

Standard ECMA-320

June 2001

ECMA

Standardizing Information and Communication Systems

**Data Interchange on 12,7 mm -
448-Track Magnetic Tape
Cartridges - SDLT1 Format**

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Brief History

Technical Committee ECMA TC17 has produced a series of ECMA Standards for magnetic tape cassettes and cartridges of different widths, e.g. 12,7 mm, 8 mm, 6,35 mm and 3,81 mm. In each series, the new standards correspond to specific types of application and different user requirements. Enhanced and new media correspond also to advancements in drive technology. The series of such cartridges with a magnetic tape of 12,7 mm width and longitudinally recorded tracks comprises the following standards.

ECMA-120 (1993) : Data Interchange on 12,7 mm 18-Track Magnetic Tape Cartridges
ISO 9661

ECMA-152 (1993) : Data Interchange on 12,7 mm 18-Track Magnetic Tape Cartridges - Extended Format
ISO/IEC 11559

ECMA-182 (1992) : Data Interchange on 12,7 mm 48-Track Magnetic Tape Cartridges - DLT 1 Format -
ISO/IEC 13421

ECMA-196 (1993) : Data Interchange on 12,7 mm 36-Track Magnetic Tape Cartridges
ISO/IEC 14251

ECMA-197 (1993) : Data Interchange on 12,7 mm 112-Track Magnetic Tape Cartridges - DLT 2 Format -
ISO/IEC 13962

ECMA-209 (1994) : Data Interchange on 12,7 mm 128-Track Magnetic Tape Cartridges - DLT 3 Format
ISO/IEC 14833

ECMA-231 (1995) : Data Interchange on 12,7 mm 128-Track Magnetic Tape Cartridges - DLT 4 Format
ISO/IEC 15305

ECMA-258 (1997) : Data Interchange on 12,7 mm 128-Track Magnetic Tape Cartridges - DLT 3-XT Format
ISO/IEC 15895

ECMA-259 (1997) : Data Interchange on 12,7 mm 208-Track Magnetic Tape Cartridge - DLT 5 Format
ISO/IEC 15896

ECMA-278 (1998) : Data Interchange on 12,7 mm 128-Track Magnetic Tape Cartridge
ISO/IEC 17913 Parallel Serpentine Format

ECMA-286 (1999) : Data Interchange on 12,7 mm 208-Track Magnetic Tape Cartridge - DLT 6 Format
ISO/IEC 16282

ECMA-319 (2001) : Data Interchange on 12,7 mm 384-Track Magnetic Tape Cartridges – Ultrium-1 Format

This ECMA Standard is the first of a new family of cartridges containing a linearly recorded 448-track 12,7 mm magnetic tape. It represents a further advance by using a combination of magnetic and optical technologies known as Laser-Guided Magnetic Recording (LGMR). The back surface of the tape presents optically detected servo marks. The format is derived from the DLT Format, it provides for a capacity of 110 Gbytes of uncompressed user data, or typically 220 Gbytes of compressed user data.

All ECMA Standards listed above have been or will be adopted by ISO/IEC as International Standards. The present ECMA Standard has also been contributed to ISO/IEC for adoption as an International Standard under the fast-track procedure.

This Standard has been adopted by the ECMA General Assembly of June 2001.

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Section 1 - General

1 Scope

This ECMA Standard specifies the physical and magnetic characteristics of a 12,7 mm wide, 448-track magnetic tape cartridge, to enable physical interchangeability of such cartridges between drives. It also specifies the quality of the recorded signals, a format - called Super Digital Linear Tape 1 (SDLT 1) - and a recording method, thereby allowing data interchange between drives. Together with a labelling standard, for instance Standard ECMA-13 for Magnetic Tape Labelling, it allows full data interchange by means of such magnetic tape cartridges.

2 Conformance

2.1 Magnetic tape cartridges

A magnetic tape cartridge shall be in conformance with this ECMA Standard if it satisfies all mandatory requirements of this ECMA Standard. The tape requirements shall be satisfied throughout the extent of the tape.

