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Technologies de l'information — Spécification du format de système de fichier à bande magnétique

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This document was prepared by the Storage Networking Industry Association (SNIA) (as Linear Tape File System (LTFS) Format Specification, Version 2.5) 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*.

This second edition cancels and replaces the first edition (ISO/IEC 20919:2016), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Volume Advisory Locking — a method of marking a volume as locked against future modification;

— Percent Encoding — method of including previously reserved characters in names of files and directories;

— Incremental Indexes — a method of recording a smaller index containing only changes since the last index;

— File hashes — a method of recording fils hash information in the index in an interchangeable manner;

— Open For Write — a method of noting files in the index which were still open at the time the index is written to tape.

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Revision History

Revision	Date	Sections	Originator	Comments
2.3.0 rev 1	3/18/14	Add section F.3	SNIA LTFS TWG	Edits during TWG F2F
2.3.0 rev 2	12/15/14	Add Changes per TWG	SNIA LTFS TWG	Edits adding Volume Advisory Locking, Volume UUID and LTFS Name Encoding
2.3.0 rev 3	3/18/15	Add changes per TWG	SNIA LTFS TWG	Edits Advisory Locking, Sha512,Media Pool Extended Attributes &MAM
2.3.0 rev 4	3/24/15	Add edits from TWG review	SNIA LTFS TWG	Cleanup some reference errors and minor editorial changes
2.3.0 rev 5	9/15/15	Add example 3 to Appendix F.1.6	SNIA LTFS TWG	Added additional description and example to describe reclamation of spanned file segments
2.3.0 rev 6	9/15/15	Add edits from TWG review	SNIA LTFS TWG	Revised wording in Appendix F.1.6 example 3
2.4.0 rev 0	11/14/15	Add work from TWG	SNIA LTFS TWG	Added changes listed in Change history
2.4.0 rev 1	1/12/17	Add edits from TWG review	SNIA LTFS TWG	Cleaned up some hyperlinks and minor editorial changes
2.4.0 rev 2	1/17/17	Add edits from TWG F2F	SNIA LTFS TWG	Minor editorial changes
2.4.0 rev3	6/12/17	Add edits from TWG	SNIA LTFS TWG	Added Advisory Locking changes
2.4.0 rev 4	6/13/17	Add Media Pool changes per TWG	SNIA LTFS TWG	Added additional extended attributes for Media Pool
2.4.0 rev 5	6/19/17	Add edits per TWG	SNIA LTFS TWG	Cleaned up a couple of typographical errors
2.4.0 rev 6	10/10/17	Add edits per TWG	SNIA LTFS TWG	Incorporated public review editorial comments
2.4.0 rev 7	10/18/17	Add edits per TWG	SNIA LTFS TWG	Minor editorial changes
2.4.0 rev 8	10/24/17	Annex G	SNIA LTFS TWG	Minor editorial change
2.4.0 rev 9	11/14/17	Annex G	SNIA LTFS TWG	Minor editorial change
2.5.0 rev 0	12/04/18	Sections 5 & 9, Annex B, etc.	SNIA LTFS TWG	Add incremental indexes; changes for sync behavior
2.5.0 rev 1	02/11/19	Add Annex H; edits per TWG	SNIA LTFS TWG	New Annex describing incremental indexes
2.5.0 rev 2	04/02/19	Section 9.2; Annex H	SNIA LTFS TWG	Corrected typos in example XML, updated flowchart in Annex H to clarify intent
2.5.1 rev 0	08/18/20	Section 3; Annex I	SNIA LTFS TWG	Editorial changes to References per feedback from ISO

Suggestion for changes or modifications to this document should be sent to the SNIA Linear Tape File System Technical Work Group at http://www.snia.org/feedback/.

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Changes between v1.0 and v2.0.0

