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Information technology — Linear Tape File System (LTFS) Format Specification

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2016

ISBN 978 0 580 91317 4

ICS 35.220.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2016.

Amendments/corrigenda issued since publication

Date	Text affected

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INTERNATIONAL STANDARD

ISO/IEC 20919

First edition
2016-04-01

Information technology — Linear Tape File System (LTFS) Format Specification

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

Reference number
ISO/IEC 20919:2016(E)

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Linear Tape File System (LTFS) Format Specification

Version 2.2.0

This document has been released and approved by the SNIA. The SNIA believes that the ideas, methodologies and technologies described in this document accurately represent the SNIA goals and are appropriate for widespread distribution. Suggestions for revision should be directed to http://www.snia.org/feedback/

SNIA Technical Position

December 21, 2013

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Revision History

Revision	Date	Sections	Originator:	Comments
2.1.0	May 18, 2012	Entire Document	David Pease	LaTeX version contributed by IBM
2.2.0 rev a	January 15, 2013	Entire document	Arnold Jones	Converted to Microsoft Word
2.2.0 rev b	March 15, 2013	Entire document	Carl Madison	Edits/Additions per TWG
2.2.0 rev c	April 4, 2013	Entire document	Carl Madison	Edits/Additions per TWG F2F
2.2.0 rev d	May 7, 2013	Entire document	Carl Madison	Diagram Replacement/edits
2.2.0 rev e	May 28, 2013	Entire document	Carl Madison	F2F edits, misc edits
2.2.0 rev f	July 16, 2013	Entire document	Carl Madison	Edits per TWG
2.2.0 rev g	July 23, 2013	Entire document	Carl Madison	Edits per TWG F2F
2.2.0 rev h	July 29, 2013	Entire document	Carl Madison	Edits per TWG
2.2.0 rev i	July 30, 2013	Entire document	Carl Madison	Edits per TWG 7/30/13 mtg
2.2.0 rev j	August 13, 2013	Entire document	Carl Madison	Edits per TWG 8/13/13 mtg
2.2.0 rev k	August 27, 2013	Entire Document	Carl Madison	Edits per TWG 8/27/13 mtg.
2.2.0 SNIA Technical Position	December 21, 2013* March 14, 2013**	Entire Document	Carl Madison	*2.2.0 rev k formatted as a *SNIA Technical Position* after SNIA membership approval. **Additional editorial revisions

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/.

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 9 Medium Auxiliary Memory.
- Removed reference to a specific version of the Unicode standard in Section 6.5 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 6.5 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 7.1.2 LTFS Label.
- Added definition of allowed version numbers to Section 7.1.2 LTFS Label and Section 8.2 Index.
- Added definition of fileoffset tag in Section 8.2 Index.
- Extended description in Section 5 Data Extents to support addition of fileoffset tag and associated functionality.
- Added definition of highestfileuid tag in Section 8.2 Index.
- Added definition of fileuid tag in Section 8.2 Index.

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- Added definition of backuptime tag in Section 8.2 Index.
- Incremented version number in Application Client Specific Information (ACSI) structure shown in 9.3 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 8.2.10 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 4.4.1 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 4.4.1 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.

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 8.2 Index.
- Added example of symlink tag use in Annex E (informative) Complete Example LTFS Index.
- 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.

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- Changed “extentinfo” definition in Section 8.2 Index.
- Changed “symlink” definition in Section 8.2 Index.
- Added additional paragraph to “symlink” definition in Section 8.2 Index.
- Added general comments at start of Section 9 Medium Auxiliary Memory.
- Added Section 9.4 Use of Host-type Attributes for LTFS.
- Removed Section 9 Certification from document.
- Added “ltfs.mamBarcode” extended attribute in Annex C.4 Volume Metadata.
- Added “ltfs.mamApplicationVendor” extended attribute in Annex C.4 Volume Metadata.
- Added “ltfs.mamApplicationVersion” extended attribute in Annex C.4 Volume Metadata.
- Added “ltfs.mamApplicationFormatVersion” extended attribute in Annex C.4 Volume Metadata.
- Added new Annex F Interoperability Recommendation and added File Spanning and File Permissions subsections

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Acknowledgements

The SNIA LTFS Technical Working Group, which developed and reviewed this specification, would like to recognize the significant contributions made by the following members:

EMC Corporation.....Don Deel
Hewlett-Packard .....Chris Martin
IBM.....David Pease
.....Ed Childers
NetApp.....David Slik
Oracle Corporation.....Matthew Gaffney
.....Carl Madison
Quantum Corporation.....Paul Stone
SNIA.....Arnold Jones

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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 2.2.0 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.