2.2 Generating systems

A system generating a magnetic tape cartridge for interchange shall be in conformance with this ECMA Standard if all the recordings that it makes on a tape according to 2.1 meet the mandatory requirements of this ECMA Standard.

In addition, a claim of conformance shall state

- whether or not one, or more registered algorithm(s) are implemented within the system,
- the registered identification number(s) of the implemented compression algorithm(s).

2.3 Receiving systems

A system receiving a magnetic tape cartridge for interchange shall be in conformance with this ECMA Standard if it is able to handle any recording made on a tape according to 2.1.

In addition, a claim of conformance shall state

- whether or not one, or more de-compression algorithm(s) are implemented within the system, and are able to be applied to de-compress data prior to making such data available to the host,
- the registered identification number(s) of the implemented compression algorithm(s).

3 References

ECMA-13:1985	File Structure and Labelling of Magnetic Tapes for Information Interchange
ECMA-287:1999	Safety of Electronic equipment
ISO 1302:1992	Technical drawings - Method of indicating surface texture on drawings.
ISO/IEC 11576:1994	Information technology - Procedure for the registration of algorithms for the lossless compression of data.

4 Definitions

For the purpose of this ECMA Standard, the following definitions apply.

4.1 back surface

The surface of the tape opposite the magnetic coating which is used to record data.

4.2 Beginning-Of-Tape marker (BOT)

A hole punched on the centreline of the tape towards the end nearest to the leader.

4.3 block

A set of contiguous bytes recorded on a physical track and considered as a unit.

4.4 byte

An ordered set of bits acted upon as a unit.

NOTE

In this ECMA Standard, all bytes are 8-bit bytes.

4.5 cartridge

A case containing a single supply reel of 12,7 mm wide magnetic tape with a leader attached at the outer end.

4.6 Cyclic Redundancy Check (CRC) character

A 64-bit character, generated by a mathematical computation, used for error detection.

4.7 Error-Detecting Code (EDC)

A mathematical computation yielding check bytes used for error detection.

4.8 End-Of-Tape marker (EOT)

A hole punched on the centreline of the tape towards the end farthest from the leader.

4.9 Entity

A group of twenty blocks treated as a logical unit.

4.10 Error-Correcting Code (ECC)

A mathematical computation yielding check bytes used for the correction of errors detected by the CRC and the EDC.

4.11 Envelope

A group of Entities.

4.12 Envelope size

The number of Entities in an Envelope.

4.13 flux transition position

The point that exhibits the maximum free-space flux density normal to the tape surface.

4.14 flux transition spacing

The distance on the magnetic tape between successive flux transitions.

4.15 logical track

A group of eight physical tracks that are written or read simultaneously.

4.16 magnetic tape

A tape that accepts and retains magnetic signals intended for input, output, and storage purposes on computers and associated equipment.

4.17 Master Standard Reference Tape

A tape selected as the standard for Reference Field, signal amplitude, resolution, and overwrite characteristics.

NOTE

The Master Standard Reference Tape has been established by the Quantum Corporation.

4.18 object

A Record or a page of type Tape Mark.

4.19 page

A logical division of a block.

4.20 recording density

The number of recorded flux transitions per unit length of track.

4.21 physical track

A longitudinal area on the tape along which a series of magnetic signals can be recorded.

4.22 Record

User data processed as described in Clause 12.

4.23 Reference Edge

The bottom edge of the tape when viewing the magnetic coating of the tape with the BOT to the left and the EOT to the right of the observer.

4.24 Reference Field

The Typical Field of the Master Standard Reference Tape.

4.25 Secondary Standard Reference Tape

A tape the characteristics of which are known and stated in relation to those of the Master Standard Reference Tape.

NOTE

Secondary Standard Reference Tapes can be ordered under Reference "SSRT/SDLT1" from Quantum Corporation, 333 South Street, Shrewsbury, Mass. 01545-4195, USA. It is intended that these be used for calibrating tertiary reference tapes for routine calibration.