- Incremented version number to 2.0.0 and updated date to March 11, 2011.
- Improvements in specification text to remove ambiguity and clarify intention of the specification. These changes were made at several locations throughout the document.
- Improvements to clarify description of MAM parameters in Section 10 Medium Auxiliary Memory.
- Removed reference to a specific version of the Unicode standard in Section 7.5 Name pattern format. This removes any requirement to use specific versions of Unicode support code in an implementation.
- Improved description of Name pattern format to remove ambiguity in Section 7.5 Name pattern format.
- Added description of LTFS Format specification version numbering in Section 2.1 Versions.
- Updated XML Schema for Label and Index to match version number format in Annex A and Annex B.
- Added specification of minimum and recommended blocksize value for LTFS Volumes to Section 8.1.2 LTFS Label.
- Added definition of allowed version numbers to Section 8.1.2 LTFS Label and Section 9.2 Index.
- Added definition of fileoffset tag in Section 9.2 Index.
- Extended description in Section 6 Data Extents to support addition of fileoffset tag and associated functionality.
- Added definition of highestfileuid tag in Section 9.2 Index.
- Added definition of fileuid tag in Section 9.2 Index.
- Added definition of backuptime tag in Section 9.2 Index.
- Incremented version number in Application Client Specific Information (ACSI) structure shown in Section 10.3 Use of Volume Coherency Information for LTFS. This increment allows identification of LTFS Volumes written with a LTFS v1.0 compliant implementation. A widely used v1.0 implementation wrote ambiguous ACSI values due to an implementation bug.
- Added definition of extended attributes in the ltfs.* namespace in Annex C.
- Added description for handling unknown XML tags in Index to Section 9.2.13 Managing LTFS Indexes.

Changes between v2.0.0 and v2.0.1

- Incremented specification version number to 2.0.1.
- Updated specification date to August 17, 2011.
- Expanded historical record of changes between revisions of LTFS Format Specification.
- Improved description of constraints for two Indexes having the same generation number in Section 5.4.1 Generation Number to make it clear that differences in access time values is permitted between Indexes that are otherwise except for self pointer and index pointer values.
- Added note in Section 5.4.1 Generation Number to explicitly state that Index generation numbers may increase by integer values other than 1.
- Expanded description of the ltfs.sync extended attribute in Annex C . The expanded description explicitly states that this extended attribute triggers a sync of the in-memory data to the storage media. That is, the operation is analogous to a POSIX sync operation.

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Changes between v2.0.1 and v2.1.0

- Incremented specification version number to 2.1.0.
- Updated specification date to October 18, 2012.
- Added definition of symlink tag in Section 9.2 Index.
- Added example of symlink tag use in Annex E.
- Added symlink tag to Annex B.
- Added description of “ltfs.vendor.X.Y” extended attribute namespace in Annex C .
- Added description of software metadata section in Annex C.
- Added description of drive metadata section in Annex C.
- Added ”ltfs.labelVersion” extended attribute in Annex C.
- Added ”ltfs.indexVersion” extended attribute in Annex C
- Added ”ltfs.mediaEncrypted” extended attribute in Annex C .
- Improved description of ”ltfs.mediaStorageAlert” extended attribute in Annex C.

Changes between v2.1.0 and v2.2.0

- Incremented specification version number to 2.2.0.
- Updated specification date to July 16, 2013.
- Changed “2010” to “2013” in XML examples.
- Editorial Cleanup.
- Changed “extentinfo” definition in Section 9.2 Index.
- Changed “symlink” definition in Section 9.2 Index.
- Added additional paragraph to “symlink” definition in Section 9.2 Index.
- Added general comments at start of Section 10 Medium Auxiliary Memory.
- Added Section 10.4 Use of Host-type Attributes for LTFS.
- Removed Section 9 Certification from document.
- Added “ltfs.mamBarcode” extended attribute in Volume Metadata.
- Added “ltfs.mamApplicationVendor” extended attribute in Volume Metadata.
- Added “ltfs.mamApplicationVersion” extended attribute in Volume Metadata.
- Added “ltfs.mamApplicationFormatVersion” extended attribute in Volume Metadata.
- Added new Annex F Interoperability Recommendation and added File Spanning and File Permissions subsections

Changes between v2.2.0 and 2.3.0 rev 1

- Add section F.3 Storing File Hash Values in LTFS
- Add Section 10.5 Volume Advisory Locking to Section 10 Medium Auxiliary Memory
- Added Volume UUID to Section 10.4 and Section 10.4.8
- Added LTFS Name Encoding to Sections 3.1, 7.4, 9.2.1 and 9.2.2
- Added SHA512 to Section F.3 Storing Hash Values in LTFS
- ISO document formatting changes

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- Add Media Pool Extended Attributes and MAM

Changes between v2.3.0 rev 1 and v2.4.0

- Incremented specification version number to 2.4.0.
- Added new text to Section 10.5 Volume Advisory Locking
- Added new text to Annex C.4 VolumeMetadata, ltfs.volumeLockState
- Added new text for “openforwrite” to Section 9.2.9
- Added new entry to the file element list in Annex B
- Added new descriptive text to Annex E
- Added new example file “partialfile.bin” to Annex E
- Updated the compliance statement to “version 2.4.0” in Section 7.4 Name Format
- Added new percentencoding text to Section 7.4 Name Format
- Removed percentencoding definition from Section 9.2.7
- Removed percentencoding definition from Section 9.2.9
- Added new text to symlink definition in Section 9.2.9
- Removed percentencoding paragraph(s) from Section 9.2.10
- Removed the percentencoded entry from the directory, file and extended attributes sections in Annex B
- Changed the name definition in the directory section of Annex B
- Changed the name definition in the file section of Annex B
- Changed the symlink definition in the file section of Annex B
- Changed the key definition in the extendedattributes section of Annex B
- Added new NameType definition to Annex B
- Changed the entry for fileuid “10” in Annex E

