
**Information technology — Power
efficiency measurement specification
for data center storage**

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Foreword

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by SNIA (as SNIA Emerald™ Power Efficiency Measurement Specification V3.0.3) and drafted in accordance with its editorial rules. It was adopted, under the JTC 1 PAS procedure, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Contents

1	Introduction	vii
2	Scope	1
2.1	Abstract.....	1
2.2	Introduction.....	1
2.3	Current Revision.....	1
2.4	Purpose.....	1
2.5	Disclaimer.....	2
3	Normative References	3
4	Definitions, Symbols, Abbreviations, and Conventions	4
4.1	Overview.....	4
4.2	Definitions.....	4
4.3	Symbols and Abbreviated Terms.....	9
4.4	Expression of Provisions.....	9
4.5	Conventions.....	10
5	Taxonomy	11
5.1	Introduction.....	11
5.2	Taxonomy Categories.....	12
5.3	Taxonomy Classifications.....	12
5.4	Taxonomy Rules.....	12
5.5	Online Category.....	13
5.6	Near-Online Category.....	15
5.7	Removable Media Library Category.....	15
5.8	Virtual Media Library Category.....	16
6	Capacity Optimization	17
6.1	Introduction.....	17
6.2	Space Consuming Practices.....	17
6.3	COMs Characterized.....	17
7	Test Definition and Execution Rules	18
7.1	Overview.....	18
7.2	General Requirements and Definitions.....	18
7.3	Block Access Online and Near-Online Tests.....	30
7.4	File Access Online and Near-Online Active Test.....	33
7.5	Block and File Access Ready Idle Test.....	37
7.6	Block and File Access Capacity Optimization Test.....	37
7.7	Removable Media Library Testing.....	42
7.8	Virtual Media Library Testing.....	46

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8	Metrics	50
8.1	Taxonomy Considerations	50
8.2	Block Access Primary Metrics.....	50
8.3	File Access Primary Metrics.....	50
8.4	Power Efficiency Metric for Online and Near-Online Systems.....	50
8.5	Power Efficiency Metric for Removable Media Library Systems	52
8.6	Storage Power Efficiency Metric for Virtual Media Library Systems.....	52
8.7	Secondary Metrics	52
9	Disclosure Requirements	54
9.1	General.....	54
9.2	Product Identification.....	54
9.3	Test Metrics.....	54
9.4	Test Characterization	56
9.5	Product Under Test Description.....	57
Annex A	(Normative) Suggested Power and Environmental Meters	59
A.1	Overview	59
A.2	Alternate Meter Usage	59
Annex B	(Normative) Measurement Requirements	60
B.1	Online and Near-Online Block Access Data Collection and Processing Requirements.....	60
B.2	Removable and Virtual Media Library Block Access Data Collection and Processing Requirements.....	60
B.3	Online and Near-Online File Access Data Collection and Processing Requirements.....	60
Annex C	(Normative) Stable Storage	62
Annex D	(Normative) Vdbench	63
Annex E	(Normative) Vdbench Test Scripts	64
Annex F	(Normative) SPEC SFS® 2014 Benchmark	65
Annex G	(Normative) File Access IO Load Driver Configuration File	66
Annex H	(Informative) sFlow®	67
Annex I	(Normative) COM Test Data Set Generator	68
Annex J	(Informative) gzip	69
	Bibliography	70