In principle, these Secondary Standard Reference Tapes will be available for a period of 10 years from the publication of the first version of this ECMA Standard. However, by agreement between ECMA and Quantum Corporation, this period may be changed to take into account the demand for such Secondary Standard Reference Tapes.

4.26 Standard Reference Amplitude (SRA)

The Average Signal Amplitude from the Master Standard Reference Tape when it is recorded with the Test Recording Current at 2 700 ftpmm.

4.27 Standard Reference Current

The current that produces the Reference Field.

4.28 Test Recording Current

The current that is 1,1 times the Standard Reference Current.

4.29 Typical Field

In the plot of the Average Signal Amplitude against the recording field at 2 700 ftpmm, the minimum field that causes an Average Signal Amplitude equal to 95 % of the maximum Average Signal Amplitude.

5 Conventions and notations

5.1 Representation of numbers

The following conventions and notations apply in this ECMA Standard, unless otherwise stated.

- 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 +0,01, and a negative tolerance -0,02 allows a range of measured values from 1,235 to 1,275.
- In each block and in each field the bytes shall be arranged with Byte 1, the least significant, first. Within each byte the bits shall be arranged with Bit 1, the least significant, first and Bit 8, the most

significant bit, last. This order applies to the data, and to the input and output of the error-detecting and error-correcting codes, and to the cyclic redundancy characters.

- Letters and digits in parentheses represent numbers in hexadecimal notation.
- The setting of bits is denoted by ZERO or ONE.
- Numbers in binary notation and bit patterns are represented by strings of digits 0 and 1 shown with the most significant bit to the left.

5.2 Dimensions

The dimensions in figures 1 to 3 are nominal dimensions. Unless otherwise stated, all dimensions in the other figures are in millimetres with a tolerance of ± 50 mm.

5.3 Names

The names of basic elements, e.g. specific fields, are written with a capital initial letter.

5.4 Acronyms

BOT	Beginning of Tape
CAF	Coarse Alignment Field
CF1	Control Field 1
CF2	Control Field 2
CRC	Cyclic Redundancy Check (character)
CT1	Calibration Track 1
CT2	Calibration Track 2
FAF1	Fine Alignment Field 1
FAF2	Fine Alignment Field 2
ECC	Error-Correcting Code
EDC	Error-Detecting Code
EOD	End of Data
EOT	End of Tape
EOTR	End of Track
SRA	Standard Reference Amplitude

6 Environment and safety

Unless otherwise stated, the conditions specified below refer to the ambient conditions in the test or computer room and not to those within the tape drive.

6.1 Cartridge and tape testing environment

Unless otherwise stated, tests and measurements made on the cartridge and tape to check the requirements of this ECMA Standard shall be carried out under the following conditions:

- temperature: 23 °C \pm 2 °C
- relative humidity: 40 % to 60 %
- conditioning before testing: 24 h min.

6.2 Cartridge operating environment

Cartridges used for data interchange shall be capable of operating under the following conditions:

- temperature: 10 °C to 40 °C
- relative humidity: 20 % to 80 %
- wet bulb temperature: 26 °C max.

NOTE

Localised tape temperatures in excess of 49 °C may cause tape damage.

If during storage and/or transportation a cartridge has been exposed to conditions outside the above values, it shall be conditioned before use by exposure to the operating environment for a time equal to, or greater

than, the time away from the operating environment up to a maximum of 24 h. There shall be no deposit of moisture on or in the cartridge.

6.3 Cartridge storage environment

Cartridges shall be stored under the following conditions:

- temperature: 16 °C to 32 °C
- relative humidity: 20 % to 80 %

The stray magnetic field at any point on the tape shall not exceed 4000 A/m. There shall be no deposit of moisture on or in the cartridge.

6.4 Safety

The cartridge and its components shall satisfy the requirements of Standard ECMA-287 when used in the intended manner or in any foreseeable use in an information processing system.