Changes between v2.4.0 and v2.4.0 rev 1

- Incremented specification version number to 2.4.0 rev 1.
- Changed version from 2.3.0 to 2.4.0 in Section 2.1 Versions
- Changed version from 2.3.0 to 2.4.0 in Annex E
- Cleaned up some hyperlinks and minor editorial changes

Changes between v2.4.0 rev 1 and v2.4.0 rev 2

- Changed version from 2.3.0 to 2.4.0 throughout document except for Section 9.2.19
- Changed updatetime in Annex E to reflect correct date/time value for example shown
- Changed highestfileuid in Annex E to reflect correct value for example shown
- Changed lockType to locktype throughout document
- Changed NameType to nametype throughout document

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Changes between v2.4.0 rev 2 and v2.4.0 rev 3

- Updated the definition of the volumeLockState virtual extended attribute in Section 10.5 and Annex C.4

Changes between v2.4.0 rev 3 and v2.4.0 rev 4

- Updated the definition of the Media Pool MAM attribute in Section 10.4 and Annex F.4.1.1

Changes between v2.4.0 rev 4 and v2.4.0 rev 5

- Fixed a couple of typographical errors

Changes between v2.4.0 rev 5 and v2.4.0 rev 6

- Corrections to Annex B – XML Schema
- Added Annex G – character representations
- Clarified in Section 7.4 that percent encoding does not apply to Table 13, and added reference to Annex G
- Added two further IBM contributors to the Acknowledgements

Changes between v2.4.0 rev 6 and v2.4.0 rev 7

- Changed title and reference of table G.1 in Annex G – applies to 2.3 and later
- Added clarifying note for symlinks in Annex G

Changes between v2.4.0 rev 7 and v2.4.0 rev 8

- Changed column heading in tables G.1 and G.2 to “symlink target name”
- Improved wording of Note 3 in Annex G

Changes between v2.4.0 rev 8 and v2.4.0 rev 9

- Changed column heading in tables G.1 and G.2 to “File name, directory name, filename pattern”
- Added corresponding Note 4 in Annex G

Changes between v2.4.0 rev 9 and v2.5.0

- Incremented specification version number to 2.5.0.
- Added new text to describe Full and Incremental Indexes, in particular in 5.4 Index Layout and 9 Index Format.
- Added new virtual extended attributes related to Incremental Indexes in C.4.
- Specify required behavior in response to writing ltfs.commitMessage and ltfs.sync VEAs in Annex C.

Changes between v2.5.0 rev 0 and v2.5.0 rev 1

- Added new informative Annex H describing background information on Incremental Indexes
- Editorial changes to clarify required vs optional elements in Incremental Indexes in 9 Index Format.
- Clarified that the required behavior for ltfs.commitMessage and ltfs.sync applies only to implementations supporting those VEAs.

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Changes between v2.5.0 rev 1 and v2.5.0 rev 2

- Corrected typos in Incremental Indexes example XML in 9.2.2 and 9.2.12
- Corrected typos in Annex H and amended flowchart H.1 to clarify the intent

Changes between v2.5.0 rev 2 and v2.5.1 rev 0

- Moved informative references from Section 3 to new Annex I Bibliography
- Amended all references to SPC-3 / SPC-4 to SPC-5

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1 Introduction

This document defines a Linear Tape File System (LTFS) Format separate from any implementation on data storage media. Using this format, data is stored in LTFS Volumes. An LTFS Volume holds data files and corresponding metadata to completely describe the directory and file structures stored on the volume.

The LTFS Format has these features:

- An LTFS Volume can be mounted and volume content accessed with full use of the data without the need to access other information sources.
- Data can be passed between sites and applications using only the information written to an LTFS Volume.
- Files can be written to, and read from, an LTFS Volume using standard POSIX file operations.

The LTFS Format is particularly suited to these usages:

- Data export and import.
- Data interchange and exchange.
- Direct file and partial file recall from sequential access media.
- Archival storage of files using a simplified, self-contained or “self-describing” format on sequential access media.

