INTERNATIONAL STANDARD

ISO/IEC 14417

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Information technology — Data recording format DD-1 for magnetic tape cassette conforming to ISO/IEC 1016

Technologies de l'information — Format d'enregistrement des données DD-1 pour cassette à bande magnétique conforme à l'ISO/CEI 1016

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Contents

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Annexes

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 14417 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 11, *Flexible magnetic media for digital data interchange*.

Annexes A to C form an integral part of this International Standard. Annexes D to I are for information only.

Information technology - Data recording format DD-1 for magnetic tape cassette conforming to IEC 61016

1 Scope

This International Standard specifies the media characteristics, the recorded tape format and file structure requirements to enable information interchange between information processing systems using 19,0 mm wide magnetic tape and cassette conforming to IEC 61016 Section 2.

1.1 Purpose

The purpose of this International Standard is to define the format necessary to ensure information interchange at acceptable performance levels.

The interchange parties complying with the applicable standards should be able to achieve compatibility without the need for additional exchange of technical information.

2 Conformance

2.1 Magnetic tape cassettes

Each size / capacity of magnetic tape cassette shall be in conformance with this International Standard if it satisfies all mandatory requirements of this International Standard and IEC 61016 Section Two. If both Standards specify the same subjects differently, then this International Standard shall prevail. The tape requirements shall be satisfied throughout the extent of the tape.

2.2 Generating systems

A system generating a magnetic tape cassette for interchange shall be entitled to claim conformance with this International Standard if all the recordings that it makes on a tape according to 2.1 meet the mandatory requirements of this International Standard. If there is a choice, e.g. cassette size, at least one shall meet the mandatory requirements of this International Standard.

2.3 Receiving systems

A system receiving a magnetic tape cassette for interchange shall be entitled to claim conformance with this International Standard if it is able to handle any recording made on the tape according to 2.1. If there is a choice, e.g. tape thickness, at least one shall meet the mandatory requirements of this International Standard.

3 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC 646:1991, *Information technology — ISO 7-bit coded character set for information interchange.*

ISO 1001:1986, *Information processing — File structure and labelling of magnetic tapes for information interchange*.

IEC 61016, *Helical-scan digital component video cassette recording system using 19 mm magnetic tape (format D-1), Section 2 — Videotape cassette.*

4 Definitions

4.1 Auxiliary data

Optional information of secondary importance.

4.2 Annotation record

The magnetization pattern or associated information recorded in the annotation track.

4.3 Annotation tracks

Two longitudinal tracks one each at each tape edge.

4.4 Average Signal Amplitude (ASA)

The average peak-to-peak value of the signal output of the read head measured over a minimum of 280 000 flux transitions, exclusive of dropouts.

4.5 azimuth

The angular deviation, in degrees and minutes of arc, of the recorded flux transitions on a track from the line perpendicular to the track centerline.

4.6 block

A group of bytes transported between host and controller as a unit and considered a minimum locatable unit; containing one or more logical records or portions of logical records.

4.7 byte

An ordered set of 8 bits acted on as a unit.

4.8 Codeword Digital Sum (CDS)

The digital sum variation from the beginning to the end of a NRZI(1) symbol's waveform. The CDS is calculated assuming that the NRZI(1) waveform starts at a negative level, the binary -1 and +1, and the waveform transitions are centred relative to the corresponding bit cells.

4.9 Data area

An area on tape that is defined by the end points of all possible helical track center lines.

4.10 Data area reference line

A basic dimension which shall be exactly 1,8075 mm from the tape reference edge (no tolerence).

4.11 Data area reference point

The point on the centreline of a helical track at the boundry between preamble run-up and preamble sync pattern.

4.12 Data field

A continuous string of bits that is error protected.

4.13 Digital Sum Variation (DSV)

The accumulated sum of the CDS values of the NRZI(1) symbols.

4.14 Dropout

The point of read signal amplitude below a given threshold.

4.15 Erase

The removal of all magnetically recorded information from the tape.

4.16 Erasing field

An a. c. magnetic field of sufficient strength to remove the recorded signals from the tape.

4.17 Equivalent reference edge

For measurement of the recorded track format, the average location of the reference edge over a given length.

4.18 flux transition spacing

The distance along a track between successive flux transitions. The spacing is derived from the inverse of flux transitions per millimeter (ftpmm) (See physical record density.)

4.19 Helical (data) record

The magnetization pattern or associated information recorded in all possible helical tracks.

4.20 Helical track

An area on tape, inclined at a small angle to the reference edge of the tape.

4.21 Home track ID

A recorder manufacturer defined field used to identify the scanner head recording the first track of a track set.

4.22 Inner code

Of the sequential error detection and correction codes, the first encountered on playback from tape (C1).

4.23 Leader

A nonmagnetic length of transparent tape joined to each end of the magnetic tape to provide strength and convenience. At the beginning of the tape, it identifies the storage position of the tape. At the end of the tape, it indicates that the permissible recording area has been exceeded.

4.24 Logical volume

A collection of related files, without regard to physical container size.

4.25 magnetic tape

A tape which will accept and retain the magnetic signals intended for input, output, and storage purposes on computers and associated equipment.

4.26 Master Standard Reference Tape

The tape selected to establish the standard for tape properties essential to data interchange.

Note - A master standard reference tape has been established. It has been agreed that Sony Corporation will maintain the master standard reference tape. (See secondary standard reference tape.)

4.27 Outer code

Of the sequential error detection and correction codes, the second encountered on playback from tape (C2).

4.28 physical recording density

The number of recorded flux transitions per unit length of track, e.g., flux transitions per millimeter (ftpmm).

4.29 Postamble

A sequence of bits recorded at the end of each helical track on a magnetic tape to provide flux transitions and special padding area to clear the decoding circuitry and provide tolerance area.

4.30 Preamble

A sequence of bits recorded at the beginning of each helical track on a magnetic tape to provide electronic synchronization.

4.31 reference edge

The lower edge of the tape when viewing the recording surface with the supply reel to the observer’s right.

4.32 reference field

The typical field of the master standard reference tape.

4.33 Resolution

The ratio of the average signal amplitude at the physical recording density of 2252 ftpmm to that at the physical recording density of 280 ftpmm.

4.34 Secondary Standard Reference Tape

A tape, the performance of which is known and stated in relation to that of the master standard reference tape.

Note - A master standard reference tape has been established. The Sony Corporation will make available for purchase, secondary standard reference tapes that can be ordered (P/N C2B-D1) until the year 2007. For information contact:

Sony Corporation, Magnetic Products Group, Major Customer Sales Division,
6-7-35 Kitashinagawa, Shinagawa-ku, Tokyo 141, Japan,
Tel: 81-3-5448-3560, Fax: 81-3-5448-7701, Tlx: SONYCORPJ22262

4.35 Sector

The helical record pertaining to a single helical track.

4.36 Sector recording tolerance

The maximum allowable distance of the data area reference point from the intersection of track center line and data area reference line.

4.37 Standard Reference Amplitude

The average peak-to-peak signal amplitude output from the master standard reference tape when it is recorded with the standard reference current. The signal amplitude shall be averaged over at least 280 000 flux transitions. Traceability to the standard reference is provided by the secondary standard reference tape.

4.38 Standard Reference Current

The current required to produce the reference field.

4.39 Sync pattern

A magnetization pattern defining the start of each sync block and the postamble or, following the preamble run-up.

4.40 Tape mark

A special block recorded on magnetic tape to serve as a separator between files and file labels, or to define the end of recorded data.

4.41 Tolerance zones

Narrow zones established to contain completely the track center lines of six consecutive helical tracks.

4.42 track

A narrow, defined area on tape along which a series of magnetic signals may be recorded.

4.43 track angle

The angular deviation, expressed in degrees and minutes of arc calculated from arcsine of (16/170), of the centerline of the recorded helical track from the equivalent reference edge of the tape.

4.44 Track Set

Four consecutive helical tracks uniquely identified by a track set ID.

4.45 Track Set ID (TSID)

A 23 bit binary field which is a common identifier for a set of four consecutive helical tracks. Each track set ID is recorded at the start of the helical tracks as part of the control record, and also recorded on the control track.

4.46 Volume set

A collection of logical volumes.

5 Conventions and notations

5.1 Representation of numbers

- A measured value is rounded off to the least significant digit of the corresponding specified value. It implies that a specified value of 1,26 with a positive tolerance of 0,01, and a negative tolerance of 0,02 allows a range of measured values from 1,235 (inclusive) to 1,275 (exclusive).
- Letters and digits in parentheses represent numbers in hexadecimal notation.
- The setting of a bit is denoted by ZERO or ONE.
- Numbers in binary notation and bit combinations are represented by strings of 0s and 1s. Within such strings, X may be used to indicate that the setting of a bit is not specified within the string.
- Numbers in binary notation and bit combinations are shown as Words with the MSB to the left, and with the msb in each byte to the left.
- Negative values of numbers in binary notion are given in TWOs complement.

5.2 Names

Proper names and basic elements are written with a capital initial letter.

5.3 Acronyms

ASA	Average Signal Amplitude
CRC	Cyclic Redundancy Check
DIT	Directory Information Table
DM	Dummy
DSV	Digital Sum Variation
ECC	Error Correction Code
EOD	End of Data
FIT	File Information Table
LBOT	Logical Beginning of Tape
LEOT	Logical End of Tape
ELD	End of Label Data
LSB	Least Significant Byte
lsb	least significant bit
MSB	Most Significant Byte
msb	most significant bit
NEOT	Near End of Tape
PBOT	Physical Beginning of Tape
PEOT	Physical End of Tape
TM	Tape Mark
TSID	Track Set Identification
UD	User Data
UHL	User Header Label
UIT	User Information Table
UT	Update Table

VEOV	Virtual End of Volume
VIT	Volume Information Table
VSIT	Volume Set Information Table

6 Environmental and safety

6.1 Testing environment

Tests and measurements made on the tape to check the requirements of this standard shall be made under the following conditions unless otherwise specified:

temperature:	20 °C ± 1 °C (Ref. ISO/IEC 1016);
relative humidity:	48% to 52%;
barometric pressure:	96 kPa ± 10 kPa;
tape tension:	0,80N ± 0,05N;
conditioning before testing:	cassette shall be exposed to the test environment for 24 h min.

6.2 Operating environment

Cassettes used for data interchange shall be operated under the following conditions:

temperature:	5 °C to 45 °C;
relative humidity:	20% to 80% non-condensing;
wet bulb temperature:	26 °C max.

6.3 Cassette conditioning

For interchange, the cassette shall be conditioned by exposure to the operating environment for a time equal to or greater than the time away from the operating environment (up to maximum of 24 hours).

Conditioning of the tape stock before recording and testing for compliance to this standard shall be as follows:

storage conditioning:	not less than 24 hours;
environmental:	stabilized to the conditions specified in 6.1;
tape tension:	wound on a reel at a tension of 0,6 N to 1,5 N.

6.4 Storage environment

Cassettes shall be stored under the following conditions:

temperature:	5°C to 32°C;
relative humidity:	40% to 60%.

6.5 Safety

6.5.1 Safeness

The components of the tape and cassette assembly shall not constitute any safety or health hazard when used in the intended manner, or through any foreseeable misuse in an information processing system.

6.5.2 Flammability

Tape or cassette components that will ignite from a match flame, and when so ignited will continue to burn in a still carbon dioxide atmosphere, shall not be used.

6.5.3 Toxicity

Tape or cassette components that may cause bodily harm by contact, inhalation, or ingestion during normal use of the cassette shall not be used.

7 Cassette

7.1 General description

The cassette is a coplanar design in three sizes with the tape and hubs completely enclosed by the case, except for the hinged door opening. The drive is via hub couplings which are mechanically connected to external reeling motors. Tape velocity is stabilized by an external capstan. A clear plastic window allows visual monitoring of the tape from the top of the cassette.

7.2 Dimensions

Dimensions of the three sizes of cassettes are defined in normative reference IEC 1016. section 2.

7.3 Identification holes

There shall be two sets of identification holes, one for the use of the manufacturer and the other for the user. Manufacturers' coding holes, detailed in normative reference IEC 1016 are further defined in the following clauses.

7.3.1 Manufacturer coding holes

7.3.1.1 Media thickness

Manufacturer holes 1 and 2 shall be used in combination to indicate tape thickness according to the following logic table:

Hole #1	Hole #2	Meaning
0	0	16 µm tape
0	1	13 µm tape
1	0	Undefined/reserved
1	1	Reserved, cleaning cassette only

Note - A 0 in the above tables indicates that the indicator tab is removed or open, denoting an undetected status (0 state) by the recorder/player sensor mechanism.

7.3.1.2 Media coercivity

Manufacturer holes 3 and 4 shall be used to indicate the coercivity of the magnetic recording tape according to the following table:

Hole #3	Hole #4	Meaning
0	0	Class 68kA/m
0	1	Reserved
1	0	Undefined/reserved
1	1	Reserved, cleaning cassette only

Note - A 0 in the above tables indicates that the indicator tab is removed or open, denoting an undetected status (0 state) by the recorder/player sensor mechanism

7.3.2 User coding holes

The user plug mechanism shall withstand a minimum axial force of 0,5 N
The dimensions and location of the users' holes specified in normative reference IEC 1016 are defined as follows:

When a *0* state exists, the user holes shall identify the following conditions:

Hole	Condition
1	Total record lock out (data/auxiliary/time code/control track)
2	Reserved and undefined
3	Reserved and undefined
4	Reserved and undefined

8 Tape mechanical and electrical properties

8.1 Materials

The tape shall consist of a base film material (oriented polyethylene terephthalate film or its equivalent) coated on one surface with a strong yet flexible layer of ferromagnetic material dispersed in a suitable binder. A backcoating material may be used.

8.2 Tape width and tolerance

8.2.1 Requirement

The tape width shall be 19,010 mm ± 0,015 mm.

8.2.2 Procedure

The tape, covered with a glass plate, shall be measured without tension at a minimum of five different positions along the tape using a calibrated microscope or profile projector having an accuracy of at least 2,5 mm. Tape width is defined as the average of the five readings.

8.3 Delta width

8.3.1 Requirement

Delta width (width fluctuation) shall not exceed 6 mm peak to peak.

8.3.2 Procedure

Measurement of delta width shall be over a minimum tape length of 230 mm with a tension of 1,39 N ± 0,28 N.

8.4 Reference edge straightness

Reference edge straightness is the departure of the reference edge of the tape from a straight line along the longitudinal dimension of the tape in the plane of the tape surface.

8.4.1 Requirement

The reference edge straightness maximum deviation is 6 mm peak to peak.

8.4.2 Procedure

Edge straightness fluctuation is measured at the edge of a moving tape guided by two guides having contact to the same edge and separated at a distance of 115 mm. Edge measurements are averaged over 10 mm lengths and are made at the mid-point between the first and second guide at a tension of 1,00 N ± 0,28 N.

8.5 Tape thickness

Use of tapes with various thicknesses is permitted with the total tape thickness being within the following values:

- nominal 16 µm tape shall have a thickness between 13,5 µm - 16,0 µm;
- nominal 13 µm tape shall have a thickness between 11,0 µm - 13,0 µm.

8.6 Magnetic recording surface coating thickness

The magnetic recording surface coating thickness shall be 2,0 µm - 3,6 µm

Backcoating surface thickness is not specified.

8.7 Tape length

The minimum length of magnetic tape between leader and header tapes shall be

Cassette \ Tape Thickness	16mm	13mm
Small	190 m	225 m
Medium	587 m	708 m
Large	1311 m	1622 m

The maximum lengths of tape shall be determined by the maximum diameter of the tape pack permitted in their respective cassettes.

8.8 Discontinuity

There shall be no discontinuities in the tape between the beginning of tape (BOT) and end of tape (EOT) leaders such as those produced by tape splicing or perforations except those caused by leader or trailer attachment.

8.9 Longitudinal curvature

Longitudinal curvature is the departure of the reference edge of the tape from a straight line along the longitudinal dimension of the tape in the plane of the tape surface.

8.9.1 Requirement

Any deviation of the reference edge from a straight line must be gradual and shall not exceed 0,04 mm within a 229 mm span of tape.

8.9.2 Procedure

Measure at a tension of 1,39 N ± 0,28 N in a test fixture equipped with two guides spaced at 229 mm ± 1 mm. The two guides shall be spring loaded to position the reference edge of the tape against two edge control surfaces. Measure the maximum deviation of the reference edge of the tape from the line drawn between the two control surfaces.

8.10 Out-of-plane distortions

Out-of-plane distortions are local deformations that cause portions of the tape to deviate from the plane of the surface of the tape. Out-of-plane distortions are most readily observed when the tape is lying on a flat surface under no tension. All visual evidence of out-of-plane distortion shall be removed when the tape is subjected to a uniform tension of 0,6 N ± 0,03 N.

8.11 Leaders, trailers and splices

8.11.1 Leaders and trailers

The cassette shall include leader and trailer tape. When attached to the hub, there shall be a length of 300 mm ± 30 mm between the splice point and the outside of the cassette shell. The leader/trailer tape material shall be polyester or equivalent having a transmissivity of at least 60% when measured with a 700 nm - 900 nm light source. When attached to the hub, the leader/trailer tape shall not separate from the hub when subjected to a force of 22 N or less. The width of the leader/trailer tape shall be 19,010 mm ± 0,025 mm The thickness of the leader/trailer tape shall be 10 mm to 40 mm. The break tensile strength of the leader/trailer tape shall be at least 22 N.

8.11.2 Splices

The splicing tape to attach the leader and trailer shall be of a polyester material which may be with a metal foil backing. The splicing tape width shall be 19,010 mm ± 0,025 mm The splice shall not separate when subjected to a force of 22 N or less.

8.12 Tape wind

The tape shall be wound on the hubs with the magnetic coating out, and in such a way that during forward read/write operations the tape is unwound in a counterclockwise direction (reel turns clockwise) viewed from the top of the cassette.

8.13 Tensile yield force

The tensile yield force shall be taken as the force required to elongate the sample by 3% (tape or leader/trailer).

8.13.1 Requirement

The tensile yield force at 3% elongation shall be a minimum of 13,4 N.

8.13.2 Procedure

Use a static weighting, constant rate-of-separation tester capable of indicating the load to an accuracy of ±2%. Clamp a specimen of at least 178 mm in length, with an initial 102 mm separation between the jaws. Elongate the specimen at a rate of 51 mm per minute until a minimum of 10% is reached. The force required to produce an elongation of 3% is the tensile yield force.

8.14 Inhibitor tape

An inhibitor tape is a tape that degrades the performance of the tape drive or other tapes.

Certain tape characteristics can contribute to poor tape drive performance. Tapes that exhibit these characteristics may not give satisfactory performance, can result in excessive errors and can interfere with the subsequent performance of other tapes.

These characteristics include the following:

- high abrasivity;
- high friction to tape path components;
- poor edge conditions;
- excessive tape wear residual products;
- electro-static charge build-up on the tape or tape path components;
- interlayer slippage;
- transfer of oxide coating to the back of the next tape layer;
- separation of tape constituents causing deposits that may lead to tape sticking or poor performance of other tapes.

The inherent characteristics of the tape should be such that the tape will not inhibit interchange performance.

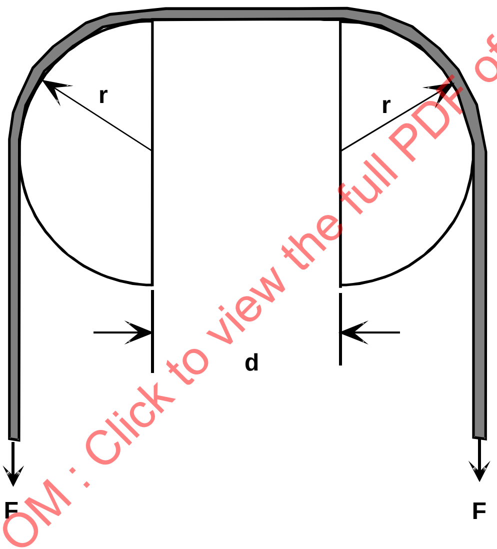


Figure 1 - Measurement of electrical resistance

8.15 Electrical resistance of the magnetic coating and back surface

Electrical resistance is defined as the ohms of the magnetic coating and back surface.

8.15.1 Requirement

The resistance for the magnetic coating surface shall not exceed 10^{12} ohms, but shall be greater than 5 x 10^5 ohms. The resistance for the back surface shall not exceed 5 x 10^6 ohms.

8.15.2 Procedure (see figure 1)

After conditioning to the test environment, position the test piece over two 24-carat gold-plated semicircular electrodes having a radius r = 25,4 mm and a finish of at least N4, so that the magnetic coating surface is in contact with each electrode. The electrodes shall be placed parallel to the ground and parallel to each other and spaced d = 19 mm apart (see figure 1). Apply force of 0,250 N ± 0,012 N to each end of the test piece. Apply a DC voltage of 500 V ± 10 V across the electrodes and measure the resulting current flow. From this value, determine the electrical resistance.

Repeat for a total of five positions along the test piece and average the five resistance readings.

Repeat the test for the back surface.

Note - Neither the specimen nor the insulating surfaces shall be handled with bare fingers. (The use of clean, lint-free gloves is recommended).