6.5 Flammability

The cartridge and its components shall be made from materials which, if ignited from a match flame and when so ignited, do not continue to burn in a still carbon dioxide atmosphere.

6.5 Transportation

This ECMA Standard does not specify parameters for the environment in which cartridges should be transported. Annex G gives some recommendations for transportation.

Section 2 - Requirements for the unrecorded tape

The measurements specified in Section 2 shall be performed on an unrecorded tape with servo marks (See 7.20) on the back surface.

7 Mechanical and electrical requirements

7.1 Material

The tape shall consist of a base 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. The back surface of the tape shall be coated with a non-ferromagnetic conductive coating.

7.2 Tape length

The length of the tape from the leader splice to the hub shall be $558 \text{ m} \pm 1 \text{ m}$.

7.3 Tape width

The width of the tape shall be $12,649 \text{ mm} \pm 0,010 \text{ mm}$.

The width shall be measured across the tape from edge to edge when the tape is under a tension of less than 0,28 N.

7.4 Tape thickness

The total thickness of the magnetic tape at any point shall be between $8,20 \text{ }\mu\text{m}$ and $9,30 \text{ }\mu\text{m}$.

7.5 Discontinuity

There shall be no discontinuities in the tape between the BOT and EOT such as those produced by tape splicing or perforations.

7.6 Longitudinal curvature

The longitudinal curvature is measured as 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.

7.6.1 Requirements

Any deviation of the Reference Edge from a straight line shall be continuous and shall not exceed 0,076 mm within any 229 mm length of tape.

7.6.2 Procedure

- i. Measure at a tension of $1,39 \text{ N} \pm 0,28 \text{ N}$ in a test fixture equipped with two guides spaced at 229 mm.
- ii. Spring-load the two guides to position the Reference Edge of the tape against two edge control surfaces.
- iii. Measure the maximum deviation of the Reference Edge of the tape from the line drawn between the two control surfaces.

7.7 Out-of-Plane distortions

All visual evidence of out-of-plane distortion shall be removed when the tape is subjected to a uniform tension of 0,6 N. Out-of-plane distortions are local deformations which 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.

7.8 Cupping

The departure across the width of the tape from a flat surface shall not exceed 2,54 mm.

Procedure

- i. Cut a $1,0 \text{ m} \pm 0,1 \text{ m}$ length of tape. Condition it for a minimum of 3 h in the test environment by hanging it so that both surfaces are freely exposed to the test environment.
- ii. From the centre portion of the conditioned tape cut a test piece of approximately 25 mm length. Stand the test piece on its end in a cylinder that is at least 25 mm high with an inside diameter of $13,0 \text{ mm} \pm 0,2 \text{ mm}$.
- iii. With the cylinder standing on an optical comparator measure the cupping by aligning the edges of the test piece to the reticle and determining the distance from the aligned edges to the corresponding surface of the test piece at its centre.

7.9 Roughness of the coating surfaces

7.9.1 Roughness of the back coating surface

The back coating surface shall have an arithmetic average roughness R_{ab} between $0,003 \text{ }\mu\text{m}$ and $0,027 \text{ }\mu\text{m}$ (ISO 1302:N 2). This measurement shall be made using a contacting stylus of radius $12,5 \text{ }\mu\text{m}$ with a 20 mg load, and a $254 \text{ }\mu\text{m}$ cut-off range.

7.9.2 Roughness of the magnetic coating surface

The magnetic coating surface shall have an arithmetic average roughness R_{am} between $0,003 \text{ }\mu\text{m}$ and $0,008 \text{ }\mu\text{m}$ (ISO 1302: N 3). The set up for this measurement shall be identical with that of 7.9.1.

7.10 Coating adhesion

The force required to peel any part of the coating from the tape base material shall not be less than 0,016 N.