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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.

2.2 Conformance

Recorded media claiming conformance to this format shall be in a consistent state when interchanged or stored. See Section 3.1.4.

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 7 Label Format and in Section 8 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 Definitions and Acronyms

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

3.1 Definitions

3.1.1

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.

3.1.2

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.

3.1.3

Content Area

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

3.1.4

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 Index Construct in the Data Partition.

3.1.5

Data Extent

A contiguous sequence of recorded blocks.

3.1.6

Data Partition

An LTFS partition primarily used for data files.

3.1.7

File

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

3.1.8

filesystem sync

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

3.1.9

generation number

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

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3.1.10

Index

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

3.1.11

Index Construct

A data construct comprised of an Index and file marks.

3.1.12

Index Partition

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

3.1.13

Label Construct

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

3.1.14

Linear Tape File System (LTFS)

This document describes the Linear Tape File System Format.

3.1.15

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.

3.1.16

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.

3.1.17

LTFS Partition

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

3.1.18

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*.

3.1.19

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 T10/SPC-4 standard.

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3.1.20

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.

3.1.21

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).

3.1.22

UUID

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

3.1.23

Volume Change Reference (VCR)

A value that represents the state of all partitions on a medium.

3.2 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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4 Volume Layout

An LTFS volume is comprised of a pair of LTFS partitions. LTFS defines two partition types: data partition and index partition. An LTFS volume shall contain exactly one Data Partition and exactly one Index Partition.

4.1 LTFS Partitions

Each partition in an LTFS volume shall consist of a Label Construct followed by a Content Area. This logical structure is shown in Figure 1.

Figure 1 — LTFS Partition

The Label Construct is described in Section 4.2 LTFS Constructs and in Section 7 Label Format. The Content Area contains some number of interleaved Index Constructs and Data Extents. These constructs are described in Section 4.2 LTFS Constructs and in Section 8 Index Format. The precise layout of the partitions is defined in Section 4.3 Partition Layout.

4.2 LTFS Constructs

LTFS constructs are comprised of file marks and records. These are also known as ‘logical objects’ as found in T10 SSC specifications and are not described here. An LTFS volume contains three kinds of constructs.

- A Label Construct contains identifying information for the LTFS volume.
- A Data Extent contains file data written as sequential logical blocks. A file consists of zero or more Data Extents plus associated metadata stored in the Index Construct.
- An Index Construct contains an Index, which is an XML data structure which describes the mapping between files and Data Extents.

4.2.1 Label Construct

Each partition in an LTFS volume shall contain a Label Construct with the following structure. As shown in Figure 2, the construct shall consist of an ANSI VOL1 label, followed by a single file mark, followed by one record in LTFS Label format, followed by a single file mark. Each Label construct for an LTFS volume shall contain identical information except for the “location” field of the LTFS Label.

The content of the ANSI VOL1 label and the LTFS Label is specified in Section 7 Label Format.

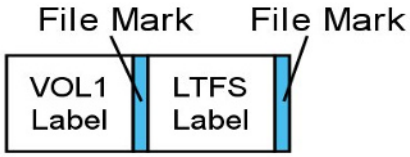

Figure 2 — Label Construct

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4.2.2 Data Extent

A Data Extent is a set of one or more sequential logical blocks used to store file data. The “blocksize” field of the LTFS Label defines the block size used in Data Extents. All blocks within a Data Extent shall have this fixed block size except the last block, which may be smaller.

The use of Data Extents to store file data is specified in Section 5 Data Extents.

4.2.3 Index Construct

Figure 3 shows the structure of an Index Construct. An Index Construct consists of a file mark, followed by an Index, followed by a file mark. An Index consists of a record that follows the same rules as a Data Extent, but it does not contain file data. That is, the Index is written as a sequence of one or more logical blocks of size “blocksize” using the value stored in the LTFS Label. Each block in this sequence shall have this fixed block size except the last block, which may be smaller. This sequence of blocks records the Index XML data that holds the file metadata and the mapping from files to Data Extents. The Index XML data recorded in an Index Construct shall be written from the start of each logical block used. That is, Index XML data may not be recorded offset from the start of the logical block.

