPS. The SPC-3BR specific meaning for the term can be found in the glossary at the end of the specification.

0.5.2 Requirements

The SPC-3BR specification includes both informative content, meant to highlight the intention or assumptions surrounding a particular portion of the specification, and normative content detailing the precise requirements to produce compliance with the specification. Whenever a requirement is being stated, the verb "shall" is used (e.g., "The cost of the tested system shall be disclosed"). Whenever a component or action is optional and may be included or omitted from a benchmark submission at the benchmark sponsor's choice, the verb "may" is used (e.g., "The sponsor may include additional pricing information").

0.6 Disclaimer

While the SPC-3BR benchmark emulates a broad range of applications, it neither represents the entire range of requirements for server systems nor precisely mimics any particular application. In addition, the extent to which anyone is capable of achieving the results reported by a vendor is highly dependent upon how closely the customer's application maps to the SPC-3BR workload. The extrapolation of SPC-3BR results to other environments is therefore not recommended.

Actual system performance is highly dependent upon specific workload characteristics, platform configuration, and application-specific tuning. Relative system performance will vary as a result of these and other factors. Thus, SPC-3BR should not be used as a substitute for customer application benchmarking when critical performance requirements are called for.

SPC-3BR uses terminology and metrics that are similar to other benchmarks. This similarity does not imply that results from this benchmark are comparable with other benchmarks.

0.7 SPC Benchmark Series

The family of benchmarks, such as SPC-3BR, which are based upon the SPC-3 foundation model, is the third family of system benchmarks released by the SPC. It utilizes a common SPC benchmark framework, which was previously used by SPC-1 and SPC-2.

Clause 1 Workload Environment

1.1 Business and Application Environment

SPC-3BR is designed to demonstrate the performance of a file-oriented storage subsystem when running business critical backup and restore operations. To assure the reproducibility and relevance of these s performance measurements, the benchmark requires large-scale movement of data in the form of files, and manipulates a data repository whose contents have been available to, and manipulated by, a broad community of users for some time

1.2 High-Level Workload Model

The SPC-3 content model, defined in Clause 3, defines a realistic, scalable, synthetic hierarchy of files and directories ("FILESET"). SPC-3BR is the first performance test defined against the SPC-3 content model. The SPC-3BR benchmark consists of two, reciprocal operations: file backup and restore.

During the backup phase of the benchmark, the FILESET is traversed, transferring the files from their primary location to a test-sponsor-selectable target area.

During the second phase of the benchmark, a restore operation retrieves the FILESET from that target area and returns it to the primary storage location.

The SPC-3BR benchmark is defined at a high level. The abstract modeling of the FILESET and storage configuration provides a general context for product evaluation. The performance test is defined in terms of the business-level operations to be completed: backup and restore the FILESET. The benchmark sponsor has great latitude in the selection and configuration of the product(s) to be tested, but must provide extensive disclosure of configuration details and settings. The unique characteristics of the file system and storage subsystem selected, and the precise parameters and options employed may change the low-level IO pattern seen by different parts of any given configuration. For example, one system may employ parallel backup or restore operations to fully exploit the performance of the configuration, while another relies on data analysis and file system awareness. That low-level sponsor selected flexibility allows each product to highlight its particular strengths. The high-level benchmark design assures a valid, verifiable, understandable evaluation of real products solving a common business problem.

While the content model and execution rules defined in this specification have been carefully designed to provide a robust basis for product comparison, they are not intended to answer all questions about backup and recovery configurations. In particular:

- The SPC-3BR benchmark is not intended to evaluate the disaster preparedness of a given system configuration;
- The SPC-3BR benchmark is not intended to evaluate the migration of operational data from one system configuration to another.

Rather, SPC-3BR, as the first member of the SPC-3 family of benchmarks, seeks to characterize the ability of a tested system to satisfy the day-to-day requirement to produce and restore a backup and replace operational data that has been invalidated for whatever reason. Additional benchmarks in the family will build upon the foundation of SPC-3BR to

address additional concerns, including, for example, disaster recovery, hierarchical storage and distributed systems.

1.3 High-Level Storage Model

The files used by SPC-3BR represent a common segment of file content that might be found in a document management system, a corporate document vault or an online collaboration system. While this specification may refer to particular file names or suffixes to make the content model more accessible, the goal of the benchmark is to provide performance comparisons that would be relevant and valuable to a business consumer of storage, regardless of their underlying industry or focus.

Since the benchmark is focused on an end-user view, it makes no assumptions about the topology of the storage configuration whose performance is being characterized. Any storage subsystem, regardless of interconnect, topology or communications protocol can produce valid, comparable SPC-3BR results

The separation of physical storage configuration from end-user content manipulated by the benchmark is strengthened by the introduction of the APPLICATION LAYER. The top-most layer the SPC storage hierarchy, the APPLICATION LAYER consists of all end-user data that is manipulated by the benchmark's performance tests, independent of the subordinate layers that hold the data. For SPC-3BR, the APPLICATION LAYER consists of the FILESET.

The SPC storage hierarchy does not require any particular physical implementation. The implementation is determined by the Test Sponsor and must meet the storage configuration requirements stated in Clause 2. See Clause 4 for examples of supported configurations.

Clause 2 Data Repository

2.1 Overview

The Data Repository clause defines the modeling approach used for storage and storage subsystems in SPC-3BR. See Clause 4 and Clause 6 for specific implementation guidelines.

2.2 Generic Storage Layer (GSL)

2.2.1 A GENERIC STORAGE LAYER (GSL) is the abstract representation of a layer in the SPC-3BR STORAGE HIERARCHY (see 0).

2.2.2 The level of data protection provided by a GSL ("PROTECTION LEVEL") shall be disclosed as one of the following:

- RAID6: User data is distributed across multiple storage devices, along with two sets of parity data;
- RAID5: User data is distributed across multiple storage devices, along with a single set of parity data;
- MIRRORING: Two or more identical copies of user data are maintained on separate storage devices;
- UNPROTECTED: no data protection provided.
- OTHER: Any other data protection, including tape-based storage systems.

2.2.3 All storage capacity in a GSL shall be classified as one of the following:

- AVAILABLE SPACE, defined in 2.2.4
- OVERHEAD, defined in 2.2.5

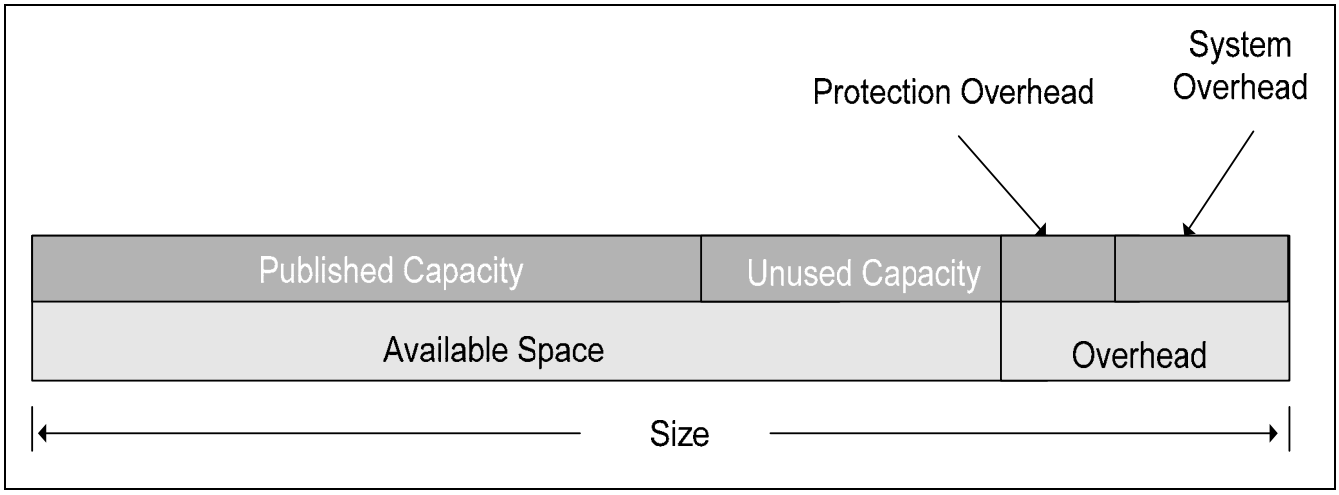
2.2.4 Within a GSL, AVAILABLE SPACE is capacity that could be used by the next level in the storage hierarchy. All AVAILABLE SPACE shall be classified as either:

- PUBLISHED CAPACITY, capacity that has been made available to the next higher level in the hierarchy, or
- UNUSED CAPACITY, capacity that could have been made available to the next layer in the hierarchy, but was explicitly excluded.

2.2.5 OVERHEAD is storage capacity that is required to implement the layer and is not available to application programs. Within a GSL, all OVERHEAD shall be classified as either:

- SYSTEM OVERHEAD: Examples include metadata
- PROTECTION OVERHEAD: capacity that is required to provide data protection. Examples include RAID or spares.

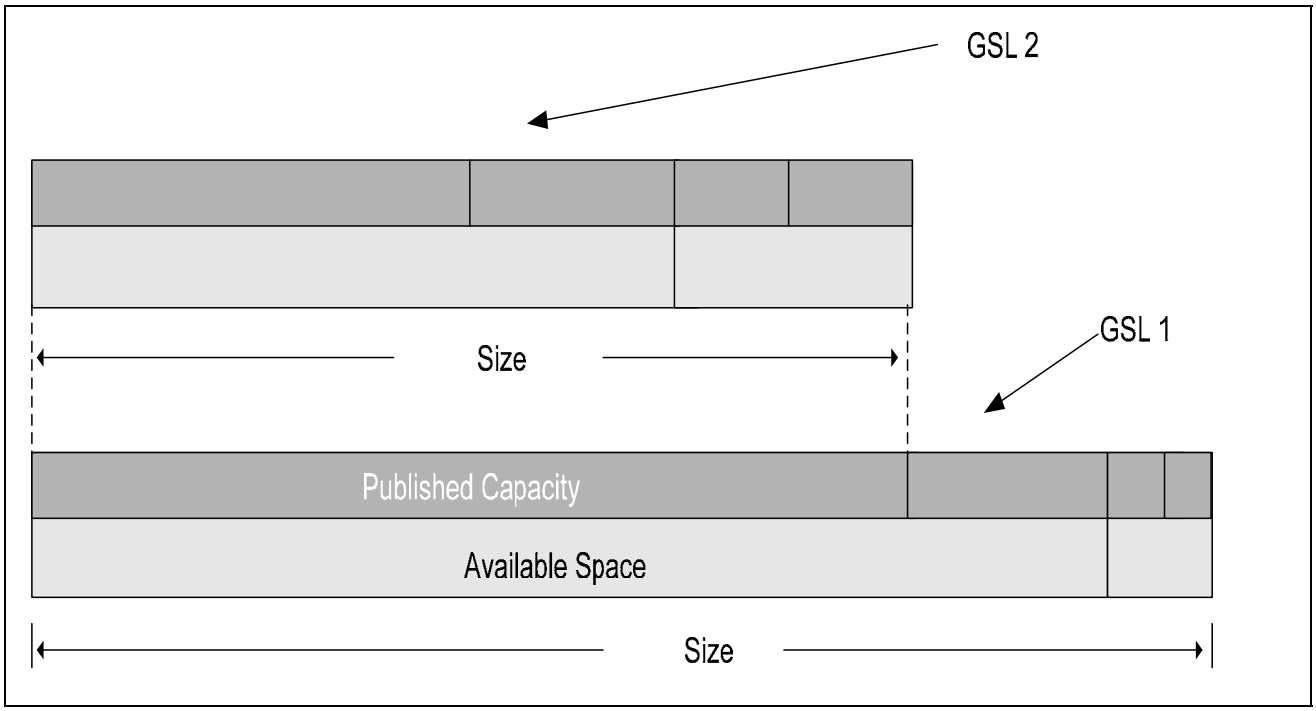
Figure 2-1: GSL Components



2.2.6 The following terms are defined for each GSL:

- The sum of AVAILABLE SPACE and OVERHEAD is the SIZE of a GSL;
- The SIZE of a GSL shall equal the PUBLISHED CAPACITY of its immediately subordinate layer;
- The ratio of the PUBLISHED CAPACITY to SIZE is the EFFICIENCY of a GSL.

Figure 2-2 GSL Relationships



illustrates the different components of a GSL, and their relationships. Figure 2-2 illustrates the relationship between two GENERIC STORAGE LAYERS.

Data Repository

2.3 Transformation

2.3.1 A TRANSFORMATION is a sequence of one or more steps required to create the component capacities of a GSL (e.g., AVAILABLE SPACE, OVERHEAD, etc.) from the PUBLISHED CAPACITY that is provided to it by a subordinate GSL.

2.3.2 A TRANSFORMATION shall not introduce physical storage.

2.3.3 A TRANSFORMATION shall not prevent the retention and recovery of data stored within the storage hierarchy. While a transformation may mandate or alter the precise manner in which the data stored in a GSL is accessed by superior layers, it shall not alter the completeness or correctness of the stored data as seen from the superior layer.

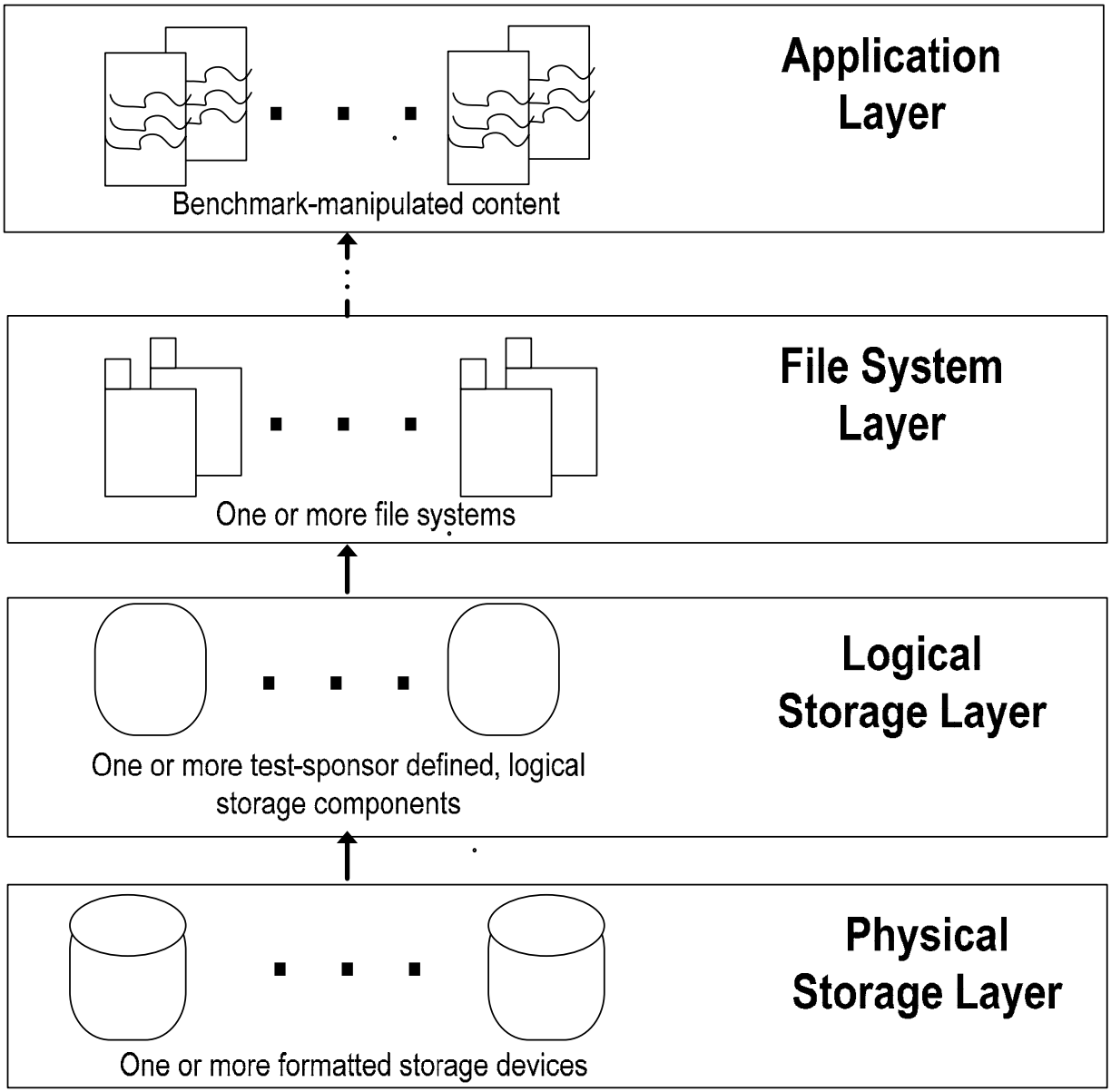
2.3.4 A TRANSFORMATION can increase the logical capacity of a storage layer. That is, the PUBLISHED CAPACITY of a layer may be larger than its SIZE. For example, a transformation that provides lossless data compression can increase the amount of information that can be stored on a given amount of physical storage (e.g., a tape cartridge or disk drive) without altering its physical dimensions or bit density.

Data Repository

2.4 SPC-3BR Storage Hierarchy

2.4.1 Overview

Figure 2-3SPC-BR Storage Hierarchy



The SPC-3BR storage hierarchy defines four distinct tiers as shown in Figure 2-3:

- PHYSICAL STORAGE LAYER (PSL) defined in 2.4.2;
- LOGICAL STORAGE LAYER (LSL) defined in 2.4.3;
- FILE SYSTEM LAYER (FSL) defined in 2.4.4;
- APPLICATION LAYER defined in 2.4.5.

Data Repository

2.4.2 Physical Storage Layer (PSL)

2.4.2.1 The PHYSICAL STORAGE LAYER (PSL) is the foundation of the SPC STORAGE HIERARCHY. It is an instance of the GENERIC STORAGE LAYER defined in clause 2.1.2.

2.4.2.2 All physical storage present in the TSC shall be included in PSL, whether or not it is cabled in or powered up.

Comment: TESTED STORAGE CONFIGURATION (TSC) consists of all software and hardware necessary to implement, support and drive persistent storage which is subjected to the stimuli defined by the SPC-3BR benchmark. See 4.3 for additional information.

2.4.2.3 The PUBLISHED CAPACITY of the PSL is the PHYSICAL STORAGE CAPACITY (PSC).

2.4.2.4 Physical Storage Capacity excludes any storage that is unavailable to either application programs such as the SPC-3BR application or the administrative tools provided with the TSC. Examples of storage which are excluded from PSC include:

- The difference between formatted and unformatted storage;
- Storage devices that have failed.

2.4.3 Logical Storage Layer (LSL)

2.4.3.1 The LOGICAL STORAGE LAYER (LSL) is an instance of the GSL, derived from the PHYSICAL STORAGE LAYER.

2.4.3.2 The LOGICAL STORAGE LAYER represents all logical storage components, defined by the test sponsor, that form the basis for the next level in the hierarchy (e.g., LUNs, partitions, volumes).

2.4.3.3 The PUBLISHED CAPACITY of the LSL is the LOGICAL STORAGE CAPACITY.

2.4.4 File System Layer (FSL)

2.4.4.1 The FILE SYSTEM LAYER (FSL) is an instance of the GSL, derived from the LOGICAL STORAGE LAYER.

2.4.4.2 A FILE SYSTEM is a collection of file management structures on a physical or logical mass storage device.

2.4.4.3 The FILE SYSTEM LAYER provides the persistent, non-volatile storage that contains FILE SYSTEMS.

2.4.4.4 The PUBLISHED CAPACITY of the FSL is the FILE STORAGE CAPACITY.

2.4.5 Application Layer

2.4.5.1 The APPLICATION LAYER is the top of the SPC-3BR storage hierarchy. It represents the user-level data that populates the FSL.