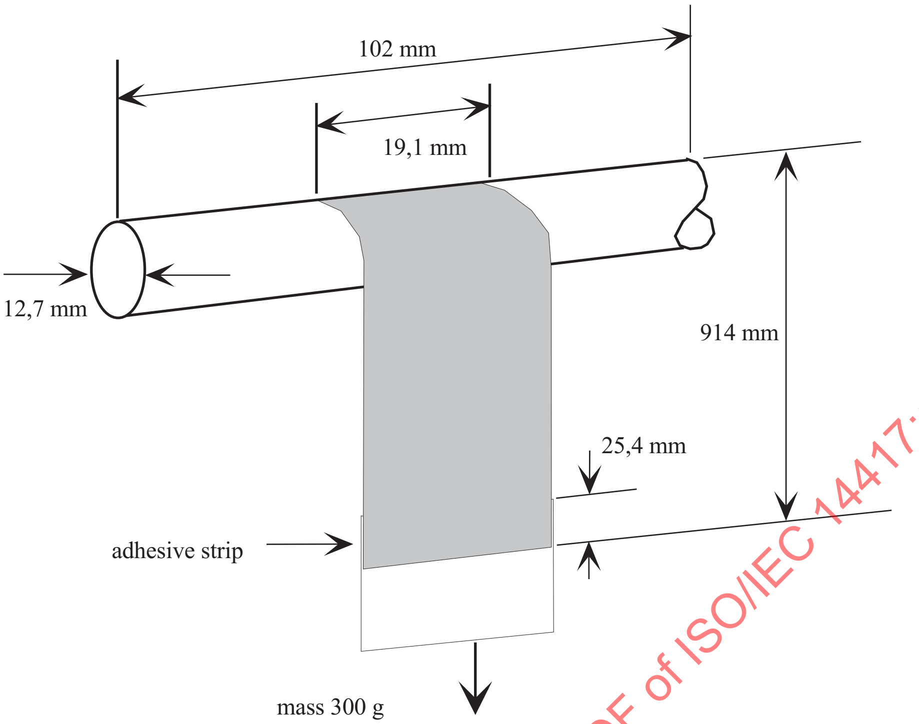


Figure 2 - Measurement of layer-to-layer adhesion

8.16 Layer-to-layer adhesion

Layer-to-layer adhesion refers to that property of a magnetic tape wherein one layer when held in close proximity to the adjacent layer exhibits an adhesive nature and bonds itself to an adjacent layer so that free and smooth separation of the layers is difficult.

8.16.1 Requirement

There shall be no evidence of layer-to-layer adhesion or coating delamination.

8.16.2 Procedure (see figure 2)

A 914 mm length of tape shall be fastened at one end, magnetic coating surface side down, to a 12,7 mm diameter by a 102 mm long stainless steel cylinder with a non-oozing adhesive material. Attach the opposite end of the tape to a 300 gram weight. A small strip of double coated adhesive tape shall be affixed to the magnetic side of the tape 25,4 mm above the weight. The cylinder shall then be slowly and uniformly rotated so that the tape, held in tension by the weight, winds uniformly around the tube into a compact and even roll. The double coated adhesive tape when wound into the roll acts to secure the end and prevent unwinding when the weight is removed. The cylinder supporting the weight is then exposed to the following temperature and humidity cycle:

Time (hr)	Temperature	Relative humidity
16 - 18	55 °C	85% ± 5%
4	55 °C	10% or less
1 - 2	21 °C	45% ± 5%

To evaluate the tape for adhesion, the end of the roll should be opened and the double coated adhesive tape removed. The free end of the tape should be released and the outer one or two wraps should spring loose with no adhesion. The free end of the tape should then be held and the cylinder allowed to fall, thereby unwinding the tape. The unwound tape should then be checked for coating delamination with the exception of the last 54 mm of tape nearest the cylinder.

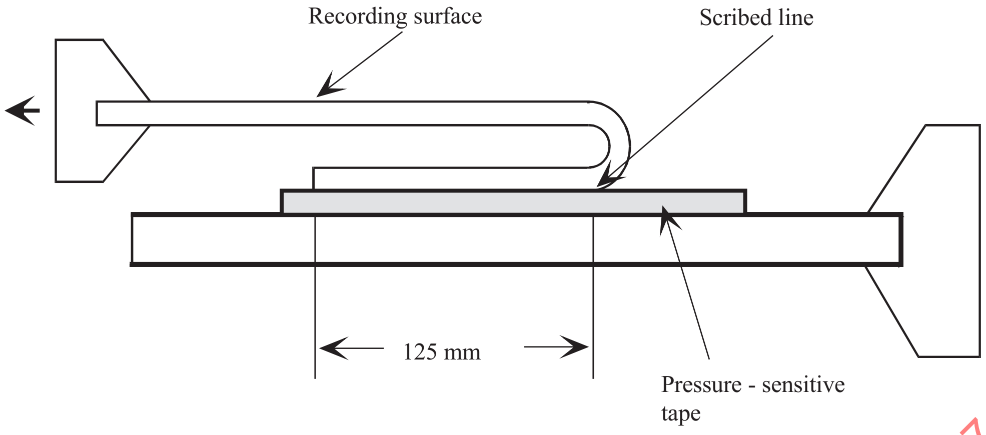


Figure 3 - Measurement of coating adhesion

8.17 Coating adhesion

Coating adhesion is the force required to separate any part of the coating from the tape base film material.

8.17.1 Requirement

The force required to separate any part of the coating from the tape base film material shall not be less than 1,0 N The force required to separate any part of the back coating from the tape base film material shall not be less than 1,0 N.

8.17.2 Procedure (see figure 3)

a) Take a sample of the tape approximately 381 mm long and scribe a line through the coating across the width of the tape, 125 mm from one end;

b) Using double-sided pressure sensitive tape applied to the full width of the sample, attach the sample to a smooth metal plate, with the magnetic coating surface facing the plate;

c) Fold the sample 180 degrees adjacent to, and parallel with the scribed line. Attach the metal plate and the free end of the sample to the jaws of a universal testing machine such that when the jaws are extended the tape is separated. Set the jaw extension rate to 254 mm/min;

d) Note the force at which any part of the coating first separates from the base film material. If the sample separates away from the double-sided pressure sensitive tape before the force exceeds the requirement, an alternative type of double-sided pressure sensitive tape shall be used;

e) Repeat a - d for the back coating, if present.

8.18 Residual elongation

The residual elongation shall be taken as the elongation of a sample over a specified period of time.

8.18.1 Requirement

The residual elongation of the tape shall be no more than 0,1%.

8.18.2 Procedure

Cut a tape length of 1 m and fasten one end so that the tape hangs freely. Attach a 0,3 N load to the loose end and measure the length. Attach an additional 10,5 N for 10 minutes. Remove the additional 10,5 N and after 10 minutes measure the change in length from the original. The residual elongation is the change in length expressed as a percent of the original tape length.

8.19 Tape cupping

The departure across a tape (transverse to motion) from a flat surface is defined as cupping.

8.19.1 Requirement

The departure from a flat surface shall not exceed 0,12 mm in the tape sample.

8.19.2 Procedure

Cut a 0,9 m sample of the tape. Condition it for a minimum of three hours in the test environment by hanging it so that the recording surface is freely exposed to the test environment. From the center portion of the acclimated tape sample cut a sample 25,4 mm in length. Stand the cut sample on its end in a cylinder, which is at least 25,4 mm high and has an inside diameter of 19,21 mm ± 0,20 mm. With the cylinder standing on an optical comparator measure the cupping by aligning the edges of the sample to the reticule and determining the distance from the aligned edges to the corresponding surface of the sample at its highest point.

8.20 Light transmittance of the tape and the leader

The tape shall have a light transmittance of less than 5% when measured according to the method specified in Annex A.

The leader tape shall have a light transmittance of more than 60 when measured according to the method specified in Annex A..

9 Magnetic properties

9.1 Magnetic coating

The coating formulation shall produce a coercivity on the order of 68 kA/m (850 oersted class) as measured by a 50 Hz or 60 Hz BH meter. The magnetic particles (pigment) shall be longitudinally oriented.

9.2 Ease of erasure

The maximum peak-to-peak signal amplitude remaining after subjecting a tape recorded at 170 ftpmm with the standard reference current to a maximum longitudinal steady field of 204 kA/m (2 550 oersteds) shall be less than 3% of the average peak-to-peak signal amplitude prior to exposure to the erasing field.

9.3 Average signal amplitude

The average peak-to-peak signal amplitude of the tape under test shall not deviate more than +25% or -10% from the standard reference amplitude. The averaging shall be done over a minimum of 280 000 flux transitions, exclusive of dropouts.

The tape under test and the secondary standard reference tape shall be recorded on the same equipment with 2 252 ftpmm using the standard reference current. The output amplitude shall be measured on the same equipment.

9.4 Resolution

The resolution of the tape under test shall not deviate more than +35% or -15% from that of the standard reference tape.

The tape under test and the secondary standard reference tape shall be recorded on the same equipment using the standard reference current. The output amplitude shall be measured on the same equipment.

9.5 Typical field

The typical field of the tape under test shall not deviate more than +10% or -10% from that of the Master Standard Reference Tape.

9.6 Tape quality

9.6.1 Dropout

Dropout refers to any read-back signal that falls below a base-to-peak amplitude of less than 35% of the average base-to-peak (one-half of the peak-to-peak) signal obtained from the ASA when recorded at 2 252 ftpmm.

9.6.2 Dropout region

A dropout region commences when a dropout occurs and ends when the dropout ceases or the length reaches 25,4 mm in the helical track direction. If a dropout continues beyond 25,4 mm a further dropout region shall be counted. A dropout region does not continue from one track to another.

The number of dropout regions allowed in an interchange environment is a matter of agreement between interchange parties. For purposes of evaluation of an unrecorded tape to be used for interchange, an average of one dropout region per 30,5 m of usable tape is the recommended limit (equivalent to 180 tracks or 45 track sets).

This test shall be performed over the entire tested recording area during a read-while-write operation using the standard reference current. The track spacing shall conform to the recording format for which the cassette is intended to be used in data interchange.

10 Format for helical tracks

10.1 General description of the write data path (figure 4)

The host system, operating under one of several directory file system structures, views the tape drive system, comprising controller and tape drive, as a logical storage system. The host expects the controller to support the following capabilities

- block as a minimum unit of data transfer between host and controller
- file as a concatenation of blocks
- file demarcation
- directory of file locations in a volume
- volume as a concatenation of files
- management information of files
- multiple volumes and associated management
- fast search and retrieval of data files and blocks
- high degree of data protection
- and restoration of a failed directory.

This format provides a generic set of container tables and track types to contain such information with specific definitions of their usage and location. All track types provided by this format are processed into a Track Set comprising four helical tracks, uniquely identified by a TSID, represent the minimum data transfer unit to and from tape.

The processing of information preparatory to recording begins with the identification of the type of Logical Track Set to be created and then proceeds through the following processes

- generation of the Logical Track Set destined to occupy 4 tracks, including a Subcode data field, padding data and C3 ECC code blocks,
- the C3 code blocks shall be interleaved within all 4 tracks to form a track set array,
- then further processed with outer C2 and inner C1 ECCs, interleaved, randomized and channel coded,
- the formation of sectors including a preamble and postamble completing the contents of a helical track.

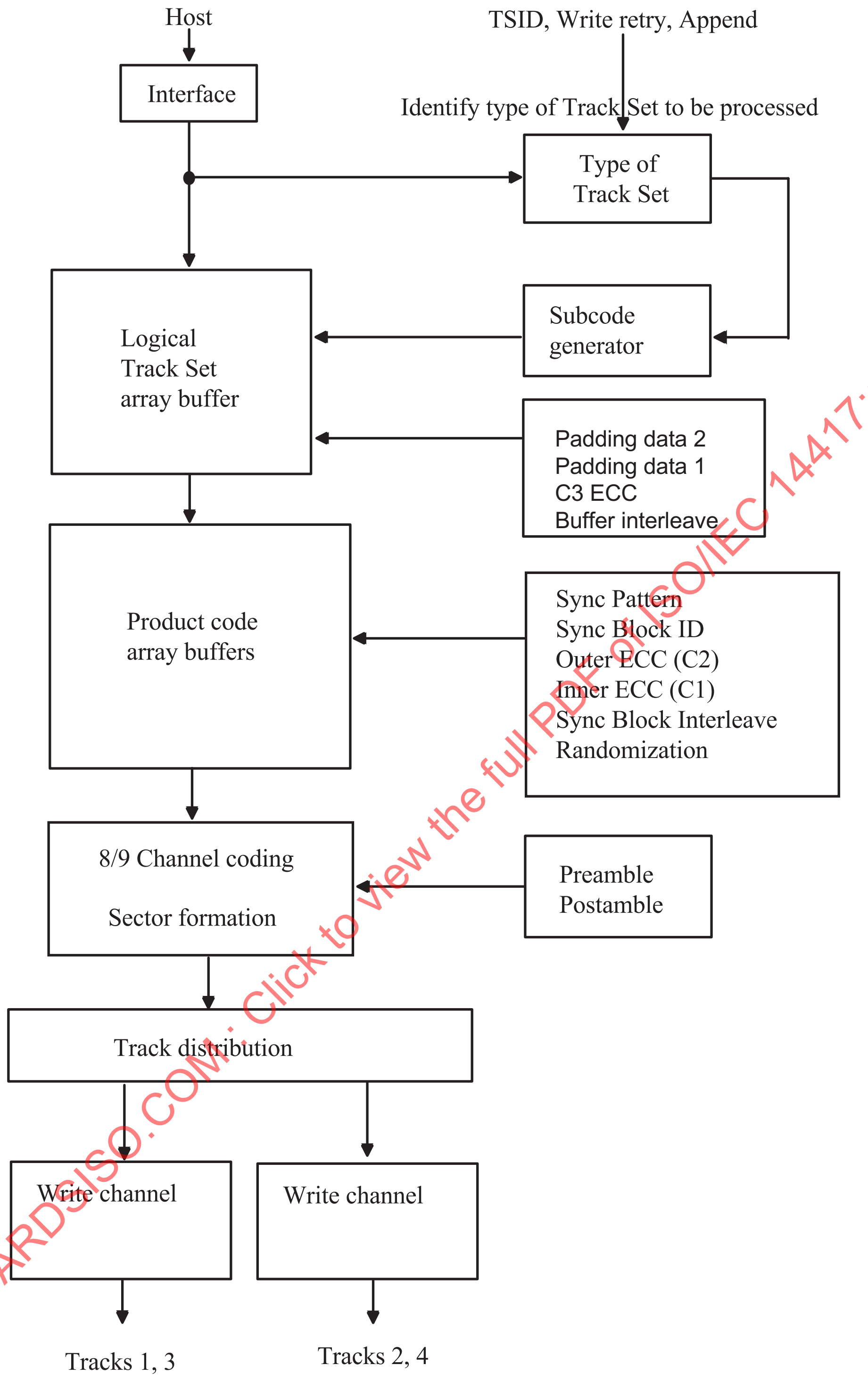


Figure 4 - Dataflow of record information processing

10.2 Formation of a Logical Track Set

10.2.1 Types of information track sets

There are 9 types of information track sets.

1. Volume Set Information Table (VSIT) track set
2. Volume Information Table (VIT) track set
3. File Information Table (FIT) track set
4. User Information Tables (UIT) track set
5. Update Table (UT) track set
6. User Data (UD) track set
7. Tape Mark (TM) track set
8. Dummy (DM) track set
9. End of Data (EOD) track set

This tape format supports multiple logical volume function both within and exceeding one physical volume.

A VSIT at the beginning of the tape contains information to manage one or more logical volumes on this tape. The VSIT has location information for each logical volume on the this tape.

A logical volume consists of a DIT followed by the User Data area.
The DIT contains information to locate and manage files within the logical volume
and comprises the VIT, FIT, UIT and UT.

In the case of UD, the following definitions shall apply:
UD blocks shall be allocated to one or more logical tracks.
Each logical track shall contain data from only one user data block.
If the user data for the track is less than 32 768 bytes, it shall be padded with padding data 1 to fill the user data area.
Each logical track shall comprise a subcode data field and the user data area C3 error corrected plus padding data 2, which is not C3 error corrected, thus forming 36 108 bytes of information prepared for further processing.

The demarcation of files may be defined by the host and be referred to as a Tape Mark (TM).

EOD tracks identify the end of recorded data area in a logical volume as indicated by the host.

DM tracks identify fill areas on the tape where continuous control track signals are required and are transparent to the host.

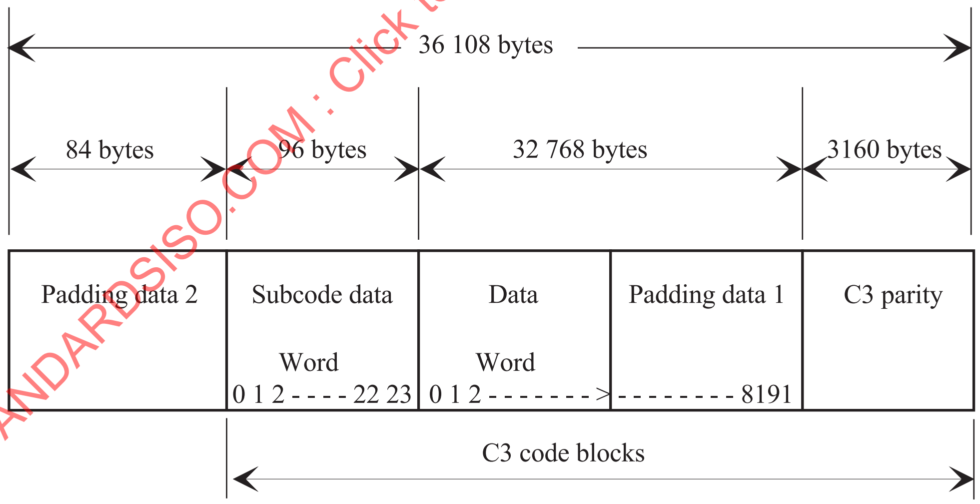


Figure 5 - Logical track structure of format

10.3 Data structuring

10.3.1 Logical track structure

Figure 5 shows the logical structure of information destined for a helical track for the format. The figure defines the size of each data field and presents conceptual allocation of the entire data field. The data, except padding data 2 are interleaved over 4 adjacent tracks within the same track set so as to make C3 error correction effective. The data fields are C1, C2, and C3 error protected, and the other, i.e padding data 2 field, is error protected by C1 and C2 code blocks and is not covered by C3 error correction.

10.3.1.1 Padding data 2 field

The padding data 2 consists of 84 bytes of C1 and C2 error protected data. Data bytes in this field are not used for data interchange purpose. The first 4 bytes of padding data 2 shall be (00000000) when the tape conforms to this interchange standard. The remaining 80 bytes are undefined for the purpose of this ISO Standard and shall be set to all ZEROs..

10.3.1.2 Subcode data field

The subcode data field consists of 96 bytes of C1, C2, and C3 error protected data. The administrative information associated with the track shall be recorded in this field for the purpose of housekeeping. Each track, i.e. DIT track, user data track, tape mark track, end of record track, etc. is defined by the track identification in the word 0 of the subcode data field.

10.3.1.3 Data field

The data field carries up to 32 768 bytes per track of user data or control data. The data field is protected by C1, C2, and C3 error correction codes. The content of the data field is indicated by the track identification, word 0 of subcode data field. The byte count indicates the number of valid data bytes in the data field.

10.3.1.4 Padding data 1 field

In case valid data does not fill the data field to its capacity of 32 768 bytes, the padding data 1 fills the rest. Further, when a track set is partially filled by valid data, the rest of the track(s) are assigned to padding data 1 field. The padding data 1 is C1, C2 and C3 protected. The padding data 1 shall be binary all ZEROs. When the data field consists entirely of padding data 1, the byte count of this track shall be zero.

10.3.1.5 C3 parity field

The third layer of error correction is Reed-Solomon code to protect subcode data, user data and padding data 1, and is interleaved over a track set consisting of four consecutive tracks.

10.3.2 Format and contents of information tables

Unless otherwise stated the contents of each word field within the information tables shall be unsigned binary representations according to the data ordering. Where character fields are used they shall be coded in accordance with ISO/IEC 646. The 57 characters used shall be those in the following positions of the standard code table in ISO/IEC 646.

Character	Graphic	Code position
Space		2/0
Exclamation point	!	2/1
Quotation mark	"	2/2
Percent sign	%	2/5
Ampersand	&	2/6
Apostrophe	'	2/7
Left parenthesis	(	2/7
Right parenthesis	)	2/8
Asterisk	*	2/9
Plus sign	+	2/10
Comma	,	2/11
Hyphen	-	2/13
Period	.	2/14
Slant	/	2/15
Digit zero to nine	0 ... 9	3/0-3/9
Colon	:	3/10
Semicolon	;	3/11
Less-than sign	<	3/12
Equals sign	=	3/13

Greater-than sign	>	3/14
Question mark	?	3/15
Capital letters	A ... Z	4/1-5/10
Underline	_	5/15

Justification of numeric entries shall be right justified within the total field having any remaining positions on the left filled with the zero character. Justification of alphanumeric data shall be left justified with any remaining positions on the right filled with the space character.

10.4 Track types

10.4.1 Volume set information table (VSIT)

The VSIT shall be recorded at the beginning of tape near LBOT and be followed by UT. The VSIT includes information on the number of volumes contained on the tape cassette, as well as the number of tape cassettes in the volume set. This allows for multiple tape cassettes to be used in a volume set, with multiple volumes on a cassette. A logical volume set which has data striped across multiple parallel physical volumes are indicated through the striping fields. For UT, refer to 10.4.2.4 - Update Table.

Information on the volume set can be recorded in either a volume sequential mode or random volume mode as indicated by the access type field of word 59. Volume sets recorded in sequential mode have all files of the first volume recorded and then all files of the second volume etc. If the volume space which was allocated is filled additional volume space can be obtained by extending the volume space by creating a secondary VIT with the same logical volume number using the previous and following physical volume pointers.

Volume set recorded in random mode has the files for each volume interspersed such that the files of each volume have no specific ordering except that they are added to the end of recorded data (an example of such one such sequence is: V1F1, V1F2, V2F1, V1F3, V3F1.... etc. Where VnFn represents Volume n File n)

The logical volume set number (words 0 ... 3), physical volume number which follows in the set (words 46 ... 49), physical volume number which precedes in this set (words 50 ... 53), tape number of this physical volume (words 55 ... 58) and total number of stripes in this logical volume set as well as stripe number of this physical volume (word 59) shall be character numeric. The volume set label (words 4 ... 43) shall be character alphanumeric.