List of Tables, Figures and Equations

Table 1 – Normative References	3
Table 2 – Taxonomy Overview	11
Table 3 – Common Category Attributes.....	12
Table 4 – Online Classifications.....	14
Table 5 – Near-Online Classifications.....	15
Table 6 – Removable Media Library Classifications	16
Table 7 – Virtual Media Library Classifications	16
Figure 1 - Sample Configuration Block Access.....	19
Figure 2 - Sample Configuration File Access.....	19
Table 8 – Example RAS Features.....	20
Table 9 – Input Power Requirements (Products with Nameplate Rated Power ≤ 1 500 W)	21
Table 10 – Input Power Requirements (Products with Nameplate Rated Power > 1 500 W)	21
Table 11 – Power Meter Resolution.....	22
Equation 7-1: Sequential Transfer Offset.....	24
Figure 3 - Percentage of Address Hit vs. Cache Size.....	24
Table 12 – Workloads within the Hot Band IO Profile.....	25
Table 13 – IO Transfer Size within the Hot Band IO Profile for 512 Byte Native Devices.....	25
Table 14 – IO Transfer Size within the Hot Band IO Profile for 4 KiB Native Devices	26
Equation 7-2: Average Power	27
Equation 7-3: Periodic Power Efficiency.....	28
Equation 7-4: Least Squares Linear Fit Calculation.....	29
Equation 7-5: Weighted Moving Average Calculation.....	29
Table 15 – Pre-fill Test IO Profile	30
Table 16 – Online and Near-Online Testing: Conditioning Test IO Profiles	31
Table 17 – Online and Near-Online Testing: Active Test Phase IO Profiles	32
Table 18 – Business Metrics for Workload Type	35
Table 19 – Business Metrics for File Access Active Test Sequence	36
Table 20 – Data Sets.....	38
Table 21 – Drive Counts	42
Table 22 – Removable Media Library Testing: Conditioning Test IO Profiles	43
Table 23 – Removable Media Library Testing: Active Test Phase IO Profiles	44
Equation 7-6: Sequential Transfer Offset.....	45
Table 24 – Virtual Media Library Testing: Conditioning Test IO Profiles	47
Table 25 – Virtual Media Library Testing: Active Test Phase IO Profiles	48
Equation 7-7: Sequential Transfer Offset.....	48
Equation 8-1: Power Efficiency, Ready Idle.....	51
Equation 8-2: Power Efficiency, Active (Block Access)	51
Equation 8-3: Power Efficiency, Active (File Access)	51
Table B-1 Online and Near-Online Block Access Summary.....	60
Table B-2 Removable and Virtual Media Library Summary.....	60
Table B-3 Online and Near-Online File Access Summary.....	61

1 Introduction

There is a growing awareness of the environmental impact of IT equipment use. This impact takes several forms: the energy expended in equipment manufacture and distribution, the impact of materials reclamation, and the energy consumed in operation and cooling of the equipment. IT equipment users of all kinds now wish to make their IT operations as energy efficient as possible. This new priority can be driven by one or more of several requirements:

- Rising energy costs have made power and cooling expenses a more significant percentage of total cost of ownership of server and storage equipment;
- Some data centers are physically unable to add more power and cooling load, which means that new applications and data can only be brought on if old ones are retired or consolidated onto new, more efficient configurations;
- Increased regulatory and societal pressures provide incentives for companies to lower their total energy footprints. For many companies, IT is a significant portion of overall energy consumption, and corporate Green goals can only be achieved by reducing IT's energy needs or by making operations more efficient.

IT equipment users will seek advice on the most energy efficient approach to getting their work done. It is not practical for customers to test a wide range of storage products and architectures for themselves. A more effective approach is to create a collection of standard metrics that allow IT architects to objectively compare a range of possible solutions. This objective, metric-based approach has a dual impact:

- Users can select the mode of storage usage that accomplishes their work objectives with the lowest overall energy consumption;
- Companies will be driven to innovate and compete in the development of energy efficient products as measured by the standard yardsticks.

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2 Scope

2.1 Abstract

This document describes a standardized method to assess the energy efficiency of commercial storage products in both active and idle states of operation. A taxonomy is defined that classifies storage products in terms of operational profiles and supported features. Test definition and execution rules for measuring the power efficiency of each taxonomy category are described; these include test sequence, test configuration, instrumentation, benchmark driver, IO profiles, measurement interval, and metric stability assessment. Qualitative heuristic tests are defined to verify the existence of several capacity optimization methods. Resulting power efficiency metrics are defined as ratios of idle capacity or active operations during a selected stable measurement interval to the average measured power.

2.2 Introduction

This document defines methodologies and metrics for the evaluation of the related performance and energy consumption of storage products in specific active and idle states.

Storage products and components are said to be in an “active” state when they are processing externally initiated, application-level requests for data transfer between host(s) and the storage product(s). For purposes of this document, idle is defined as “ready idle”, in which storage systems and components are configured, powered up, connected to one or more hosts and capable of satisfying externally initiated, application-level initiated IO requests within normal response time constraints, but no such IO requests are being submitted.