2.4.5.2 The benchmark manipulates the contents of the APPLICATION LAYER. The underlying layers of the SPC-3BR storage hierarchy shall not change during the execution of the benchmark unless explicitly allowed in the execution rules (see Clause 6).

Clause 3 Data Model

3.1 Overview

The Files and File Operations clause defines the characteristics and usage of the SPC-3BR file content.

3.2 Data Model

3.2.1 Definitions

3.2.1.1 The file content produced by SPC-3BR and written, in the form of files, to the APPLICATION LAYER of the STORAGE HIERARCHY shall be referred to as the FILESET.

3.2.1.2 GENERATED DATA VOLUME (GDV) is a measure of the volume of user data contained in the FILESET. It is defined as the sum of the user-accessible data contained within each generated file, and is measured in bytes. GDV does not include additional space allocation required by the TSC or file system to track the existence or state of the generated file (e.g., inodes, directory entries, or other metadata).

3.2.1.3 SCALE FACTOR (SF) is the discrete scaling level selected for a given execution of SPC-3BR, and is based on GDV. See 6.4 for a list of approved scale factors.

3.2.1.4 FILE SYSTEM UTILIZATION (FSU) is the ratio of GDV to the PUBLISHED CAPACITY of THE FILE SYSTEM LAYER of the STORAGE HIERARCHY.

3.2.2 FILESET Parameters

3.2.2.1 Introduction

This clause defines the parameters used to define statistically comparable FILESETS across the range of storage configurations permitted under Clause 4.

3.2.2.2 Distributions

The following clauses define the parameters used to characterize individual files within the FILESET. With one exception, each randomized parameter is a count with an associated unit (e.g. a number of days, a number of 512 byte storage blocks, or a number of directory levels). The probability distribution associated with each such parameter is provided by presenting its cumulative distribution function (CDF). In some cases, abbreviations are introduced to simplify the presentation (e.g., the notations MiB and GiB are used to show large file sizes); however, the underlying unit of the distribution is provided along with each distribution. In cases where the CDF presented does not include every whole number of the underlying unit, linear interpolation may be used to determine the probabilities of events in between those shown.

If the final probability shown in a table is less than unity by a positive amount, then that amount is the probability that the statistical outcome calculated for a given file exceeds the largest value shown in the table. However, when the statistical outcome exceeds its range in this way, the generator shall substitute the maximum value that appears in the affected table.

Comment: The range of some parameters is capped in this manner to improve the statistical repeatability of tests conducted against the FILESET.

3.2.2.3 File Size

The file size parameter in SPC-3 determines the number bytes stored in a given file after the initial FILESET creation is complete. Table 3-1 defines the file size distribution.

Comment: File size is capped at 1 GiB.

Table 3-1 File Size Distribution

File Size	Cumulative Percentage	Notes
0	2.708	
512B	40.525	
4KiB	72.348	
32KiB	91.744	
256KiB	98.294	
2MiB	99.508	
16MiB	99.892	
128MiB	99.971	
1GiB	99.984%	

3.2.2.4 File Modification Date

The file modification date parameter in SPC-3 determines the modification date of a file in the FILESET. Table 3-2 defines the file modification date distribution.

Comment: File modification is capped at 1825 days (approximately 5 years).

Table 3-2 File Modification Date Distribution

Days	Cumulative Percentage	Notes
0	0	
15	41.5	
45	61.9	
90	74.6	

Days	Cumulative Percentage	Notes
180	83.1	
365	88.9	1 year
730	93.6	2 years
1095	95,9	3 years
1460	96.8	4 years
1825	97.4	5 years

3.2.2.5 File Name Length

The file name length parameter in SPC-3BR determines file name length for the files in the FILESET.

Table 3-3 defines the File Name Length distribution.

Table 3-3 File Services File Name Length Distribution

File Name Length	Cumulative Percentage	Notes
1	1	
10	44.1	
20	79	
30	87.9	
40	95.5	
50	100	

3.2.2.6 Directory Depth

The directory depth parameter in SPC-3BR determines each generated file's depth in the FILESET.

Table 3-4 defines the directory depth parameter.

Table 3-4 Directory Depth Distribution

Depth	Cumulative Percentage	Notes
0	0	
2	0.01	
5	1.57	
8	14.66	
11	66.73	
14	87.85	
17	95.48	
20	98.82	
23	99.67	
26	99.95	
29	99.99	
32	100	

3.2.2.7 Directory Fanout

The Directory Fanout parameter in SPC-3BR determines the number of subordinate directories found in a particular directory in the initial FILESET.

Table 3-5 defines the Directory Fanout Distribution.

Table 3-5 Directory Fanout Distribution

Subdirectories per directory	Cumulative Percentage	Notes
0	41.8	
1	69.5	
2	83.9	
3	88.9	

4	93.5	
5	94.6	
6	96.0	
7	96.5	
8	97.5	
9	97.8	
10	98.0	
20	99.0	
40	100	

3.2.2.8 Directory Entries

The Directory Entries parameter in SPC-3BR determines the number of files found in a particular directory in the initial FILESET.

Table 3-6 defines the Directory Entries Distribution.

Comment: The Directory Entries distribution is capped at 500 files.

Table 3-6 Directory Entries Distribution

Files per directory	Cumulative Percentage	Notes
0	27.02	
1	58.24	
2	70.48	
3	77.11	
4	81.39	
5	83.80	
10	90.1	
15	93.36	
25	95.75	
100	99.21	

Files per directory	Cumulative Percentage	Notes
200	99.71	
300	99.83	
400	99.90	
500	99.92	

3.2.2.9 File Compressibility

The File Compressibility parameter in SPC-3BR determines the number of files in the initial FILESET that are compressible to a given extent. SPC-3 does not create or operate on compressed files. Rather, it defines a FILESET that includes files that could be compressed to a known extent using commonly available algorithms, if the TSC were to include compression functionality. SPC-3 defines three levels of susceptibility to compression:

- SPARSE: A file in this category is assumed to contain sparse data where a large amount of the file contains all zeros (or any single value) and can be reduced to a small number of bytes (e.g., a representative value and the number of occurrences), regardless of the original file size.
- TEXT: A file in this category is assumed to contain ASCII English text and is subject to up to 3:1 compression through common techniques.
- PRE-COMPRESSED: A file in this category is assumed to contain the binary output of a prior compression process and to therefore not be a candidate for further compression.

This parameter's permissible values are defined in Table 3-7.

Table 3-7 Compressibility Values

Compressibility	Percentage	Notes
Sparse	20%	
Text	50%	
Pre-compressed	30%	

3.3 File Aging

3.3.1 SPC-3BR defines a process to mimic the aging of a file system, called File Aging. Its goal is to induce a degree of fragmentation of data and free space within the FILE SYSTEM LAYER that is similar to that which would be observed in a mature file system. The aging process has been defined terms of GDV and FSU so that it is independent of the size of the file system being populated. Table 3-8 show typical levels of available file system space during file aging.

Table 3-8 Typical Free Space

Phase	Beginning Free Space	Ending Free Space
Creation	100%	15%
Expansion	15%	5%
Reduction	5%	20%
Completion	20%	15%

The precise file aging steps required by SPC-3BR are defined in the following sections, and summarized in Table 3-9: File Aging Process Outline.

3.3.2 SPC-3BR uses POSIX-compliant file operations as the basis for file system aging. Because the precise syntax and formulation of these operations may vary slightly across the operating systems supported by SPC-3BR, they are referred to by generic, high-level names, rather than specific POSIX API calls (e.g., “Read” rather than “fread()”). The operations and their expected impact on the FILESET are:

- Read: This operation transfers data sequentially from a file into a defined buffer until the entire file has been copied. The transfer begins at the first byte in the file.
- Write: This operation transfers data sequentially from a defined buffer to a file, until a specified number of bytes has been copied. This operation is not valid on a directory.
- Create: This operation adds a file to the FILESET.
- Delete: This operation removes a file from the FILESET.
- Append: This operation adds data at the end of an existing file in the FILESET.
- Truncate: This operation shortens an existing file in the FILESET. Data beyond the point of truncation is lost.

3.3.3 File Aging begins with a FILE SYSTEM LAYER that has been configured, but contains no user-data.

3.3.4 The creation phase of the file system aging process populates the bulk of the data set. During this phase, multiple files are created simultaneously, following the data set definitions and distributions defined 3.2.2. This phase is complete when the GDV reaches 100% of SF.

3.3.5 The expansion phase of the file system aging process begins immediately following the creation phase. It increases the FSU, and may introduce some degree of fragmentation to the file set. During this phase, multiple, simultaneous append operations are executed against randomly selected files that were created during the initial creation phase. This phase is complete when the GDV reaches 112% of SF.

3.3.6 The reduction phase of the file system aging process begins immediately following the expansion phase. It decreases the FSU, and may introduce some degree of fragmentation to the free space. During this phase, multiple, simultaneous delete and truncate operations are executed against randomly selected files that were created during the initial creation phase. This phase is complete when the GDV reaches 94% of SF.

3.3.7 The completion phase of the file system aging process begins immediately following the reduction phase. It increases the FSU, and may introduce additional fragmentation to the file set. During this phase, multiple, simultaneous append operations are executed against randomly selected files that were created during the initial creation phase. This phase is complete when the GDV reaches 100% of SF.

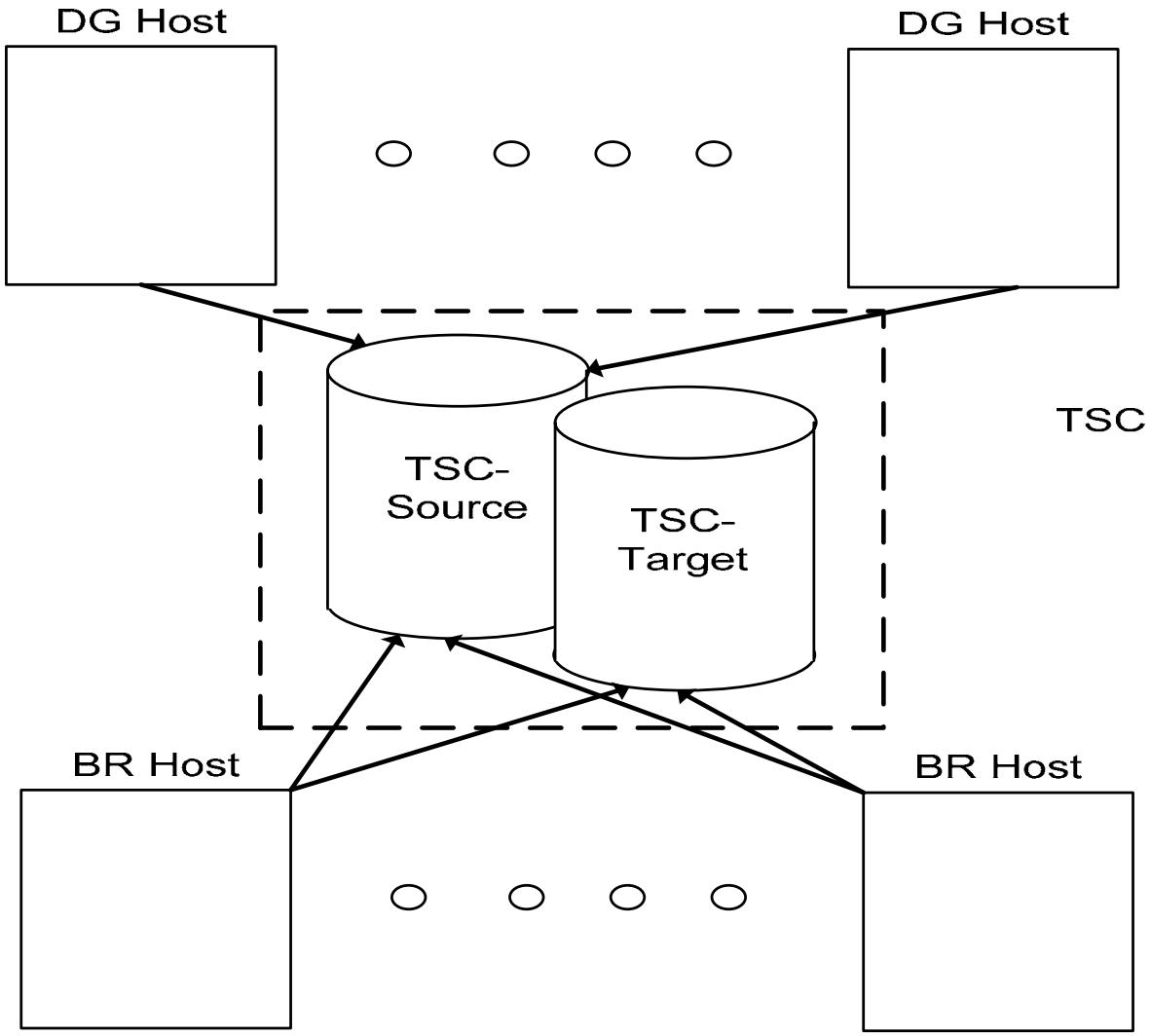
Table 3-9: File Aging Process Outline

Phase	Operations	Ending GDV	Fragmentation Likely?	
			File Set	Free Space
Initial Conditions	N/A	0%	No	No
Creation	Create	100%	No	No
Expansion	Append	112%	Yes	No
Reduction	Delete/Truncate	94%	Yes	Yes
Completion	Append/Create	100%	Yes	Yes

Clause 4 Benchmark Configuration (BC), Tested Storage Configuration (TSC), and Tested Storage Product (TSP)

4.1 Overview

Figure 4-1 Generic Benchmark Configuration



This clause defines the hardware and software configuration and components that are used by SPC-3BR as illustrated in Figure 4-1:

- The BENCHMARK CONFIGURATION (BC), defined in 4.2;
- The TESTED STORAGE CONFIGURATION (TSC), defined in 4.3;
- The TESTED STORAGE PRODUCT (TSP), defined in 4.4.

4.2 Benchmark Configuration (BC)

4.2.1 The Benchmark Configuration consists of all hardware and software components used in the execution of the SPC-3BR benchmark.

4.2.2 The BENCHMARK CONFIGURATION consists of the following components:

- One or more HOST SYSTEMS as defined in Clause 4.2.3.
- All hardware and software needed to communicate between the HOST SYSTEM(s) and TESTED STORAGE CONFIGURATION.
- System and Application Software, as defined in 4.2.4.
- The Tested Storage Configuration (TSC), defined in 4.3.
- The Tested Storage Product (TSP) defined in 4.4.

4.2.3 Host System(s)

4.2.3.1 Each computer system in the BENCHMARK CONFIGURATION shall be used in one or more of the following roles:

- Data Generation, defined in 4.2.3.4;
- Backup/Restore, defined in 4.2.3.5.1.

4.2.3.2 Each HOST SYSTEM in the BENCHMARK CONFIGURATION shall be employed in at least one role. A host system may be employed in both roles.

4.2.3.3 A BENCHMARK CONFIGURATION may contain more than one host system.

4.2.3.4 Data Generation Hosts

4.2.3.4.1 A Data Generation host (DG HOST) is used to execute the SPC-3BR data generator as part of the data load test (see 6.7.3).

4.2.3.4.2 A DG HOST shall be connected to the TSC-Source (see 4.3.2).

4.2.3.4.3 A DG HOST shall be present in the BENCHMARK CONFIGURATION during the execution of the data load test. It may be removed for other tests, unless it is serving as a BR host.

4.2.3.5 Backup/Restore Hosts

4.2.3.5.1 A Backup/Restore Host (BR HOST) is used to execute the backup or restore application(s) used in the execution of the backup test and the restore test (see 6.7.3.4 and 6.7.5).

4.2.3.5.2 A BR Host shall be connected to the TSC-Source and TSC-Target (see 4.3.2 and 4.3.3).

4.2.3.5.3 A BR Host shall be present in the BENCHMARK CONFIGURATION during the execution of the backup and restore tests. It may be removed for the data load tests, unless it is serving as a DG host.

4.2.4 System and Application Software

4.2.4.1 System Software, which may include the Host System's operating system, is responsible for presenting and managing unique names that instantiate the FILESET, as well as organizing and managing the underlying File System(s) used to implement the APPLICATION LAYER.

4.2.4.2 System Software shall provide for error recovery, as well as all services needed to execute the SPC-3BR utilities and backup/restore functionality on the Benchmark Configuration.

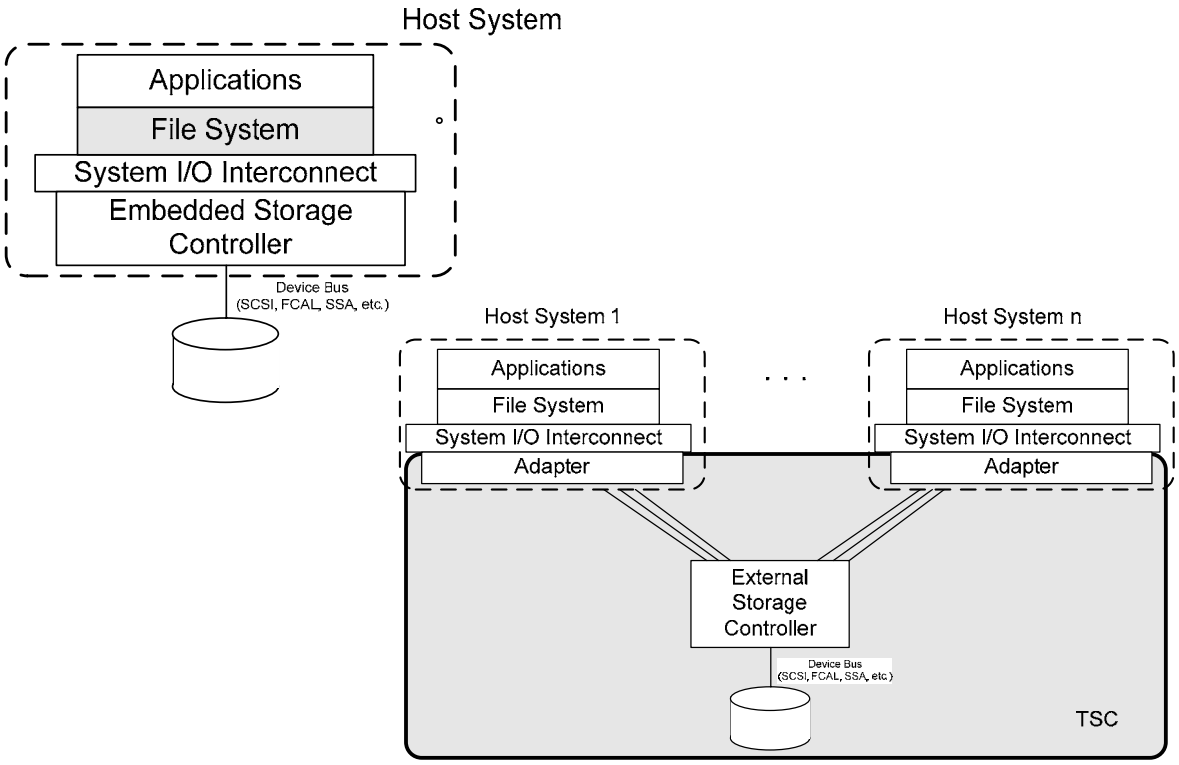
4.2.4.3 System Software may be used to implement RAID 0 (striping) and/or data protection functionality for any protected layers in the Storage Hierarchy, as defined in 2.2.2.

4.2.4.4 Application Software includes the required, commercially available SPC-3BR backup and restore functionality. Examples of Application Software that provides that required functionality include the following:

- An operating system component
- A distinct Host System component, which is included by default
- A distinct Test Sponsor or third-party product, which is required to be separately purchased.