VSIT shall have the following Word definitions:

Word 0	Shall contain the Logical volume set number, bytes 0 - 3
Word 1	Shall contain the Logical volume set number, bytes 4 - 7
Word 2	Shall contain the Logical volume set number, bytes 8 - 11
Word 3	Shall contain the Logical volume set number, bytes 12 - 15
Word 4	Shall contain the Volume set label, byte 0 - 3
Word 5	Shall contain the Volume set label, byte 4 - 7
...	...
Word 42	Shall contain the Volume set label, byte 152 - 155
Word 43	Shall contain the Volume set label, byte 156 - 159
Word 44	Shall contain the physical TSID of the VIT track set of the first Logical volume in this physical volume.
Word 45	Shall contain the physical TSID of the first EOD track set of the last Logical volume in this physical volume.
Word 46 to 53	Shall be Reserved and set to all ZERO's
Word 54	Shall contain the Binary physical volume number of this tape
Word 55	Shall contain the physical volume number of this tape bytes 0 - 3
Word 56	Shall contain the physical volume number of this tape bytes 4 - 7
Word 57	Shall contain the physical volume number of this tape bytes 8 - 11
Word 58	Shall contain the physical volume number of this tape bytes 12 - 15

Word 59	Most significant bit 31, "T" indicates access type and shall be ZERO for sequential or ONE for random. Bits 16 to 30 shall be Reserved and set to all ZERO's. Bits 8 to 15 shall contain the Total # of Stripes in this logical volume Bits 0 to 7 shall contain the Stripe # of this physical volume
Word 60	Shall be Reserved and set to all ZERO's.
Word 61	Shall be Reserved and set to all ZERO's.
Word 62	Shall contain the Number of DIT entries that follow in this physical volume.
Word 63	Shall be Reserved and set to all ZERO's.
Word 64	Shall be Reserved and set to all ZERO's.
Word 65	Shall contain the Physical TSID of VIT #1
Word 66	Shall be Reserved and set to all ZERO's.
Word 67	Shall contain the Physical TSID of VIT #2, if present.
...	...
Word 8190	Shall be Reserved and set to all ZERO's.
Word 8191	Shall contain the Physical TSID of VIT #4063, if present.

10.4.2 Directory information table (DIT)

The DIT shall be recorded at the start of each logical volume on tape. The DIT includes the volume and file control information. This table allows a tape drive to search at high speed. The track format configuration is the same as the usual data track, and shall be so indicated by the track identification field, word 0 of the subcode data field. The DIT consists of a volume information table (VIT), file information table (FIT) an update status table (UT) and a user information table (UIT).

10.4.2.1 Volume information table (VIT)

The VIT shall contain volume control information. This data shall be recorded in the data field of all 4 tracks of the VIT track set. The remainder of the track shall be filled with padding data 1.

Each of the user table entries (words 64 ... 127) shall provide information about the user table type (UIT,User) and a pointer to the starting TSID's of the table. The end of the user table list is indicated by a (00000000) type indicator field. The type indicator for the user table matches the type indicator (W8) of the user data subcode assignment when the user table is written to tape.

The logical volume number (words 0 ... 3), physical volume number which follows in the set (words 46 ... 49), physical volume number which precedes in this set (words 50 ... 53) tape number of this physical volume (words 55 ... 58) shall be character numeric and volume label (words 4 ... 43) shall be character alphanumeric.

VIT shall have the following Word definitions:

Word 0	Shall contain the Logical volume number, bytes 0 - 3
Word 1	Shall contain the Logical volume number, bytes 4 - 7
Word 2	Shall contain the Logical volume number, bytes 8 - 11
Word 3	Shall contain the Logical volume number, bytes 12 - 15
Word 4	Shall contain the Volume label, byte 0 - 3
Word 5	Shall contain the Volume label, byte 4 - 7
...	...
Word 42	Shall contain the Volume label, byte 152 - 155
Word 43	Shall contain the Volume label, byte 156 - 159
Word 44	Shall contain the physical TSID of the first track set after the run up track sets for user data of this logical volume.
Word 45	Shall contain the physical TSID of the first track set of the EOD track sets of this logical volume.
Word 46	Shall contain the Physical volume number which follows in this logical volume bytes 0 - 3

Word 47	Shall contain the Physical volume number which follows in this logical volume bytes 4 - 7
Word 48	Shall contain the Physical volume number which follows in this logical volume bytes 8 - 11
Word 49	Shall contain the Physical volume number which follows in this logical volume bytes 12 - 15
Word 50	Shall contain the Physical volume number which precedes in this logical volume bytes 0 - 3
Word 51	Shall contain the Physical volume number which precedes in this logical volume bytes 4 - 7
Word 52	Shall contain the Physical volume number which precedes in this logical volume bytes 8 - 11
Word 53	Shall contain the Physical volume number which precedes in this logical volume bytes 12 - 15
Word 54	Shall contain the Binary physical volume number of this tape
Word 55	Shall contain the Tape physical volume number of this tape bytes 0 - 3
Word 56	Shall contain the Tape physical volume number of this tape bytes 4 - 7
Word 57	Shall contain the Tape physical volume number of this tape bytes 8 - 11
Word 58	Shall contain the Tape physical volume number of this tape bytes 12 - 15
Word 59	Most significant bit 31, "T" indicates access type and shall be ZERO for sequential or ONE for random. Bits 16 to 30 shall be Reserved and set to all ZERO's. Bits 8 to 15 shall contain the Total # of Stripes in this logical volume Bits 0 to 7 shall contain the Stripe # of this physical volume
Word 60	Shall be Reserved and set to all ZERO's.
Word 61	Shall contain the Data compression type identifier.
Word 62	Shall contain the Number of entries in FIT
Word 63	Shall contain the Physical TSID for UT
Word 64	Shall contain the Table type for UIT #1, if present.
Word 65	Shall contain the Physical TSID for table UIT #1, if present.
Word 66	Shall contain the Table type for UIT #2, if present.
Word 67	Shall contain the Physical TSID for table UIT #2, if present.
...	...
Word 126	Shall contain the Table type for UIT #32, if present.
Word 127	Shall contain the Physical TSID for table UIT #32, if present.
Word 128	Shall be Reserved and set to all ZERO's.
...	...
Word 8191	Shall be Reserved and set to all ZERO's.

10.4.2.2 File information table (FIT)

The FIT includes file control information. The number of valid words in the FIT shall be identified in the VIT. The remainder of the data area shall be filled by padding data 1. The order of TM to UD and UD to TM are considered as two cases for the definition of FIT.

Word 0	Shall contain the Physical TSID of the first track set after the run up track sets for user data of this logical volume.
Word 1	Shall contain the Absolute block number of the first track set after the run up track sets for user data of this logical volume.
Word 2*n*	Shall contain the Physical TSID of the TM #*n* track set.
Word 2*n*+1	Shall contain the Absolute block number of the TM #*n* track set.
	Where n = 0 (option), 1, 2, ...

The first track set after run up may be a TM track set, which corresponds to the case n = 0 (option).

10.4.2.3 User information tables (UIT)

The UIT may be used to record additional user information. This includes file and volume labels, error statistics information etc. Each UIT shall be identified by a type code indicating the format of the table, and the information it contains. This type indicator shall be written at W8 of the subcode data field to identify that the track carries a UIT. The words, W3-W5, shall be set to (FFFFFFFF). Table types defined by this standard shall be in the range of (00000001) - (7FFFFFFF). Table types between the range of (80000000) - (FFFFFFFF), shall be defined between interchange parties.

File structure and labeling table type (00000001):

The file structure and labeling table provides implementation of volume header, file header and user headers similar to those of ISO 1001. The space for each header shall be 1024 bytes in length. Refer to ISO 1001 for additional information on the field contents and levels of interchange. The end of label data (ELD) header shall be used to signify the end of the file structure and labeling table.

Volume header:

The volume header label shall identify the volume, the owner, the accessibility conditions, the implementation recording the volume header label, and the version of this standard that applies. The following definitions shall apply:

Bytes	Field name	Length	Content
0-2	Label identifier	3	VOL
3	Label number	1	1
4-19	Logical volume number in VIT	16	Alphanumeric
20-23	Volume Accessibility	4	Alphanumeric
24-36	Implementation Identifier	13	Alphanumeric
37-50	Owner Identifier	14	Alphanumeric
51	Label standard version	1	1
52-1023	Reserved	972	Spaces

File header label:

The file header label shall identify the file section, specify the position of the file section within a file set, and specify certain attributes of the file section:

Bytes	Field name	Length	Content
0-2	Label identifier	3	HDR
3	Label number	1	1
4-259	File identifier	256	Alphanumeric
260-263	File number in the FIT	4	Binary number
264-269	File set identifier	6	Alphanumeric
270-273	File section number	4	Character numeric
274-277	File sequence number	4	Character numeric
278-281	Generation number	4	Character numeric
282-283	Generation version number	2	Character numeric
284-289	Creation date	6	Space, Char. numeric
290-295	Expiration date	6	Space, Char. numeric
296-299	File accessibility	4	Alphanumeric
300-306	Block count on this volume	7	Character numeric
307-319	Implementation Identifier	13	Alphanumeric
320	Record format	1	F, D or S
321-332	Block length	12	Character numeric
333-344	Record length	12	Character numeric
345-1023	Reserved	683	Spaces

User file header label:

A user file header label set is optional. If present, its labels shall have the following layout:

Bytes	Field name	Length	Content
0-2	Label identifier	3	UHL
3	Label number	1	Alphanumeric
4-1023	(Implementation dependent)	1020	Alphanumeric

End of label data label:

At the end of the file structure and label table entries the end of label data (ELD) label shall be used to indicate the end of the user table. The ELD shall be of the following format:

Bytes	Field Name	Length	Content
0-2	Label identifier	3	ELD
3	Label number	1	1
4-1023	Reserved	1020	Spaces

10.4.2.4 Update table (UT)

The UT includes information of temporary update status of the volume. When a tape cassette is loaded into a tape drive, the UT is read first and then word 0 of UT is set to all ONEs in the UT following VSIT and of the UT in the DIT of the logical volume of interest. Just before a tape is unloaded from a tape drive for the purpose of interchange, firstly the VIT, FIT and UIT shall be updated and then word 0 of the UT shall be set to all ZEROs in the updated logical volume, secondly the VSIT shall be updated and word 0 of the UT following VSIT shall be set to all ZEROs. This data shall be recorded in the data field of all 4 tracks of the UT track set. The remainder of the track shall be padding data 1 field.

UT shall have the following word definitions:

Word 0	Shall contain the Update status, before update = (FFFFFFFF), after update = (00000000)
Word 1	Shall be Reserved and set to all ZERO’s.
Word 2	Shall be Reserved and set to all ZERO’s.
Word 3	Shall be Reserved and set to all ZERO’s.
Word 4	Shall be Reserved and set to all ZERO’s.
Word 5	Shall be Reserved and set to all ZERO’s.
Word 6	Shall be Reserved and set to all ZERO’s.
Word 7	Shall be Reserved and set to all ZERO’s.

10.4.3 Data track configuration

10.4.3.1 User data track(UD)

The User data shall occupy up to 32 768 bytes of the data field per track and is error protected by C1, C2, and C3 code block. The track shall be identified by the subcode data field as follows:

Absolute block number shall be incremented by one for each data block and each TM. The counter shall be set to all ZEROs for the first block or TM which ever appears first following DIT.

The type indicator field, W8, of the subcode data field shall be set to all ZEROs.

Logical track set ID shall be reset to ZERO at the beginning of VSIT, VIT and user data for a volume, in other words at the first track set carrying valid data after each run up area.

10.4.3.2 Tape mark track (TM)

The TM shall consist of a track set. The TM identification in the subcode field indicates that this track is a part of a TM and the data field is not used for any representation of the TM tracks. Padding data 1 shall be recorded in the data field. The TM track set shall be used as a separator of two adjacent files and/or file labels.

10.4.3.3 End of data (EOD) track

The end of data indication shall consist of 16 or more track sets. The EOD track Identification in the subcode data field indicates that these tracks are EOD tracks. The data recorded in the data field shall be set to all (76).

Less than 16 EOD track sets shall indicate that more data or retried data follows. No new data tracks or retried tracks follow the 16 or more EOD track sets.

When append data operation is performed, at least one EOD track set shall be left to separate old and new writings. The rest of the EOD track sets shall be over written by new data, DM tracks included.

10.4.3.4 Dummy track (DM)

DM tracks shall be used to fill areas where continuous recording of the control track is required. DM tracks are identified by the subcode data field and shall carry padding data 1 in the data field.

10.5 Subcode generation

10.5.1 Subcode word defintions

Word 0	Shall contain the track type identification as follows: VSIT (00FFFFFF) VIT (00FFFF00) FIT (00FF00FF) UIT (FF000000) UT (00FF0000) UD (0000FFFF) TM (0000FF00) EOD (000000FF) DM (00000000)
Word 1	For VSIT, VIT, FIT, UT, UIT and UD track types shall contain the byte count of track. For TM, EOD and DM track types shall contain all ZERO's
Word 2	Shall contain the track number in corresponding block.
Word 3	For UD and TM track types shall contain the Absolute block number. For VSIT, VIT, FIT, UT, UIT, EOD and DM track types shall contain all ZERO's
Word 4	For UD and TM track types shall contain the Block number in file. For VSIT, VIT, FIT, UT, UIT, EOD and DM track types shall contain all ZERO's
Word 5	For UD and TM track types shall contain the File number. For VSIT, VIT, FIT, UT, UIT, EOD and DM track types shall contain all ZERO's
Word 6	For VSIT, VIT, FIT, UT, UIT, UD and TM track types shall contain the Logical TSID number incremented starting with 0 at the beginning of VSIT, VIT and the first UD after VIT. For EOD and DM track types shall contain the Logical TSID number not incremented. The Append file bit "A", msb of Byte 3, shall be set to ONE for the first Track Set of appended data.
Word 7	Shall contain the Write retry count. See 11.8.
Word 8	For UIT and UD track type shall contain the type of user data indication For VSIT, VIT, FIT, UT, TM, EOD and DM shall contain all ZEROs.
Word 9	Shall contain the Logical volume #, bytes 0-3
Word 10	Shall contain the Logical volume #, bytes 4-7
Word 11	Shall contain the Logical volume #, bytes 8-11
Word 12	Shall contain the Logical volume #, bytes 12-15
Word 13 to 23	Shall be Reserved and contain all ZEROs.

10.5.2 Summary of subcode data configuration

Word	DIT Track					Data Track			
0	VSIT	VIT	FIT	UT	UIT	UD	TM	EOD	DM
1	Byte count of track						All ZEROs		
2	Track number in belonging block								
3	All ONEs					Absolute block #		All ONEs	
4	All ONEs					Block # in file		All ONEs	
5	All ONEs					File number		All ONEs	
6	Logical track set ID (increment)							(No increment)	
7	Write retry count								
8	Reserved				Type of User Data		Reserved		
9	Logical volume #, bytes 0-3								
10	Logical volume #, bytes 4-7								
11	Logical volume #, bytes 8-11								
12	Logical volume #, bytes 12-15								
13	Reserved								
...	...								
23	Reserved								

NOTE:

VSIT:	Volume Set Information Table	(00FFFFFF)
VIT:	Volume Information Table	(00FFFF00)
FIT:	File Information Table	(00FF00FF)
UIT:	User Information Table	(FF000000)
UT:	Update Table	(00FF0000)
UD:	User Data	(0000FFFF)
TM:	Tape Mark	(0000FF00)
EOD:	End of Data	(000000FF)
DM:	Dummy Track	(00000000)

10.6 Information processing

10.6.1 Introduction

Information data shall be partitioned into tracks. Each track set comprising 4 tracks shall be recorded as a unit to tape. Processing of information data includes the blocking of user data bytes, its error correction coding (C3), and arrangement in product-code arrays (C2 and C1) prior to sector data field processing.

10.6.2 Data ordering to tape

All input data to be recorded in the helical area of the tape shall be recorded track set sequentially. Sequentially numbered track sets shall contain successive data with respect to time. There shall be no intertrack set shuffling of data versus time except for rewrites. For example, if track set *n* contains the first 131 072 input data bytes, then track set *n* +1 shall contain the next 131 072 input data bytes, and so forth.

Data to a track set is track sequential. However, due to C3 interleaving, input data is spread cyclically across all four tracks within a trackset in incoming order.

For the purposes of describing the processes for creating this format, the following definitions shall apply. Data may be ordered in word or byte formats. With the least significant byte of a word having the lowest binary weight and being considered the oldest in time:

Byte position in word	4	3	2	1
Byte designation	B_3	B_2	B_1	B_0
Binary weight	2^{24}	2^{16}	2^8	2^0

The following format or an appropriately modified version, shall be used to illustrate the relationship between the bit position and bit designation and binary weight as assigned to that bit.

Bit position in the byte	8	7	6	5	4	3	2	1
Bit designation	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
Binary weight	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

10.7 Error protection of data

10.7.1 User data segmentation

Bytes of user data to be recorded onto the helical tracks are assembled such that the data "oldest" in time is assigned the least significant position in a byte stream. This byte stream combined with track subcode data and or padding data 1 is then divided into consecutive blocks of 104 bytes and shall be called a data segment. The 104-byte data segments are then C3 error correction coded.

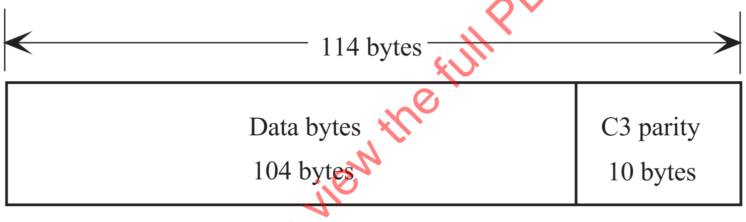


Figure 6 - C3 Error correction code block

10.7.2 C3 error correction code

The C3 code block shall consist of a 104 byte data segment with a 10 byte C3 parity code appended The C3 code block shall be interleaved over one full track set. Each track set shall contain 1264 C3 code blocks. Each code block shall be composed of 114 bytes forming Reed-Solomon code RS(114,104) as follows:

data segment - 104 bytes of segmented user data and track subcode data;

error protection - 10 bytes of C3 parity.

Each logical track shall contain 96 bytes of the track subcode data field and the 32 768 bytes of user data or padding data 1. The C3 correction code blocks shall be distributed over four adjacent tracks by applying data interleave operation as shown in figure 7. These adjacent tracks shall belong to the same track set.

Prior to C3 encoding, the C3 array shall be filled with track 0 subcode data followed by 32 768 bytes of user data. If less than 32 768 bytes of user data is available, it shall be padded to 32 768 bytes with padding data 1. In the same fashion the C3 array shall be filled with track 1 subcode data followed by user data then track 2 and track 3 (See figure 8 for an example consisting of 2,5 tracks worth of user data). Data interleaving shall be done while data and C3 parity are read out from memory along a different axis from the write process. C3 encoding and data interleaving over 4 tracks are shown in figure 7.

The array shall be filled horizontally 4 rows in parallel assuming, but not limited to, word length of 32 bits or 4 bytes, and then read out vertically column by column.

28,5 columns of data/parity preceded by 84 bytes of padding data 2 shall fill outer code blocks of one complete track.

As a result, the byte serial input data stream for the track outer code blocks shall be as follows.

84 Bytes of Padding Data 2, B_0, B_1, B_2, B_3, B_{416}, B_{417}, B_{418}, B_{419}, ..., $B_{131\,042}$, $B_{131\,043}$,

B_4, B_5, B_6, B_7, ..., $B_{65\,428}$, $B_{65\,429}$, $B_{65\,430}$, $B_{65\,431}$.

For the next track outer code blocks of the track set;

84 bytes of padding data 2, $B_{65\,844}$, $B_{65\,845}$, $B_{65\,846}$, $B_{65\,847}$, ...

and so forth for the remaining outer code blocks in the track set.