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2 Scope

This document defines the LTFS Format requirements for interchanged media that claims LTFS compliance. Those requirements are specified as the size and sequence of data blocks and file marks on the media, the content and form of special data constructs (the LTFS Label and LTFS Index), and the content of the partition labels and use of MAM parameters.

The data content (not the physical media) of the LTFS format shall be interchangeable among all data storage systems claiming conformance to this format. Physical media interchange is dependent on compatibility of physical media and the media access devices in use.

NOTE: This document does not contain instructions or tape command sequences to build the LTFS structure.

2.1 Versions

This document describes version 2.5.0 of the Linear Tape File System (LTFS) Format Specification.

The version number for the LTFS Format Specification consists of three integer elements separated by period characters of the form *M.N.R*, where *M*, *N* and *R* are positive integers or zero. Differences in the version number between different revisions of this specification indicate the nature of the changes made between the two revisions. Each of the integers in the format specification are incremented according to Table 1.

Table 1 — Version elements

Element	Description
M	Incremented when a major update has been made to the LTFS Format Specification. Major updates are defined as any change to the on-media format or specification semantics that are expected to break compatibility with older versions of the specification.
N	Incremented when a minor update has been made to the LTFS Format Specification. Minor updates are defined as any change to the on-media format or specification semantics that is not expected to break compatibility with older versions of the specification that have the same value for *M* in the version number.
R	Incremented when textual revisions are made to the LTFS Format Specification. Textual revisions are defined as revisions that improve the clarity of the specification document *without* changing the intent of the document. By definition, minor changes do not alter the on-media format or specification semantics.

NOTE 1: When any element of the specification version number is incremented, all sub-ordinate elements to the right are reset to zero. For example, if the version is 1.0.12 and N is incremented to 1, then R is set to zero resulting in version 1.1.0.

NOTE 2: The first public version of this document used version number 1.0. This value should be interpreted as equivalent to 1.0.0 in the version numbering defined in this document.

The result of comparison between two LTFS version numbers $M_A.N_A.R_A$ and $M_B.N_B.R_B$ is defined in Table 2.

Table 2 — Version comparisons

Conditional	Description
$M_A < M_B$	$M_A.N_A.R_A$ is an earlier version than $M_B.N_B.R_B$.
$M_A = M_B$ *and* $M_A < N_B$	$M_A.N_A.R_A$ is an earlier version than $M_B.N_B.R_B$.
$M_A = M_B$ *and* $N_A = N_B$ *and* $R_A < R_B$	$M_A.N_A.R_A$ is an earlier version than $M_B.N_B.R_B$. However, as defined above, changes that result only in a different *R* value are descriptive changes in the specification rather than on media changes.

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2.2 Conformance

Recorded media claiming conformance to this format shall be in a consistent state when interchanged or stored. See Section 4.1.4.

Any implementation conforming to this specification should be able to correctly read Label and Index structures from all prior versions of this specification and write Label and Index structures conforming to the descriptions in this document. The current Label and Index structures are defined in Section 8 Label Format and in Section 9 Index Format.

NOTE: Where practical, any implementation supporting a given version value for M should endeavor to support LTFS volumes with version numbers containing higher values for N and R than those defined at the time of implementation.

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3 Normative references

The following referenced documents are indispensable for the application 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.

ISO/IEC 14776-455, Information Technology - Small Computer System Interface (SCSI) – Part 455: SCSI Primary Commands - 5 (SPC-5) [ANSI INCITS.502-219]

SSC-4 SCSI Stream Commands – 4 (SSC-4) [ANSI INCITS 516-2013]

ISO 8601:2004 Data elements and interchange formats – Information interchange – Representation of dates and times – (UTC)

ISO/IEC 10646:2012: Information technology - Universal Coded Character Set (UCS) (UTF-8)

IETF RFC 4648, The Base16, Base32, and Base64 Data Encodings, http://www.ietf.org/rfc/rfc4648.txt

IETF RFC 4122, Universally Unique Identifier (UUID) URN Namespace http://www.ietf.org/rfc/rfc4122.txt

IETF RFC 3986, Uniform Resource Identifier (URI): Generic Syntax, http://www.ietf.org/rfc/rfc3986.txt

ANSI X3.27-1978 American National Standard Magnetic Tape Labels and File Structure for Information

W3C - Extensible Markup Language (XML) http://www.w3.org/XML

OSF CDE 1.1, Remote Procedure Call – Universal Unique Identifier (UUID) http://pubs.opengroup.org/onlinepubs/9629399/toc.pdf

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4 Definitions and Acronyms

For the purposes of this document the following definitions and acronyms shall apply.