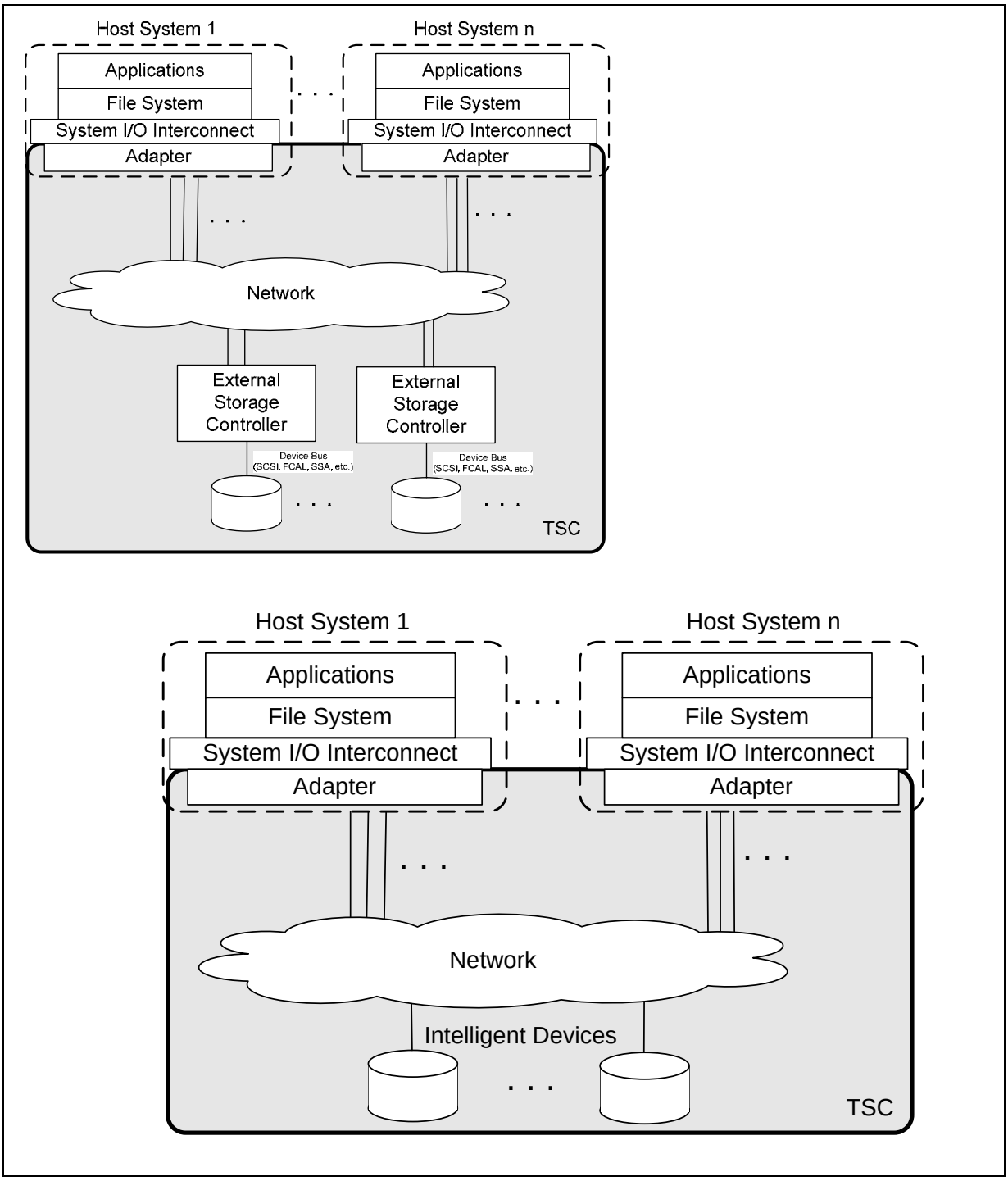
4.2.5 Benchmark Interconnect Examples

Figure 4-2 Direct Attached Configurations



SPC-3BR Test Sponsors may utilize a wide range of BENCHMARK CONFIGURATIONS. Figure 4-2 illustrates two direct attach configurations, one with an embedded storage controller and the other with an external controller. Figure 4-3 illustrates two network attached configurations, one with intelligent devices that include controller functionality and the other with external controllers.

Figure 4-3 Network Attached Configurations



These are examples of acceptable BENCHMARK CONFIGURATIONS, but should not be considered the only valid alternatives. A Test Sponsor may utilize a configuration that is different from the examples provided. In that case, the Test Sponsor is encouraged to contact the SPC prior to engaging in an Audit to ensure the proposed configuration will meet the SPC-3BR benchmark requirements.

4.3 The Tested Storage Configuration (TSC)

4.3.1 The Tested Storage Configuration consists of all software and hardware necessary to implement and support the performance tests defined in Clause 6. The TSC fulfills of two distinct roles:

- TSC-SOURCE defined in 4.3.2, and
- TSC-TARGET, defined in 4.3.3.

4.3.2 TSC-Source

4.3.2.1 The TSC-SOURCE consists of all software and hardware necessary to implement and support a complete STORAGE HIERARCHY as defined in Clause 2.

4.3.2.2 The PHYSICAL LAYER of the TSC-SOURCE shall be physically present at the benchmark location, and shall not be virtualized from other storage components that are not included in the BENCHMARK CONFIGURATION.

4.3.3 TSC-Target

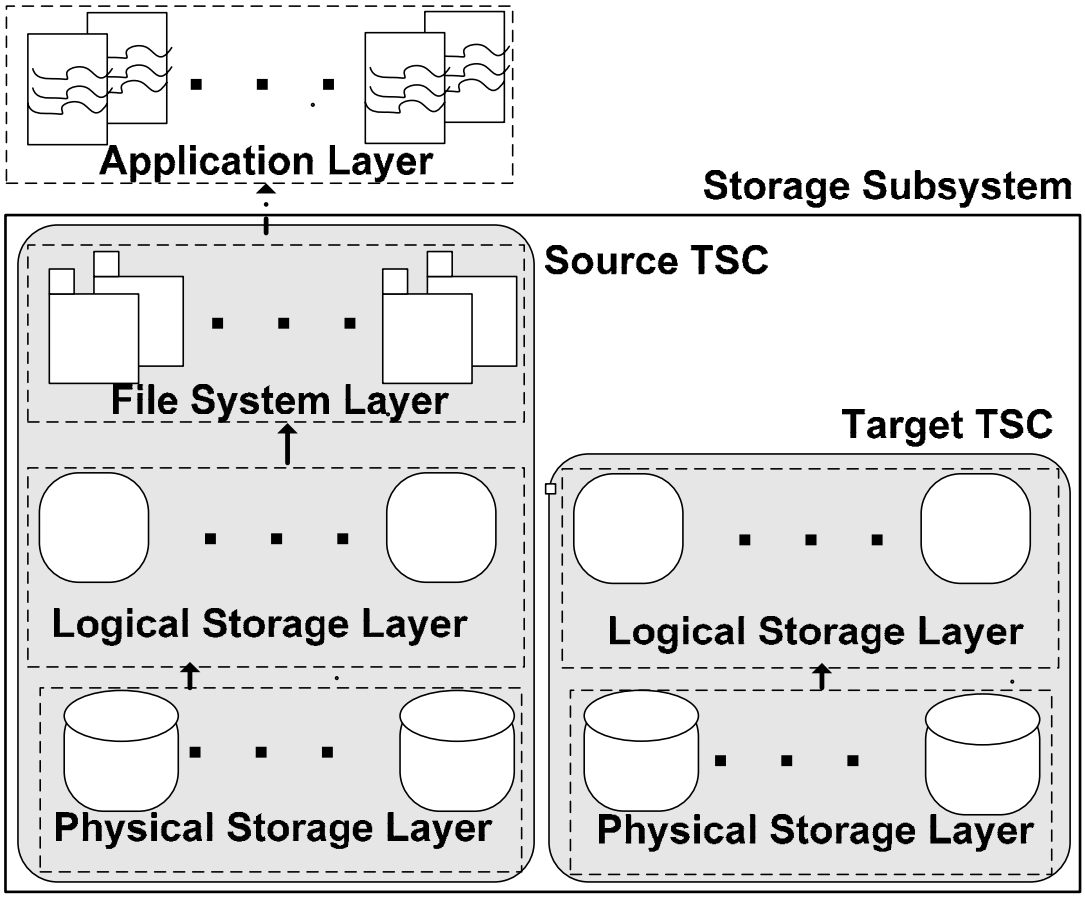
4.3.3.1 The TSC-TARGET consists of all software and hardware necessary to implement and support the storage repository that is the destination ("target") of the SPC-3BR backup operation.

4.3.3.2 While the TSC-TARGET is not required to implement a FILE SYSTEM LAYER, it shall include a PHYSICAL STORAGE LAYER, and any additional storage hierarchy layers that are necessary to implement the interfaces required by the backup and restore application used in the performance tests (see Clause 6).

4.3.3.3 The PHYSICAL LAYER of the TSC-TARGET shall be physically present at the benchmark location, and shall not be virtualized from other storage components that are not included in the BENCHMARK CONFIGURATION.

4.3.4 TSC-Source/TSC-Target – Single Storage Subsystem

Figure 4-4 Target and Source TSC on a Single Storage System



4.3.4.1 The TSC-Source and TSC-Target may reside on a single storage subsystem with or without formal partitioning.

4.3.4.2 The media used to define the PHYSICAL STORAGE LAYER for the TSC-Source shall be distinct from that used to define the PHYSICAL STORAGE LAYER for the TSC-Target (see 2.4)

4.3.4.3 When the TSC-SOURCE and TSC-TARGET are part of a single Storage Subsystem, components other than physical media (e.g., cache, interconnects, controllers) may be shared between the TSC-SOURCE and TSC-TARGET.

4.3.4.4 When the TSC-SOURCE and TSC-TARGET are part of a single Storage Subsystem, at least one of the GSL's in the TSC-TARGET shall have a protection level other than UNPROTECTED (see 2.2.2).

4.3.5 Host System as a TSC Component

Each Host System in the Benchmark Configuration (BC) must be included as a Tested Storage Configuration (TSC) component if any of the following conditions are true:

1. The Host System contains an integral component that is a TSC hardware component, which cannot be unplugged and moved to a different Host System.

2. The Host System contains storage devices that are connected internally as integral Host System components.

3. System Software that provides data protection functionality, as defined in 2.2.2.

An example of a TSC that includes the HOST SYSTEM as a TSC component is described in 4.2.4.1 and illustrated in Figure 4-5.

System Software, executing on a HOST SYSTEM, which provides RAID-0 (striping) functionality for the TSC will not require the Host System to be included as a TSC component.

Test Sponsors should request a recommendation from the Compliance Review Committee if the above wording does not clarify the TSC component status of a Host System in their Benchmark Configuration.

4.3.6 Multiple Storage Subsystem Configurations

A Test Sponsor may choose to configure the TSC-Source and/or the TSC-Target using multiple, independent storage subsystems. In such a configuration, the multiple, independent storage subsystems must comprise an actual orderable storage configuration that a customer would purchase and not a collection of individually orderable products.

If the TSC-Source is configured using multiple, independent storage subsystems, the File System Layer shall be configured across the storage subsystems and meet the requirements of Clause 2.

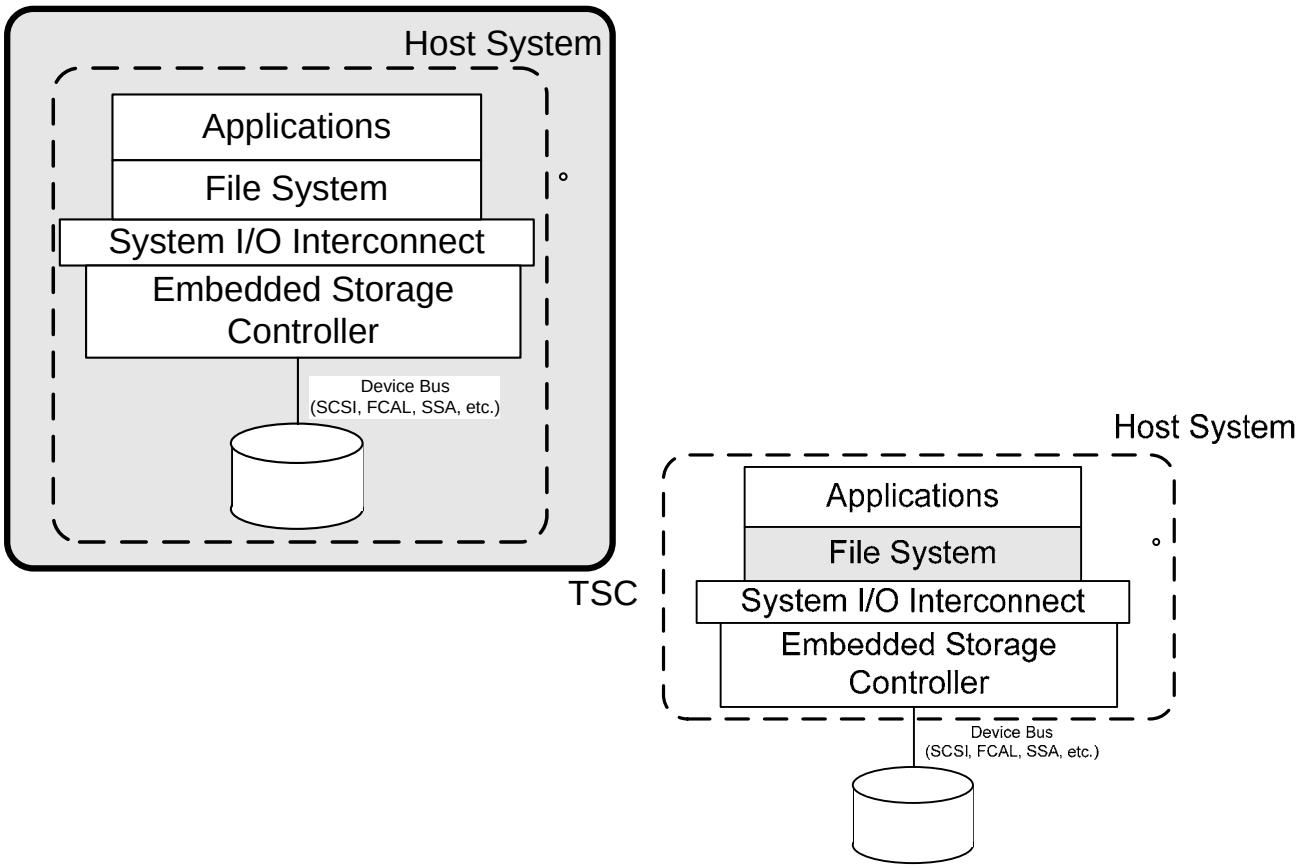
Comment: It is the intent of this clause that multiple, independent storage subsystems not be configured as a TSC-Source and/or TSC-Target solely for the purpose of this benchmark, which is prohibited in 0.2 and Clause 8. A TSC-Source and/or TSC-Target that is comprised of multiple, independent storage subsystems will be evaluated based on 0.2 and Clause 8 for compliance with this clause.

4.3.7 Tested Storage Configuration (TSC) Examples

4.3.7.1 Embedded Storage Controller – Embedded Storage Devices

This configuration is illustrated in Figure 4-5. While the following list is not exhaustive, components that comprise the TSC typically include:

Figure 4-5 Embedded Configurations



1. A storage controller that either plugs into a system I/O interconnect on the HOST SYSTEM or is an integral HOST SYSTEM component.

2. Batteries used to maintain power to cache/memory in the storage controller in the event of unexpected power failure.

3. Storage devices (e.g., disks) to provide the various levels of storage described in Clause 2. The storage devices may either be connected externally to the HOST SYSTEM or connected internally as an integral HOST SYSTEM component.

4. Cabling between the storage controller and the storage devices used to implement the STORAGE HIERARCHY.

5. All cabinetry used to house components of the TSC.

6. Environmental monitoring systems and related cabling used to monitor the health of components of the TSC.

7. Fans used to cool components of the TSC.

8. Power supplies and related cabling used to power components of the TSC.

9. Power distribution systems and related cabling in cabinetry used to route power to the individual component power supplies in the TSC.

10. All management software necessary to present the FILE SYSTEM LAYER to the SPC-3BR Workload Generator.

4.3.7.2 Embedded Storage Controller – External Storage Devices

This configuration is illustrated in Figure 4-5. While the following list is not exhaustive, components that comprise the TSC typically include:

1. A storage controller that plugs into a system I/O interconnect on the HOST SYSTEM.

2. Batteries used to maintain power to cache/memory in the storage controller in the event of unexpected power failure.

3. Cabling between the storage controller and the storage devices used to implement the STORAGE HIERARCHY.

4. All cabinetry used to house components of the TSC (excluding the cabinetry, cooling, power, and monitoring systems required to house the storage controller embedded in the HOST SYSTEM cabinet).

5. Environmental monitoring systems and related cabling used to monitor the health of components of the TSC.

6. Fans used to cool components of the TSC.

7. Power supplies and related cabling used to power components of the TSC.

8. Power distribution systems and related cabling in cabinetry used to route power to the individual component power supplies in the TSC.

9. All management software necessary to present the FILE SYSTEM LAYER to the SPC-3BR Workload Generator.

10. Storage devices (e.g., disks) to provide the various levels of storage described in Clause 2.

4.3.7.3 Network Storage, External Controller – External Storage Devices

This configuration is illustrated in Figure 4-3. While the following list is not exhaustive, components that comprise the TSC typically include:

1. One or more host bus adapters that connect the storage network into system I/O interconnect(s) on the HOST SYSTEM(S).

2. All network infrastructure including hubs, switches, bridges, routers, cables, connectors, as well as supporting cabinetry, cooling, power systems, and monitoring equipment/systems used to connect the storage controllers to the HOST SYSTEMS.

3. All software used to manage and maintain the network infrastructure.

4. External storage controllers or domain controllers including:

   a) Batteries used to maintain power to write cache in the storage controller in the event of unexpected power failure.

   b) Cabinetry used to house the storage controller.

   c) Monitoring systems and related cabling used to monitor the health of the storage controller.

   d) Equipment used to cool the storage controller.

   e) Power supplies and related cabling used to power the storage controller.

   f) Power distribution systems and related cabling used to route power to the storage controllers.

   g) All management software necessary to allow the storage controller to present the FILE SYSTEM LAYER to the SPC-3BR Workload Generator.

5. Storage devices (e.g., disks) to provide the various levels of storage described in Clause 2.

6. Cabling between the storage controller and the storage devices.

7. Cabinetry used to house the storage devices.

8. Monitoring systems and related cabling used to monitor the health of the storage devices.

9. Equipment used to cool the storage devices.

10. Power supplies and related cabling used to power the storage devices.

11. Power distribution systems and related cabling used to route power to the individual storage device power supplies.

12. All management software necessary to present and manage the FILE SYSTEM LAYER to the SPC-3BR Workload generator.

4.3.7.4 0 through 4.3.7.3 describe several typical TESTED STORAGE CONFIGURATIONS. A Test Sponsor may utilize a configuration that is different from the examples provided. In that case, the Test Sponsor is encouraged to contact the SPC prior to engaging in an Audit to ensure that the proposed configuration will meet the SPC-3BR benchmark requirements.

4.3.8 Benchmark Configuration Component Availability and Support

All hardware and software used in the Benchmark Configuration must be commercially available and supported either as individual items or as a part of a larger package. Hardware and software used in the Benchmark Configuration that is NOT included in the Tested Storage Configuration is exempt from the preceding requirement if it is no longer commercially available and/or supported due to obsolescence.

Comment: The intent is to allow the use of components in the Benchmark Configuration that were at one time commercially available and supported as long as the components are not a part of the Tested Storage Configuration.

4.4 The Tested Storage Product (TSP)

4.4.1 The Tested Storage Product (TSP) is a distinct, customer orderable product, which is the focal point of a SPC-3BR result.

The TSP shall have one of the following relationships to the TSC:

- The TSP encompasses the entire TSC-Source.
- The TSP is a component within the TSC-Source.
- The TSP encompasses the entire TSC-Target.
- The TSP is a component within the TSC-Target

4.4.2 Each SPC-3BR result shall be labeled with the formal name of the TSP.

Clause 5 Benchmark Tools

5.1 Overview

An SPC-3BR result must be produced using a valid SPC-3BR benchmark kit. The current SPC-3BR benchmark kit is available from the SPC to Test Sponsors. It includes:

- Benchmark Driver in machine executable format;
- Results Processing tools;
- Users' Guide.