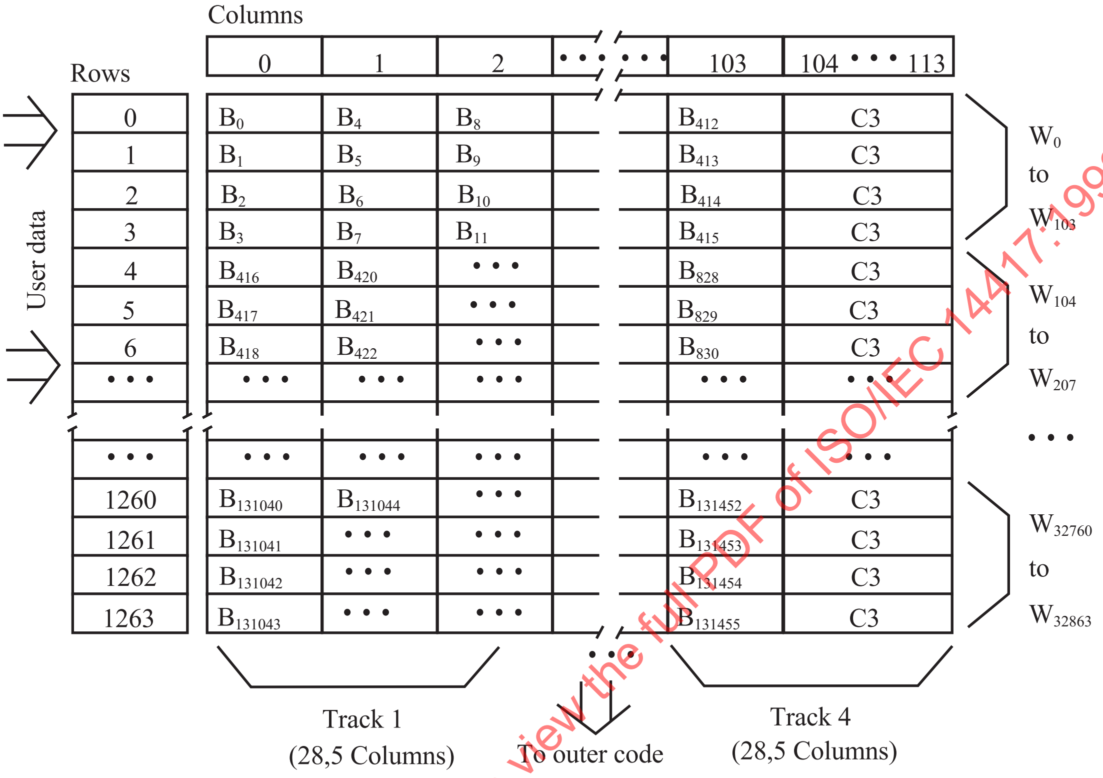


Figure 7 - C3 Encode and data interleave block structure

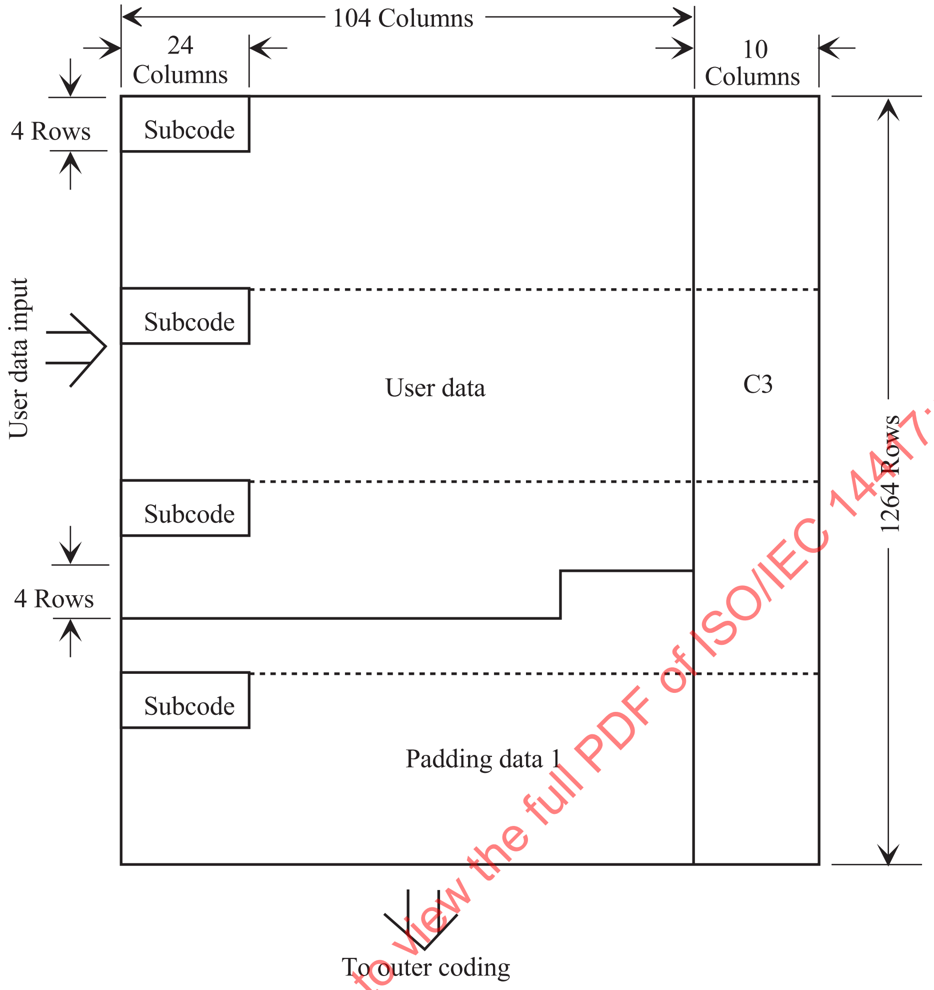


Figure 8 - Boundary of user data and padding data 1

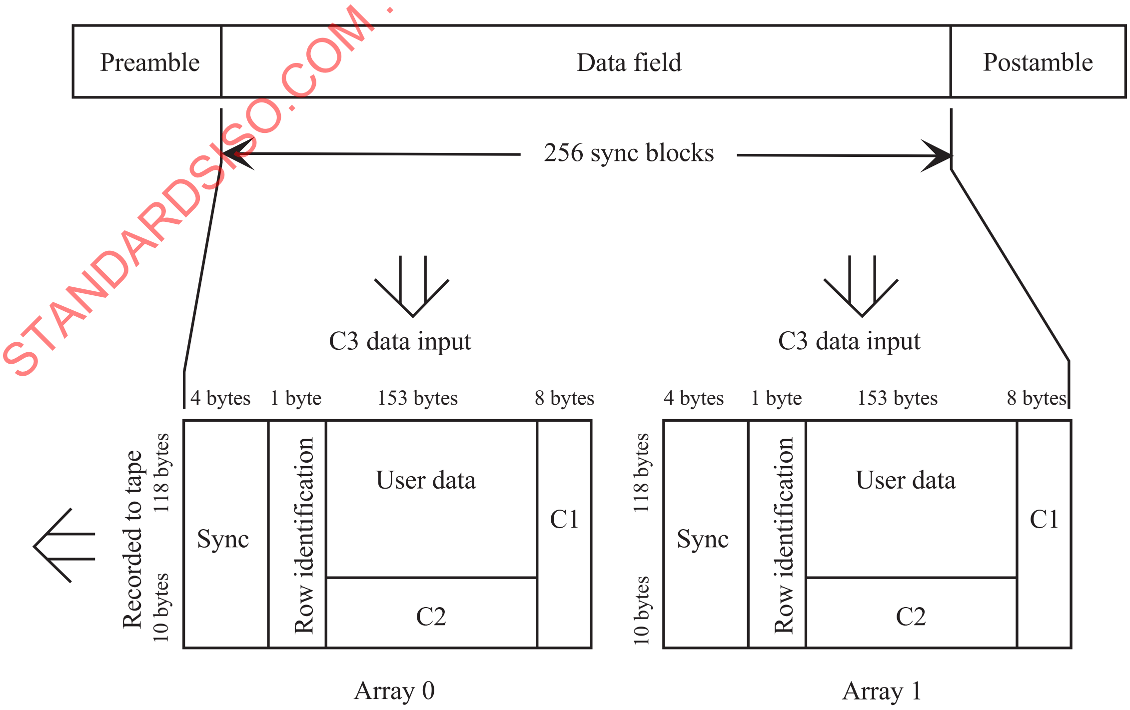


Figure 9 - C1 and C2 ECC

10.7.3 Outer code blocks - C2

An outer code block shall comprise 128 bytes consisting of a 118 byte data segment with a 10 byte parity forming Reed-Solomon code RS(128,118) as follows:

data segment - 118 bytes of segmented C3 data read by column;

error protection - 10 bytes of C2 parity.

10.7.4 Inner code blocks - C1

An inner code block shall comprise 162 bytes consisting of one byte of row ID, 153 byte data segment with 8 bytes of parity forming Reed-Solomon code RS(162,154) as follows:

1 byte Row ID identifying inner code row number;

data segment - 153 bytes of segmented outer code data read by row.

error protection - 8 bytes of C1 parity.

10.7.5 Error correction methods

10.7.5.1 Error correction coding for C3 code

Each C3 code block shall be error protected by the following error correction code, referred to as C3 code.

104 bytes of segmented user data to be encoded.

10 bytes of error check code generated as follows:

1) Type: Reed-Solomon RS(114,104);

2) Galois field: GF(2^8);

3) Field generator: $P(X) = X^8 + X^4 + X^3 + X^2 + X^0$;

(X^i are place-keeping variables in GF(2^1), the binary field);

4) Order of Use: Left most term is "oldest" in time computationally and first received for coding or applied to product code arrays;

5) Code generator polynomial: $G(X) = (X + a^0) (X + a^1) (X + a^2) (X + a^3) (X + a^4) (X + a^5) (X + a^6) (X + a^7) (X + a^8) (X + a^9)$

in GF(2^8) where a^1 is a root of $P(X) = 0$ and given by (02) in GF(2^8)

6) C3 error check code:

$K_9, K_8, K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$, in $K_9 \bullet X^9 + K_8 \bullet X^8 + ... + K_1 \bullet X^1 + K \bullet X^0$

obtained as the remainder after dividing $X^{10} \bullet D(X)$ by $G(X)$;

Where: $D(X)=D_{103} \bullet X^{103} + D_{102} \bullet X^{102} + ... + D_1 \bullet X^1 + D_0 \bullet X^0$;

7) Equation of: $C(X) = D_{103} \bullet X^{113} + D_{102} \bullet X^{112} + ... + D_1 \bullet X^{11} + D_0 \bullet X^{10} + K_9 \bullet X^9 + K_8 \bullet X^8 + ... + K_0 \bullet X^0$;

Where:

D_{103} through D_0 represent the 104 bytes of user data, and K_9 through K_0 represent the 10 bytes of outer error check code (a byte Q_{n+1} is processed before a byte Q_n).

10.7.5.2 Error correction coding for outer code - C2

Each outer code block shall be error protected by the following error correction code, referred to as outer or C2 code.

118 bytes of segmented C3 data to be encoded.

10 bytes of outer error check code generated as follows:

1) Type: Reed-Solomon RS(128,118);

2) Galois field: GF(2^8)

3) Field generator: $P(X) = X^8 + X^4 + X^3 + X^2 + X^0$;

(X^i are place-keeping variables in GF(2^1), the binary field);

4) Order of Use: Left most term is "oldest" in time computationally and first received for coding or applied to product code arrays;

5) Code generator polynomial: $G(X) = (X + a^0)\ (X + a^1)\ (X + a^2)\ (X + a^3)\ (X + a^4)\ (X + a^5)\ (X + a^6)\ (X + a^7)\ (X + a^8)\ (X + a^9)$

in $GF(2^8)$ where a^1 is a root of $P(X) = 0$ and given by (02) in $GF(2^8)$;

6) Outer error check code:

$K_9, K_8, K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$, in $K_9 \bullet X^9 + K_8 \bullet X^8 + ... + K_1 \bullet X^1 + K \bullet X^0$

obtained as the remainder after dividing $X^{10} \bullet D(X)$ by $G(X)$;

Where: $D(X)=D_{117} \bullet X^{117} + D_{116} \bullet X^{116} + ... + D_1 \bullet X^1 + D_0 \bullet X^0$;

7) Equation of: $C(X) = D_{117} \bullet X^{127} + D_{116} \bullet X^{126} + ... + D_1 \bullet X^{11} + D_0 \bullet X^{10} + K_9 \bullet X^9 + K_8 \bullet X^8 + ... + K_0 \bullet X^0$;

Where: D_{117} through D_0 represent the 118 bytes of user data, and K_9 through K_0 represent the 10 bytes of outer error check code (a byte Q_{n+1} is processed before a byte Q_n).

10.7.5.2.1 Coding examples for outer code

An example of three byte patterns in hexadecimal (XX) notation is shown in table 5 of Annex A, where Pattern 1 is the impulse function, with the values in the error-code locations representing the expansion of the code generator polynomial.

10.7.5.3 Error correction coding for inner code - C1

The data field of each sync block shall be error protected by the following error correction code, referred to as the inner or C1 code.

154 bytes total to be encoded, shall consist of 1 byte of sync block identification, followed by 153 bytes of source information.

8 bytes of inner error checkcode shall be generated as follows:

1) Type: Reed-Solomon RS(162,154);

2) Galois field: $GF(2^8)$

3) Field generator: $P(X) = X^8 + X^4 + X^3 + X^2 + X^0$

(X^i are place-keeping variables in $GF(2^1)$, the binary field);

4) Order of use: Left-most term is "oldest" in time computationally and the first written on tape;

5) Code generator: $G(X) = (X + a^0)(X + a^1)(X + a^2)(X + a^3)(X + a^4)(X + a^5)(X + a^6)(X + a^7)$;

in $GF(2^8)$ where a^1 is a root of $P(X) = 0$ and given by (02) in $GF(2^8)$;

6) Inner error check code: $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ in $K_7 \bullet X^7 + K_6 \bullet X^6 + ... + K_1 \bullet X^1 + K_0 \bullet X^0$;

obtained as the remainder after dividing $X^8 \bullet D(X)$ by $G(X)$.

Where: $D(X)=I_0 \bullet X^{153} + D_{152} \bullet X^{152} + ... + D_1 \bullet X^1 + D_0 \bullet X^0$;

7) Equation of:

$C(X) = I_0 \bullet X^{161} + D_{152} \bullet X^{160} + D_{151} \bullet X^{159} + D_{150} \bullet X^{158} + ... + D_0 \bullet X^8 + K_7 \bullet X^7 + K_6 \bullet X^6 + ... + K_1 \bullet X^1 + K_0 \bullet X^0$;

Where:

I_0 represents the 1 byte of sync block identification, D_{152} through D_0 represent the 153 bytes of sync block source information, and K_7 through K_0 represent the 8 bytes of inner error check code (a byte Q_{n+1} is recorded before a byte Q_n).

10.7.5.3.1 Coding examples for inner code

An example of three byte patterns in hexadecimal (XX) notation is shown in table 4 of Annex A, where pattern 1 is the impulse function with the values in the error code locations representing the expansion of the code generator polynomial.

10.7.6 Outer code block destination

Although all outer-code blocks are ultimately recorded on tape, it is helpful to visualize them as being arranged into two product-code arrays first, before their bytes are processed as sync block source information. In order to provide a link between outer-code blocks and sync block source information, the bytes of the outer-code blocks have assigned to them a byte marker in the form (*W* : *X* : *Y*).

Array locator *W*:	*W* has 2 values: 0 for left array 1 for right array
Column locator *X*:	*X* has 161 values: 0 for first and left-most column 1 for second column, etc. 160 for last and right-most column
Row locator *Y*:	*Y* has 128 values: 0 for first and top most row 1 for second row, etc. 127 for last and bottom-most row

The bytes of each outer-code block destined for the same track shall be assigned a byte marker (*W* : *X* : *Y*) in the following manner:

Outer code block	Byte marker (*W* : *X* : *Y*)					
1	(0:0:0)	(0:0:1)	(0:0:2)	...	(0:0:126)	(0:0:127)
2	(0:1:0)	(0:1:1)	(0:1:2)	...	(0:1:126)	(0:1:127)
3	(0:2:0)	(0:2:1)	(0:2:2)	...	(0:2:126)	(0:2:127)
...	...	...	...	...	...	...
153	(0:152:0)	(0:152:1)	(0:152:2)	...	(0:152:126)	(0:152:127)
154	(1:0:0)	(1:0:1)	(1:0:2)	...	(1:0:126)	(1:0:127)
155	(1:1:0)	(1:1:1)	(0:0:2)	...	(1:1:126)	(1:1:127)
156	(1:2:0)	(1:2:1)	(1:2:2)	...	(1:2:126)	(1:2:127)
...	...	...	...	...	...	...
306	(1:152:0)	(1:152:1)	(1:152:2)	...	(1:152:126)	(1:152:127)

Note - The user data byte marked (0:0:0) is the first user data byte recorded to tape.

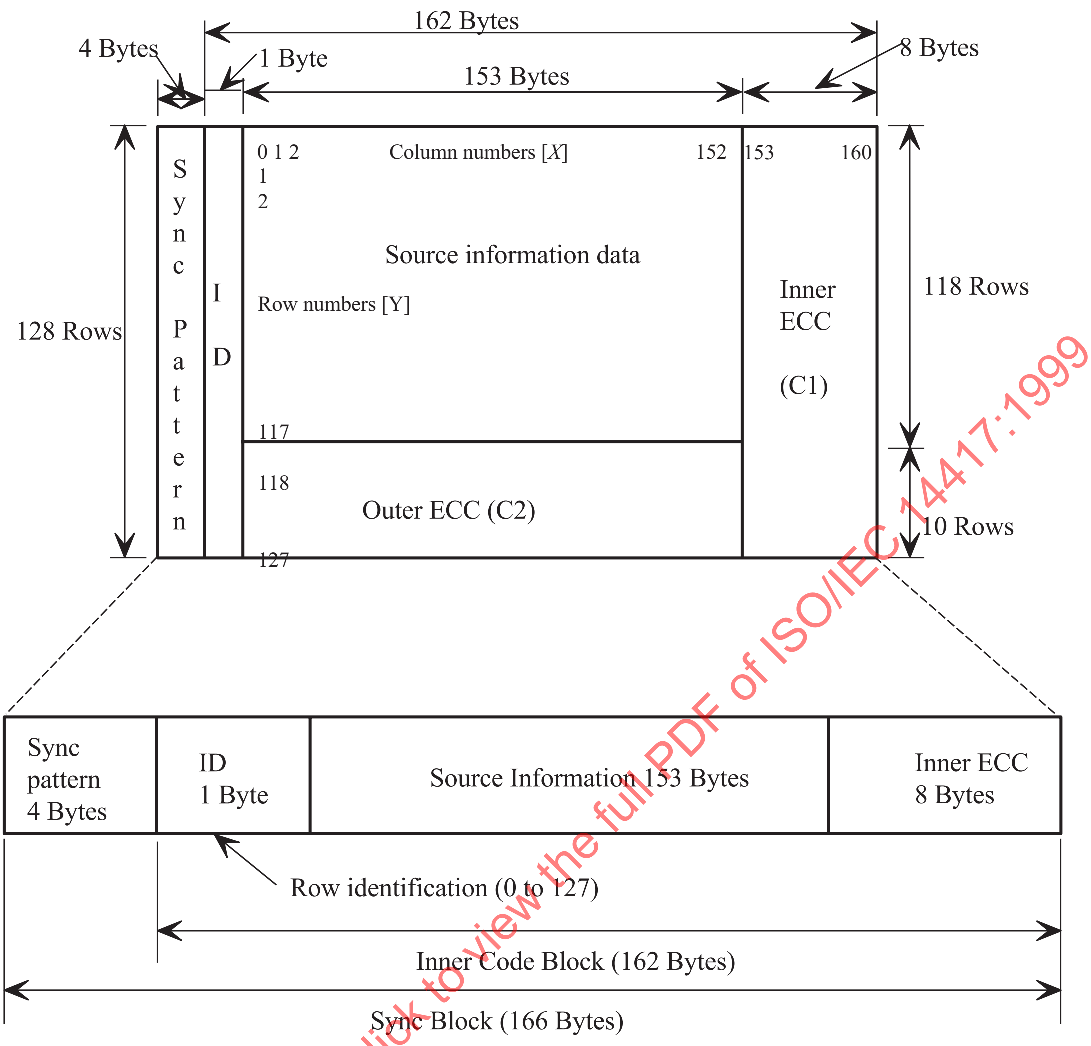


Figure 10 - Sync block

10.7.6.1 Sync block formation and interleave

A sync block comprises a sync word of 4 bytes and an inner code block of 162 bytes.

Interleaving sync blocks to form a sector comprised of 256 sync blocks is accomplished by taking sync blocks alternately first from array 0, then from array 1, then from array 0, etc.

The source information bytes for each sync block have a byte marker (W:X:Y) in the following order:

Sync block	Byte marker (W : X : Y)					
1	(0:0:0)	(0:1:0)	(0:2:0)	...	(0:159:0)	(0:160:0)
2	(1:0:0)	(1:1:0)	(1:2:0)	...	(1:159:0)	(1:160:0)
3	(0:0:1)	(0:1:1)	(0:2:1)	...	(0:159:1)	(0:160:1)
4	(1:0:1)	(1:1:1)	(1:2:1)	...	(1:159:1)	(1:160:1)
...	...	...	...	...	...	...
255	(0:0:127)	(0:1:127)	(0:2:127)	...	(0:159:127)	(0:160:127)
256	(1:0:127)	(1:1:127)	(1:2:127)	...	(1:159:127)	(1:160:127)

10.7.7 Randomization

All sector data fields (identification, auxiliary data, source information and inner error code) shall be randomized before 8/9 coding (preamble run-up sequence and sync patterns are not randomized).

The randomizing is equivalent to performing the XOR operation between the serial byte stream destined for recording and the serial byte stream generated by the following polynomial function:

$$G\ (X) = X^8 + X^4 + X^3 + X^2 + X^0 \text{ (in GF}(2^1))$$

The left term shall enter the division computation first. The polynomial is preset to (80) at the end of every sync pattern.

Note - With the data stream set to ZEROs, this operation will generate a byte sequence beginning with (80), (38), (D2), (81), (49), etc., hexadecimal bytes in standard notation (most significant bit on left-hand side).

10.7.8 Channel coding

8/9 coding includes the mapping of the randomized serial byte stream into a 9-bit NRZL word stream in such a manner that after the NRZI(1) modulation of this 9-bit NRZL word stream, a d.c.free recording waveform is obtained. With this NRZI(1) modulation, one is represented by a transition at the centre of a bit cell and zero by the absense of such a transition.

10.7.9 Control of digital sum variation (DSV)

In order to affect the d.c.free encoding of the randomized byte sequence, the channel coding system shall actively maintain an NRZI(1) DSV, calculated from the NRZI(1) symbol codeword digital sum (CDS) for each of the allowable 8-bit to 9- bit mappings. This mapping (see table 1 in annex A) includes both a one-to-one selection of "zero CDS" 9-bit NRZL words and a one-to-two selection of "positive or negative CDS" 9-bit NRZL words. Positive CDS or negative CDS 9-bit NRZL words shall be chosen from table 1 in annex A according to the NRZI(1) waveform's DSV and polarity obtained thus far and in accordance with table 2 in annex A. The CDS listed in table 1 assumes a negative NRZI(1) waveform polarity at the end of the previous 9-bit symbol. When this is true, the next DSV shall be calculated by adding the CDS listed in table 1 in annex A to the previously obtained DSV. If the NRZI(1) waveform polarity at the end of the previous 9-bit symbol is positive, then the next DSV shall be calculated by subtracting the listed CDS from the previous DSV. Each one-to-one selection maintains the DSV by using a 9-bit NRZL word whose NRZI(1) modulation results in a CDS of zero. Table 1 in annex A also contains an NRZI(1) waveform polarity inversion indicator for conveniently selecting positive or negative CDS 9-bit NRZL words using table 2 in annex A. A *Yes* indicates that a polarity inversion across the next NRZI(1) 9- bit symbol will take place as the corresponding 9-bit NRZL word is NRZI(1)-modulated.