2.3 Current Revision

This document addresses storage products supporting block or file data access. Block access and file access refer to the type of service provided typically by Storage Area Network (SAN) and Network Attached Storage (NAS) systems, respectively. It is not appropriate to use this document to ascertain power efficiency for anything other than these two access modes. This document includes:

- A generalized taxonomy for storage products (clause 5);
- An assessment mechanism for software-based Capacity Optimization Methods (clause 6);
- Measurement and data collection guidelines for assessing the power efficiency of block- and file-based storage products in both active and ready idle states (clause 7);
- Metrics describing storage product power efficiency (clause 8);
- Required disclosures for a test result published as a SNIA Emerald™¹ Power Efficiency Measurement test result (clause 9).

2.4 Purpose

The purpose of a SNIA Emerald™ Power Efficiency Measurement is to provide a reproducible and standardized assessment of the energy efficiency of commercial storage products in both active and ready idle states.

1. Tested systems shall be comprised of commercially released products and components;
2. Tested systems shall employ settings, parameters, and configurations that would allow end-users to achieve power efficiency levels equivalent to the published result;
3. All data published as an SNIA Emerald™ Power Efficiency Measurement test result shall be gathered from test execution conducted according to this document;

¹ SNIA Emerald™ is a trademark of the Storage Networking Industry Association. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

4. Test execution shall complete in its entirety and without test failure or test error messages;
5. Software features which invoke, generate, or use software designed specifically for the test shall not be used. Configuration options chosen for test execution shall be options that are generally recommended for the customer;
6. Energy for powering the equipment shall be provided by the power mains that are being monitored (not by an internal UPS).

A SNIA Emerald™ Power Efficiency Measurement shall be a good faith effort to accurately characterize the power requirements of the tested system. The precise configuration used in a SNIA Emerald™ Power Efficiency Measurement is left to the sponsor of a test. Any commercially released components may be used, and a focus on new or emerging components or technologies is encouraged.

2.5 Disclaimer

A SNIA Emerald™ Power Efficiency Measurement test result provides a high-level assessment of the energy efficiency of the tested system in specific ready idle and active states. It is not an attempt to precisely model or reproduce any specific installation.

Actual performance and energy consumption behavior is highly dependent upon precise workload, environmental and usage parameters. While a SNIA Emerald™ Power Efficiency Measurement test result is intended to provide a realistic and reproducible assessment of the relative power efficiency of a system across a broad range of configurations and usage patterns, it cannot completely match the precise needs of any one specific installation.

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3 Normative References

The following documents are referred to in the text in a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Table 1 lists these documents.

Table 1 – Normative References

Author/Owner	Title	Revision	URL
ISO/IEC	<i>ISO/IEC Directives Part II</i>	Eighth edition, 2018	https://www.iso.org/directives-and-policies.html

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4 Definitions, Symbols, Abbreviations, and Conventions

4.1 Overview

For the purposes of this document, the terms and definitions given in The SNIA Dictionary^[2] and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

The terms and definitions defined in this document are based on those found in The SNIA Dictionary^[2]. They have been extended, as needed, for use in this document. In cases where the current definitions in the SNIA dictionary conflict with those presented in this document, the definitions in this document shall apply.

4.2 Definitions

4.2.1

auto-tiering

policy-based system that automatically places and moves data across tiers to optimize performance service levels, cost targets, and overall energy consumption

Note 1 to entry: Each storage tier may comprise different storage technologies, offering varying performance, cost, and energy consumption characteristics.

4.2.2

cache

temporary storage used to transparently store data for expedited access to or from slower media, and not directly addressable by end-user applications

4.2.3

capacity optimization method (COM)

subsystem, whether implemented in hardware or software, which reduces the consumption of space required to store a data set

4.2.4

committed data

data that has been written to stable storage

4.2.5

compression

the process of encoding data to reduce its size

4.2.6

count-key-data (CKD)

disk data organization model in which the disk is assumed to consist of a fixed number of tracks, each having a maximum data capacity

Note 1 to entry: The CKD architecture derives its name from the record format, which consists of a field containing the number of bytes of data and a record address, an optional key field by which particular records can be easily recognized, and the data itself.