The SPC-3BR Benchmark Driver is a user-space application, and can be run using either a single Host System or a collection of Host Systems that will collectively execute the benchmark against a common storage configuration. Functions of the SPC-3BR Workload Generator include:

- Creating an initial FILESET;
- Aging the FILESET;
- Validating an initial or restored FILESET.

5.2 Hosts

5.2.1 A computer system used to generate the FILESET is known as a DATA GENERATION HOST (see 4.2.3.4). A BENCHMARK CONFIGURATION that includes more than one DATA GENERATION HOST is known as a MULTI-HOST CONFIGURATION. A BENCHMARK CONFIGURATION that includes a single one DATA GENERATION HOST is known as a MONOLITHIC CONFIGURATION.

5.2.2 A DATA GENERATION HOST may execute one or more instances of the Benchmark Driver concurrently during a benchmark.

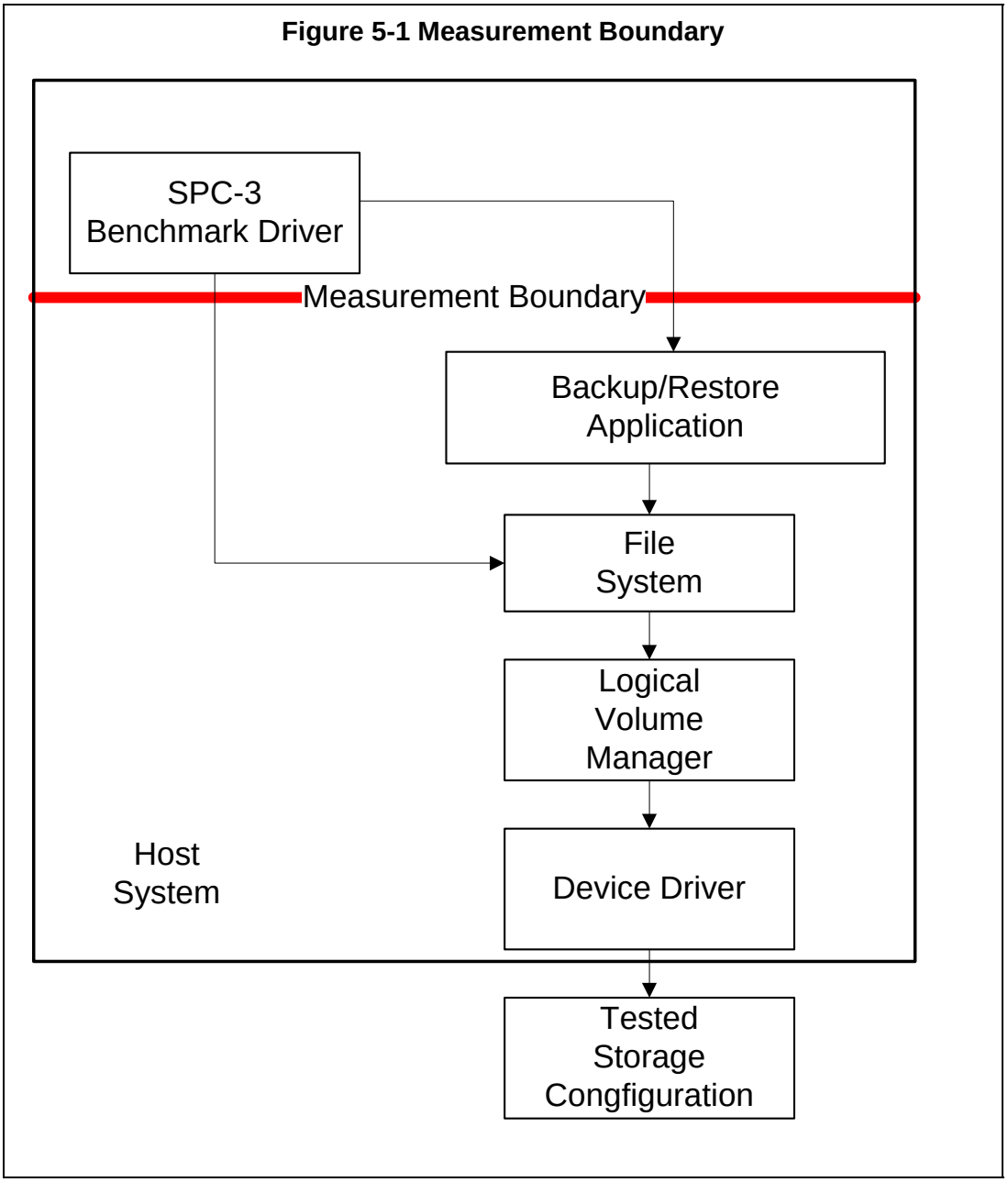
5.2.3 All instances of the Benchmark Driver shall be executed without any special privileges or permissions, other than the ability to access the FILE SYSTEMS being populated or validated. In particular, the application shall not be executed in a super-user or privileged user mode.

5.2.4 In a MULTI-HOST CONFIGURATION, the work presented to the TSC from all DATA GENERATION HOSTS shall be synchronized in time and preserve the workload parameters defined in Clause 3.

Comment: It is the intent of this clause that multiple Benchmark Drivers spread across multiple DATA GENERATION HOSTS effectively behave as a single Benchmark Driver relative to the workload offered to the TSC.

5.2.5 Measurement Boundary

Figure 5-1 Measurement Boundary



5.2.5.1 All SPC-3 environments employ the same MEASUREMENT BOUNDARY, the point within a benchmark configuration at which all performance data is gathered.

5.2.5.2 For SPC-3, the benchmark driver defines the MEASUREMENT BOUNDARY. The SPC-3BR benchmark driver and MEASUREMENT BOUNDARY are illustrated in Figure 5-1 Measurement Boundary

Clause 6 Test Measurement Requirements (Execution Rules)

6.1 Overview

This clause defines the precise steps required to produce a valid SPC-3BR benchmark measurement.

6.2 General Requirements

6.2.1 SPC Approved benchmark kit

An SPC-3BR result shall be produced using an approved SPC-3BR benchmark kit. The documentation included with the kit is to be considered an extension of this benchmark specification and describes the appropriate use of the SPC-3BR benchmark kit. The procedures, requirements, and constraints described in the kit documentation shall be adhered to in order to produce a SPC-3BR result.

6.2.2 BC Consistency

The physical and logical configuration of the BC, as well as all configuration and tuning parameters, shall not be changed between or during a test or test phase unless explicitly allowed in the definition of the test or test phase.

6.2.3 No Warm Up

Other than booting/starting the Host System(s), bringing storage online for use by the SPC-3BR benchmark kit and starting tools within the SPC-3BR benchmark kit, no substantive work shall be performed on the BC between SPC-3BR Tests or Test Phases unless explicitly allowed in the definition of the test or test phase.

Comment: It is the specific intent of this clause that Test Sponsors shall not warm up caches or optimize automated tuning parameters between Tests or Test Phases.

6.2.4 Audit

An SPC-3BR benchmark measurement shall successfully complete an Audit as defined in Clause 10 before it can be submitted to the SPC to become a SPC-3BR result.

6.3 Storage Configuration Requirements

6.3.1 TSC-Source

6.3.1.1 The TSC-Source shall implement a complete SPC-3BR Storage Hierarchy, as defined in Clause 2.

6.3.1.2 The Logical Storage Capacity shall not be greater than twice the chosen scale factor (see 6.4).

6.3.2 TSC-Target

6.3.2.1 The TSC-Target shall implement the storage hierarchy layers (as defined in Clause 2 above) that are necessary to completely define the storage devices and capacities used during the Backup Test (see 6.7.3.4) and the Recovery Test (see 6.7.5).

Comment: The data repository used as the target for the SPC-3BR backup process is not required to implement the complete SPC-3BR Storage Hierarchy.

6.4 Data Set Scaling Requirements

6.4.1 SPC-3BR defines a set of discrete scaling points ("SCALE FACTORS") based on the Generated Data Volume. The actual byte count may vary depending on individual hardware and software platforms.

6.4.2 The set of scale factors defined for SPC-3BR is:

- 100GiB,
- 300GiB,
- 1TiB,
- 3TiB,
- 10TiB,
- 30TiB,
- 100TiB,
- 300TiB,
- 1PiB.

where GiB is defined to be 2^{30} bytes, TiB is defined to be 2^{40} bytes, and PiB is defined to be 2^{50} bytes.

Comment: The maximum scale factor for a valid performance test is currently set at 1PiB. Sponsors wishing to test a larger configuration should contact the SPC.

6.4.3 Test sponsors shall choose a scale factor from the series defined in 6.4.2. Other scale factors shall not be used to produce an SPC-3BR result.

6.4.4 Test sponsors shall choose the largest scale factor that can fit within the FILE STORAGE CAPACITY of the TSC-SOURCE, assuming no UNUSED SPACE in the LOGICAL LAYER or PHYSICAL LAYER of the TSC-SOURCE.

6.4.5 The ratio of GDV to FSC shall be greater than or equal to 85%.

6.5 FILESET Generation Requirements

6.5.1 The FILESET used to populate the TSC-SOURCE shall be created using an SPC-approved data generator. File sets produced by other means shall not be used to produce SPC-3BR benchmark results.

6.5.2 The FILESET produced by an approved SPC-3BR data generator shall not differ significantly from the data model outlined in Clause 3.

Editors Note The precise tolerance for this requirement will be determined during prototyping.

6.5.3 The major version number of the data generation tool used to prepare the data set shall match the major version number of the specification against which any results produced with that data set are to be audited.

6.6 Data Gathering Requirements

6.6.1 This section outlines the measurement data that shall be gathered during all SPC-3BR tests, test phases and test runs. Unless explicitly exempted in sections that follow, these rules and requirements shall be followed in all tests, test phases and test runs of a SPC-3BR execution. Any failure to satisfy a requirement that is not explicitly exempted in the sections that follow shall render the benchmark execution non-compliant.

6.6.2 All timestamps shall be captured at a resolution of at least 1 ms.

6.7 Test Execution

6.7.1 Common Test Phases

6.7.1.1 Overview

SPC-3BR defines two test phases that are used repeatedly in the course of the benchmark execution, File System Initialization (6.7.1.2) and Signature Creation (6.7.1.3). Whenever these test phases are encountered in the definition of a test execution (e.g., 6.7), they are to be executed in their entirety. Any disclosure requirements called for in the given test phase must be satisfied as part of documenting the invoking test.

6.7.1.2 File System Initialization

6.7.1.2.1 The File System Initialization Test Phase prepares the FILE SYSTEM LAYER of the TSC-Source to receive data that conforms to Clause 3. It is employed, both as part of the Data Set Creation Phase of the Data Load Test, and as part of the Data Restoration Phase of the Recovery Test.

Comment: This phase does not include the logical definition or creation of the storage elements on which the FILE SYSTEM LAYER is built (e.g., LUNS, Logical Volumes, etc). Their creation need only be accomplished once, in accordance with 6.3 and Clause 2.

6.7.1.2.2 The File System Initialization Test Phase begins when the script(s) or command(s) used to initialize the file system(s) on the TSC-Source are invoked.

6.7.1.2.3 The File System Initialization Test Phase ends when the script(s) or command(s) used to initialize the file system on the TSC-Source complete, and the TSC-Source is ready to store data that conforms to Clause 3.

6.7.1.2.4 If a single file system is created during file system initialization, the root of the file system is also the ROOT of the TSC component (i.e., TSC-Source or TSC-Target) being initialized. If multiple file systems are created during file system initialization, they shall share a common parent directory, the ROOT of the TSC.

6.7.1.3 Signature Creation

6.7.1.3.1 The Signature Creation Test Phase traverses the directory tree with a given root on the TSC-Source and produces a profile of its contents ("SIGNATURE") sufficient to assure its accuracy, completeness and conformance to the requirements of 3.2. It is employed at the completion of the Data Load Test, and in the Recovery Test.

6.7.1.3.2 The SPC-3BR benchmark kit shall be used to create a signature.

6.7.1.3.3 The Signature Creation Test begins when the directory at the named directory is opened.

6.7.1.3.4 The Signature Creation Test ends when the last byte of the signature is transferred to the requesting client system.

6.7.1.3.5 There shall be no changes made to the TSC-Source or its contents between the completion of the preceding Test Phase and the beginning of the Signature Creation.

6.7.2 General Test Execution Sequence

Each SPC-3BR benchmark execution shall include the following steps, executed in sequence:

13. A Data Load Test, defined in 6.7.3, during which an initial data population is created on the TSC-Source. The goal of this step is produce a data population that is compliant with the appropriate sections of Clause 3.

14. A Backup Test, defined in 6.7.3.4, during which an archive of the initial data population created during the Data Load Test is created on TSC-Target.;

15. A Restore Test, defined in 6.7.5, during which the archive from the Backup Test is used to recreate the initial data population on the TSC-Source.

6.7.3 Data Load Test

6.7.3.1 Overview

The Data Load Test is composed of the following phases, which shall be executed in sequence:

- Initialization of the TSC-Source, defined in 6.7.1.2.
- Creation of a data set defined in 6.7.3.2;
- Initial aging of that data set, defined in 6.7.3.3;
- Creation of a data set signature, defined in 6.7.3.4.

6.7.3.2 Data Set Creation Phase

6.7.3.2.1 The Data Set Creation Phase begins when the first data generation process is started, and ends when the complete FILESET has been written to the TSC-Source.

6.7.3.2.2 The generated FILESET shall be created at and below the ROOT of the TSC-Source.

6.7.3.2.3 Table 6-2 defines the minimum concurrency level for the Data Set Creation Phase. Data Set Creation shall employ at least the level of concurrency required for the selected Scale Factor.

Comment: The intent of this requirement is to assure that self-tuning storage system do not see an undue performance gain due to the limit nature of a benchmark environment.

Table 6-1 Data Set Creation Concurrency Requirements

Scale Factor	Concurrency	Scale Factor	Concurrency
100 GiB	4	30 TiB	128
300 GiB	8	100 TiB	256
1 TiB	16	300 TiB	512
3 TiB	32	1 PiB	1024
10 TiB	64		

6.7.3.3 Initial Aging

6.7.3.3.1 Initial File Aging begins after the completion of the Data Set Creation Phase, and ends when the data set has been aged according to the process defined in 3.3, and all outstanding data has been written to the TSC-SOURCE.

6.7.3.3.2 Table 6-2 defines the minimum concurrency level for each phase in File Aging. Initial Data Set Aging shall employ at least the level of concurrency required for the selected Scale Factor.

Comment: The intent of this requirement is to assure that self-tuning storage system do not see an undue performance gain due to the limit nature of a benchmark environment.

Table 6-2 Initial Aging Concurrency Requirements

Scale Factor	Concurrency	Scale Factor	Concurrency
100 GiB	4	30 TiB	128
300 GiB	8	100 TiB	256
1 TiB	16	300 TiB	512
3 TiB	32	1 PiB	1024
10 TiB	64		

6.7.3.4 Signature Creation

6.7.3.4.1 A signature of each file system populated during the data population phase shall be created after the completion of the File Aging Test Phase, according to the process defined in 6.7.1.3.

6.7.3.4.2 If multiple data generation hosts are used in the benchmark configuration, each data generation host shall produce a signature for each file system that it populated.

6.7.4 Backup Test

6.7.4.1 Overview

The Backup Test creates a self-sufficient, physically distinct copy of the FILESET created during the Data Load Test ("ARCHIVE"). The identical ARCHIVE is then used in the Recovery Test (see 6.7.5). The Backup Test consists of:

- Creation of FILESET signatures, as defined in 6.7.4.8;
- Initialization of the TSC-Target;
- Creation of an ARCHIVE on the TSC-Target.

6.7.4.2 Any commercially-available tool or application may be used to produce the archive.

6.7.4.3 The Backup Test begins when the selected tool is invoked.

6.7.4.4 The Backup Test ends when the tool has terminated and an archive has been created on the TSC-Target.

6.7.4.5 The FILESET created on the TSC-Source shall be unchanged between the completion of the Data Load Test and the completion of the Backup Test.

6.7.4.6 The physical layout of the BC shall not be changed between the completion of the Data Load Test and the start of the Backup Test except for the following modifications:

- Removal of DG HOST;
- Addition of BR HOSTS;
- Alteration of the connections between the TSC and the hosts.

Comment: No changes may be made to the underlying storage configuration.

6.7.4.7 The Backup Test shall not employ snapshot-based backup except as part of a larger process that produces a self-sufficient, physically distinct copy of the FILESET. Mechanisms that rely on pointers and other data references that would be invalidated by the loss of the TSC-SOURCE data shall not be used.

6.7.4.8 Each Backup Host that was not employed as a data generation host shall produce a SIGNATURE of each file system used to hold the FILESET, using the process defined in 6.7.1.3.

6.7.5 Recovery Test

6.7.5.1 Overview

The Recovery Test restores the ARCHIVE created during the Backup Test, recreating the FILESET created during the Data Load Test on the TSC-SOURCE. The Recovery Test is composed of the following phases, which shall be executed in sequence:

- Initialization of the TSC-Source, defined in 6.7.1.2;
- Creation of validation files, defined in 6.7.5.2;
- Restoration of the backup created during the Backup Test, defined in 6.7.5.3;
- Creation of recovery signatures, defined in 6.7.5.4;

- Verification of validation files, as defined in 6.7.5.2.

6.7.5.2 Validation Files

6.7.5.2.1 Following the initialization of the TSC-Source and prior to the restoration of the backup created during the Backup Test, the SPC-3BR workload generator shall be used to create a set of files that are distinct from the FILESET, but whose root shall be the same as that used to create the FILESET during the Data Load Test ("VALIDATION FILES").

6.7.5.2.2 If the BC includes multiple BR HOSTS, a unique set of validation files shall be created by an invocation of the SPC-3BR benchmark driver on each BR HOST.

6.7.5.2.3 Following the creation of the VALIDATION FILES, the SPC-3BR workload generator shall be used to create a signature of them.

6.7.5.2.4 If the BC includes multiple BR HOSTS, a signature of the validation files shall be created from each BR HOST.

6.7.5.2.5 Following the restoration of the backup created during the Backup Test, the SPC-3BR workload generator shall be used to create a signature of the VALIDATION FILES. This signature shall match that created in 6.7.5.2.3.

Comment: The intent of this requirement is to assure that the restoration of the backup has preserved any prior contents of the target file system, as required in 6.7.5.3.5.

6.7.5.3 Restoration Test Phase

6.7.5.3.1 The Restoration Test Phase shall recreate the FILESET present on the TSC-SOURCE at the conclusion of the Data Load Test.

6.7.5.3.2 Any commercially-available tool or application may be used to restore the archive.

6.7.5.3.3 The Restoration Test Phase begins when the selected tool is invoked.

6.7.5.3.4 The Restoration Test Phase ends when the file set present on the TSC-Source at the conclusion of the Data Load Test has been recreated and the tool has terminated.

6.7.5.3.5 The restoration process used shall access the archive created during the Backup test on a file-by-file basis, and make no assumptions about the underlying type, configuration or size of the file system or storage configuration to which the archive is being restored.

Comment: It is the intent of this clause to explicitly prohibit the use of a block-oriented, image restore, and to require the use of a file-oriented, logical restore that would allow the migration of the source data set from one storage or file system configuration to another.

6.7.5.3.6 No file system activity shall occur on the TSC-Target between the completion of the Backup Test and the start of the Restoration Test Phase.

6.7.5.4 Recovery Signatures

6.7.5.5 A signature of the FILESET shall be created on each BR HOST following the completion of the Restoration Test Phase, according to the process defined in 6.7.1.3.

6.7.5.6 The signature shall use the root directory that was employed for signature creation during the Data Load Test (see 6.7.3.4).