11 Formation of a sector

11.1 Overview

The content, format, and recording method of the data blocks forming the helical data records are defined. In addition, the content, format, and recording method of the longitudinal control record containing tracking information for the scanning head associated with the helical record are defined. Track dimensions and locations are specified. Figure 11 shows a block diagram of the processes involved in the recorder. The helical track shall be comprised of formatted computer digital data.

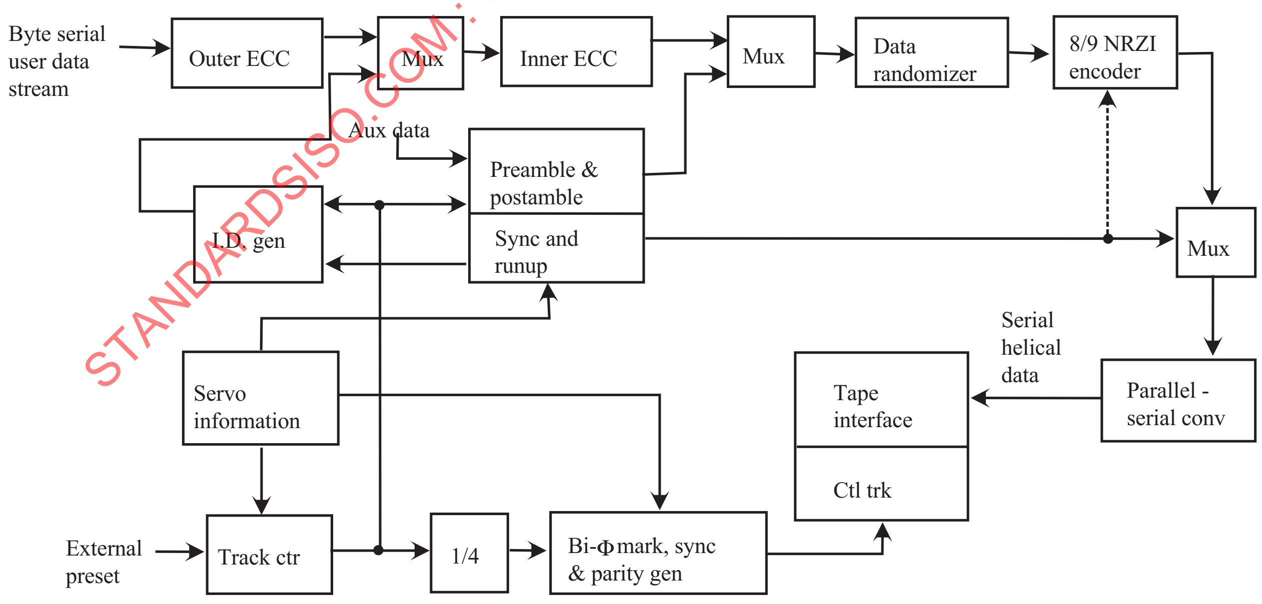


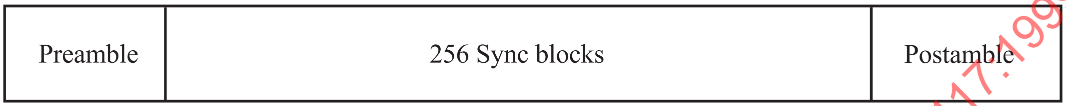
Figure 11 - Digital recorder: conceptual block diagram of record path

Data shall be arranged in one sector per track, as shown in figure 12 The sector (figure 12(a)) is divided into the following elements:

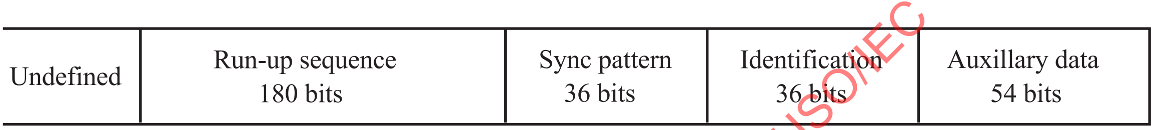
– preamble (figure 12(b)) containing a clock run-up sequence, a synchronization (sync) pattern, an identification pattern, and auxiliary data;

– sync blocks (figure 12(c)) containing a sync pattern followed by an identification pattern and an information block, both of which are protected by error control;

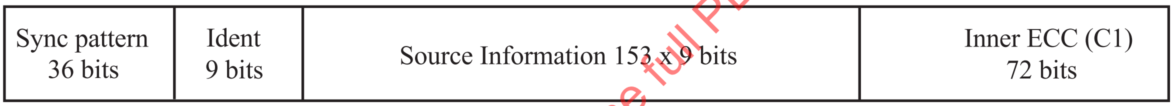
– postamble (figure 12(d)) containing a sync pattern and an identification pattern.



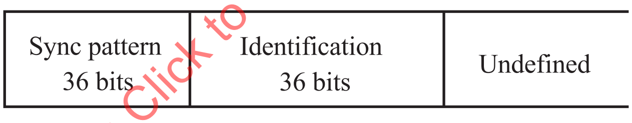
(a) Sector



(b) Preamble



(c) Sync block



(d) Postamble

Figure 12 - Sector details

11.2 Sector details

11.2.1 General

Details of the sector are shown in figure 12(a). All sectors shall contain a preamble, 256 sync blocks, and a postamble and shall account for a total of 382 842 coded bits in 42 538 symbols of 9-bits. A portion of the guard space, not shown in 12(a), at the beginning of the sector may contain extended run-up sequences of up to 90 symbols of 9-bits in length. Any extended run-up sequence must be added in pairs of run-up 9-bit symbols.

11.2.2 Preamble

Details of the preamble are shown in figure 12(b). All sectors shall commence with a preamble of 34 symbols of 9-bits arranged as follows:

- run-up 20 symbols of 9-bits, magnetization pattern as follows:

- LSB 001110001 110001110...001110001 110001110 MSB

- sync pattern 4 symbols of 9-bits, magnetization pattern as follows:

- LSB 000011001 111111110 010111000 000001101 MSB

- data field 10 symbols of 9-bits, comprised of 4 bytes of track identification followed by 6 bytes of auxiliary data

(a) Identification - 4 bytes as follows:

LSB 11111111 TTSSSSSS SSSSSSSS SSSSSSSS MSB

Where:

LSB SS...S MSB are the 22 least significant bits of the corresponding TSID on the control track and LSB TT MSB indicates the track position with respect to the corresponding control track sync word as follows:

- 0 for track coincident with the control track sync word;
- 1 for first track after the control track sync word;
- 2 for second track after the control track sync word;
- 3 for track before the next control track sync word;

(b) auxiliary Data - 6 bytes of unspecified content;

11.2.3 User data sync block

Details of the sync block are shown in figure 12(c). All sectors shall contain 256 sync blocks. Each sync block shall comprise 166 symbols of 9-bits arranged as follows:

- sync pattern 4 symbols of 9-bits, magnetization pattern as follows:

- LSB 111100110 000000001 101000111 111110010 MSB

- data field 162 symbols of 9-bits, shall comprise 1 byte of sync block identification followed by 153 bytes of source information, both protected by 8 bytes of inner error code, all of which are processed as defined below.

(a) Identification - 1 byte as follows:

LSB PPPPPPPP MSB

Where:

LSB PP...P MSB shall be the identification byte indicating the sync block position within the sector, starting with 0 for the first sync block and ending with 255 for the last sync block;

(b) source information - 153 bytes of row information derived from the product code arrays

(c) error protection - 8 bytes from encoding (a) and (b) above with Reed-Solomon RS (162, 154) code;

11.2.4 Postamble

Details of the postamble are shown in figure 12(d). All sectors shall terminate with a postamble of 8 symbols of 9-bits arranged as follows:

- sync pattern 4 symbols of 9-bits, magnetization pattern as follows:

- LSB 000011001 111111110 010111000 000001101 MSB

- data field 4 symbols of 9-bits, comprise 4 bytes of post identification processed as defined below

Identification - 4 bytes created as follows:

- LSB 00000000 TTSSSSSS SSSSSSSS SSSSSSSS MSB

Where:

LSB SS...S MSB are the 22 least significant bits of the corresponding TSID on the control track and LSB TT MSB indicates the track position with respect to the corresponding control track sync word on the control track as follows:

- 0 for track coincident with control track sync word;
- 1 for first track after the control track sync word;
- 2 for second track after the control track sync word;
- 3 for track before the next control track sync word;

11.3 Recording method

The method of recording shall be the "non-return to zero, change on ones" (NRZI(1)), which utilizes a serial bit stream modulated with an 8/9 run length limited (RLL) group code. For recording, a flux transition representing ONE shall be moved to the beginning of a bit cell. It shall be recorded to tape at a density of 2 252 ftpmm max.

11.3.1 Influence of the preamble run-up and sync patterns on DSV

The DSV at the beginning of each track is defined as zero and is not changed by an even number of run-up 9-bit symbols. The non-zero contribution to the DSV by each 36-bit sync pattern, however, shall be included in the calculation of the DSV used as the entry for table 2 in annex A. Table 3 in annex A summarizes the change in DSV effected by preamble run-up and sync patterns.

11.3.2 Magnetization

For the preamble run-up, sync patterns, and data fields, during the time interval of a recorded "+" level of NRZI(1), the polarity of cell flux shall be such that the north pole of the magnetic domain shall point in the direction of head motion. Similarly, during the time interval of a recorded "-" level of NRZI(1), the polarity of cell flux shall be such that the south pole of the magnetic domain shall point in the direction of head motion.

11.4 Record optimization

11.4.1 Second harmonic distortion

The recorded magnetization as measured by the playback signal amplitude on tape shall have a second harmonic distortion component which is at least 26 dB below the total signal amplitude correcting for equalization effects (equivalent flat equalized measurement). This distortion level shall be verified by making measurements on recorded wavelengths approximately equal to 4 times, 8 times and 16 times the bit length.

11.4.2 Residual signal level

If a previously recorded tape at 170 ftpmm is over-recorded with 2 252 ftpmm signal or erased, the 170 ftpmm playback amplitude shall be suppressed by at least 26 dB relative to the original 170 ftpmm playback amplitude.

11.4.3 Record level optimization

Using either a previously recorded or erased tape and a record waveform with rise time and other wave shape characteristics chosen to meet the second harmonic distortion, non-linear intersymbol interference, and residual signal level criteria, the record current shall be chosen to maximize the playback amplitude of a signal component recorded at 2 252 ftpmm. If no clear peak occurs, then the record current shall be set at the lowest level which produces the maximum playback amplitude.

11.5 Helical tracks

11.5.1 Track geometry

The measurement edge of the tape for dimensions specified in this standard shall be the equivalent reference edge as shown in figure 14.

The magnetic coating, with the direction of tape travel as shown in figure 13 shall be on the side facing the observer.

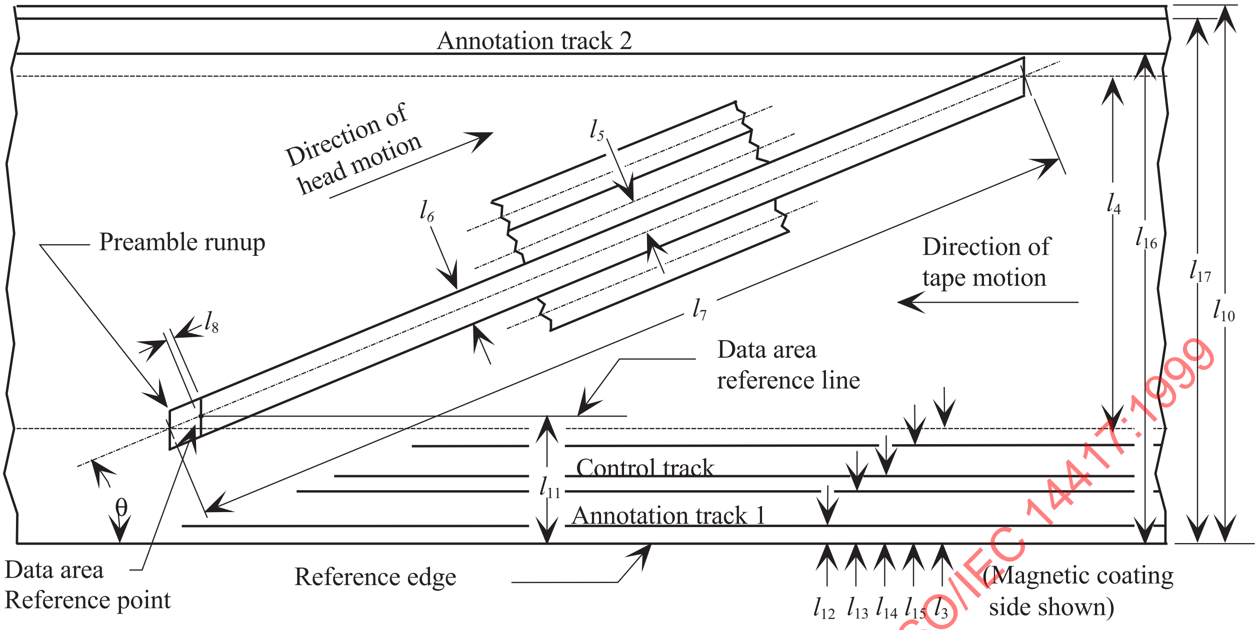


Figure 13 - Location and dimensions of recorded tracks

11.5.1.1 Dimensions

All dimensions in the figures 13 and 15 shall be measured from an equivalent reference edge. The equivalent tape reference edge shall be defined as a line through three points on the edge of tape. These points shall be separated by

l_1 = 115 mm ± 3 mm and constrained to lie in one straight line.

This constraint may be a physical deformation or an equivalent mathematical transformation.
The data area center line shown in figure 14 shall be a theoretical line parallel to the equivalent reference edge and

l_2 = 8,9 mm ± 0,1 mm above the center point of the equivalent reference edge.

As shown in figure 14, the center point of the equivalent reference edge shall be chosen along the tape such that the centerline of the track for zone 1 intersects the data-area centerline along a perpendicular from the center point of the equivalent reference edge.
All tape edge measurements shall be based on an average over a tape edge length of 10 mm ± 1 mm.

11.5.2 Helical recorded track geometry

The distance of the data area lower edge from the Reference edge of the tape shall be

l_3 = 1,8 mm nominal.

The distance from the lower to the upper data area edge shall be
l_4 = 16,00 mm nominal.

The helical track pitch as measured from one centreline to the centreline of an adjacent track shall be

l_5 = 0,045 mm nominal.

The helical track width shall be

l_6 = 0,045 mm nominal.

The helical record head width and position tolerances shall be chosen so as to ensure a minimum recorded track width of 0,040 mm and a maximum recorded overlap of 0,015 mm.

The length of a helical track as measured from the beginning to the end on the centreline shall be

l_7 = 170,00 mm ± 0,3 mm

11.5.2.1 Helical track angle

The nominal angle of the helical track shall be arc-sine (16/170) nominal

$\Theta = 5,4005°$

11.5.2.2 Azimuth angle, helical tracks

The azimuth angle of the head gaps used for the helical records shall be ± 15° with respect to the perpendicular of the helical track within a tolerance of ±10 minutes of arc. Alternating negative and positive azimuth angles shall result in magnetization patterns on tracks that are inclined relative to the data area reference line by

α_1 = 80° 24' for the first and third tracks and
α_2 = 110° 24' for the second and fourth tracks of every track set *n*.

11.5.2.3 Relative position of recorded signals

The Data area reference point shall be defined as a point corresponding to the end of the preamble run-up sequence in the helical track.

The distance from the Reference edge to the Data area reference line shall be

l_{11} = 1,8075 mm nominal

The Nominal data area reference point shall be the point determined by the Data area reference line intersecting the helical track center line as shown in figures 13 and 15.

The Sector recording tolerance shall be the distance between the Data area reference point and the Nominal data area reference point and shall be

l_8 = 0,0 mm ± 0,1 mm

The spatial relationship between the helical tracks and Control record is shown in figures 13 and 15.
The Control track sync tolerance shall be the distance the Nominal data area reference point on every fourth helical track to the Control timing reference point.
The Control track sync tolerance shall be

l_9 = 0,0 mm ± 0,1 mm

The distance between Data area reference point and the Point of annotation records shall be

l_{18} = 118,7 mm ± 0,3 mm

For every recorded helical track set (track set *n*) there shall exist continuous control track information extending at least from *n*-127 to *n*+63, with the TSID for track set *n* located relative to the corresponding Data area reference point as shown in figure 15.

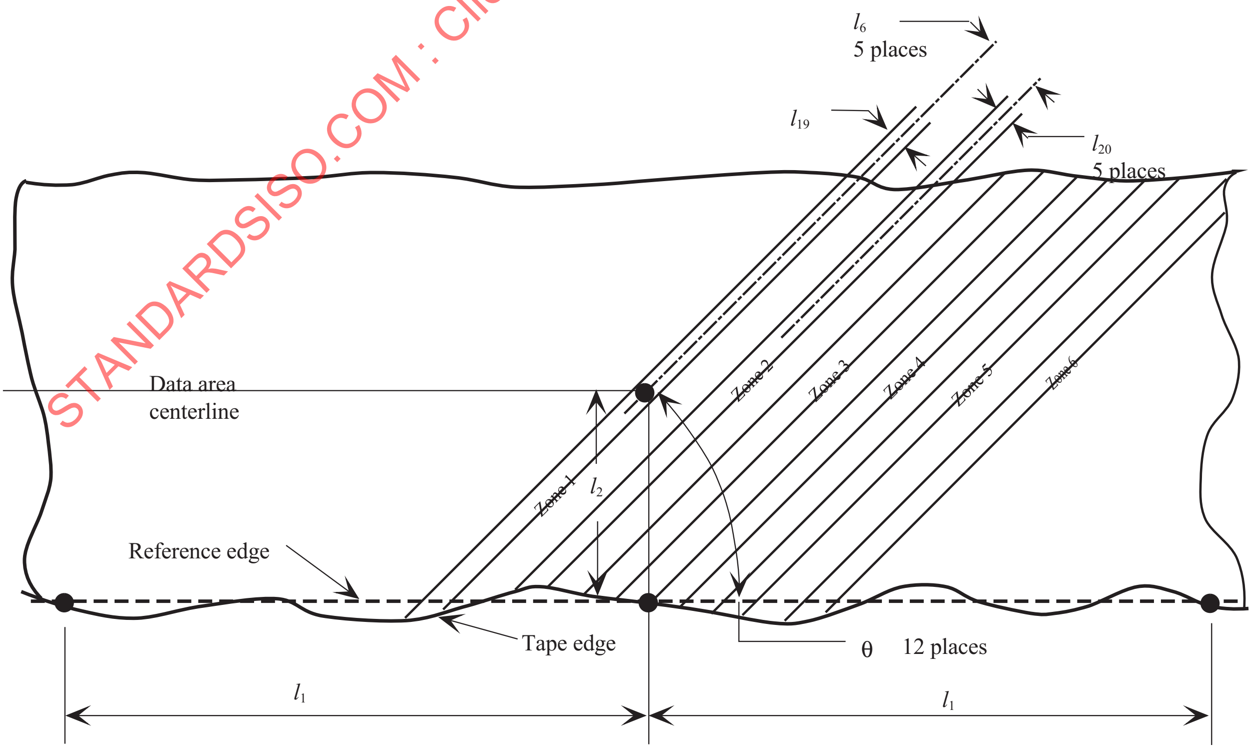


Figure 14 - Location and dimensions of tolerance zones for helical tracks

11.5.2.4 Track curvature

The centrelines of any six consecutive tracks shall be contained within the pattern of the six tolerance zones established in figure 14.

Each zone shall be defined by two parallel lines which are inclined at an angle θ with respect to the tape reference edge.

The centrelines of all zones shall be spaced l_6 apart.

The width of the first zone shall be l_{19} = 0,010 mm nominal.

The width of zones 2 through 6 shall be l_{20} = 0,015 mm nominal.

These zones are established to contain track angle errors, track straightness errors, and track pitch errors.