Procedure

- i. Take a test piece of the tape approximately 380 mm long and scribe a line through the recording coating across the width of the tape 125 mm from one end.
- ii. Using a double-sided pressure sensitive tape, attach the full width of the test piece to a smooth metal plate, with the magnetic coating (recording surface) facing the plate, as shown in figure 1.
- iii. Fold the test piece over 180° , adjacent to, and parallel with, the scribed line. Attach the metal plate and the free end of the test piece to the jaws of a universal testing machine and set the speed of the jaw separation to 254 mm per min.
- iv. Note the force at which any part of the coating first separates from the base material. If this is less than 0,016 N, the tape has failed the test. If the test piece peels away from the double-sided pressure sensitive tape before the force 0,010 N, an alternative type of double-sided pressure sensitive tape shall be used.
- v. Repeat i) to iv) for the back coating.

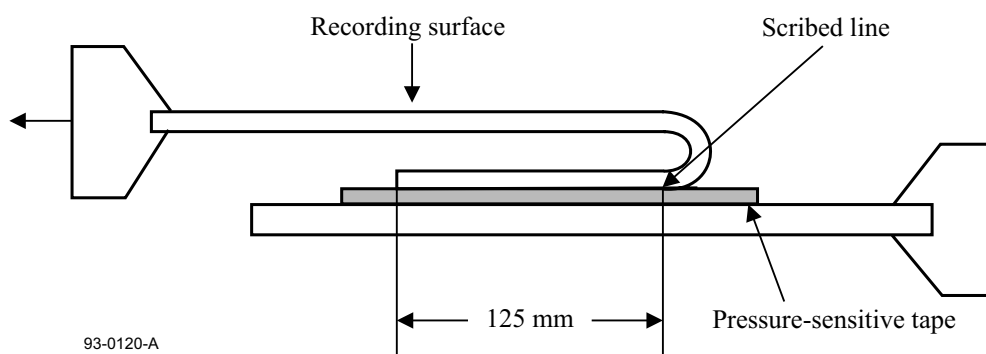


Figure 1 - Measurement of coating adhesion

7.11 Layer-to-layer adhesion

Layer-to-layer adhesion refers to the tendency of a layer, when held in close proximity to the adjacent layer, to bond itself to an adjacent layer so that free and smooth separation of the layers is difficult.

7.11.1 Requirements

There shall be no evidence of delamination or other damage to the coatings.

7.11.2 Procedure

- i. Fasten one end of a 914 mm length of tape, magnetic coating inwards, to a horizontally mounted stainless steel cylinder with a low cold-flow adhesive material.
- ii. The dimensions of the cylinder shall be:
 - diameter: 12,7 mm
 - length: 102 mm
- iii. Attach a mass of 1 000 g to the opposite end of the tape.
- iv. Attach, 25,4 mm above the mass, a narrow strip of double-sided adhesive tape to the magnetic coating.
- v. Slowly rotate the cylinder, so that the tape winds uniformly around it into a compact and even roll. The double-sided tape secures the end and prevents unwinding when the mass is removed.
- vi. The cylinder with the tape shall then be exposed to the following temperature and humidity cycle:

Time	Temperature	RH
16 h to 18 h	54 °C	85 %
4 h	54 °C	10 % or less
1 h to 2 h	21 °C	45 %

- vii. Open the end of the roll and remove the double-sided adhesive tape.
- viii. Release the free end of the tape.
- ix. The outer one or two wraps shall spring loose without adhesion.
- x. Hold the free end of the tape and allow the cylinder to fall, thereby unwinding the tape.
- xi. The tape shall show no coating delamination, except for the 51 mm of tape nearest to the cylinder.