6.7.5.6.1 If multiple file systems were populated during the data load test, a signature shall be produced for each file system.

6.7.5.6.2 The signatures created at the completion of the Restoration Test Phase shall match those created at the conclusion of the Data Load and Backup Tests.

Clause 7 Reported Metrics

7.1 Overview

The Reported Metrics clause defines the primary metrics for each SPC-3BR workload or environment for which a result may be produced, along with the constraints under which a benchmark sponsor is allowed to reference SPC-3BR results.

7.2 Primary Metrics

7.2.1 SPC-3BR defines five primary metrics:

- SPC-3BR BGH: SPC-3BR Backup Gigabytes per Hour, defined in 7.2.2;
- SPC-3BR RGH: SPC-3BR Recovery Gigabytes per Hour, defined in 7.2.3;
- Total System Price, defined in 8.2.3.2;
- SPC-3BR Backup Price-Performance, defined in 7.2.4;
- SPC-3BR Recovery Price-Performance, defined in 7.2.5

Each metric is reported in conjunction with the SCALE FACTOR used to produce it (see 9.8).

7.2.2 The SPC-3BR BGH is the average, effective data transfer rate during the Backup test, defined as:

$$BGH = \frac{GDV * 3600}{T_{end} - T_{begin}}$$

Where:

GDV is the Generated Data Volume, defined in 3.2.1.2
T_{begin} and T_{end} are the beginning and ending timestamps, respectively, for the Backup test, as defined in 6.7.4.

7.2.3 The SPC-3BR RGH is the average, effective data transfer rate during the Restore test, defined as:

$$RGH = \frac{GDV * 3600}{T_{end} - T_{begin}}$$

Where:

GDV is the Generated Data Volume, defined in 3.2.1.2
T_{begin} and T_{end} are the beginning and ending timestamps, respectively, for the Restore test, as defined in 6.7.5.

7.2.4 The SPC-3BR Backup Price Performance is defined as:

$$\text{Price-Performance} = \frac{\text{Price}}{BGH}$$

Where:

Price is the Total System Price*, defined in 8.2.3.2*
BGH is the SPC-3BR BGH, defined in 7.2.2

7.2.5 The SPC-3BR Recovery Price Performance is defined as:

$$\text{Price-Performance} = \frac{\text{Price}}{RGH}$$

Where:

Price is the Total System Price*, defined in 8.2.3.2*
RGH is the SPC-3BR RGH, defined in 7.2.3

7.3 Secondary Metrics

No secondary metrics have been defined for the SPC-3BR.

7.4 Usage Requirements

7.4.1 All external references to an SPC-3BR result shall include the GDV, as defined in 3.2.1.2, stated in gigabytes. When the GDV is included in accompanying text, it shall be identified as "Data Volume of xxx GiB". Alternatively, the GDV may be stated as a suffix to each primary and secondary metric that is referenced (e.g., "600 SPC-3BR BGH @ 300GiB")

7.4.2 All external references to an SPC-3BR result shall include the system price for the TSC, as defined in 8.2.3.1, accompanied with the appropriate symbol for local pricing, and identified as "System Price".

7.4.3 All external references to an SPC-3BR result shall include the primary metrics as defined in the sections that follow.

7.4.4 Test sponsors that publish or market an SPC-3BR result shall insure that:

1. The PRICED STORAGE CONFIGURATION, the SYSTEM PRICE for the TSC and all primary metrics (collectively, RESULTS INFORMATION) appear as a complete and coupled set of information using the same font style, font size, and text clarity.

2. An appropriately and clearly labeled SPC audit certification identifier appears with the RESULTS INFORMATION.

7.4.5 The SPC-3BR RESULTS INFORMATION must appear in the same paragraph and on the same page (or set of adjacent items in a single list) when externally communicating an SPC-3BR performance result. In addition, the results information and Audit Certification Number must be published in sequence per the examples defined for each workload. Sample wording is provided in subsequent sections.

Comment: The bold formatting in the examples is added for editorial emphasis. That specific formatting is not required for the items that are reported.

7.4.6 A given document, article, presentation, or publication may reference an individual benchmark result provided that the reference follows a paragraph which satisfies the requirements of 7.4.5.

7.4.7 Fair Metric Comparison

Results at the different scale factors may not comparable. The set of scale factors defined in 6.4 have been selected to provide appropriate separations between configurations of differing capacities and capabilities. Given the substantially different operational demands placed on configurations of widely different sizes, performance and price /performance may not scale down linearly with a decrease in data volume.

If results produced at different scale factors appear in a printed or electronic communication, then each reference to a result or metric shall clearly indicate the scale factor at which it was produced. In particular, all textual references to SPC-3BR metrics (performance or price/performance) appearing must be expressed in the form that includes the scale factor as an integral part of the metric's name; i.e. including the "@size" suffix. This applies to metrics quoted in text or tables as well as those used to annotate charts or graphs. If metrics are presented in graphical form, then the scale factor used to produce the metric must be immediately discernible either by appropriate axis labeling or data point labeling.

In addition, the results must be accompanied by a disclaimer stating:

" SPC-3BR results produced at different scale factors may not be comparable. ".

7.4.8 Referencing a Single SPC-3BR Result

Any one of the five SPC-3BR Primary Metrics may be used in public reference as a lead item or point of emphasis under the following conditions:

1. At some point in the public reference, all five SPC-3BR Primary Metrics must be stated

2. In addition to the five SPC-3BR Primary Metrics, the Total System Price, TSP category, and SPC-3BR Audit Identifier must be stated.

3. If the public reference consists of printed or displayed materials, the required items in #1 and #2 must appear as a set of information using the same font style, font size, and text clarity. The set of information may appear as a text paragraph or table of information.

7.4.9 Comparing Two or More SPC-3BR Results

Any element in the SPC-3BR Primary Metrics may be used in public reference to compare two or more SPC-3BR results under the following conditions:

1. At some point in the public reference, all five SPC-3BR Primary Metrics must be stated for each SPC-3BR result used in the comparison.

2. In addition to the three SPC-3BR Primary Metrics, the Total System Price, TSP category, and SPC-3BR Audit Identifier must be stated for each SPC-3BR result used in the comparison.

3. If the public reference consists of printed or displayed materials, the required items in #1 and #2 must appear as a set of information using the same font style, font size, and text clarity. The set of information may appear as a text paragraph or table of information.

Clause 8 Pricing

8.1 Overview

This clause defines the components and methodology necessary to calculate required SPC-3BR pricing information. The fundamental premise of this clause is that what is tested is priced and what is priced is tested.

8.2 Definitions

8.2.1 Tested Storage Configuration (TSC)

The TSC represents the physical configuration that is physically present during the benchmark measurement. The TSC, when used in pricing, must represent a customer orderable configuration. To allow the use of a valid measurement configuration that may not represent a customer orderable configuration, this clause will distinguish between the TSC and PRICED STORAGE CONFIGURATION.

8.2.2 PRICED STORAGE CONFIGURATION

The PRICED STORAGE CONFIGURATION represents a customer orderable configuration. If the TSC, without modification, is customer orderable, it is also the PRICED STORAGE CONFIGURATION.

In cases where the TSC is a valid measurement configuration but not a customer orderable configuration, the TSC and PRICED STORAGE CONFIGURATION will differ. In those cases, the PRICED STORAGE CONFIGURATION will be comprised of the TSC with the appropriate components added or deleted to create a customer orderable configuration.

For example, consider a configuration in which a portion of the Physical Storage Capacity (see 2.4.2.3) is not physically connected to the TSC, and the TSC can be ordered without that unused storage. In this case, the PRICED STORAGE CONFIGURATION would not include the unused storage.

A second example would be a configuration in which all of the Physical Storage Capacity is used in the benchmark, but that specific storage capacity is not orderable. The amount of storage included in the pricing would be adjusted to create an orderable configuration, again resulting in a PRICED STORAGE CONFIGURATION that differs from the TSC.

In those cases where there is deletion or addition of components to create a customer orderable configuration, the customer orderable configuration must be capable of providing at least the same level of reported performance as the TSC.

Comment: The intent of this requirement is to ensure that any component change to the TSC be performance-neutral.

8.2.3 Priced Components

8.2.3.1 General Requirements

The components to be priced include the hardware and software components present in the TSC, any additional operational components required by the TSC, and three-year maintenance on all of the above components.

8.2.3.2 Total System Price

Calculation of the three-year pricing, known as TOTAL SYSTEM PRICE, includes:

- The cost of the PRICED STORAGE CONFIGURATION as defined in 8.2.2.
- The cost of additional products (software or hardware) required for customary operation, administration and maintenance of the TSC for a period of three years.

8.2.3.3 Host Pricing

HOSTS used solely for data generation and not used in the backup test or the recovery test may be excluded from the pricing calculation.

HOSTS used in the backup test or the recovery test (BR HOSTS) must be included in the pricing calculation, along with all system and application software required for the HOST(s) to participate in the test(s).

8.2.4 Additional Operational Components

8.2.4.1 Additional products explicitly required for the operation, administration, or maintenance of the PRICED STORAGE CONFIGURATION must be included.

8.2.4.2 Copies of the software used by the TSC, on appropriate media, and a software load device, if required for initial load or maintenance updates, must be included.

8.2.4.3 The price of all cables used to connect components of the TSC must be included.

8.2.5 Maintenance

8.2.5.1 Hardware maintenance and software support, no matter what it is called by the vendor, provides the following:

- Acknowledgement of new and existing problems within four (4) hours.
- On-site presence of a qualified maintenance engineer or provision of a customer replaceable part within four (4) hours of the above acknowledgement for any hardware failure that results in an inoperative PRICED STORAGE CONFIGURATION that can be remedied by the repair or replacement of a PRICED STORAGE CONFIGURATION component. In either case, the remedy will result in resumption of operation.

Comment: Resumption of operation means the PRICED STORAGE CONFIGURATION must be returned to the same state/configuration that was present before the failure.

- Commitment to fix software defects within a reasonable time.

8.2.5.2 The maintenance pricing must be independent of actual failure rates over the three-year period, no matter how many failures occur during that period. The use of Mean Time Between Failure (MTBF) data to directly compute the maintenance cost for this benchmark is precluded. The hardware maintenance pricing requirements cannot be met by pricing based on the cost to fix specific failures, even if the failure rate is calculated from MTBF data.

8.2.5.3 Hardware maintenance and software support must be configured using standard pricing which covers 7 days per week, 24 hours per day coverage, either on-site, or if available as standard offering, via a central support facility for a duration of at least three years (36 months).

8.2.6 Pricing Methodology

The pricing methodology must reflect the cost of operation of the PRICED STORAGE CONFIGURATION using packages and discounts commonly practiced and generally available products. This cost must be disclosed in a line item fashion using local pricing.

8.2.7 Packages and Discounts

Packaging and pricing that are generally available to customers are acceptable. Promotional and/or limited availability offerings are explicitly excluded. Revenue discounts based on total price are permissible. Any discount must be only for the configuration being priced and cannot be based on past or future purchases. Individually negotiated discounts are not permitted. Special customer discounts (e.g., GSA schedule, educational schedule) are not permitted. This is a one time, stand-alone purchase.

8.2.7.1 Generally available discounts for the priced configuration are allowed.

8.2.7.2 Generally available packaged pricing is allowed.

8.2.7.3 Assumptions of other purchases, other sites with similar systems, or any other assumption that relies on the principle that the customer has made any other purchase from the vendor are specifically prohibited.

8.2.7.4 Local retail pricing and discount structure shall be used in each country for which results are published.

8.2.7.5 Price shall be represented by the currency with which the customer would purchase the system.

8.2.7.6 For all hardware components used in the priced system, the cost must be the price of a new component (i.e., not reconditioned or previously owned).

8.2.7.7 For Test Sponsor(s) who have only indirect sales channels, pricing must be actual generally available pricing from indirect channels that meet all other requirements of Clause 8.

8.2.7.8 Maintenance may be bundled as a component of package pricing. In that case, the maintenance component of the package must be clearly identified in the description of the bundle/package. A Test Sponsor may also include a standard multi-year maintenance option as a separately priced component. In cases where there is not such a ‘bundling’ of maintenance or a standard multi-year maintenance options is not available, the three-year maintenance cost shall be computed as three times the one-year maintenance cost. If maintenance is priced in that manner, a discount based on pre-payment in excess of 12 months is prohibited.

8.2.8 Product Availability

8.2.8.1 The PRICED STORAGE CONFIGURATION is the actual configuration the customer would purchase. However, vendors may announce new products and disclose benchmark results before new products have actually shipped. This is allowed, but any use of benchmark-special implementations is specifically disallowed (see 0.2).

8.2.8.2 Requirements from 0.2 must be fulfilled with respect to the set of possible customers (users) in the country where the PRICED STORAGE CONFIGURATION is priced

8.2.8.3 All hardware and software used in the calculations must be announced and generally orderable by customers.

8.2.8.4 Each product or collection of products that comprise the PRICED STORAGE CONFIGURATION shall have an Availability Date, the date by which all requirements of 0.2 will be fulfilled for that product or configuration, including delivery for general availability.

8.2.8.5 The PRICED STORAGE CONFIGURATION Availability Date and an availability date for any product not already generally available must be disclosed.

8.2.8.6 The PRICED STORAGE CONFIGURATION Availability Date must not exceed three months beyond the Full Disclosure Report submittal date.

Comment: The essence of the PRICED STORAGE CONFIGURATION Availability Date is the ability to take physical delivery of an integrated configuration that is identical to the priced configuration, achieves the tested performance, and demonstrates fulfillment of all the requirements of this specification.

8.2.8.7 The Test Sponsor must disclose all effective date(s) of the reported prices.

8.2.9 Third-Party Pricing

8.2.9.1 In the event that any hardware, software, or maintenance is provided by a third party not involved as a Test Sponsor of the benchmark, the pricing must satisfy all requirements for general availability, standard volume discounts, and full disclosure.

8.2.9.2 The Test Sponsor is required to clearly identify all the items, components and services that are not acquired from the Test Sponsor. Any third party supplier's items and prices, including discounts, are subject to the same disclosure requirements as those components supplied by the Test Sponsor. Discounts shall not be dependent on purchases from any other suppliers.

8.2.9.3 Any pricing that is not directly offered by the Test Sponsor and not derived from the third party supplier’s generally available pricing and discounts must be guaranteed by the third party in a written price quotation. The quotation must be valid for a period not less than 60 days from the date the results are submitted.

8.2.9.4 Third party's written quotations must be included in the Full Disclosure Report and must state:

- That the quoted prices are generally available;
- The time period for which the prices are valid;
- The basis of all discounts;
- Any terms and conditions that apply to the quoted prices.

8.2.10 Pricing Spreadsheet

8.2.10.1 The pricing spreadsheet details how the three-year cost of ownership is computed. It contains the prices, discounts, warranty information, and maintenance cost for all the hardware and software components in the PRICED STORAGE CONFIGURATION. Price disclosure shall be presented in a structured fashion to enhance clarity and comparability between test results.

8.2.10.2 The REFERENCE PRICE of a component or subsystem is defined as the price at which it could be ordered individually from the vendor or designated third-party suppler.

8.2.10.3 The pricing spreadsheet shall include the following items for each component in the PRICED STORAGE CONFIGURATION:

- Part name or brief description
- Part number
- Source of the component, whether from a Test Sponsor or a third party (note: this can be a index into a list of component sources provided that list is included in the pricing spreadsheet)
- Reference price of the component (see 8.2.10.2)
- Quantity of the component used in the PRICED STORAGE CONFIGURATION.
- The extended price of the component, based on the reference price of the component, the quantity included in the PRICED STORAGE CONFIGURATION and any component-level discounting.
- Three-year maintenance cost (including any discount for pre-payment, see Clause 8.2.7.8), or a notation that maintenance for the part is included in another maintenance charge.
- If the component is a bundle/package of parts, as allowed by Clause 8.2.7, the above items apply to the bundle but each item in the bundle/package must be clearly identified in the description of bundle/package.
- Components required to configure the PRICED STORAGE CONFIGURATION that have an aggregate price less than 0.1% of the PRICED STORAGE CONFIGURATION may be listed as a single line item with a description of the collection of components, e.g., "Miscellaneous Cables."

8.2.10.4 The total price of the PRICED STORAGE CONFIGURATION and its associated three-year maintenance cost, rounded to the nearest whole dollar amount, shall be included in the pricing spreadsheet.

8.2.10.5 The percentage, amount, and basis (including type and justification) of all discounts listed must be disclosed. A tabular summary may be employed to simplify the presentation.

Comment: Thresholds for such discounts need not be disclosed.

8.2.10.6 While package pricing is allowed, the level of discount obtained through such packages shall be disclosed by reporting the individual reference price for each component in the pricing spreadsheet (see 8.2.10.2).

Comment: This requirement does not apply to components that are not sold separately, other than as repair parts.

Clause 9 Full Disclosure

9.1 General Requirements

9.1.1 Scope and Intent

The FULL DISCLOSURE REPORT (FDR) shall provide sufficient information to allow the independent recreation of an SPC-3BR result by a knowledgeable reader.

9.1.2 FDR Submission

A FDR shall be submitted to the SPC Administrator for each SPC-3BR benchmark Result.

9.1.3 Document Submission

The FDR shall be submitted electronically as an Adobe PDF file after successful completion of the required SPC-3BR Audit and prior to any public use of the benchmark information..

9.1.4 Document Format

9.1.4.1 The FDR shall consist of the content described in clauses 9.2 - 9.10.

9.1.4.2 The FDR shall be written in the English language. Each page of the FDR shall be formatted with a minimum of one inch side and top margins, one-half inch bottom margins, and each page shall be numbered.

9.1.4.3 Graphs, tables, and illustrations shall use a minimum of 8-point sans serif font such as Arial. The text of the FDR shall use a minimum of 10-point serif font such as Century Schoolbook.

9.1.5 Full Disclosure Report Availability

The FDR shall be readily available to the public at a reasonable charge, similar to charges for similar documents by that Test Sponsor. The Test Sponsor shall have on file with the SPC, submit with the FDR, or include as a part of the FDR, a release that allows public disclosure of the FDR content.

9.1.6 Organization

9.2 - 9.10 describe the required content of the FDR. The FDR content shall follow that same order and be organized under a hierarchy of headings that correspond to those clauses.

9.2 Front Matter

9.2.1 Title Page

The Title Page of the FDR will only contain the following information:

- Title: “SPC-3BR Benchmark Full Disclosure Report”
- The applicable SPC-3BR Benchmark Specification version
- The Test Sponsor’s name, corporate website URL, and, optionally, a company logo

- The formal TESTED STORAGE PRODUCT (TSP) name.
- The "Submitted for Review" notation and date, which designates the submission as a SPC-3BR benchmark result and the start of the 60-day Peer Review.
- The SPC-3BR Submission Identifier assigned to the benchmark result.

When a SPC-3BR benchmark result successfully completes the required 60-day Peer Review (see Clause 11.3), the Title Page of its FDR may be updated with the following information:

- The "Accepted" notation and date that the SPC-3BR benchmark result successfully completed its 60-day Peer review and transitioned from "Submitted for Review" to "Accepted".
- The SPC certified logo.

9.2.2 Table of Contents

The Table of Contents will identify the location of each 1st and 2nd level heading in the FDR.

9.2.3 Audit Certification

This section of the FDR shall contain a copy of the certification letter issued by the SPC Audit Service to the Test Sponsor for this execution of the SPC-3BR Benchmark. If the FDR is a revision to an existing FDR and contains changes to the original PRICED STORAGE CONFIGURATION, the revised FDR shall contain an amended certification letter that includes auditor review and approval of those changes.

9.2.4 Letter of Good Faith

This section of the FDR shall contain a copy of the Letter of Good Faith issued by the Test Sponsor to the SPC Audit Service for this execution of the SPC-3BR Benchmark. The Letter of Good Faith is required to be identical in format and content to the template in Appendix B with the appropriate changes specific to the benchmark submission (Test Sponsor name, TSC name, date, etc.). Any other changes in content and format must be approved by the SPC Compliance Review Committee (CRC) prior to the benchmark submission.