4.1 Definitions

4.1.1

Block Position

The position or location of a recorded block as specified by its LTFS Partition ID and logical block number within that partition.

The block position of an Index is the position of the first logical block for the Index.

4.1.2

Complete Partition

An LTFS partition that consists of an LTFS Label Construct and a Content Area, where the last construct in the Content Area is an Index Construct.

4.1.3

Content Area

A contiguous area in a partition, used to record Index Constructs and Data Extents.

4.1.4

Consistent State

A volume is consistent when both partitions are complete and the last Index Construct in the Index Partition has a back pointer to the last Full Index Construct in the Data Partition.

4.1.5

Data Extent

A contiguous sequence of recorded blocks.

4.1.6

Data Partition

An LTFS partition primarily used for data files.

4.1.7

File

A group of logically related extents together with associated file metadata.

4.1.8

Filesystem sync

An operation during which all cached file data and metadata is flushed to the media.

4.1.9

Full Index

A data structure that describes all valid data files in an LTFS volume. The Full Index is an XML document conforming to the XML schema shown in Annex B (normative) LTFS Index XML Schema.

4.1.10

Generation number

A positive decimal integer which shall indicate the specific generation of an Index within an LTFS volume.

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4.1.11

Incremental Index

A data structure that describes changes made to the LTFS volume since the last index was written. The Incremental Index is an XML document conforming to the XML schema shown in Annex B (normative) LTFS Index XML Schema.

4.1.12

Index

Either a Full Index or an Incremental Index.

4.1.13

Index Construct

A data construct comprised of an Index and file marks.

4.1.14

Index Partition

An LTFS partition primarily used to store Index Constructs and optionally data files.

4.1.15

Label Construct

A data construct comprised of an ANSI VOL1 tape label, LTFS Label, and tape file marks.

4.1.16

Linear Tape File System (LTFS)

This document describes the Linear Tape File System Format.

4.1.17

LTFS Construct

Any of three defined constructs that are used in an LTFS partition. The LTFS constructs are: Label Construct, Index Construct, and Data Extent.

4.1.18

LTFS Label

A data structure that contains information about the LTFS partition on which the structure is stored. The LTFS Label is an XML document conforming to the XML schema shown in Annex A (normative) LTFS Label XML Schema.

4.1.19

LTFS Partition

A tape partition that is part of an LTFS volume. The partition contains an LTFS Label Construct and a Content Area.

4.1.20

LTFS Volume

A pair of LTFS partitions, one Data Partition and one Index Partition, that contain a logical set of files and directories. The pair of partitions in an LTFS Volume shall have the same UUID. All LTFS partitions in an LTFS volume are *related partitions*.

4.1.21

Medium Auxiliary Memory

An area of non-volatile storage that is part of an individual storage medium. The method of access to this non-volatile storage is standardized as described in the SPC-5 standard.

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4.1.22

Partition Identifier (Partition ID)
The logical partition letter to which LTFS data files and Indexes are assigned.

The linkage between LTFS partition letter and physical SCSI partition number is determined by the SCSI partition in which the LTFS Label is recorded. The LTFS partition letter is recorded in the LTFS Label construct, and the SCSI partition number is known by the SCSI positional context where they were read/written.

4.1.23

Sparse file
A file that has some number of empty (unwritten) data regions. These regions are not stored on the storage media and are implicitly filled with bytes containing the value zero (0*x*00).

4.1.24

UUID
Universally unique identifier; an identifier use to bind a set of LTFS partitions into an LTFS volume.

4.1.25

Volume Change Reference (VCR)
A value that represents the state of all partitions on a medium.

4.1.26

Volume Advisory Locking
An indication that the LTFS volume has been locked against future modifications. This is a form of write protection under the control of host software rather than physical hardware.

4.2 Acronyms

ASCII	American Standard Code for Information Interchange
CM	Cartridge Memory
DCE	Distributed Computing Environment
ISO	International Organization for Standardization
LTFS	Linear Tape File System
MAM	Media Auxiliary Memory
NFC	Normalization Form Canonical Composition
OSF	Open Software Foundation
POSIX	Portable Operating System Interface for Unix
T10/SSC-4	ISO/IEC 14776-334, SCSI Stream Commands - 4 (SSC-4) [T10/2123-D]
UTC	Coordinated Universal Time
UTF-8	8-bit UCS/Unicode Transformation Format
UUID	Universally Unique Identifier
W3C	World Wide Web Consortium
XML	Extensible Markup Language

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