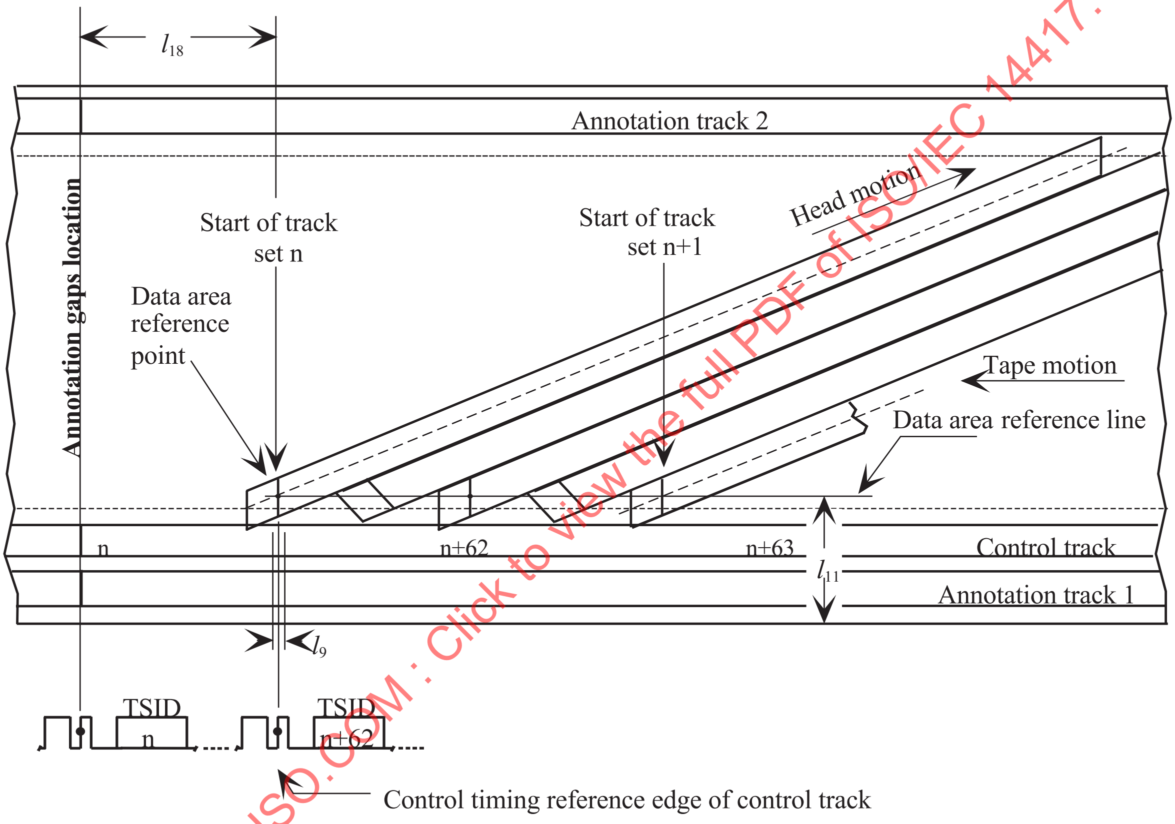


Figure 15 - Location of longitudinal tracks and 32 bit control word

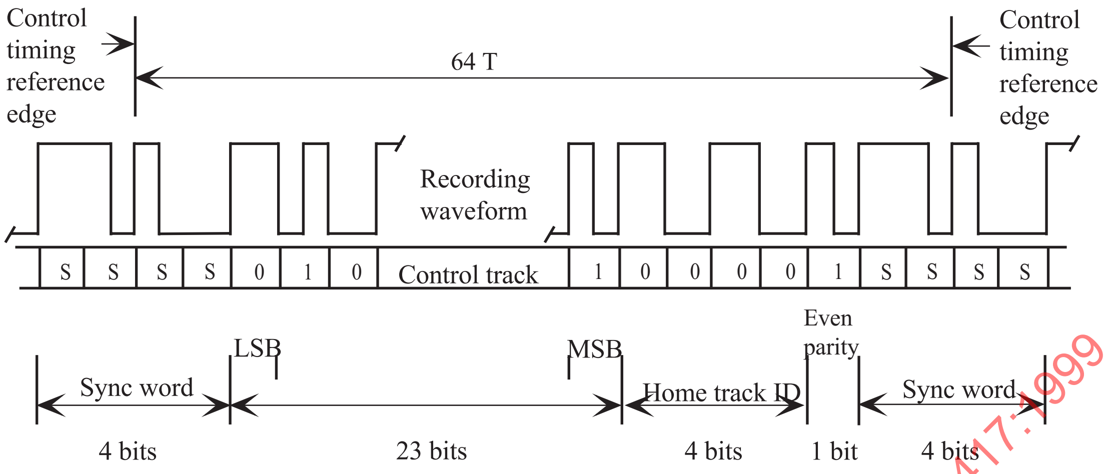
11.6 Longitudinal tracks

11.6.1 Overview

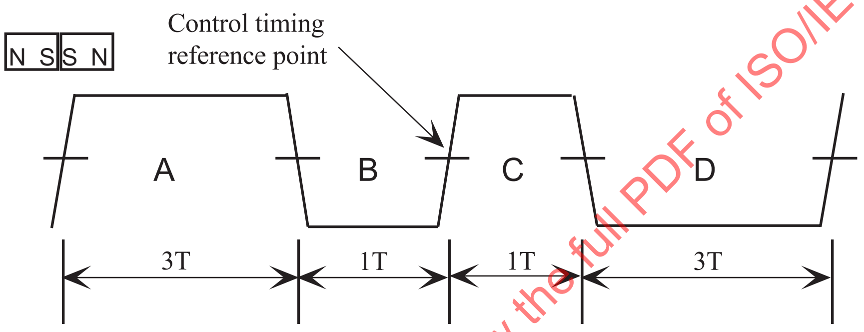
This clause of the standard specifies the content, format and modulation method of the longitudinal records contained in the control and annotation tracks for DD-1 helical scan cassettes.

11.6.1.1 Definition

The longitudinal control record shall be a series of 32-bit control words recorded as shown in figure 15. The location of the control record and its positioning relative to the helical track information shall be l_{18}.



Control track example



T is 1/64th the period of 4 helical tracks

Control track sync word

Figure 16 - Recorded control track waveform timing

11.6.1.2 Control record content

The control record uniquely identifies each set of four consecutive helical tracks with a 23-bit track set ID. The four helical tracks with TSID equal to or larger than 128 shall be the first helical tracks recorded on tape. Every four subsequent tracks shall be identified by a TSID that is one higher than the previous track set ID. In addition, there is a 4-bit home track ID that may be used to identify the heads of a scanner that were recording the four helical tracks. If the home track ID feature is not used, then the 4-bit field is set to ZERO (see figure 16)

11.6.1.3 Control track sync word

The control record content shall be set between two control track sync words as shown in figure 16. The centre points or centre edges of the control track sync words provide the control timing reference points or edges, which shall be separated by a pitch distance equivalent to four helical tracks. They shall be aligned with the Nominal data area reference point as shown in figure 15.

11.6.1.4 Recording method

The 23-bit TSID, 4-bit home track ID, and an even parity bit shall be bi-phase-mark encoded before recording between two control track sync words takes place. A flux transition occurs at every boundary of bit cells and a ONE is represented by a second transition in the center of the bit cell, while a ZERO creates no such transition (see figure 16).

During time intervals A and C of the control track sync word (see figure 16), the polarity of the control track magnetization shall be such that the south pole of the magnetic domain points in the direction of normal (forward) tape travel. Similarly, during time intervals B and D, the north pole shall point in the direction of tape travel. The recorded control track sync word shall have intervals A and D a length 3T and intervals B and C a length 1T, where T = 1/64 the period of four helical tracks.

The record current rise and fall times shall be less than 0,15T (10% to 90%) and be matched within 0,05T. The peak-to-peak recording current shall maximize the playback signal when using a test signal of period 2T.

11.6.2 Annotation tracks

11.6.2.1 Method of recording

The signals may be recorded using the anhysteretic (a.c. bias) method or the saturate recording (without bias) method. The bias wavelength shall be sufficiently shorter than (about one fifth of) the shortest signal wavelength supported by a recorder.

11.6.2.2 Flux level

11.6.2.2.1 Anhysteretic method

The recorded reference analog level shall correspond to an RMS magnetic short-circuit flux level of
70 nWb/m ± 10 nWb/m at a recorded wavelength of 250 µm.

11.6.2.2.2 Saturate method

The peak-to-peak recording current shall maximize the playback signal at a recorded wavelength of 10 µm.

11.6.2.3 Polarity

A signal which traverses from a negative level to a positive level with respect to system ground shall result in a magnetic pattern on the tape with a polarity sequence of south-north-north-south, when recorded in the forward direction of tape motion. During the south-north polarity portions, the magnetization shall be such that the south pole of the magnetic domain points in the direction of tape travel.

11.6.3 Longitudinal track geometry

The longitudinal track information shall be placed on tape toward BOT relative to the Data area reference point at a distance l_{18} shown in figure 15.

The distance from the Reference edge to the lower edge of the Annotation track 1 shall be

l_{12} = 0,2 mm ± 0,1 mm.

The distance from the Reference edge to the upper edge of the Annotation track 1 shall be

l_{13} = 0,7 mm ± 0,1 mm.

The distance from the Reference edge to the lower edge of the Control track shall be

l_{14} = 1,0 mm ± 0,1 mm.

The distance from the Reference edge to the upper edge of the Control track shall be

l_{15} = 1,50 mm ± 0,05 mm.

The distance from the Reference edge to the lower edge of the Annotation track 2 shall be

l_{16} = 18,10 mm ± 0,15 mm.

The distance from the Reference edge to the upper edge of the Annotation track 2 shall be

l_{17} = 18,8 mm ± 0,2 mm.

11.6.3.1 Azimuth angle, longitudinal tracks

The azimuth of flux transitions on Annotation track 1, Control track, and Annotation track 2 longitudinal records shall be
$\alpha_3 = 0^\circ 0' \pm 5'$.

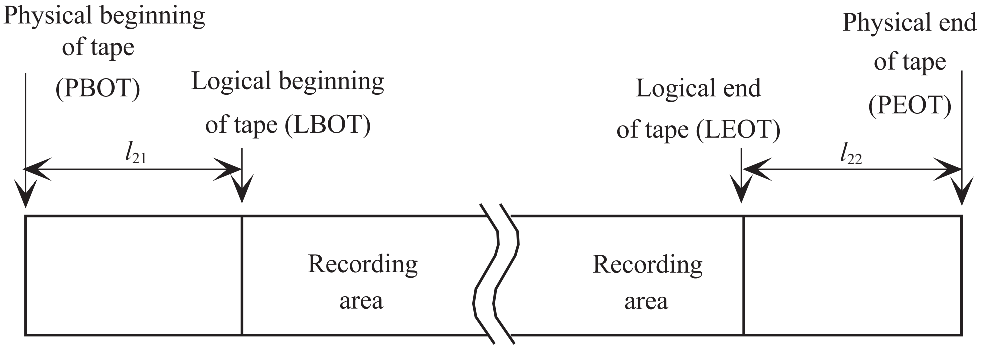


Figure 17 - Recording area

11.7 Recorded information

11.7.1 Recording area

The recording area shall be defined as the area between logical beginning of tape (LBOT) and logical end of tape (LEOT), as shown in figure 17.

The distance from the PBOT to the LBOT shall be

$$l_{21} = 10{,}0 \text{ m} \pm 0{,}5 \text{ m}.$$

The area between PBOT and LBOT is not used for recording any data for information interchange purpose.

The distance from the LEOT to the PEOT shall be

$$l_{22} = 15 \text{ m min.}$$

The area between LEOT and PEOT shall not be used for recording data for information interchange.

Both the PBOT and PEOT are defined as actual edges of a tape.

11.7.2 Magnetic tape layout

The first recorded area from LBOT on the magnetic tape shall be the volume set information table (VSIT), reference figure 18.

A position tolerance band shall follow the VSIT area. This band is used to accommodate the positioning tolerance when updating the VSIT.

The first directory information table (DIT) shall follow the first position tolerance band.

A second position tolerance band shall follow after the DIT and shall be used to accommodate the positioning tolerance when updating the DIT.

The area after the second position tolerance band and before near EOT (NEOT) shall be defined as recorded data area. This area may contain additional DIT's for subsequent volumes.

The area between NEOT and LEOT shall be defined as virtual end of volume (VEOV) area.
Any necessary processing which requires recording data on the magnetic tape shall be terminated within this area.

11.7.3 Footprint on the magnetic tape

The track format shall consist of the helical data tracks and three longitudinal tracks as shown in figure 15. The annotation track 1 and the annotation track 2 are defined as the user's area, and shall not be used for recording data for interchange purpose with this format.

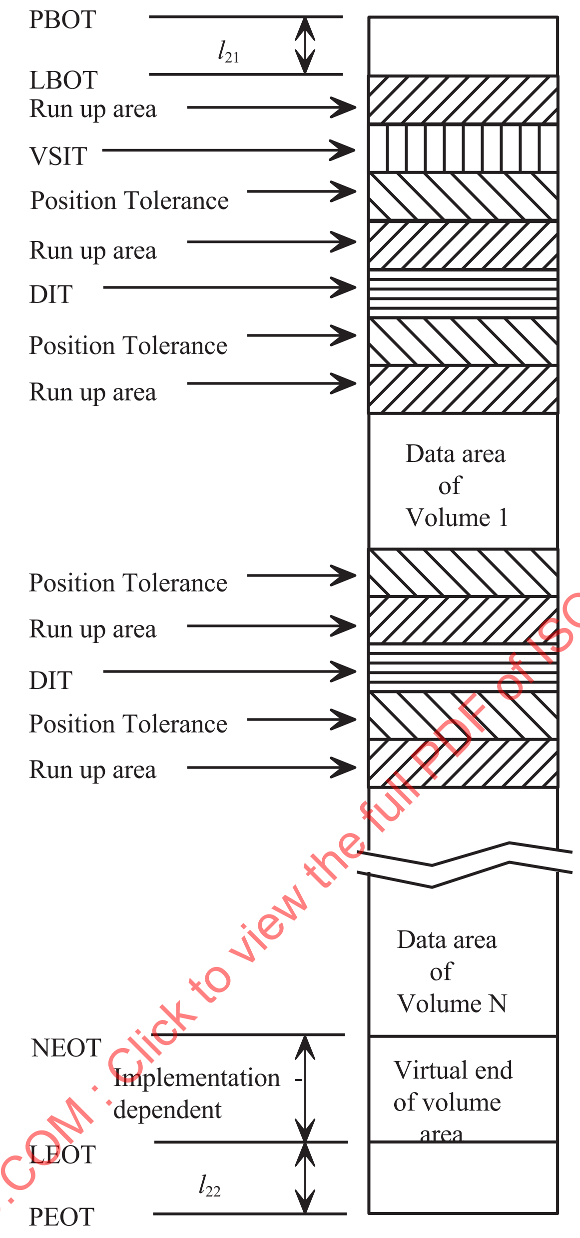


Figure 18 - Magnetic tape layout

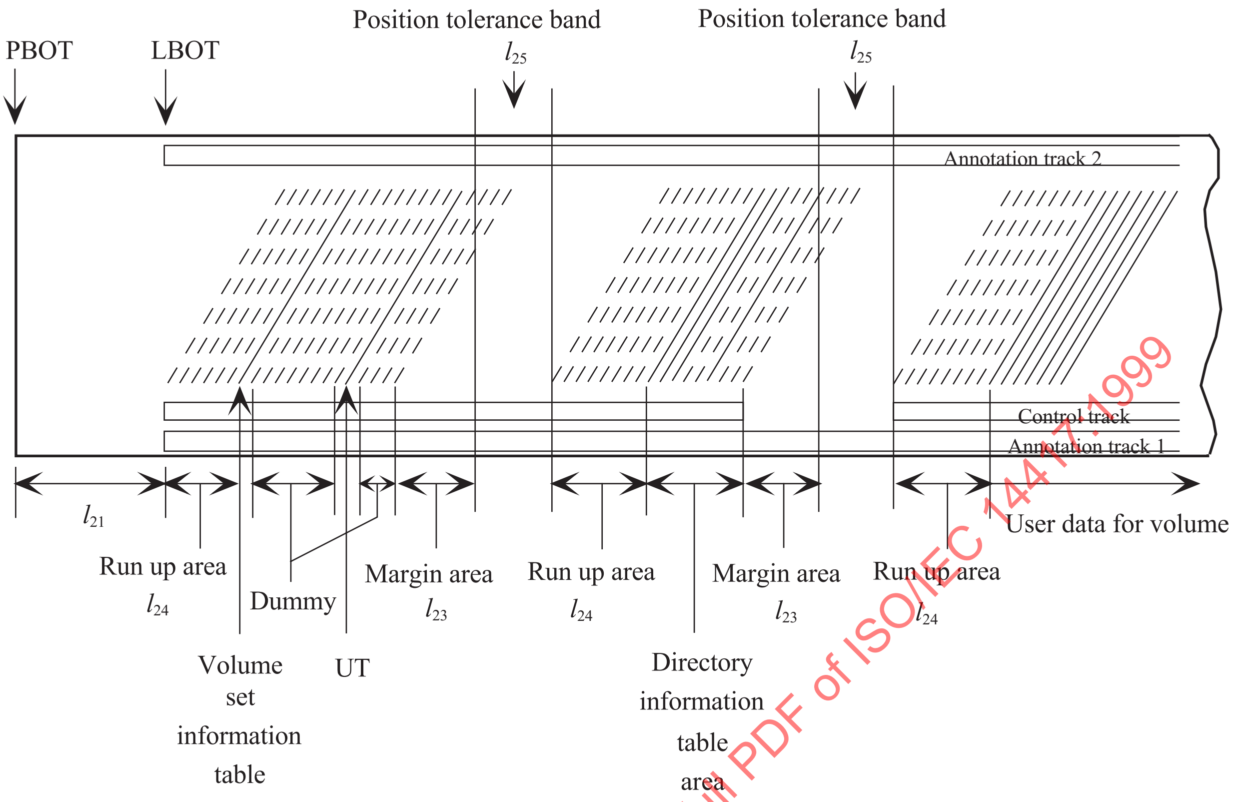


Figure 19 - Allocation of VSIT

11.7.4 Layout of VSIT

The layout of the VSIT shall include the following

the run up area for auto tracking capability starting at LBOT and shall be a distance of

l_{24} = 2,5 m ± 0,1 m

the margin area for write retry sequences and shall be a distance of

l_{23} = 2,5 m ± 0,1 m

a position tolerance band to accommodate update positioning and shall be a distance of

l_{25} = 0,5 m ± 0,1 m

The run up area shall be for recording the required 127 TSIDs prior to the first track set of the VSIT.

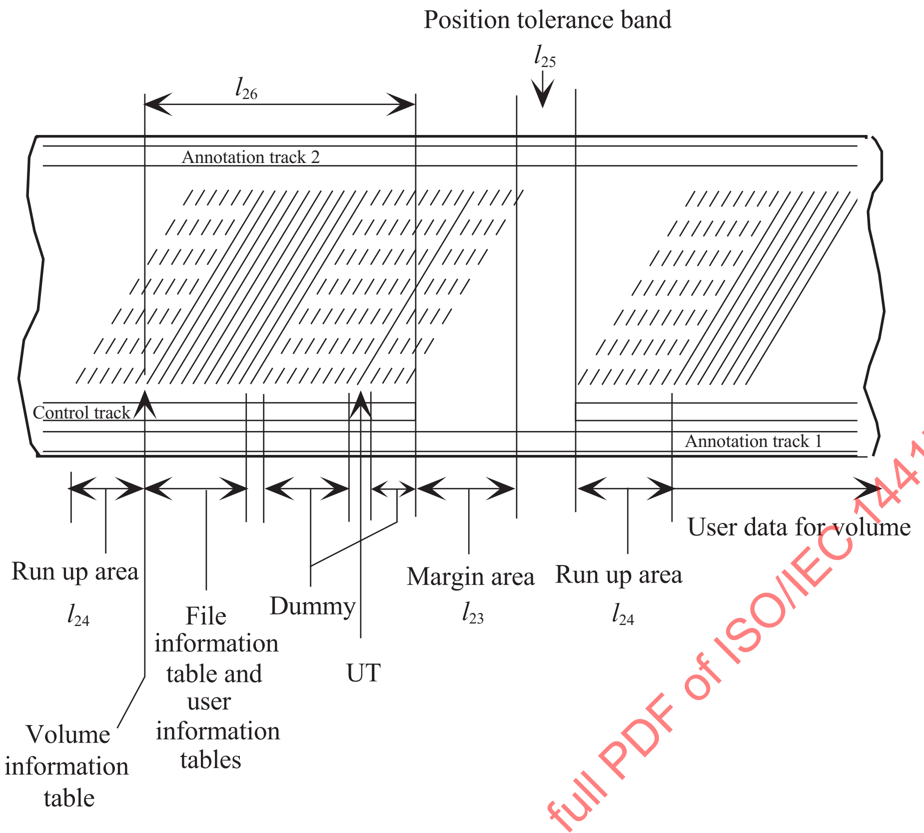


Figure 20 - Allocation of DIT

11.7.4.1 Layout of DIT

Figure 20 shows the magnetic tape layout of DIT area. The capacity of each table shall be as follows:

Table		Tracks
Volume information table	(VIT)	4
File information table	(FIT)	4*m* (*m* = number of track sets for FIT)
User Information Tables	(UIT)	4*n* (*n* = number of track sets for UIT)
…Update information table	(UT)	4

The length of the DIT shall be

l_{26} = 1,0 m min

The length of the DIT area shall be 5 m min including l_{23} of margin area and l_{24} of run up area.
The margin area shall be used for write retry when necessary in the preceding tables.

Note - With this configuration, approximately 1 million files may be addressed.

11.8 Write retry sequence

To ensure that the quality of the recording is adequate for it to be read reliably, the write-retry sequence may be used whilst recording.

A track-set found to be in error, and the following tracks sets, up to a maximum of 15, shall be recorded again; the original track-sets shall not be erased. The maximum delay to start write-retry is 16 track-sets. For each occurrence of write-retry the write-retry count in the subcode field shall be incremented by 1. Figure 21 illustrates the write-retry sequence.

11.9 Append file operation

To append a file to the end of data, overwrite EOD track sets leaving at least one EOD track set next to the TM track set. Logical TSID of subcode data field shall be given an offset of exactly 32, and also the append file pointer shall be set at the first track set of the appended file. Alternatively, to append a file on to an existing file or files, overwrite the existing file leaving one DM track set next to the TM. In this case, old files(s) from the point of append file operation beginning and beyond within the Logical volume is(are) considered to be destroyed by having been partially or totally overwritten. The append file operation shall be terminated with EOD track sets.

The Logical TSID and append file pointer in the subcode data field shall be set the same as in the previous case. Refer to tables C.2 and C.3.

Further, only if a TM track set is preceded by a DM track set, a resume operation or file extension may be performed as follows.

Overwrite the existing TM and following track sets with data to be added, leaving the DM track set preceding the TM track set. Then, the extended file shall be terminated by a DM, TM and EOD track sets. Logical TSID and append pointer in the subcode data field shall be set the same as previous cases.