9.2.5 Executive Summary

The Executive Summary will consist of the content described in clause 9.10.

9.2.6 Contact Information

This table will contain contact information for the Test Sponsor, Co-Sponsors, and the SPC Auditor. The required content and format of the table is specified in Table 9-1.

Full Disclosure

Table 9-1: Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact (1)	Company, Company Web Address, Individual Name – Email Address Postal Address, Phone, FAX
Test Sponsor Alternate Contact (2)	Company, Company Web Address, Individual Name – Email Address Postal Address Phone, FAX
Co Sponsor(s) (3)	Company, Company Web Address, Individual Name – Email Address Postal Address Phone, FAX
Auditor (4)	Company, Company Web Address, Individual Name – Email Address Postal Address Phone, FAX

Footnotes to Table 9-1:

1. *The Test Sponsor contact responsible for the submitted FDR. The primary Test Sponsor contact will be the first point of contact for any issues that may arise during the Peer Review Process.*

2. *The alternate Test Sponsor contact to be contacted only if the primary contact is not available.*

3. *An entry for each additional co-sponsor contact.*

4. *Contact information for the Auditor used to certify the SPC-3BR results.*

9.2.7 Revision Information and Key Dates

This table shall contain key dates and revision numbers associated with the SPC-3BR result. The required content and format of the table is specified in Table 9-2.

Table 9-2: Revision Information and Key Dates

Revision Information and Key Dates	
SPC-3BR Specification revision number (1)	nn.nn.nn
SPC-3BR Workload Generator revision number (2)	nn.nn.nn
Date Results were first used publicly (3)	mmmm dd, yyyy
Date FDR was submitted to the SPC (4)	mmmm dd, yyyy
Date revised FDR was submitted to the SPC (5) **Current revision text:** **Revision History:** **dd/mm/yyyy – revision text** **dd/mm/yyyy – revision text**	mmmm dd, yyyy
SPC-3BR Availability Date(6)	mmmm dd, yyyy
Date of completed audit certification (7)	mmmm dd, yyyy

Footnotes to Table 9-2:

1. *The revision number of the SPC-3BR Specification used to produce the results reported in this FDR.*
2. *The revision number of the Workload Generator used to produce the results reported in this FDR.*
3. *The calendar date that the results reported in this FDR were made public (i.e., used outside the Test Sponsors and Co-Sponsors companies).*
4. *The calendar date that the results reported in this FDR were submitted to the SPC.*
5. *The calendar date that a revised FDR was submitted to the SPC. The Revision History is a brief description of each revision.*
6. *The PRICED STORAGE CONFIGURATION Availability Date defined in 8.2.8.5.*
7. *The calendar date that the SPC-3BR Audit was successfully completed as documented by the Audit Certification Letter issued to the Test Sponsor.*

9.2.8 Results based on an existing SPC-3BR Result

The following table is required in the FDR of a new SPC-3BR Result that is based on an existing SPC-3BR Result ("BASIS"). The required content and format of the table is specified in Table 9-3.

Table 9-3: Basis SPC-3BR Result Information

Result Sponsor and Contact Information	
Basis Test Sponsor Primary Contact (1)	Company, Company Web Address, Individual Name – Email Address Postal Address Phone, FAX
Basis SPC-3BR Submission Identifier (2)	ZZZ-N
Submission Date of Basis SPC-3BR Result (3)	mmmm dd, yyyy
Status of the Basis SPC-3BR Result (4)	{Submitted for Review/Accepted}
Date the Basis SPC-3BR Result completed or will complete Peer Review (5)	mmmm dd, yyyy
Auditor for the Basis SPC-3BR Result (6)	Company, Company Web Address, Individual Name – Email Address Postal Address Phone, FAX

Footnotes to Table 9-3:

1. *The Test Sponsor contact responsible for the Basis SPC-3BR Result.*
2. *The SPC-3BR Submission Identifier of the Basis SPC-3BR Result.*
3. *The date the Basis SPC-3BR Result was submitted to the SPC.*
4. *The current Peer Review status of the Basis SPC-3BR Result.*
5. *The date the Basis SPC-3BR Result successfully completed Peer Review and transitioned to "Accepted" status or the scheduled date for that to occur.*
6. *The Auditor for the Basis SPC-3BR Result.*

9.3 Storage Hierarchy Items

9.3.1 An inventory of all physical storage used in the TSC shall be disclosed using the format of Table 9-4. There shall be one row in the table for each type of storage component (i.e., specific model of disk, tape, or memory) used to construct the storage hierarchy of the TSC. For components used in the TSC-SOURCE, the usage field shall be "Source". For components used in the TSC-TARGET, the usage field shall be "Target". If a component is used in both TSC-SOURCE and TSC-TARGET, usage shall be "Both", and an explanation shall be included in the notes column.

Table 9-4 Storage Component Inventory

Product ID	Count	Capacity (GB)	Usage	Notes
	nnn	nnn.nn	Source, Target or Both	

9.3.2 The allocation of storage capacity within each layer of the storage hierarchy of the TSC-SOURCE shall be disclosed using the format of Table 9-5.

Table 9-5 TSC-Source Capacity Allocation Summary

Storage Layer	Size (GB)	Available Space (GB)		Overhead (GB)	
		Published	Unused	System	Protection
File System	nnn.nn	nnn.nn	nnn.nn	nnn.nn	nnn.nn
Logical	nnn.nn	nnn.nn	nnn.nn	nnn.nn	nnn.nn
Physical	nnn.nn	nnn.nn	nnn.nn	nnn.nn	nnn.nn

9.3.3 The EFFICIENCY and PROTECTION LEVEL for each layer of the storage hierarchy of the TSC-SOURCE shall be disclosed using the format of Table 9-6. EFFICIENCY shall be reported as a percentage, with one digit to the right of the decimal point.

Table 9-6 TSC-Source Protection Summary

Storage Layer	Protection Level	Efficiency
File System	(see 2.2.2)	nn.n%
Logical	(see 2.2.2)	nn.n%
Physical	(see 2.2.2)	nn.n%

9.3.4 The allocation of storage capacity within each layer of the storage hierarchy of the TSC-TARGET shall be disclosed using the format of Table 9-7. Each capacity in the table shall be reported in GB, with two digits to the right of the decimal point. If the TSC-TARGET does not implement a given layer, the entries for that row in the table shall be blank.

Table 9-7 TSC-Target Capacity Allocation Summary

Storage Layer	Size (GB)	Available Space (GB)		Overhead (GB)	
		Published	Unused	System	Protection
File System	nnn.nn	nnn.nn	nnn.nn	nnn.nn	nnn.nn
Logical	nnn.nn	nnn.nn	nnn.nn	nnn.nn	nnn.nn
Physical	nnn.nn	nnn.nn	nnn.nn	nnn.nn	nnn.nn

9.3.5 The EFFICIENCY and PROTECTION LEVEL for each layer of the storage hierarchy of the TSC-TARGET shall be disclosed using the format of Table 9-8. EFFICIENCY shall be reported as a percentage, with one digit to the right of the decimal point. If the TSC-TARGET does not implement a given layer, the entries for that row in the table shall be blank.

Table 9-8 TSC-Target Hierarchy Summary

Storage Layer	Protection Level	Efficiency
File System	(see 2.2.2)	nn.n%
Logical	(see 2.2.2)	nn.n%
Physical	(see 2.2.2)	nn.n%

9.3.6 All transformations employed in the creation of the storage hierarchy of the TSC-Source shall be disclosed through either:

- Listing of scripts or commands used, or, if scripts or command-line interfaces were not used, or,
- if scripts or command-line interfaces were not used, a description of the process, tools or interfaces used, with sufficient detail to recreate storage hierarchy of the TSC-Source.

9.3.7 All transformations employed in the creation of the storage hierarchy of the TSC-Target shall be disclosed through either:

- Listing of scripts or commands used or,,
- if scripts or command-line interfaces were not used, a description of the process, tools or interfaces used, with sufficient detail to recreate storage hierarchy of the TSC-Source.

9.3.8 The disclosure provided to satisfy 9.3.6 and 9.3.7 shall include sufficient annotation or explanatory text to provide a knowledgeable reader with a high-level conceptual understanding of creation of the storage hierarchies within the TSC.

9.3.9 If the TSC-SOURCE employs multiple, independent storage subsystems, the allocation of the storage hierarchy layers between the different storage subsystems shall be disclosed using the format of Table 9-9, where:

- Subsystem shall contain a unique identifier for each independent storage subsystem within the TSC-SOURCE,
- Physical Layer shall contain the percentage of the size of the physical layer of the storage hierarchy reported in Table 9-5 that is provided by this storage subsystem, and shall be reported to a precision of two digits to the right of the decimal point
- Logical Layer shall contain the percentage of the size of the logical layer of the storage hierarchy reported in Table 9-5 that is provided by this storage subsystem, and shall be reported to a precision of two digits to the right of the decimal point
- Filesystem Layer shall contain the percentage of the size of the file system layer of the storage hierarchy reported in Table 9-5 that is provided by this storage subsystem, and shall be reported to a precision of two digits to the right of the decimal point

Table 9-9 TSC-SOURCE Storage Subsystem Mapping

Subsystem	Physical Layer	Logical Layer	Filesystem Layer
nnn	xx.xx%	xx.xx%	xx.xx%

9.3.10 If the TSC-TARGET employs multiple, independent storage subsystems, the allocation of the storage hierarchy layers between the different storage subsystems shall be disclosed using the format of Table 9-10, where:

- Subsystem shall contain a unique identifier for each independent storage subsystem within the TSC-TARGET,
- Physical Layer shall contain the percentage of the size of the physical layer of the storage hierarchy reported in Table 9-7 that is provided by this storage subsystem, and shall be reported to a precision of two digits to the right of the decimal point
- Logical Layer shall contain the percentage of the size of the logical layer of the storage hierarchy reported in Table 9-7 that is provided by this storage subsystem, and shall be reported to a precision of two digits to the right of the decimal point. If the TSC-TARGET does not implement a logical layer, the entry shall be blank.
- Filesystem Layer shall contain the percentage of the size of the file system layer of the storage hierarchy reported in Table 9-5 that is provided by this storage subsystem, and shall be reported to a precision of two digits to the right of the decimal point. If the TSC-TARGET does not implement a filesystem layer, the entry shall be blank.

Table 9-10 TSC-TARGET Storage Subsystem Mapping

Subsystem	Physical Layer	Logical Layer	Filesystem Layer
nnn	xx.xx%	xx.xx%	xx.xx%

9.4 Data Model Items

9.4.1 A comparison of the file size distribution in the FILESET created during the Data Load Test with that specified in 3.2.2.3 shall be disclosed using the format of Table 9-11, where:

- Measured Percentage shall be the value as reported by the FILESET signature created at the completion of the Data Load Test (see 6.7.3.4), stated as a percentage with three (3) digits to the right of the decimal point;
- Difference shall be: Measured Percentage – Specified Percentage

Table 9-11 File Size Distribution Comparison

File Size	Specified Percentage	Measured Percentage	Difference
0	2.708		
512B	40.525		
4KiB	72.348		
32KiB	91.744		
256KiB	98.294		
2MiB	99.508		
16MiB	99.892		
128MiB	99.971		
1GiB	99.984%		

9.4.2 A comparison of the file modification date distribution in the FILESET created during the Data Load Test with that specified in 3.2.2.4 shall be disclosed using the format of Table 9-12, where:

- Measured Percentage shall be the value as reported by the FILESET signature created at the completion of the Data Load Test (see 6.7.3.4), stated as a percentage with three (3) digits to the right of the decimal point;
- Difference shall be: Measured Percentage – Specified Percentage

Table 9-12 File Modification Date Distribution Comparison

Days	Specified Percentage	Measured Percentage	Difference
0	0		
15	41.5		
45	61.9		
90	74.6		
180	83.1		
365	88.9		
730	93.6		
1095	95.9		
1460	96.8		
1825	97.4		

9.4.3 A comparison of the file name length distribution in the FILESET created during the Data Load Test with that specified in 3.2.2.5 shall be disclosed using the format of Table 9-13, where:

- Measured Percentage shall be the value as reported by the FILESET signature created at the completion of the Data Load Test (see 6.7.3.4), stated as a percentage with one (1) digits to the right of the decimal point;
- Difference shall be: Measured Percentage – Specified Percentage

Table 9-13 File Name Length Distribution Comparison

File Name Length	Specified Percentage	Measured Percentage	Difference
1	1.0		
10	44.1		
20	79.0		
30	87.9		
40	95.5		
50	100.0		

9.4.4 A comparison of the directory depth distribution in the FILESET created during the Data Load Test with that specified in 3.2.2.6 shall be disclosed using the format of Table 9-14, where:

- Measured Percentage shall be the value as reported by the FILESET signature created at the completion of the Data Load Test (see 6.7.3.4), stated as a percentage with two (2) digits to the right of the decimal point;
- Difference shall be: Measured Percentage – Specified Percentage

Table 9-14 Directory Depth Distribution Comparison

Depth	Specified Percentage	Measured Percentage	Difference
0	0.00		
2	0.01		
5	1.57		
8	14.66		
11	66.73		
14	87.85		
17	95.48		
20	98.82		
23	99.67		
26	99.95		
29	99.99		
32	100.00		

9.4.5 A comparison of the directory fanout distribution in the FILESET created during the Data Load Test with that specified in 3.2.2.7 shall be disclosed using the format of Table 9-15, where:

- Measured Percentage shall be the value as reported by the FILESET signature created at the completion of the Data Load Test (see 6.7.3.4), stated as a percentage with one (1) digits to the right of the decimal point;
- Difference shall be: Measured Percentage – Specified Percentage

Table 9-15 Directory Fanout Distribution Comparison

Subdirectories per directory	Specified Percentage	Measured Percentage	Difference
0	41.8		
1	69.5		
2	83.9		
3	88.9		
4	93.5		
5	94.6		
6	96.0		
7	96.5		
8	97.5		
9	97.8		
10	98.0		
20	99.0		
40	100.0		

9.4.6 A comparison of the directory entries distribution in the FILESET created during the Data Load Test with that specified in 3.2.2.8 shall be disclosed using the format of Table 9-16, where:

- Measured Percentage shall be the value as reported by the FILESET signature created at the completion of the Data Load Test (see 6.7.3.4), stated as a percentage with two (2) digits to the right of the decimal point;
- Difference shall be: Measured Percentage – Specified Percentage

Table 9-16 Directory Entries Distribution Comparison

Files per directory	Specified Percentage	Measured Percentage	Difference
0	27.02		
1	58.24		
2	70.48		
3	77.11		
4	81.39		
5	83.80		
10	90.1		
15	93.36		
25	95.75		
100	99.21		
200	99.71		
300	99.83		
400	99.90		
500	99.92		

9.5 Benchmark Configuration and TSP

9.5.1 Tested Storage Product

9.5.1.1 The name of the TESTED STORAGE PRODUCT (TSP) shall be disclosed.

9.5.1.2 A detailed description of the TSP consistent with the TSP categorization defined in 4.4.2 shall be disclosed.

Features used in the benchmark by the TSP may be included in the description. For example, if the TSP is a software product that provides virtualization functionality used in the benchmark but does not include Storage Devices, the description should contain that information.

Features available in the TSP, but not used in the benchmark cannot be included in the description.

The description may include a website link to official product information available from the Test Sponsor.

9.5.2 BC Configuration Diagram

A BC Diagram (see example Figure 4-1) shall be included in the Executive Summary and illustrate the following components of the BC:

- All HOST SYSTEMS
- All storage controllers or domain controllers
- All storage devices and their capacities
- All interfaces and interconnects between the hosts systems and the storage devices or storage or domain controllers

Comment: Detailed diagrams for system configurations and architectures can widely vary, and it is impossible to provide exact guidelines suitable for all implementations. The intent here is to describe the system components and connections in sufficient detail to allow independent reconstruction of the BC environment.

9.5.3 Host Systems

The configuration of each HOST SYSTEM present in the BC shall be disclosed including:

1. Unique Identifier (UID) for use in this FDR. This should be a simple name beginning with the prefix "DG-" for Data Generation Hosts or "BR-" for Backup/Recovery Hosts.
2. Model number or name of the product.
3. Number and type of CPUs.
4. Main memory capacity.
5. Processor cache memory capacity.
6. Number and type of disk controllers or Host Bus Adapters.
7. Name and revision of operating system and other system software running on the host.
8. Type of System I/O Interconnect.
9. The type of physical connections between Adapters (connected to the System I/O Interconnect) and any Storage Controllers or Storage Devices.

9.5.4 Physical Storage

An inventory of all physical storage used in the BC shall be disclosed using the format of Table 9-4. There shall be one row in the table for each type of storage component (i.e., specific model of disk, tape, or memory) used to construct the storage hierarchy of the TSC, where:

- Product ID shall be the unique model number or name for a given type of storage component;
- Count shall be the number of such components present in the BC;
- Capacity shall be the formatted capacity of the component, stated in GB, with two (2) digits to the right of the decimal point;

- Usage shall be “Source” for components used in the TSC-SOURCE, ”Target” for components used in the TSC-TARGET, or “Both” if a component is used in both TSC-SOURCE and TSC-TARGET;
- Notes shall include any clarifying description. In cases where Usage is “Both”, an explanation of how the device(s) were split between the TSC-SOURCE and TSC-TARGET shall be included in the notes column.

Table 9-17 Physical Storage Inventory

Product ID	Count	Capacity (GB)	Usage	Notes
	Nnn	nnn.nn	Source, Target or Both	

9.5.5 Storage Controllers

The configuration of each storage controller or domain controller in the TSC shall be disclosed, including (in sequence):

1. The model or name.
2. A Unique Identifier (UID) for use in this FDR. This should be a simple name that begins with the prefix “SC-“
3. The amount of memory and cache.
4. The number of Front-end physical interconnects (unless there are none).
5. The type of Front-end interconnects (unless there are none).
6. The number of Back-end physical interconnects.
7. The type of Back-end physical interconnects.
8. The type of physical connections between Adapters (connected to the System I/O Interconnect) and any Storage Controllers or Storage Devices.

9.5.6 Storage Network Configuration

9.5.6.1 If a storage network is employed in the BC/TSC, the FDR shall contain an inventory of all components of the network not disclosed previously, including but not limited to:

1. Routers and Bridges;
2. Hubs and Switches;
3. HBAs to Host Systems and Front End Port to Storage Controllers;
4. Describe the type of each physical connection;
5. Describe the network protocol used over each physical connection;

6. Disclose the maximum theoretical transfer rate of each class of interconnect used in the configuration.

9.5.6.2 If a storage network was used in the BC/TSC, the FDR shall include a topology diagram of the storage network. This diagram should complement and correlate with the BS/TSC configuration diagram, and illustrate how the storage network interacts with the hosts and storage that it detailed.

The Test Sponsor shall additionally supply a wiring diagram of all physical connections and physical port assignments used in the storage network.

Comment: The intent of this clause is that anyone should be able to exactly replicate the physical configuration of the storage network.

9.5.7 Any changes to the physical layout of the BC between the completion of the Data Load Test and the start of the Backup Test (see 6.7.4.6) shall be disclosed.

9.5.8 Customer Tuning Parameters and Options

All BC components with customer tunable parameters and options that have been altered from their default values shall be disclosed. Examples of customer tunable parameters and options include:

- Host Bus Adapter Options.
- Storage controller and domain controller options.
- Operating system, run time environment, and application configuration parameters.
- Compilation and linkage options and run-time optimizations used to create/install any applications or the OS used on the BC.

Parameter discussion shall use the format of Table 9-18, where:

- Name is the name of the component and correlates with one of the previously disclosed BC components;
- Parameter is the name used to refer to the parameter or setting in the customer documentation for the component;
- Default Setting is default value for the parameter;
- Actual Setting is the altered value of the parameter or option;
- Notes provides additional clarification of reference information. If the parameter name is not self-explanatory to a knowledgeable practitioner, a brief description of the parameter's use shall be included here.