Figure 3 — Index Construct

Indexes also include references to other Indexes in the volume. References to other Indexes are used to maintain consistency between partitions in a volume. These references (back pointers and self pointers) are described in Section 4.4 Index Layout.

The content of the Index is described in Section 8 Index Format.

4.3 Partition Layout

This section describes the layout of an LTFS Partition in detail. An LTFS Partition contains a Label Construct followed by a Content Area. The Content Area contains zero or more Data Extents and Index Constructs in any order. The last construct in the Content Area of a complete partition shall be an Index Construct.

Figure 4 illustrates an empty complete partition. It contains a Label Construct followed by an Index Construct. This is the simplest possible complete partition.

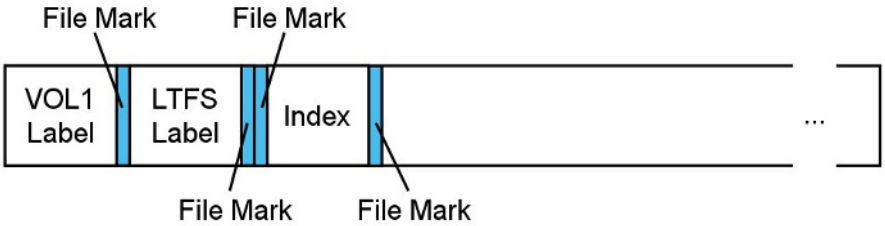

Figure 4 — Partition Layout

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Figure 5 illustrates a complete partition containing data. The Content Area on the illustrated partition contains two Data Extents (the first extent comprising the block 'A', the second extent comprising blocks 'B' and 'C') and three Index Constructs.

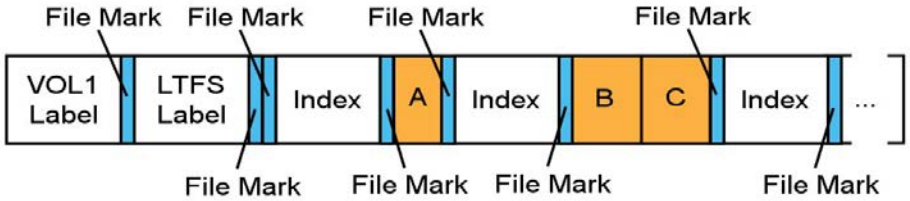

Figure 5 — Complete partition containing data

NOTE: There must not be any additional data trailing the end of the VOL1 Label, the LTFS Label, nor any Index on an LTFS Volume. The Label Construct must be recorded starting at the first logical block in each partition.

4.4 Index Layout

Each Index data structure contains three pieces of information used to verify the consistency of an LTFS volume.

- A generation number, which records the age of this Index relative to other Indexes in the volume.
- A self pointer, which records the volume to which the Index belongs and the block position of the Index within that volume.
- A back pointer, which records the block position of the last Index present on the Data Partition immediately before this Index was written.

4.4.1 Generation Number

Each Index in a volume has a generation number, a non-negative integer that increases as changes are made to the volume. In any consistent LTFS volume, the Index with the highest generation number on the volume represents the current state of the entire volume. Generation numbers are assigned in the following way:

- Given two Indexes on a partition, the one with a higher block position shall have a generation number greater than or equal to that of the one with a lower block position.
- Two Indexes in an LTFS volume may have the same generation number if and only if their contents are identical except for these elements:
  - access time values for files and directories (described in Section 8.2),
  - the self pointer (described in 4.4.2), and
  - the back pointer (described in 4.4.3).

NOTE: The value of the generation number between any two successive Indexes may increase by any positive integer value. That is, the magnitude of increase between any two successive Indexes is not assumed to be equal to 1.

The first Index on an LTFS Volume shall be generation number '1'.

4.4.2 Self Pointer

The self pointer for an Index is comprised of the following information:

- The UUID of the volume to which the Index belongs
- The block position of the Index

The self pointer is used to distinguish between Indexes and Data Extents. An otherwise valid Index with an invalid self pointer shall be considered a Data Extent for the purpose of verifying that a volume is valid

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