When the append operation is carried out under the condition that write retries took place over TM, it is performed to the last rewritten TM. Refer to table C.2.

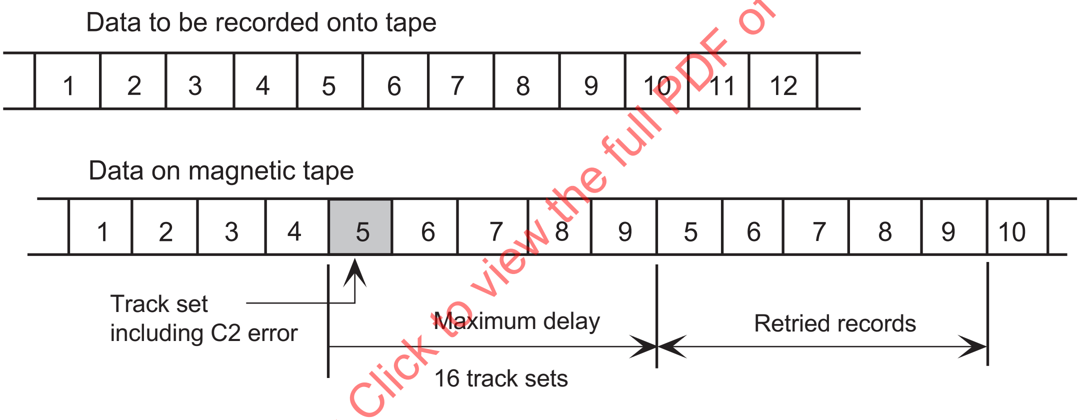


Figure 21 - Example of write retry sequence

Annex A

(normative)

Measurement of light transmittance

A.1 Introduction

The following description outlines the general principle of the measuring equipment and measuring method to be applied when measuring the light transmittance of the tape and leader.

For the purpose of the Standard light transmittance is defined by convention as the relationship between the reading obtained from the measuring equipment with the test piece inserted and the reading when no test piece is present. The transmittance value is expressed as the percentage ratio of the two readings. The requirement of a value less than 5 % for tape shall be met for the two radiation sources specified in A.2.1. The requirement of a value greater than 60 % for leader shall be met for the two radiation sources specified in A.2.1.

A.2 Description of the measuring equipment

The equipment shall comprise:

- the radiation sources,
- the radiation receiver,
- the measuring mask,
- the optical path,
- the measuring circuitry.

A.2.1 Radiation sources

A tungsten lamp operating at a color temperature of 2000 °K ± 200 °K;

A light emitting diode having a peak output at 900 nm ± 50 nm.

A.2.2 Radiation receiver

A flat silicon diode shall be used. It shall operate in the short-circuit mode.

A.2.3 Measuring mask

The measuring mask shall have a thickness of 2 mm and a circular aperture of diameter *d* such that the area is 80 % to 100 % of the active area of the photo diode.

The surface of the mask shall be mat black.

The test piece shall be held firmly against the mask to cover the aperture and to ensure that no ambient light leaks past.

A.2.4 Optical path

The optical path shall be perpendicular to the mask. The distance L from the emitting surface of the radiation source to the mask.

$$L = \frac{d}{2\tan\alpha}\,\text{mm}$$

where α is the angle where the relative intensity of the radiation source is not less than 95 % of the maximum intensity of the optical axis.

A.2.5 Finish

The whole assembly shall be enclosed in a mat black case.

A.2.6 Measuring circuitry

The components of the measuring circuitry are:

E	: regulated power supply with a variable output voltage
R	: current-limiting resister
LED	: light-emitting diode
TL	: tungsten lamp
Di	: silicon photo diode
A	: operational amplifier
R_{f0}, R_{f1}	: feedback resisters
S	: gain switch
V	: voltmeter

The forward current of the LED, and consequently its radiation power, can be varied by means of the power supply E.

Di is operating in the short circuit mode.

$V_0 = I_k \text{ x } R_f$ where I_k is the short-circuit current of Di.

The output voltage of the operational amplifier is therefore a linear function of the light intensity.

R_{f0} and R_{f1} shall be low temperature-drift resisters with an accuracy of 1 %.

The following ratio applies:

$$R_{f0} \text{ to } R_{f1} = 1 \text{ to } 20$$

A.3 Measuring method

Set switch S to position 0.

With no test piece mounted, vary the supply voltage of E until voltmeter V reads full scale 100 %.

Mount a test piece of leader on the mask. Greater than 60 % of full scale deflection is required.

Mount a test piece of magnetic tape on the mask. Set switch S to position 1. Full deflection of the voltmeter now represents a light transmittance of 5 %.

Repeat the test method twice for each test piece, once with LED and once with tungsten lamp.

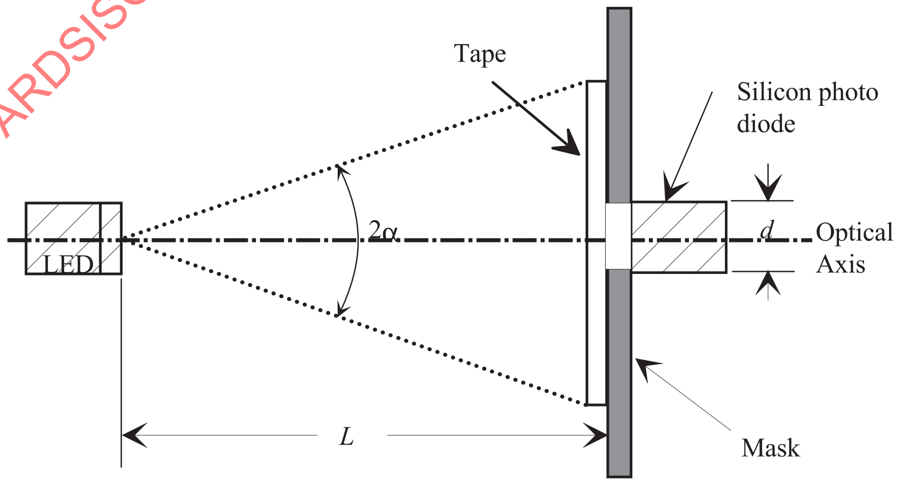


Figure A.1 - Optical arrangement

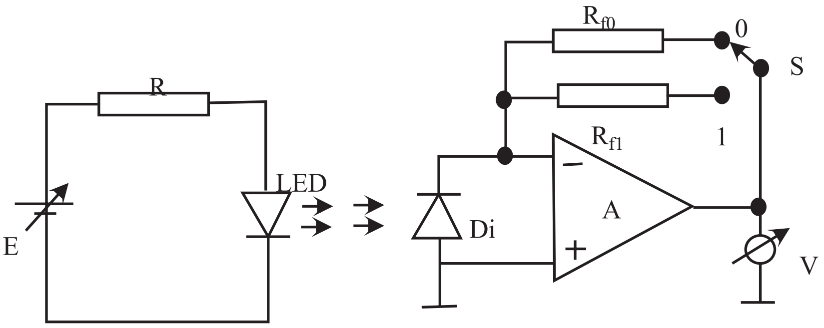


Figure A.2 - Measuring circuitry

Annex B

(normative)

Tables

Table 1 - Randomized 8-bit byte to 9-bit binary NRZL word mapping

Randomized byte value (decimal)	Positive CDS selection			Negative CDS selection		
	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?
0	000100000	+2	Yes	010011100	-1	No
1	001000011	+2	Yes	001000100	-1	No
2	001000110	+2	Yes	001001110	-1	No
3	001001100	+2	Yes	001011010	-1	No
4	001011000	+2	Yes	000100101	-2	Yes
5	001110000	+2	Yes	000101010	-2	Yes
6	010000101	+2	Yes	000101111	-2	Yes
7	010001010	+2	Yes	000110100	-2	Yes
8	010001111	+2	Yes	000111011	-2	Yes
9	010010100	+2	Yes	000111110	-2	Yes
10	010011011	+2	Yes	001001001	-2	Yes
11	010011110	+2	Yes	001010010	-2	Yes
12	010101000	+2	Yes	001010111	-2	Yes
13	010110011	+2	Yes	001011101	-2	Yes
14	010110110	+2	Yes	001100100	-2	Yes
15	010111100	+2	Yes	001101011	-2	Yes
16	011010000	+2	Yes	001101110	-2	Yes
17	011100011	+2	Yes	001110101	-2	Yes
18	011100110	+2	Yes	001111010	-2	Yes
19	011101100	+2	Yes	001111111	-2	Yes
20	011111000	+2	Yes	010010001	-2	Yes
21	100001001	+2	Yes	010100010	-2	Yes
22	100010010	+2	Yes	010100111	-2	Yes
23	100010111	+2	Yes	010101101	-2	Yes
24	100011101	+2	Yes	010111001	-2	Yes
25	100100100	+2	Yes	011000100	-2	Yes
26	100101011	+2	Yes	011001011	-2	Yes
27	100101110	+2	Yes	011001110	-2	Yes
28	100110101	+2	Yes	011010101	-2	Yes
29	100111010	+2	Yes	011011010	-2	Yes
30	100111111	+2	Yes	011011111	-2	Yes
31	101001000	+2	Yes	011101001	-2	Yes
32	101010011	+2	Yes	011110010	-2	Yes

Randomized byte value (decimal)	Positive CDS selection			Negative CDS selection		
	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?
33	101010110	+2	Yes	011110111	-2	Yes
34	101011100	+2	Yes	011111101	-2	Yes
35	101100101	+2	Yes	100100001	-2	Yes
36	101101010	+2	Yes	101000010	-2	Yes
37	101101111	+2	Yes	101000111	-2	Yes
38	101110100	+2	Yes	101001101	-2	Yes
39	101111011	+2	Yes	101011001	-2	Yes
40	101111110	+2	Yes	101110001	-2	Yes
41	110010000	+2	Yes	110000100	-2	Yes
42	110100011	+2	Yes	110001011	-2	Yes
43	110100110	+2	Yes	110001110	-2	Yes
44	110101100	+2	Yes	110010101	-2	Yes
45	110111000	+2	Yes	110011010	-2	Yes
46	111000101	+2	Yes	110011111	-2	Yes
47	111001010	+2	Yes	110101001	-2	Yes
48	111001111	+2	Yes	110110010	-2	Yes
49	111010100	+2	Yes	110110111	-2	Yes
50	111011011	+2	Yes	110111101	-2	Yes
51	111011110	+2	Yes	111010001	-2	Yes
52	111101000	+2	Yes	111100010	-2	Yes
53	111110011	+2	Yes	111100111	-2	Yes
54	111110110	+2	Yes	111101101	-2	Yes
55	111111100	+2	Yes	111111001	-2	Yes
56	000010000	0	Yes	000010000	0	Yes
57	000100011	0	Yes	000100011	0	Yes
58	000100110	0	Yes	000100110	0	Yes
59	000101100	0	Yes	000101100	0	Yes
60	000111000	0	Yes	000111000	0	Yes
61	001000101	0	Yes	001000101	0	Yes
62	001001010	0	Yes	001001010	0	Yes
63	001001111	0	Yes	001001111	0	Yes
64	001010100	0	Yes	001010100	0	Yes
65	001011011	0	Yes	001011011	0	Yes
66	001011110	0	Yes	001011110	0	Yes
67	001101000	0	Yes	001101000	0	Yes
68	001110011	0	Yes	001110011	0	Yes
69	001110110	0	Yes	001110110	0	Yes
70	001111100	0	Yes	001111100	0	Yes
71	010001001	0	Yes	010001001	0	Yes

Randomized byte value (decimal)	Positive CDS selection			Negative CDS selection		
	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?
72	010010010	0	Yes	010010010	0	Yes
73	010010111	0	Yes	010010111	0	Yes
74	010011101	0	Yes	010011101	0	Yes
75	010100100	0	Yes	010100100	0	Yes
76	010101011	0	Yes	010101011	0	Yes
77	010101110	0	Yes	010101110	0	Yes
78	010110101	0	Yes	010110101	0	Yes
79	010111010	0	Yes	010111010	0	Yes
80	010111111	0	Yes	010111111	0	Yes
81	011001000	0	Yes	011001000	0	Yes
82	011010011	0	Yes	011010011	0	Yes
83	011010110	0	Yes	011010110	0	Yes
84	011011100	0	Yes	011011100	0	Yes
85	011100101	0	Yes	011100101	0	Yes
86	011101010	0	Yes	011101010	0	Yes
87	011101111	0	Yes	011101111	0	Yes
88	011110100	0	Yes	011110100	0	Yes
89	011111011	0	Yes	011111011	0	Yes
90	011111110	0	Yes	011111110	0	Yes
91	100010001	0	Yes	100010001	0	Yes
92	100100010	0	Yes	100100010	0	Yes
93	100100111	0	Yes	100100111	0	Yes
94	100101101	0	Yes	100101101	0	Yes
95	100111001	0	Yes	100111001	0	Yes
96	101000100	0	Yes	101000100	0	Yes
97	101001011	0	Yes	101001011	0	Yes
98	101001110	0	Yes	101001110	0	Yes
99	101010101	0	Yes	101010101	0	Yes
100	101011010	0	Yes	101011010	0	Yes
101	101011111	0	Yes	101011111	0	Yes
102	101101001	0	Yes	101101001	0	Yes
103	101110010	0	Yes	101110010	0	Yes
104	101110111	0	Yes	101110111	0	Yes
105	101111101	0	Yes	101111101	0	Yes
106	110001000	0	Yes	110001000	0	Yes
107	110010011	0	Yes	110010011	0	Yes
108	110010110	0	Yes	110010110	0	Yes
109	110011100	0	Yes	110011100	0	Yes
110	110100101	0	Yes	110100101	0	Yes

Randomized byte value (decimal)	Positive CDS selection			Negative CDS selection		
	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?
111	110101010	0	Yes	110101010	0	Yes
112	110101111	0	Yes	110101111	0	Yes
113	110110100	0	Yes	110110100	0	Yes
114	110111011	0	Yes	110111011	0	Yes
115	110111110	0	Yes	110111110	0	Yes
116	111001001	0	Yes	111001001	0	Yes
117	111010010	0	Yes	111010010	0	Yes
118	111010111	0	Yes	111010111	0	Yes
119	111011101	0	Yes	111011101	0	Yes
120	111100100	0	Yes	111100100	0	Yes
121	111101011	0	Yes	111101011	0	Yes
122	111101110	0	Yes	111101110	0	Yes
123	111110101	0	Yes	111110101	0	Yes
124	111111010	0	Yes	111111010	0	Yes
125	111111111	0	Yes	000111001	-1	Yes
126	000100001	+1	No	001001011	-1	No
127	001000010	+1	No	001010101	-1	No
128	001000111	+1	No	001011111	-1	No
129	001001101	+1	No	001101001	-1	No
130	001011001	+1	No	001110010	-1	No
131	001110001	+1	No	001110111	-1	No
132	010000100	+1	No	001111101	-1	No
133	010001011	+1	No	010010011	-1	No
134	010001110	+1	No	010010110	-1	No
135	010010101	+1	No	010100101	-1	No
136	010011010	+1	No	010101010	-1	No
137	010011111	+1	No	010101111	-1	No
138	010101001	+1	No	010110100	-1	No
139	010110010	+1	No	010111011	-1	No
140	010111101	+1	No	010111110	-1	No
141	011010001	+1	No	011001001	-1	No
142	011100010	+1	No	011010010	-1	No
143	011100111	+1	No	011010111	-1	No
144	011101101	+1	No	011011101	-1	No
145	011111001	+1	No	011100100	-1	No
146	100001000	+1	No	011101011	-1	No
147	100010011	+1	No	011101110	-1	No
148	100010110	+1	No	011110101	-1	No
149	100011100	+1	No	011111010	-1	No

Randomized byte value (decimal)	Positive CDS selection			Negative CDS selection		
	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?
150	100100101	+1	No	011111111	-1	No
151	100101010	+1	No	100100011	-1	No
152	100101111	+1	No	100100110	-1	No
153	100110100	+1	No	100101100	-1	No
154	100111011	+1	No	101000101	-1	No
155	100111110	+1	No	101001010	-1	No
156	101001001	+1	No	101001111	-1	No
157	101010010	+1	No	101010100	-1	No
158	101010111	+1	No	101011011	-1	No
159	101011101	+1	No	101011110	-1	No
160	101100100	+1	No	101110011	-1	No
161	101101011	+1	No	101110110	-1	No
162	101101110	+1	No	101111100	-1	No
163	101110101	+1	No	110001001	-1	No
164	101111010	+1	No	110010010	-1	No
165	101111111	+1	No	110010111	-1	No
166	110010001	+1	No	110011101	-1	No
167	110100010	+1	No	110100100	-1	No
168	110100111	+1	No	110101011	-1	No
169	110101101	+1	No	110101110	-1	No
170	110111001	+1	No	110110101	-1	No
171	111000100	+1	No	110111010	-1	No
172	111001011	+1	No	110111111	-1	No
173	111001110	+1	No	111010011	-1	No
174	111010101	+1	No	111010110	-1	No
175	111011010	+1	No	111011100	-1	No
176	111011111	+1	No	111100101	-1	No
177	111101001	+1	No	111101010	-1	No
178	111110010	+1	No	111101111	-1	No
179	111110111	+1	No	111110100	-1	No
180	111111101	+1	No	111111011	-1	No
181	010110111	+1	No	111111110	-1	No
182	001000001	+3	No	001010011	-3	No
183	010000010	+3	No	001010110	-3	No
184	010000111	+3	No	001111011	-3	No
185	010001101	+3	No	001111110	-3	No
186	010011001	+3	No	010100011	-3	No
187	010110001	+3	No	010100110	-3	No
188	011100001	+3	No	011000101	-3	No

Randomized byte value (decimal)	Positive CDS selection			Negative CDS selection		
	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?
189	100000100	+3	No	011001010	-3	No
190	100001011	+3	No	011001111	-3	No
191	100001110	+3	No	011011011	-3	No
192	100010101	+3	No	011011110	-3	No
193	100011010	+3	No	011110011	-3	No
194	100011111	+3	No	011110110	-3	No
195	100101001	+3	No	101000011	-3	No
196	100110010	+3	No	101000110	-3	No
197	100110111	+3	No	101001100	-3	No
198	100111101	+3	No	110000101	-3	No
199	101010001	+3	No	110001010	-3	No
200	101100010	+3	No	110001111	-3	No
201	101100111	+3	No	110010100	-3	No
202	101101101	+3	No	110011011	-3	No
203	101111001	+3	No	110011110	-3	No
204	110100001	+3	No	110110011	-3	No
205	111000010	+3	No	110110110	-3	No
206	111000111	+3	No	110111100	-3	No
207	111001101	+3	No	111100011	-3	No
208	111011001	+3	No	111100110	-3	No
209	111110001	+3	No	111101100	-3	No
210	010000011	+4	Yes	001100101	-3	No
211	010000110	+4	Yes	001101010	-3	No
212	010001100	+4	Yes	001101111	-3	No
213	010011000	+4	Yes	000101001	-4	Yes
214	010110000	+4	Yes	000110010	-4	Yes
215	100000101	+4	Yes	000110111	-4	Yes
216	100001010	+4	Yes	000111101	-4	Yes
217	100001111	+4	Yes	001010001	-4	Yes
218	100010100	+4	Yes	001100010	-4	Yes
219	100011011	+4	Yes	001100111	-4	Yes
220	100011110	+4	Yes	001101101	-4	Yes
221	100101000	+4	Yes	001111001	-4	Yes
222	100110011	+4	Yes	010100001	-4	Yes
223	100110110	+4	Yes	011000010	-4	Yes
224	100111100	+4	Yes	011000111	-4	Yes
225	101010000	+4	Yes	011001101	-4	Yes
226	101100011	+4	Yes	011011001	-4	Yes
227	101100110	+4	Yes	011110001	-4	Yes

Randomized byte value (decimal)	Positive CDS selection			Negative CDS selection		
	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?	9-bit NRZL word LSB MSB	NRZI (1) symbol CDS	Selection inverts polarity?
228	101101100	+4	Yes	101000001	-4	Yes
229	101111000	+4	Yes	110000010	-4	Yes
230	111000011	+4	Yes	110000111	-4	Yes
231	111000110	+4	Yes	110001101	-4	Yes
232	111001100	+4	Yes	110011001	-4	Yes
233	111011000	+4	Yes	110110001	-4	Yes
234	111110000	+4	Yes	111100001	-4	Yes
235	001000000	+4	Yes	010101100	-3	No
236	011100000	+4	Yes	011010100	-3	No
237	110100000	+4	Yes	011111100	-3	No
238	010000001	+5	No	001100011	-5	No
239	100000010	+5	No	001100110	-5	No
240	100000111	+5	No	001101100	-5	No
241	100001101	+5	No	011000011	-5	No
242	100011001	+5	No	011000110	-5	No
243	100110001	+5	No	110000011	-5	No
244	101100001	+5	No	110000110	-5	No
245	111000001	+5	No	110001100	-5	No
246	010000000	+6	Yes	110000001	-6	Yes
247	100000011	+6	Yes	001100001	-6	Yes
248	100000110	+6	Yes	011000001	-6	Yes
249	100001100	+6	Yes	000110001	-6	Yes
250	100011000	+6	Yes	000110011	-5	No
251	100110000	+6	Yes	000110110	-5	No
252	101100000	+6	Yes	000111100	-5	No
253	111000000	+6	Yes	011001100	-5	No
254	100000001	+7	Yes	001111000	-5	No
255	100000000	+8	Yes	110011000	-5	No

Table 2 - 9-bit NRZL word selection

Condition at end of previous NRZI(1) 9-bit symbol		Next 9-bit NRZL word selection	
DSV	Waveform polarity	Positive CDS	Negative CDS
+	+	Chosen	
+	-		Chosen
- or 0	+		Chosen
- or 0	-	Chosen	

Table 3 - DSV calculation using preamble run-up and sync pattern

Condition before beginning of pattern				Condition at end of pattern
Pattern	Waveform polarity	DSV	Waveform polarity	DSV
Preamble run-up (180 bits)	None	0	-	0
Preamble sync (36 bits)	-	0	+	-1
Block sync	+	x	-	x + 1
(36 bits)	-	x	-	x
Postamble sync	+	x	+	x
(36 bits)	-	x	+	x + 1

Table 4 - Inner error coding examples (hexadecimal notation)

Byte ID	i_0	D_{152}	D_{151}	D_{150}	D_{149}	...	D_1	D_0	K_7	K_6	K_5	K_4	K_3	K_2	K_1	K_0
Pattern 1	(00)	(00)	(00)	(00)	(00)	...	(00)	(01)	(FF)	(0B)	(51)	(36)	(EF)	(AD)	(C8)	(18)
Pattern 2	(00)	(01)	(02)	(03)	(04)	...	(98)	(99)	(A1)	(93)	(20)	(86)	(F9)	(5B)	(E7)	(D0)
Pattern 3	(CC)	(CC)	(CC)	(CC)	(CC)	...	(CC)	(CC)	(24)	(4B)	(05)	(22)	(ED)	(70)	(0C)	(D9)
Timing		First processed													Last to tape	

Table 5 - Outer error coding examples (hexadecimal notation)

Byte ID	D_{117}	D_{116}	D_{115}	D_{114}	...	D_1	D_0	K_9	K_8	K_7	K_6	K_5	K_4	K_3	K_2	K_1	K_0
Pattern 1	(00)	(00)	(00)	(00)	...	(00)	(01)	(D8)	(C2)	(9F)	(6F)	(C7)	(5E)	(5F)	(71)	(9D)	(C1)
Pattern 2	(00)	(01)	(02)	(03)	...	(74)	(75)	(5B)	(78)	(59)	(23)	(8A)	(14)	(AA)	(DD)	(EF)	(5E)
Pattern 3	(CC)	(CC)	(CC)	(CC)	...	(CC)	(CC)	(33)	(32)	(4A)	(DD)	(AE)	(EB)	(E7)	(AF)	(24)	(BF)
Timing		First processed														Last processed	

Annex C

(normative)

Append file and file termination

C.1 Introduction

The appended file information shall include an append file pointer and a positive offset of the logical TSID in the logical TSID word of subcode data field to make recovery of the data more reliable.