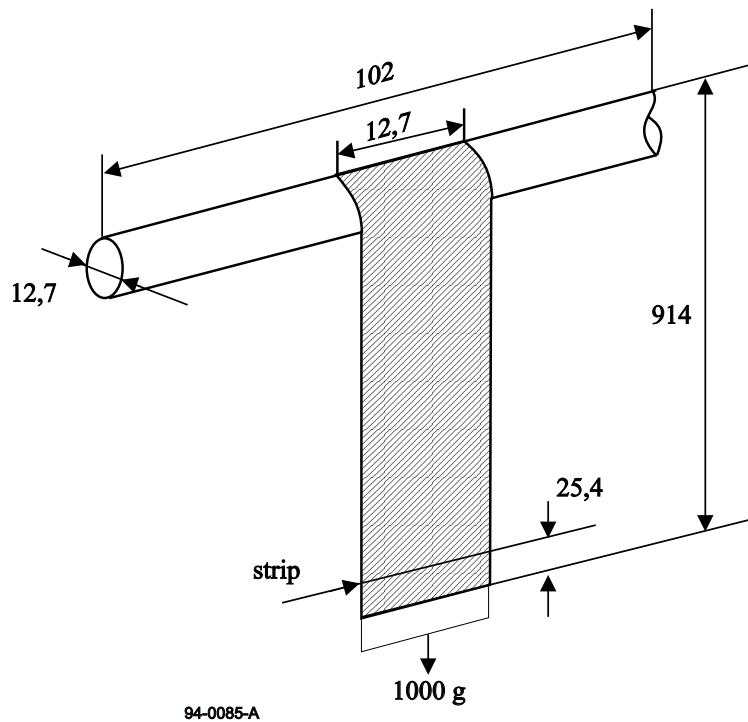


Figure 2 - Measurement of layer-to-layer adhesion

7.12 Modulus of elasticity

The modulus of elasticity (Young's modulus) is the ratio of stress to strain in the longitudinal direction.

7.12.1 Requirement

The modulus of elasticity shall be between 5 884 N/mm² and 11 768 N/mm².

7.12.2 Procedure

- i. Clamp a test piece of tape at least 180 mm in length with an initial 100 mm separation between the jaws of a universal testing machine with a nominal crosshead speed of 3 mm per minute.
- ii. Calculate the modulus using the chord of the curve between the force at 0 % and 1 % elongation.

7.13 Flexural rigidity

Flexural rigidity is the ability of the tape to resist bending in the longitudinal direction.

7.13.1 Requirement

The flexural rigidity of the tape in the longitudinal direction shall be between 3 x 10⁻⁷ N·mm and 9 x 10⁻⁷ N·mm.

7.13.2 Procedure

Calculate the flexural rigidity D from the following equation:

$$D = \frac{Et^3}{12}(1 - \nu^2)$$

where:

- E = modulus of elasticity obtained from 7.12
- t = measured thickness of the tape in mm
- ν = Poisson's ratio, set to 0,33

7.14 Tensile yield force

The tensile yield force required to elongate the test piece by 3 % shall not be less than 9,6 N.

7.14.1 Procedure

- i. Use a static-weighing-constant-rate-of-grip separation tester capable of indicating the load with an accuracy of 2 %.
- ii. Clamp a test piece of tape at least 178 mm long with an initial 102 mm separation between the jaws.
- iii. Elongate the test piece at a rate of 51 mm per minute until a minimum elongation of 10 % is reached.
- iv. The force required to produce an elongation of 3 % is the tensile yield force.

7.15 Electrical resistance

7.15.1 Requirement

The electrical resistance of any square area of the magnetic coating shall

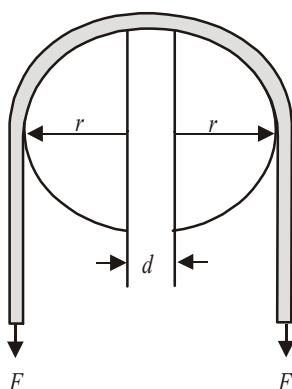
- be greater than $10^6 \Omega$
- not exceed $50 \times 10^{12} \Omega$

The electrical resistance of any square area of the back coating shall

- not exceed $100 \times 10^6 \Omega$

7.15.2 Procedure

- i. Condition a test piece of tape in the test environment for 24 h.
- ii. Position the test piece over two 24-carat gold-plated, semi-circular electrodes having a radius $r = 25,4$ mm and a finish of at least N4, so that the recording surface is in contact with each electrode.
- iii. Place these electrodes parallel to the ground and to each other at a distance $d = 12,7$ mm between their centres.
- iv. Apply a force F of 1,62 N to each end of the test piece.
- v. Apply a d.c. voltage of $100 \text{ V} \pm 10 \text{ V}$ across the electrodes and measure the resulting current flow.
- vi. From this value, determine the electrical resistance.
- vii. Repeat for a total of 5 positions along the test piece and average the 5 resistance readings.
- viii. For the back coating repeat the procedure with the back surface in contact with the electrodes.