4.2.7**data deduplication**

replacement of multiple copies of data—at variable levels of granularity—with references to a shared copy in order to save storage space and/or bandwidth

4.2.8**dedupable**

property that a collection of data is said to possess if the needed storage capacity for the data is reduced significantly by data deduplication

4.2.9**delta snapshot**

type of point in time copy that preserves the state of data at an instant in time, by storing only those blocks that are different from an already existing full copy of the data

4.2.10**direct-connected**

storage designed to be under the control of a single host, or multiple hosts in a non-shared environment

4.2.11**efficiency**

ratio of useful work to the power required to do the work

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4.2.12**file**

abstract data object made up of a) an ordered sequence of data bytes stored on a disk or tape, b) a symbolic name by which the object can be uniquely identified, and c) a set of properties, such as ownership and access permissions that allow the object to be managed by a file system or backup manager

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4.2.13**file system**

software component that imposes structure on the address space of one or more physical or virtual disks so that applications may deal more conveniently with abstract named data objects of variable size (files)

4.2.14**fixed block architecture (FBA)**

model of disks in which storage space is organized as linear, dense address spaces of blocks of a fixed size

Note 1 to entry: Fixed block architecture is the disk model on which SCSI is predicated.

4.2.15**fixed content addressable storage (FCAS)**

storage optimized to manage content addressable data that is not expected to change during its lifetime

4.2.16

formatted capacity

total number of bytes available to be written after a system or device has been formatted for use, e.g., by an object store, file system or block services manager

Note 1 to entry: Formatted capacity, also called usable capacity, is less than or equal to raw capacity. It does not include areas set aside for system use, spares, RAID parity areas, checksum space, host- or file system-level remapping, "right sizing" of disks, disk labeling and so on. However, it may include areas that are normally reserved—such as snapshot set-asides—if they can alternatively be configured for ordinary data storage by the storage administrator.

4.2.17

free space

amount of additional irreducible data that can be written to the product under test as configured

4.2.18

hot band

simulation of naturally occurring hot spots

4.2.19

hot spot

area of storage more frequently accessed across the addressable space

4.2.20

IO intensity

measure of the number of IOPS requested by a load generator

Note 1 to entry: IO intensity is phrased as a percentage of selected maximum IOPS level that satisfies the timing requirement(s) for a taxonomy category.

4.2.21

irreducible data

data that is neither compressible nor dedupable

4.2.22

load generator

hardware and software environment executing the workload generator to drive the product under test during measurements

4.2.23

Logical Unit (LU)

entity within a SCSI target that executes IO commands

4.2.24

Logical Unit Number (LUN)

synonym for logical unit

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4.2.25**Maximum Time to First Data (MaxTTFD)**

maximum time required to start receiving data from a storage system to satisfy a read request for arbitrary data

4.2.26**network-connected**

storage designed to be connected to a host via a network protocol (e.g., TCP/IP, IB, and FC)

4.2.27**non-disruptive serviceability**

support for continued availability of data during all FRU service operations, including break/fix, code patches, software/firmware upgrades, configuration changes, data migrations, and system expansion

Note 1 to entry: Service operations may impact performance, but shall not result in a loss of access.

4.2.28**parity RAID**

collective term used to refer to Berkeley RAID Levels 3, 4, 5 and 6

4.2.29**permanent storage**

data storage media which can retain data indefinitely without a power source

4.2.30**product under test**

customer-orderable system or component that is the subject of a SNIA Emerald™ Power Efficiency Measurement

4.2.31**raw capacity**

sum of the raw, unformatted, uncompressed capacity of each storage device in the product under test

4.2.32**ready idle**

operational state in which a system is capable of satisfying an arbitrary IO request within the response time and MaxTTFD constraints of its selected taxonomy category, but no user-initiated IO requests are being submitted to the system. In the ready idle state, background I/O activity, autonomously initiated by the solution under test, may take place

4.2.33**sequential read**

IO load consisting of consecutively issued read requests to logically adjacent data

4.2.34**sequential write**

IO load consisting of consecutively issued write requests to logically adjacent data