Table 9-18 Parameter Changes

Component	Parameter	Default Setting	Actual Setting	Notes

9.6 Benchmark Tools

9.6.1 The version number of the SPC-3BR benchmark kit that was used to produce the result shall be disclosed.

9.6.2 The number of instances of the benchmark driver that was executed by each DG HOST shall be disclosed, along with the precise command line used to invoke them.

9.7 Test Measurement and Execution Rules

9.7.1 The scale factor selected for the result shall be disclosed.

9.7.2 The ratio of GDV to FSC shall be disclosed.

9.7.3 Data Load Test Disclosure Requirements

9.7.3.1 The starting and ending timestamp for the Data Load Test and its test phases, along with their duration shall be disclosed using the format of Table 9-19:

- Starting Timestamp shall be the date and time when the test or test phase began, as provided by the benchmark kit and reported to a resolution of one second
- Ending Timestamp shall be the date and time when the test or test phase ended, as provided by the benchmark kit and reported to a resolution of one second;
- Duration shall be the difference between the starting and ending timestamps, reported to a resolution of one second.

Table 9-19 Data Load Test Timing

Test or Test Phase	Starting Timestamp	Ending Timestamp	Duration
Data Load Test	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
TSC Source Initialization	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Data Set Creation	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Initial Aging	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Initial Signature	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss

9.7.3.2 The command line used to invoke the SPC-3BR benchmark kit for the Data Load Test shall be disclosed for each DG HOST in the Benchmark Configuration.

9.7.4 If the initial aging of the FILESET was accomplished through a separate invocation of the SPC-3BR benchmark kit, the command line used on each DG HOST shall be disclosed.

9.7.5 If the initial signature of the FILESET was accomplished through a separate invocation of the SPC-3BR benchmark kit, the command line used on each DG HOST shall be disclosed.

9.7.6 The signature created at the end of the data load test shall be disclosed.

9.7.7 The log files produced by each invocation of the SPC-3BR benchmark driver during the data load test shall be disclosed.

9.7.8 Backup Test Disclosure Requirements

9.7.8.1 Any changes to the physical layout of the BC between the completion of the data load test and the beginning of the backup test shall be disclosed.

9.7.8.2 The starting and ending timestamp for the Backup Test and its test phases, along with their duration shall be disclosed using the format of Table 9-20:

- Starting Timestamp shall be the date and time when the test or test phase began, as provided by the benchmark kit and reported to a resolution of one second
- Ending Timestamp shall be the date and time when the test or test phase ended, as provided by the benchmark kit and reported to a resolution of one second;
- Duration shall be the difference between the starting and ending timestamps, reported to a resolution of one second.

Table 9-20 Backup Test Timing

Test or Test Phase	Starting Timestamp	Ending Timestamp	Duration
Backup Test	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Signature Creation	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
TSC Target Initialization	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Archive Creation	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss

9.7.8.3 The process used to initialize the TSC-Target shall be disclosed through either:

- Listing of scripts or commands used, or,
- if scripts or command-line interfaces were not used,a description of the process, tools or interfaces used, with sufficient detail to reinitialize the TSC-SOURCE.

9.7.8.4 A signature of each file system created in the data load test shall be created on each backup host in the benchmark configuration that was not used as a data generation host and disclosed, along with the command line used to invoke the SPC-3BR benchmark driver.

9.7.8.5 The tool, command or script used to create the archive shall be disclosed, including:

- Product name and manufacturer;
- Complete version information;
- Command line parameters and setting used to invoke the command, script or tool;
- Configuration files employed

9.7.9 The log files produced by each invocation of the SPC-3BR benchmark driver during the backup test shall be disclosed.

9.7.10 Recovery Test Disclosure Requirements

9.7.10.1 Any changes to the physical layout of the BC between the completion of the backup test and the beginning of the recovery test shall be disclosed.

9.7.10.2 The starting and ending timestamp for the Recovery Test and its test phases, along with their duration shall be disclosed using the format of Table 9-21:

- Starting Timestamp shall be the date and time when the test or test phase began, as provided by the benchmark kit and reported to a resolution of one second
- Ending Timestamp shall be the date and time when the test or test phase ended, as provided by the benchmark kit and reported to a resolution of one second;
- Duration shall be the difference between the starting and ending timestamps of a test or test phase, reported to a resolution of one second.

Table 9-21 Recovery Test Timing

Test or Test Phase	Starting Timestamp	Ending Timestamp	Duration
Recovery Test	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
TSC Source Initialization	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Validation File Creation	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Initial Validation File Signature Creation	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Archive Restoration	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Fileset Signature Creation	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss
Final Validation Signature Creation	mm/dd/yy hh:mm:ss	mm/dd/yy hh:mm:ss	hh:mm:ss

9.7.10.3 The process used to initialize the TSC-Source shall be disclosed through either:

- Listing of scripts or commands used, or,
- if scripts or command-line interfaces were not used, a description of the process, tools or interfaces used, with sufficient detail to reinitialize the TSC-Source.

9.7.10.4 The command line(s) used to invoke the SPC-3BR benchmark kit for the creation of the validation files shall be disclosed for each BR HOST in the Benchmark Configuration.

9.7.10.5 A signature of validation files in each file system created in the data load test shall be created on each br host in the benchmark configuration and disclosed.

Comment: The intent of this clause is to assure a uniform view of the file systems between all BR HOSTS.

9.7.10.6 The tool, command or script used to restore the archive shall be disclosed, including:

- Product name and manufacturer;
- Complete version information;
- Command line parameters and setting used to invoke the command, script or tool;
- Configuration files employed

9.7.10.6.1 The log files produced by each invocation of the SPC-3BR benchmark driver during the recovery test shall be disclosed.

9.8 Reported Metrics

9.8.1 The five SPC-3BR primary metrics as defined in 7.2 shall be disclosed using the format of Table 9-22.

Table 9-22 Primary Metrics

Metric Name	Format
SPC-3BR BGH	xxxx.x @ xxx GB
SPC-3BR RGH	xxxx.x @ xxx GB
Total System Price	$ x,xxx,xxx.xx
SPC-3BR Backup Price-Performance	$ xxx @ xxx GB
SPC-3BR Recovery Price-Performance	$ xxx @ xxx GB

9.9 Pricing

9.9.1 Any component substitution necessary to change the TSC into the PRICED STORAGE CONFIGURATION shall be disclosed.

9.9.2 The Availability Date for the PRICED STORAGE CONFIGURATION shall be disclosed, along with the Availabilty Date of any component of the PRICED STORAGE CONFIGURATION whose Availalbility Date differs from that of the PRICED STORAGE CONFIGURATION.

9.9.3 The pricing spreadsheet shall be disclosed, along with the effective date of the prices used for the PRICED STORAGE CONFIGURATION.

Full Disclosure

9.9.4 If the PRICED STORAGE CONFIGURATION relies on Third Party Pricing, written pricing quotation for all Third Party components in the PRICED STORAGE CONFIGURATION shall be disclosed.

9.9.5 Priced Storage Configuration Availability Date

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 PRICED STORAGE CONFIGURATION are currently available for customer order and shipment.

9.9.6 Anomalies or Irregularities

The FDR shall include a clear and complete description of any anomalies or irregularities encountered in the course of executing the SPC-3BR benchmark that may in any way call into question the accuracy, verifiability, or authenticity of information published in the FDR.

9.10 Executive Summary

9.10.1 Goal and Scope

The executive summary provides a high level overview of an SPC-3BR result. It serves as a concise summary of the detail found in the FDR, and provides an accurate sense of a benchmark execution (metrics, configuration, pricing, etc.) without the detail found in the FDR.

9.10.2 The executive summary for SPC-3BR is a two-page document:

- A test summary, including an overview of the BC, performance tests and metrics, defined in 9.10.4;
- The pricing summary, defined in 8.2.10 and presented according to 9.10.5

9.10.3 Formatting Guidelines

In addition to the general formatting requirements for the FDR found in 9.1.4, the executive summary shall adhere to the following formatting guidelines:

- 2 pt. frame around the body of the page. All interior lines shall be 1 pt;
- Unless otherwise specified, each section shall be laid out across the page as a sequence of boxes using 1 pt. rule, with a title above the required quantity.
- Unless otherwise specified, all information shall use a 10 pt, sans-serif font (e.g., Arial).
- Each quantity shall be reported using the specified format, and including the specified unit designation.

9.10.4 Test Summary

9.10.4.1 Overview

The Test Summary contains six sets of data:

- Result Identification, defined in 9.10.4.2;
- Metrics Summary, defined in 9.10.4.3;
- Tool Summary, defined in 9.10.4.4;
- Configuration Diagram, defined in 9.10.4.5;
- Timing Summary, defined in 9.10.4.6;
- TSC Overview, defined in 9.10.4.7.

9.10.4.2 Result Identification

The first section shall identify the benchmark result being summarized, according to the requirements in Table 9-23.

Table 9-23 Result Identification

Title	Quantity	Format	Precision/ Units	Font
None	Name of the Test Sponsor (see 9.2.6)			16-20 pt. Bold
None	Name of TSP (see 9.5.1)			16-20 pt. Bold
SPC-3BR Revision (1)	Revision of the specification	x.y.z		
Report Date(1)	Publication Date of FDR (see 9.2.7)	mm/yy/dd	1 day	
Availability Date(1)	System Availability Date (see 9.9.5)	mm/yy/dd	1 day	

Footnotes for Table 9-23

1. *These items shall be stacked in a third column, similar in size to those used for Sponsor Name and TSP*

9.10.4.3 Metrics Summary

This section shall identify the primary metrics for the result being summarized, according to the requirements in Table 9-24.

Full Disclosure

Table 9-24 Metrics Summary

Title	Quantity	Format	Precision/ Units	Font
Performance	SPC-3BR BGH, SPC-3BR RGH	See 7.2		
Price-Performance	$/SPC-3BR BGH, $/SPC-3BR RGH	See 7.2		
Total System Cost (1)	Total System Cost	(2)	(2)	
Fileset Size (1)	Scale Factor (see 6.5.1)	nnn	1 GiB	

Footnotes for Table 9-24

1. *These items shall be presented as a stack of boxes in a third column*
2. *Format shall match the currency used for the Priced Configuration*

9.10.4.4 Tool Summary

This section shall identify the tools and system software used in the benchmark being summarized, according to the requirements in Table 9-25.

Table 9-25 Tool Identification

Title	Quantity	Format	Precision/ Units	Font
Backup Tool	See 9.7.8.5			
Recovery Tool	See 9.7.10.6			
Other Software	See 4.2.4			

9.10.4.5 Configuration Diagram

This section of Test Summary Page shall be as large as possible, within the 1-page constraint, and shall contain the BC Configuration Diagram (see 9.5.2).

9.10.4.6 Timing Summary

This section shall be formatted as a sub-table, with one row for the reported timing for each test phases of the result being summarized, as illustrated in Table 9-26.

Full Disclosure

Table 9-26 Test Timing

Phase	Start Date	Start Time	End Date	End Time	Elapsed Time
Data Load Test	(1)	(2)	(1)	(2)	(3)
Backup Test	(1)	(2)	(1)	(2)	(3)
Recovery Test	(1)	(2)	(1)	(2)	(3)

Footnotes for Table 9-26

1. *Reported to a precision of 1 day, and formatted as mm/dd/yyyy*
2. *Reported to a precision of 1 second, and formatted as hh:mm:dd using a 24-hour clock*
3. *The difference between the start and end times for each phase, Reported to a precision of 1 second, and formatted as hh:mm:dd using a 24-hour clock.*

9.10.4.7 TSC Overview

This section shall provide a synopsis of the BC in the benchmark being summarized, according to the requirements in Table 9-27. Each quantity should summarize, in order, as much of the disclosure required by the referenced section as will fit in the available space.

Table 9-27 TSC Overview

Title	Quantity	Format	Precision/ Units	Font
Backup Server	See 9.5.3			
TSC Source (1)	See 9.3.1			
TSC Target (1)	See 9.3.1			

Footnotes for Table 9-27

1. *List only components used in the TSC-SOURCE or TSC-TARGET. Shared items shall appear in both lists, with a "(s)" notation after the model name.*

9.10.5 Pricing Summary

9.10.5.1 Overview

The Pricing Summary contains three sets of data:

- Header Section, defined in 9.10.4.2;
- Pricing Spreadsheet, defined in 9.10.4.3;
- Audit Identification, defined in 9.10.4.4;

Full Disclosure

9.10.5.2 Header Identification

The first section shall is a reduced version of the 9.10.4.2 from the first page of the Executive Summary. Its requirements are given in Table 9-23.

Table 9-28 Pricing Header

Title	Quantity	Format	Precision/ Units	Font
None	Name of the Test Sponsor (see 9.2.6)			16-20 pt. Bold
None	Name of TSP (see 9.5.1)			16-20 pt. Bold
SPC-3BR Revision (1)	Revision of the specification	x.y.z		
Report Date(1)	Publication Date of FDR (see 9.2.7)	mm/yy/dd	1 day	

Footnotes for Table 9-28

1. *These items shall be stacked in a third column, similar in size to those used for Sponsor Name and TSP*

9.10.5.3 Pricing Spreadsheet

This section of Pricing Summary Page shall be as large as possible, within the 1-page constraint, and shall contain the **Pricing Spreadsheet** (8.2.10).

9.10.5.4 Audit Identifier

This section includes the submission identifier for the result being summarized, as shown in Table 9-23.

Table 9-29 Audit Identifier

Title	Quantity	Format	Precision/ Units	Font
Submission Identifier	See 10.5.4			12 pt. Bold

Clause 10 Measurement, Audit, and Results Submission

10.1 Introduction

While it is not possible to preclude the possibility of an erroneous SPC-3BR Result, the SPC-3BR Validation process is designed to minimize the possibility that an Audited SPC-3BR Result could lead a consumer of that benchmark data to an erroneous or misleading conclusion about the Test Storage Product.

There are two possible sources for a new SPC-3BR result:

- An original submission, according to the process defined in 10.2;
- A result based on an existing result, according to the process defined in 10.7;

10.2 Original SPC-3BR Result

The creation of a new, original SPC-3BR Result requires completion of the SPC-3BR Result Validation process, which consists of the following:

- Creation of a complete set of SPC-3BR Results Files resulting from an SPC-3BR measurement (see Clause 6);
- Successful completion of an SPC-3BR Audit (see 10.3);
- Submission of the required materials to the SPC (see 10.3.3);
- Successful completion of the required SPC Peer Review (see 10.6).

10.3 SPC-3BR Audit

10.3.1 The purpose of an SPC-3BR Audit is to verify an SPC-3BR measurement is eligible for submission to the SPC as part of the SPC-3BR Result Validation process. The SPC-3BR Audit includes:

- Verification of the compliant execution of the complete set of SPC-3BR Tests and generation of the resultant complete set of SPC-3BR Results Files.
- Verification that the required SPC-3BR Full Disclosure Report is complete, accurate, and compliant with the appropriate version of the SPC-3BR specification.

10.3.2 Audit Methods

10.3.2.1 On-Site Audit

10.3.2.1.1 A Test Sponsor may elect to satisfy the SPC-3BR audit requirements by means of an On-Site Audit.

10.3.2.1.2 It is the intent of this option to allow Test Sponsors to add credibility to their results by requesting an On-Site Audit.

Audit

10.3.2.1.3 A Test Sponsor that fails a Remote Audit or submits a SPC-3BR benchmark result that has been found non-compliant, as defined in the SPC Policies and Procedures, will be required to use an On-Site Audit for their next benchmark result submission. Additionally, a Test Sponsor may be required to undertake an On-Site Audit at the discretion of the SPC Auditing Service. While this requirement will not be imposed unreasonably, it may be imposed at the sole discretion of the SPC Auditing Service.

10.3.2.1.4 Test Sponsors are required to pay the costs for an On-Site Audit.

10.3.2.1.5 The protocol and results of an On-Site Audit shall be summarized in an audit report prepared by the SPC Audit Service and submitted by the Test Sponsor as part of the Audit.

10.3.2.2 Remote Audit

10.3.2.2.1 An SPC-3BR benchmark execution may satisfy Audit requirements without an On-Site Audit subject to specific limitations. This is referred to as a REMOTE AUDIT.

10.3.2.2.2 A REMOTE AUDIT requires submission of all Results Files produced by the SPC-3BR benchmark execution, along with other materials, to the SPC Audit Service.

10.3.2.2.3 In order to be eligible for an REMOTE AUDIT, the Benchmark Configuration (BC) to be audited and the Test Sponsor must satisfy the following criteria:

1. The Host Systems being benchmarked must be supported by the SPC-3BR Workload Generator.

2. The SPC Workload Generator version that will be used in the Remote Audit has been validated in an On-Site Audit or via some other SPC Audit Service approved method.

10.3.2.2.4 A Test Sponsor who cannot satisfy the requirements of Clause 10.3.2.2.3 must complete an On-Site Audit. Additionally, if there are questions concerning completeness and/or authenticity of the results, the SPC Audit Service may require an On-Site Audit. The costs of an On-Site Audit are the responsibility of the Test Sponsor.

10.3.3 Clause 0 – Audit Items

1. Obtain a Letter of Good Faith from the Test Sponsor signed by an appropriate senior executive.

Comment: The Letter of Good Faith is required to appear on company letterhead. The document must be identical in format and content to the template in Appendix B with the appropriate changes specific to the benchmark submission (Test Sponsor name, TSP name, date, etc.). Any other changes in content and format must be approved by the SPC Auditor prior to the benchmark submission.

10.3.4 Clause 1: Workload Environment – Audit Items

None

10.3.5 Clause 2: Data Repository – Audit Items

10.3.5.1 Required Items

1. Verify the inventory of physical storage used in the TSC (see 9.3.1).

Audit

2. Verify the SIZE, EFFICIENCY and PROTECTION LEVEL for each layer of the storage hierarchy (see 9.3.4).

3. Verify the allocation of storage capacity within each layer of the storage hierarchy of the TSC (see 9.3.2).

4. Review the disclosure of transformations employed in the creation of the storage hierarchy of the TSC (see 9.3.6), to assure that they are clear, complete and adequately annotated.

Comment: The Test Sponsor is required to provide documentation of tools/utilities available with the TSC to generate to appropriate listings to complete the above verification.

10.3.5.2 Verification Methods

Verification of the required items shall be accomplished using one or more of the following methods:

- A review of appropriate listings provided by the Test Sponsor.
- Physical and remote access to the Tested Storage Configuration.

Remote access may optionally be supplied by the Test Sponsor. It is not required for a Remote Audit.

10.3.6 Clause 3: Data Model – Audit Items

10.3.6.1 Required Items

1. Verify the file size distribution comparison (see 9.4.1).

2. Verify the file modification date distribution comparison (see 9.4.2).

3. Verify the file name length distribution comparison (see 9.4.3).

4. Verify the directory depth distribution comparison (see 9.4.4).

5. Verify the directory fanout distribution comparison (see 9.4.5).

6. Verify the directory entries distribution comparison (see 9.4.6).

7. Verify that any difference between the measured in steps 1-6 is within acceptable tolerances (see 6.5.1)

10.3.6.2 Verification Methods

Verification of the required items shall be based on results files produced by the SPC-3BR benchmark kit.

10.3.7 Clause 4: Benchmark Configuration (BC), Tested Storage Configuration – Audit Items

10.3.7.1 Required Items

1. Verify the configuration summary of hosts systems.

2. Verify the inventory of the physical storage.

Audit

3. Verify the configuration summary of the storage controllers.

4. Confirm the accuracy and completeness the BC/TSC configuration diagram.

5. If a storage network was used in the BC, verify the storage network configuration summary.

6. If a storage network was used in the BC, confirm the accuracy and completeness of the storage network configuration diagram and associated wiring diagram.

7. Obtain a listing of all customer tunable parameters and options that have been altered from their default values

10.3.7.2 Verification Methods

Verification of the required items shall be accomplished using one or more of the following methods:

- A review of appropriate listings provided by the Test Sponsor.
- Physical access to the Tested Storage Configuration.
- Remote access to the Tested Storage Configuration.