93-0050-B

Figure 3 - Measurement of electrical resistance

When mounting the test piece, make sure that no conducting paths exist between the electrodes except that through the coating under test.

NOTE

Particular attention should be given to keeping the surfaces clean.

7.16 Inhibitor tape

This ECMA Standard does not specify parameters for assessing whether or not a tape is an inhibitor tape. However, annex H gives further information on inhibitor tapes.

7.17 Light transmittance of the tape and the leader

The light transmittance of the tape and the leader shall be less than 5 % when measured according to the method specified in annex A.

7.18 Abrasivity

Tape abrasivity is the tendency of the magnetic coating to wear the magnetic heads. When measured according to annex B, the depth of the wear pattern in the specified ferrite bar shall be in the range 45 µm to 65 µm.

7.19 Coefficient of dynamic friction

The coefficient of dynamic friction shall be measured between the two surfaces of the tape and between them and calcium titanate ceramic.

7.19.1 Requirements

Between the magnetic surface and the back surface :	greater than 0,15
Between the magnetic surface and calcium titanate ceramic:	0,05 to 0,35
Between the back surface and calcium titanate ceramic:	0,05 to 0,20

7.19.2 Procedure for the measurement of the friction between the magnetic surface and the back surface

- i. Wrap a first piece of tape around a calcium titanate ceramic cylinder ($R_a = 0,05 \mu\text{m}$) of diameter 25,4 mm and wrap it with a total wrap angle of more than 90° with the back surface outwards.
- ii. Wrap a second test piece, with the magnetic surface inwards, around the first test piece with a total wrap angle of 90°.
- iii. Exert on one end of the outer test piece a force of $F_1 = 0,64 \text{ N}$.
- iv. Attach the other end to a force gauge mounted on a linear slide.
- v. Drive the slide at a speed of 1 mm/s, measure the force F_2 required.
- vi. Calculate the coefficient of dynamic friction γ from the equation

$$\gamma = \frac{1}{\phi} \ln \left(\frac{F_2}{F_1} \right)$$

where ϕ is the value of the wrap angle in radians.

7.19.3 Procedure for the measurement of the friction between the magnetic surface or the back surface and calcium titanate ceramic

- i. Wrap a piece of tape around a calcium titanate ceramic cylinder ($R_a = 0,05 \mu\text{m}$) of diameter 25,4 mm and wrap it with a total wrap angle of 90° with the magnetic surface or the back surface, as appropriate, inwards.
- ii. Exert on one end of the test piece a force of $F_1 = 0,64 \text{ N}$.
- iii. Attach the other end to a force gauge mounted on a linear slide.
- iv. Drive the slide at a speed of 1 mm/s, measure the force F_2 required.
- v. Calculate the coefficient of dynamic friction γ from the equation

$$\gamma = \frac{1}{\phi} \ln \left(\frac{F_2}{F_1} \right)$$

where ϕ is the value of the wrap angle in radians.

7.20 Servo

There shall be four servo bands of 17 servo tracks each. In each servo band these servo tracks shall be numbered 0 to 16. Each servo track shall consist of servo marks recorded on the back side of the tape.