C.1.1 Append file pointer

The MSB of logical TSID word is the append file pointer and shall set the same for all four tracks of belonging track set as follows:

– Set to ONE: Only if the associated track set is the first track set of those appended as a single session, possibly of multiple files, and also is the track set next to the DM track set right after a TM track set.

– Otherwise set to ZERO.

The logical TSID becomes a 31 bit long binary number in the range 00 - - 00 to 7F - - FF.

C.1.2 Positive track offset

Positive offset, of 32 (20) shall be added to subsequent logical TSIDs. The first appended track-set shall have the append file pointer set to ONE.

C.2 Read out

During playback, the combination of two pieces of information provides a means to detect loss of file(s) and/or faulty file(s) even where multiple short sessions of append file were executed and in cases where write re-tries have taken place.

A monotonic discontinuity of the logical TSID may mean that there is loss of data, the intentional positive offset of 32 (20) and the append file pointer indicate that it is a legal operation.

The attached tables and figures explain the cases as examples.

C.3 Attached tables and figures

Table C.1: Example of write re-try

For simplicity, all four tracks of a track set are assumed to be the same category of data. Resolution down to a track set.
The delay of re-tried records is assumed to be five track sets.

Table C.2: Example of append file

For simplicity, all four tracks of a track set are assumed to be the same category of data. Resolution down to a track set.
The delay of re-tried records is assumed to be five track sets.

Table C.3: Example of subcode data field

Details of more general case. Resolution down to a track.

Next four figures show visual (conceptual) explanations of how logical TSID changes under different conditions.

Figure C.1: Normal TSID sequence

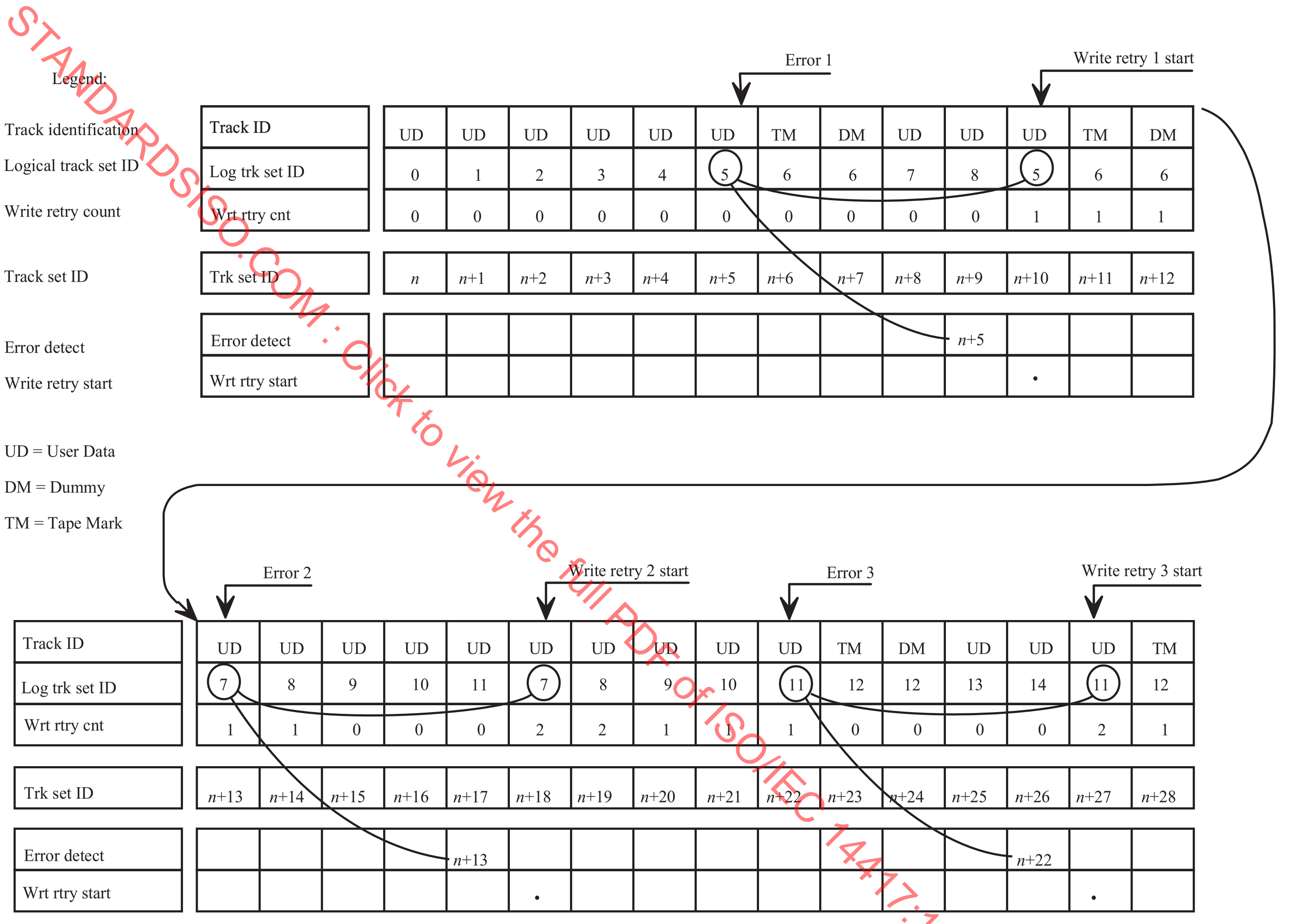
Figure C.2: Write re-try TSID sequence

Figure C 3: Append file over write re-tried area without track set ID offset

Figure C.4: Append file with track set ID offset

C.4 Termination of file

The file shall be terminated with just the TM track set and DM track set, optionally with DM, TM and DM track sets.



Legend:

Track identification	Track ID
Logical track set ID	Log trk set ID
Write retry count	Wrt rtry cnt
Track set ID	Trk set ID
Error detect	Error detect
Write retry start	Wrt rtry start

UD = User Data

DM = Dummy

TM = Tape Mark

Track ID	UD	UD	UD	UD	UD	UD	TM	DM	UD	UD	UD	TM	DM
Log trk set ID	0	1	2	3	4	5	6	6	7	8	5	6	6
Wrt rtry cnt	0	0	0	0	0	0	0	0	0	0	1	1	1
Trk set ID	*n*	*n*+1	*n*+2	*n*+3	*n*+4	*n*+5	*n*+6	*n*+7	*n*+8	*n*+9	*n*+10	*n*+11	*n*+12
Error detect										*n*+5			
Wrt rtry start											•		

Track ID	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	TM	DM	UD	UD	UD	TM
Log trk set ID	7	8	9	10	11	7	8	9	10	11	12	12	13	14	11	12
Wrt rtry cnt	1	1	0	0	0	2	2	1	1	1	0	0	0	0	2	1
Trk set ID	*n*+13	*n*+14	*n*+15	*n*+16	*n*+17	*n*+18	*n*+19	*n*+20	*n*+21	*n*+22	*n*+23	*n*+24	*n*+25	*n*+26	*n*+27	*n*+28
Error detect					*n*+13									*n*+22		
Wrt rtry start						•									•	

Table C.1 - Write retry

Legend:

Track identification	Track ID
Logical track set ID	Log trk set ID
Append file pointer	Append file pntr
Write retry count	Wrt rtry cnt
Track set ID	Trk set ID
Error detect	Error detect
Write retry start	Wrt rtry start

UD = User Data

DM = Dummy

TM = Tape Mark

		Error 1					Write retry 1 start			Append file 1			
Track ID	UD	UD	TM	DM	UD	UD	UD	TM	DM	UD	UD	UD	UD
Log trk set ID	0	①	2	2	3	4	①	2	2	34	35	36	37
Append file pntr										#			
Wrt rtry cnt	0	0	0	0	0	0	1	1	1	0	0	0	0
Trk set ID	*n*	*n*+1	*n*+2	*n*+3	*n*+4	*n*+5	*n*+6	*n*+7	*n*+8	*n*+9	*n*+10	*n*+11	*n*+12
Error detect						*n*+1							
Wrt rtry start							•						

	Error 2					Write retry 2 start								Append file 2		
Track ID	UD	TM	DM	UD	UD	UD	TM	DM	UD	UD	UD	TM	DM	UD	UD	UD
Log trk set ID	㊳	39	39	40	41	㊳	39	39	40	41	42	43	43	75	76	77
Append file pntr														#		
Wrt rtry cnt	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
Trk set ID	*n*+13	*n*+14	*n*+15	*n*+16	*n*+17	*n*+18	*n*+19	*n*+20	*n*+21	*n*+22	*n*+23	*n*+24	*n*+25	*n*+26	*n*+27	*n*+28
Error detect					*n*+13											
Wrt rtry start						•										

Table C.2 - Append file

Table C.3 - Example of subcode data field

Track identification

Byte count

Track number in belonging block

Absolute block number

Block number in belonging file

File number

Logical track set ID number

Append file pointer

Write retry count

Track set ID number

Append file start

Error

Trk ID	User data			Dummy track					Tape mark				End of data				User data			
Byte cnt	X	A	X	0	0	0	0	0	0	0	0	0	0	0	0	0	A	X	A	X
Trk no in blk	0	0	1	0	1	2	3	4	0	1	2	3	0	1	2	3	0	1	0	1
Abs blk no	10	11		F					12				F				13		14	
Blk no in file	3	4		F					5				F				0		1	
File no	2			F					2				F				3			
Log trk set ID no	8				8				9				9				41			
Append file pntr	0				0				0				0				1			
Wrt rtry cnt	0				0				0				0				0			
Trk set ID no	*n*				*n*+1				*n*+2				*n*+3				*n*+4			

X = X Bytes of user data

A = All Bytes are user data

F = All "1's" hex

UD = User data

DM = Dummy track

Error detect

Write retry

Trk ID	UD	DM	User data			DM		User data			DM		Tape mark				User data					DM	User dat	
Byte cnt	A	0	A	A	X	0	0	X	A	X	0	0	0	0	0	0	A	X	A	X	A	0	A	A
Trk no in blk	0	0	1	2	3	0	1	0	0	1	0	1	0	1	2	3	0	1	0	1	0	0	1	2
Abs blk no	15	F	15			F		16	17		F		18				13		14		15	F	15	
Blk no in file	2	F	2			F		3	4		F		5				0		1		2	F	2	
File no	3	F	3			F		3			F		3									F	3	
Log trk set ID no	42				43				44				45				41				42			
Append file pntr	0				0				0				0				0				0			
Wrt rtry cnt	0				0				0				0				1				1			
Trk set ID no	*n*+5				*n*+6				*n*+7				*n*+8				*n*+9				*n*+10			

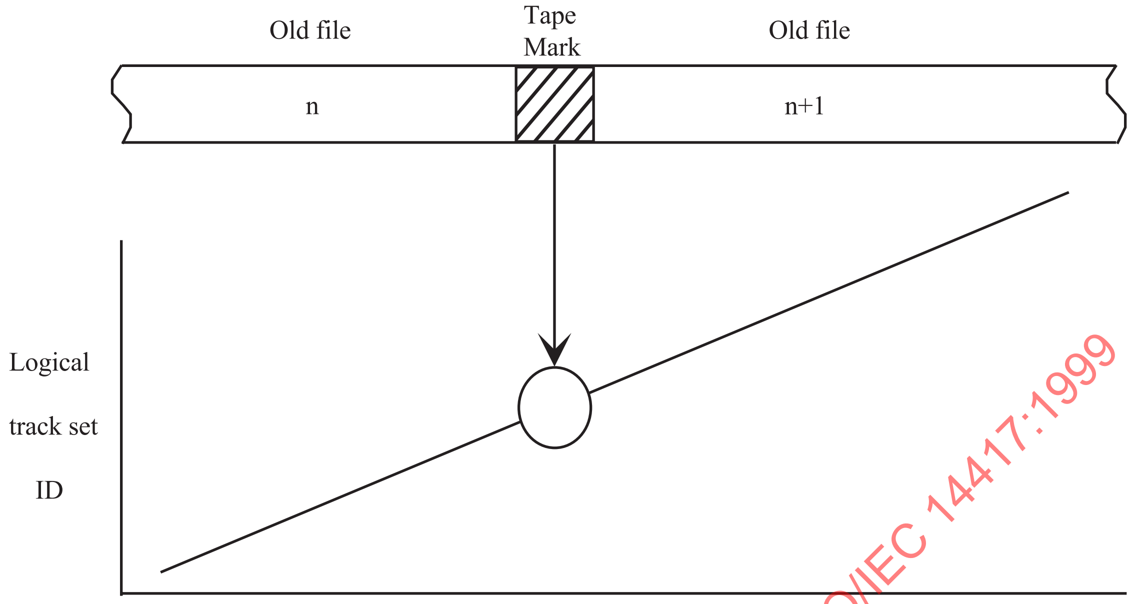


Figure C.1 - Normal track set ID sequence

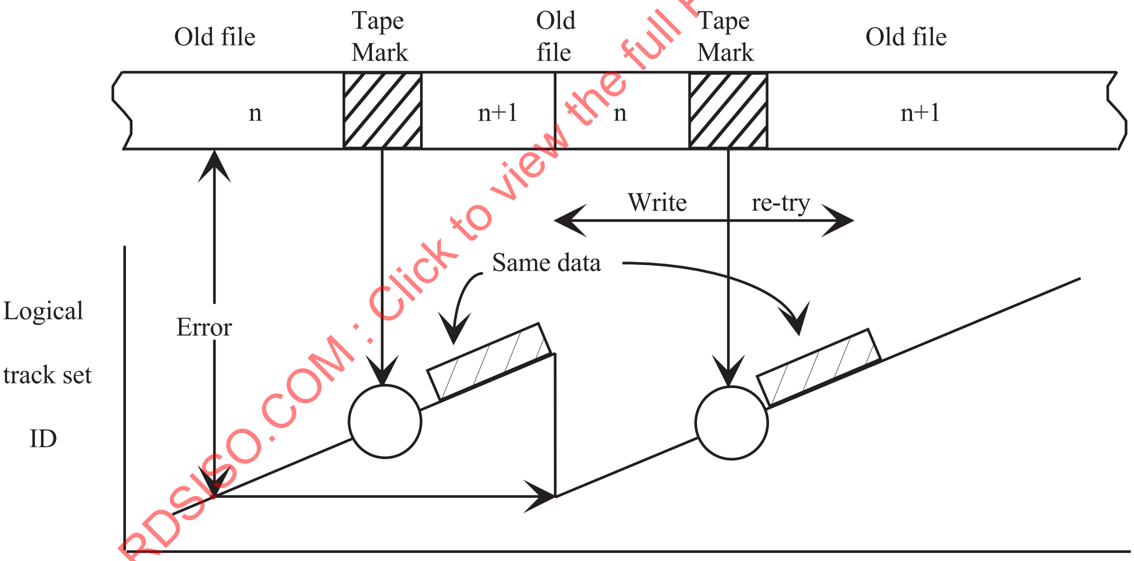


Figure C.2 - Write retry track set ID sequence

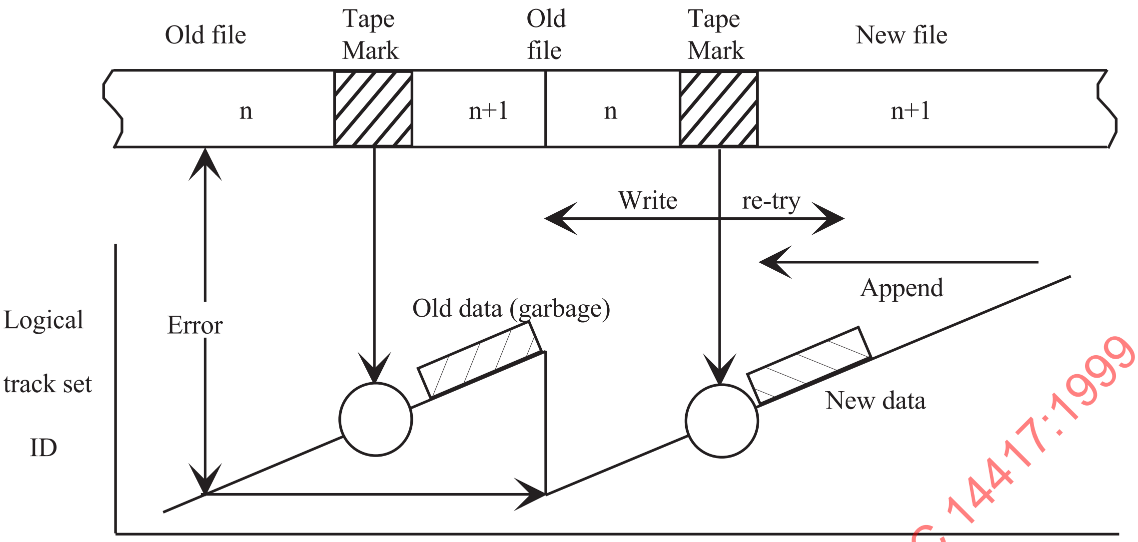


Figure C.3 - Appending file over re-tried area without track set ID offset

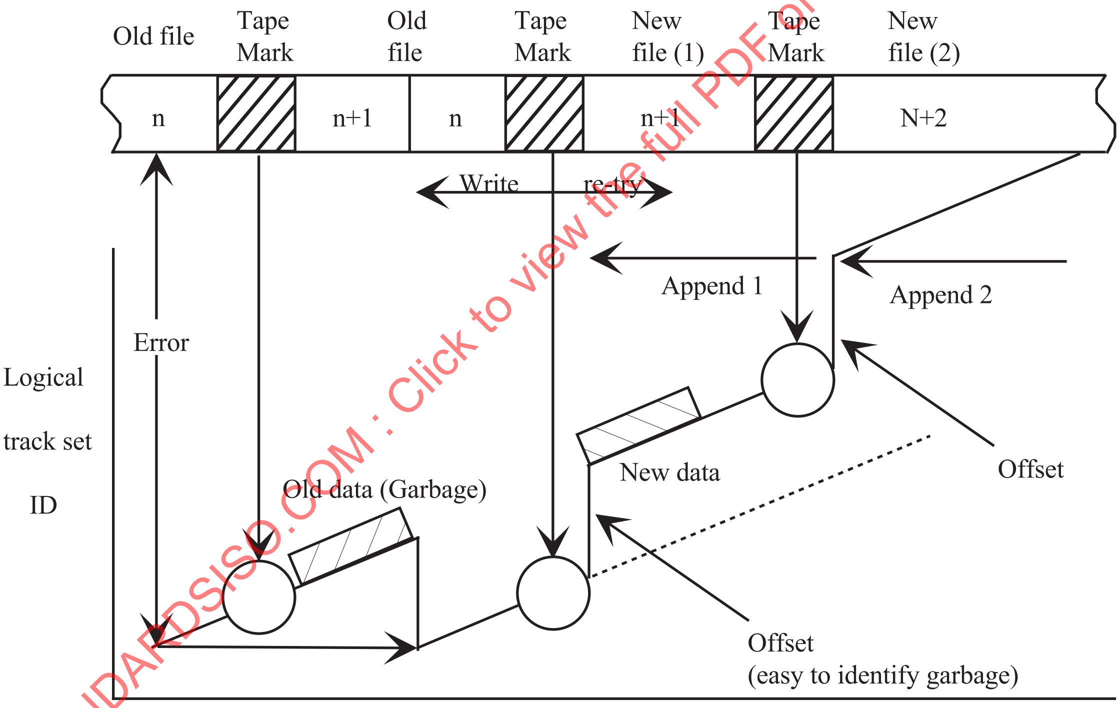


Figure C.4 - Append file with track set ID offset