Comment: Remote access may optionally be supplied by the Test Sponsor. It is not required for a Remote Audit.

10.3.8 Clause 5: Benchmark Tools – Audit Items

10.3.8.1 Required Items

1. Verify the presence, number and version number of the SPC-3BR Benchmark Driver on each HOST SYSTEM in the BC.

2. Verify the presence of a valid, appropriate SPC-3BR Site/Corporate License.

3. Verify the command line used to invoke each benchmark driver.

4. In a multi-host configuration, verify that the execution of multiple SPC-3BR Benchmark Driver on multiple HOST SYSTEMS was synchronized in time.

Comment: Verification done using the appropriate Test Results files.

10.3.8.2 Verification Methods

Verification of the required items shall be based on results files produced by the SPC-3BR benchmark kit.

10.3.9 Clause 6: Test Measurement Requirements (Execution Rules) – Audit Items

10.3.9.1 Required Items

1. Verify the scale factor selected for the result.

2. Verify the ratio of GDV and FSC.

3. Observe the execution of each SPC-3BR Test, Test Phase, and Test Run, if possible, and determine compliance with the requirements and constraints of Clause 6.

Audit

4. Obtain the SPC-3BR Results Files for each Test Run.

5. Authenticate the Results Files obtained in #4.

6. Inspect each authenticated Results File to determine compliance with all the constraints and requirements of the specification.

7. Determine the completeness of the scripts and/or supporting details used to describe the initialization of the TSC-SOURCE and TSC-TARGET.

8. Verify the tool, command or script used to create the archive in the Backup Test.

9. Verify the tool, command or script used to restore the archive in the Recovery Test.

10. If changes were made to the BC between the completion of the data load test and the beginning of the backup test, verify that they are appropriately documented.

10.3.9.2 Verification Methods

Verification of the required items shall be accomplished using one or more of the following methods:

- Observation of tests (on-site audit only).
- A review of appropriate listings provided by the Test Sponsor.

Comment: Remote access may optionally be supplied by the Test Sponsor. It is not required for a Remote Audit.

10.3.10 Clause 7: Reported Metrics – Audit Items

None.

10.3.11 Clause 8: Pricing – Audit Items

10.3.11.1 Required Items

1. If the TSC and PRICED STORAGE CONFIGURATION are not identical, verify that the differences between the two configurations are disclosed and that the PRICED STORAGE CONFIGURATION would be capable of providing at least the same level of reported performance as the TSC.

2. Review a preliminary copy of the pricing spreadsheet, described in Clause 8.2.10, and verify that it meets all the requirements and constraints of the specification.

Comment: It is not required to review the final pricing prior to issuing the audit certification letter.

10.3.11.2 Verification Methods

Verification of the required items shall be based on a review of appropriate listings provided by the Test Sponsor.

Audit

10.3.12 Clause 9: Full Disclosure– Audit Items

10.3.12.1 Required Items

1. Verify the SPC-3BR FULL DISCLOSURE REPORT (FDR) is complete and accurate based on the requirements in this specification.

10.3.12.2 Verification Methods

Verification of the required items shall be based on a review of appropriate listings provided by the Test Sponsor.

10.4 SPC-3BR Audit Certification

10.4.1.1 The SPC Audit personnel will, in the course of the SPC-3BR Audit, determine if the SPC-3BR Measurement is eligible for submission to the SPC.

10.4.1.2 If the SPC Audit personnel determine the SPC-3BR Measurement is eligible for submission, the SPC Audit personnel will produce an SPC-3BR Audit Certification report attesting to the successful completion of the SPC-3BR Audit and issue that report to the Test Sponsor.

10.4.1.3 The SPC-3BR Audit Certification report will document execution of the SPC-3BR Audit procedures defined in 10.3. The SPC-3BR Audit Certification report for a successful SPC-3BR Audit will contain any anomalous or inconsistent element encountered during the audit. While those elements did not prevent successful completion of the audit, their presence warranted documentation.

10.4.1.4 If the SPC-3BR measurement is eligible for submission to the SPC, the Test Sponsor may then submit the required materials to the SPC to establish a new SPC-3BR Result (10.3.3) and begin the SPC Peer Review (10.6).

10.4.1.5 If the SPC Audit personnel determine the SPC-3BR measurement is not eligible for submission to the SPC, the Test Sponsor may request an SPC-3BR Audit Report that documents the compliance issues encountered during the audit. In addition, the SPC-3BR Audit Report will include recommendations to address those compliance issues.

10.4.1.6 If the Test Sponsor disagrees with the SPC Audit personnel's determination of eligibility, the Test Sponsor may submit an appeal to the SPC Compliance Review Committee.

10.5 SPC-3BR Measurement Submission

10.5.1 Eligibility

A Test Sponsor may submit to the SPC an SPC-3BR measurement that has successfully completed an SPC-3BR Audit.

10.5.2 SPC-3BR Submission Materials

A complete SPC-3BR measurement submission consists of the following items submitted to the SPC by the Test Sponsor:

1. A PDF version of the audited FDR and Executive Summary.

2. Payment to the SPC of all SPC-3BR Audit costs and SPC-3BR Result filing fee.

Audit

3. A release, if not previously submitted, allowing public disclosure of the SPC-3BR Result and FDR.

10.5.3 SPC-3BR Result

When the SPC-3BR measurement submission is successfully completed:

- A unique SPC-3BR Submission Identifier is created for the submitted SPC-3BR measurement.
- The submitted SPC-3BRC measurement becomes a new SPC-3BR Result that is in "Submitted For Review" status.
- A copy of both the SPC-3BR Full Disclosure Report and Executive Summary are placed on the SPC website in the "Benchmark Results" section.
- A notification email is sent to the SPC membership announcing the new SPC-3BR result.
- The SPC Peer Review begins (10.6).

10.5.4 SPC-3BR Submission Identifier

An SPC-3BR Submission Identifier takes the following format: **ZZZ-N**. Where:

ZZZ is a unique code assigned by the SPC that identifies an original SPC-3BR Result and Audit.

N is the identifier for a republished SPC-3BR result and Audit. The identifier will be omitted in the case of the original SPC-3BR result and Audit (Submission Identifier -= ZZZ). The first reuse of a Submission Identifier will set the value of N to 1 (Submission Identifier = ZZZ-1). Each subsequent reuse will increment the value of N by 1.

10.6 SPC Peer Review

The SPC Peer Review of a new SPC-3BR Result begins when the result is created *(10.5.3)* and encompasses all the information contained in the SPC-3BR Full Disclosure Report submitted for the result.

SPC Peer Review of revisions to an existing SPC-3BR Result begins when the revised FDR is submitted to the SPC. The peer review, in this case, is limited to the revised information in the newly submitted FDR, which includes any component changes in the PRICED STORAGE CONFIGURATION.

The SPC Peer Review is the final step to certify the SPC-3BR Result's compliance with this specification. The details of the SPC Peer Review are described in the SPC Policies and Procedures.

10.7 Creating a new SPC-3BR Result based on an existing SPC-3BR Result

10.7.1 Overview

An existing SPC-3BR Result may be the basis of a submission to create a new SPC-3BR Result if the following requirements are met:

Audit

a) The Tested Storage Product (TSP) for the new SPC-3BR Result is not the same as the TSP in the existing SPC-3BR Result.

b) The hardware and software components that comprise the PRICED STORAGE CONFIGURATION (**Error! Reference source not found.**) in the new SPC-3BR Result are materially the same as those used in the existing SPC-3BR Result.

c) Any hardware and/or software differences between the existing and new PRICED STORAGE CONFIGURATION s do not impact the performance-related primary metrics.

d) All performance data disclosed in the new SPC-3BR Full Disclosure Report is identical to that which is contained in the original FDR.

e) The existing SPC-3BR Result is either in "Submitted for Review" or "Accepted" status.

Comment: The intent of this clause is to allow a reseller of equipment from a given supplier to publish a result naming their particular brand or model number without requiring any additional performance testing.

10.7.2 Audit Requirements

The SPC-3BR Audit for a new SPC-3BR Result based on an existing SPC-3BR Result may not follow the complete set of procedures defined in 10.3.

10.7.3 Full Disclosure Report Requirements

10.7.3.1 A new SPC-3BR Result based on an existing SPC-3BR Result shall include in its Full Disclosure Report the table of required information described in 9.2.8, which will contain key information about the existing SPC-3BR Result.

10.7.3.2 All differences in hardware and software products that comprise the original and new PRICED STORAGE CONFIGURATION s shall be listed in the Full Disclosure Report.

10.7.4 Withdrawal of the existing SPC-3BR Result

If an SPC-3BR Result successfully completes Peer Review and is subsequently withdrawn with no compliance issue outstanding, SPC-3BR Results based on the withdrawn SPC-3BR Result are not required to be withdrawn.

10.8 SPC-3BR Result Revisions

10.8.1 Overview

Revisions to an existing SPC-3BR Result can occur only under the following conditions:

1. Fully documented pricing changes to the PRICED STORAGE CONFIGURATION.
2. A change in the SPC-3BR Availability Date.
3. As directed by the SPC Policies.

In all cases, the resulting revised SPC-3BR Full Disclosure Report is required to be reviewed and approved by an SPC Auditor prior to submission to the SPC.

10.8.2 SPC-3BR Pricing Revisions

PRICED STORAGE CONFIGURATION pricing of an existing SPC-3BR Result may be revised based on fully documented price changes (decreases and increases). If the cumulative price changes result in an increase of 5% or more from the reported SPC-3BR Total Price, the Test Sponsor shall submit a revised FDR with the new pricing information to the SPC within 30 days of the effective date of the price changes for the SPC-3BR Result to remain compliant. Pricing changes below the 5% increase threshold are submitted at the discretion of the Test Sponsor. In either case, the SPC-3BR measurement need not be re-executed to remain compliant if there are no changes in the PRICED STORAGE CONFIGURATION components resulting from the revised pricing.

Comment: The intent of this clause is that published the SPC-3BR Total Price- reflects the actual, current SPC-3BR Total Price.

10.8.3 SPC-3BR Availability Date Revisions

The original SPC-3BR Availability Date for the PRICED STORAGE CONFIGURATION may be revised consistent with the Availability requirement specified in 8.2.8. The SPC-3BR measurement need not be re-executed to remain compliant if there are no changes in the PRICED STORAGE CONFIGURATION resulting from the revised SPC-3BR Availability Date.

10.8.4 SPC Policies Directed Revisions

Revisions to an SPC-3BR Result may result from provisions in the SPC Policies and Procedures such as in the case of a compliance issue identified during the SPC Peer Review.

10.8.5 Component Substitution in a revised SPC-3BR Result

If a revision to an existing SPC-3BR Result would result in a change to the PRICED STORAGE CONFIGURATION documented in the corresponding SPC-3BR FDR), the Test Sponsor must submit, for review by an SPC Auditor, a list of components that would be changed. The auditor may require additional information and/or specific tests to be executed to ensure the revised PRICED STORAGE CONFIGURATION is capable of providing at least the same level of reported performance as stated in the current FDR.

Examples of component substitutions include:

- Replacement of a now obsolete component that was included in the existing PRICED STORAGE CONFIGURATION.
- Replacement of a component when a change in the component's availability would extend the SPC-3BR Availability Date beyond the period allowed by the specification.

If the PRICED STORAGE CONFIGURATION component changes are approved by the SPC Auditor, an amended SPC-3BR Audit Certification report will be issued to the Test Sponsor for inclusion in a revised FDR, which will contain a list of all changes. If the auditor does not approve the component changes, the Test Sponsor may appeal that decision to the SPC Compliance Review Committee.

Appendix A Glossary

Change bars are relative to the 0.0.2 specification, reviewed at the July '07 Face-to-face.

A.1 Overview

Most parameters and terms associated with an I/O workload are self-explanatory. Some are subject to interpretation, particularly across the multiple operating systems and hardware platforms supported by SPC-3BR. The following definitions are intended to minimize ambiguity by providing the definition that should be assumed whenever a given term is used in this specification.

A.2 Definitions

A

APPLICATION LAYER
: The top-most layer the SPC storage hierarchy, derived from the FILE SYSTEM LAYER.

ARCHIVE
: a self-sufficient, physically distinct copy of the FILESET created during the Data Load Test.

AVAILABLE SPACE
: capacity of a GSL that could be used by the next layer in the storage hierarchy.

B

BENCHMARK CONFIGURATION (BC)
: all hardware and software components used in the execution of the SPC-3BR benchmark.

BR HOST
: A HOST SYSTEM used to used to execute backup or restore application(s).

C

No terms defined.

D

DG HOST
: A HOST SYSTEM used to execute the SPC-3BR data generator.

DIRECTORY
: A uniquely identifiable container for a (possibly empty) collection of filenames and subordinate directories.

E

EFFICIENCY
: in a GSL, ratio of the PUBLISHED CAPACITY to SIZE.

F

FILE
: A collection of information. It is not dependent on a particular operating system, language or storage configuration

FILESET
: a realistic, scalable, synthetic hierarchy of files and directories

FILE STORAGE CAPACITY (FSC)
: the PUBLISHED CAPACITY of the FILE SYSTEM LAYER.

FILE SYSTEM
: A file system is a collection of directory paths which share a common prefix and their subordinate files.

FILE SYSTEM LAYER
: the third GSL in a storage hierarchy, derived from the LOGICAL STORAGE LAYER

FILE SYSTEM UTILIZATION (FSU)
: the ratio of GDV to FILE STORAGE CAPACITY.

FULL DISCLOSURE REPORT (FDR)
: A detailed summary of a benchmark execution sufficient to allow the independent recreation of a benchmark result by a knowledgeable reader

G

GENERATED DATA VOLUME (GDV)
: sum of the user-accessible data contained within each generated file within the FILESET.

GENERIC STORAGE LAYER (GSL)
: the abstract representation of a layer in the SPC-3BR STORAGE HIERARCHY

H

HOST SYSTEM
: a computer system in the BENCHMARK CONFIGURATION i

J

No terms defined.

K

No terms defined.

L

LOGICAL STORAGE CAPACITY
: the PUBLISHED CAPACITY of the LOGICAL STORAGE LAYER.

LOGICAL STORAGE LAYER
: the second GSL in a storage hierarchy, derived from the PHYSICAL STORAGE LAYER.

M

MEASUREMENT BOUNDARY
: the point within a benchmark configuration at which all performance data is gathered.

MEASUREMENT UNITS
: in the storage industry, the terms “kilo”, “mega”, “giga“, and “tera” are commonly used prefixes for computing performance and capacity. For the purposes of the SPC workload definitions, all of these terms are defined in powers of 10. Specifically:

- 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 kibibyte (KiB) is equal to 2^{10} bytes.
- A mibibyte (MiB) is equal to 2^{20} bytes.
- A gibibyte (GiB) is equal to 2^{30}) bytes.
- A tibibyte (TiB) is equal to 2^{40} bytes.

As larger values, such as “peta“ and “exa” come into common use, they will be similarly defined ..

MONOLITHIC CONFIGURATION
: A BENCHMARK CONFIGURATION that includes a single DG HOST.

MULTI-HOST CONFIGURATION
: A BENCHMARK CONFIGURATION that includes multiple DG HOSTS.

N

No terms defined.

O

OVERHEAD
: capacity of a GSL required to implement the layer and is not available to application programs.

P

PHYSICAL STORAGE CAPACITY (PSC)
: the PUBLISHED CAPACITY of the PHYSICAL STORAGE LAYER.

PHYSICAL STORAGE LAYER
: the lowest GSL in a storage hierarchy.

PRE-COMPRESSED
: of a file, not a candidate for further compression.

PRICED STORAGE CONFIGURATION (PSC)
: a customer orderable configuration, similar to the TSC, used in pricing.

PUBLISHED CAPACITY
: portion of AVAILABLE SPACE that is made available to the next higher level in the hierarchy.

Q

No terms defined.

R

RESULTS INFORMATION
: PRICED STORAGE CONFIGURATION, the TOTAL SYSTEM PRICE for the TSC and all primary metrics as a set.

S

SCALE FACTOR (SF)
: the discrete scaling level selected for a given execution of SPC-3BR.

SIGNATURE
: a profile of a FILE SYSTEM sufficient to assure its accuracy, completeness and conformance to the requirements of the specification.

SPARSE
: of a FILE, can be reduced to a small number of bytes (e.g., a representative value and the number of occurrences), regardless of the original file size.

SYSTEM OVERHEAD
: portion of OVERHEAD required by the storage subsystem (e.g., metadata)..

T

TESTED STORAGE CONFIGURATION (TSC)
: all software and hardware necessary to implement and support the performance tests defined in this benchmark.

TESTED STORAGE PRODUCT (TSP)
: a distinct, customer orderable product; the focal point of a SPC-3BR result.

TEXT
: of a FILE, to contain ASCII English text.

TSC-SOURCE
: a subset of the TSC that holds the initial (and restored) FILESET.

TOTAL SYSTEM PRICE
: the cost of purchase and three years of maintenance for the PRICED STORAGE CONFIGURATION.

TSC-TARGET
: a subset of the TSC that holds the archive.

U

UNUSED CAPACITY
: portion of AVAILABLE SPACE that could have been made available to the next layer in the hierarchy, but was explicitly excluded.

V

VALIDATION FILES
: a set of files that are distinct from the FILESET, used by the recovery test.

W

No terms defined.

X

No terms defined.

Y

No terms defined.

Z

No terms defined.

Appendix B Letter of Good Faith

The required Letter of Good Faith submitted by a Test Sponsor must be identical in format and content to the template listed below with the appropriate changes specific to the benchmark submission (Test Sponsor name, TSC name, date, etc.). Any other changes in content or format must be approved by the SPC Compliance Review Committee (CRC) prior to the benchmark submission.

Date: Date the benchmark result is submitted to the SPC Audit Service

From: Test Sponsor Name and Contact Information

To: SPC Auditor Name and Contact Information

Subject: SPC-3BR Letter of Good Faith for the ***Tested Storage Configuration name***

Test Sponsor Name is the SPC-3BR Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-3BR benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with ***Vn.n*** of the SPC-3BR 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-3BR benchmark specification.

Signed: Date:

_____ _____

Name and title of an appropriate Test Sponsor senior executive

Date of Signature

Appendix C SAMPLE EXECUTIVE SUMMARY

Sponsor (Optional Logo)	TSP Identification	SPC3-BR Revision 1.0.0 Report Date: 11/28/2007 Availability Date: 11/28/2007

Performance	Price-Performance	Total System Cost
SPC3-BR BGH xxx.x @ 30TB	$/SPC3-BR BGH xxx.xx @ 30TB	$x,xxx,xxx
SPC3-BR RGH xxx.x @ 30TB	$/SPC3-BR RGH xxx.xx @ 30TB	Fileset Size 30 TB

Backup Tool	Restore Tool	Other Software

Priced Configuration Diagram

Phase	Start Date	Start Time	End Date	End Time	Elapsed Time
Dataset Creation					
Backup Test					
Restore Test					

Backup Server	Source Configuration	Target Congfiguration
CPU: 2 x 2.0GhZ/1MB Processor Memory: 8GB Network: 2 x On-board Controllers: 4x FiSTOR 2000	Enclosure: 4 x My Storage Array Storage: 512 x 72 GB Total Capacity: 36TB RAID level: RAID 5	Enclosure: 4 x My Storage Array Storage: 512 x 72 GB Total Capacity: 36TB RAID level: RAID 0

Sponsor (Logo)	TSP Identification	**SPC3-BR** 1.0.0 **Report Date:** 11/28/2007

Description	Part Number	Source	Reference Price	Qty	Disc	Extended Price	3-yr Maint. Cost
					TOTAL System Price	$0	$0

Sources	
1	SPC-3BR BGH@
2	SPC-3BR RGH@
3	**$/SPC3-BR BGH@**
4	**$/SPC3-BR RGH@**

Audit ID