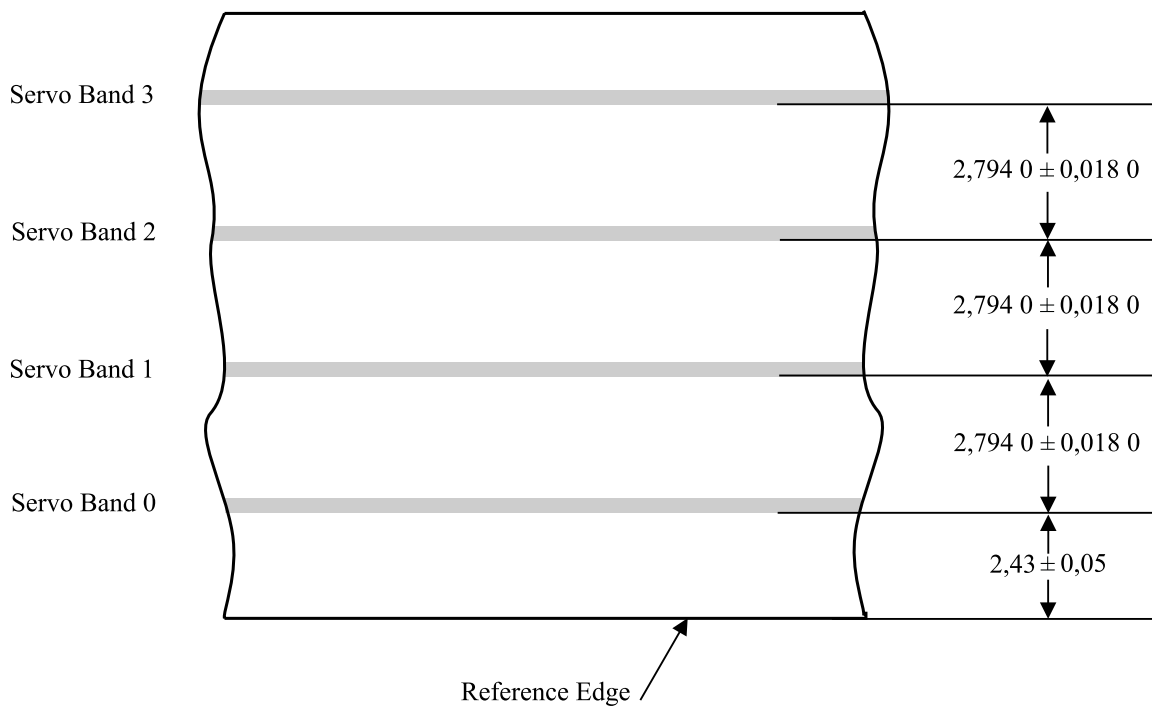
7.20.1 Servo Bands

The four servo bands recorded optically are designated as Servo Bands 0, 1, 2 and 3.

The centreline of Servo Track 0 of Servo Band 0 shall be at a distance of $2,43 \text{ mm} \pm 0,05 \text{ mm}$ from the Reference Edge.

All Servo Bands shall be at a distance from their adjacent band(s) of $2,794 0 \text{ mm} \pm 0,018 0$ when measured between the centrelines of their respective Servo Track 0.

The cumulative error over the distance between Servo band 0 and Servo band 3 shall not exceed $\pm 0,0018 0 \text{ mm}$.



00-0055-A

Figure 4 – Servo Bands

7.20.2 Servo Tracks

Each servo mark shall have a diameter of $12,0 \mu\text{m} \pm 0,6 \mu\text{m}$ (See figure 5). They shall be at a distance of $141,0 \mu\text{m} \pm 2,0 \mu\text{m}$ from each other. The servo tracks shall be at a distance of $24 \mu\text{m} \pm 1 \mu\text{m}$ from each other. In every second servo tracks the servo marks shall be shifted by $70,5 \mu\text{m} \pm 2,0 \mu\text{m}$ relative to those in the adjacent servo tracks. In each servo band the cumulative tolerance over the distance between Servo Track 0 and Servo Track 16 shall not exceed $1 \mu\text{m}$.

7.20.3 Signal

When the optical beam from an optical pickup is focussed on the back side of the moving tape, a series of pulses due to the servo marks will be detected by the detector in the pickup. The modulation

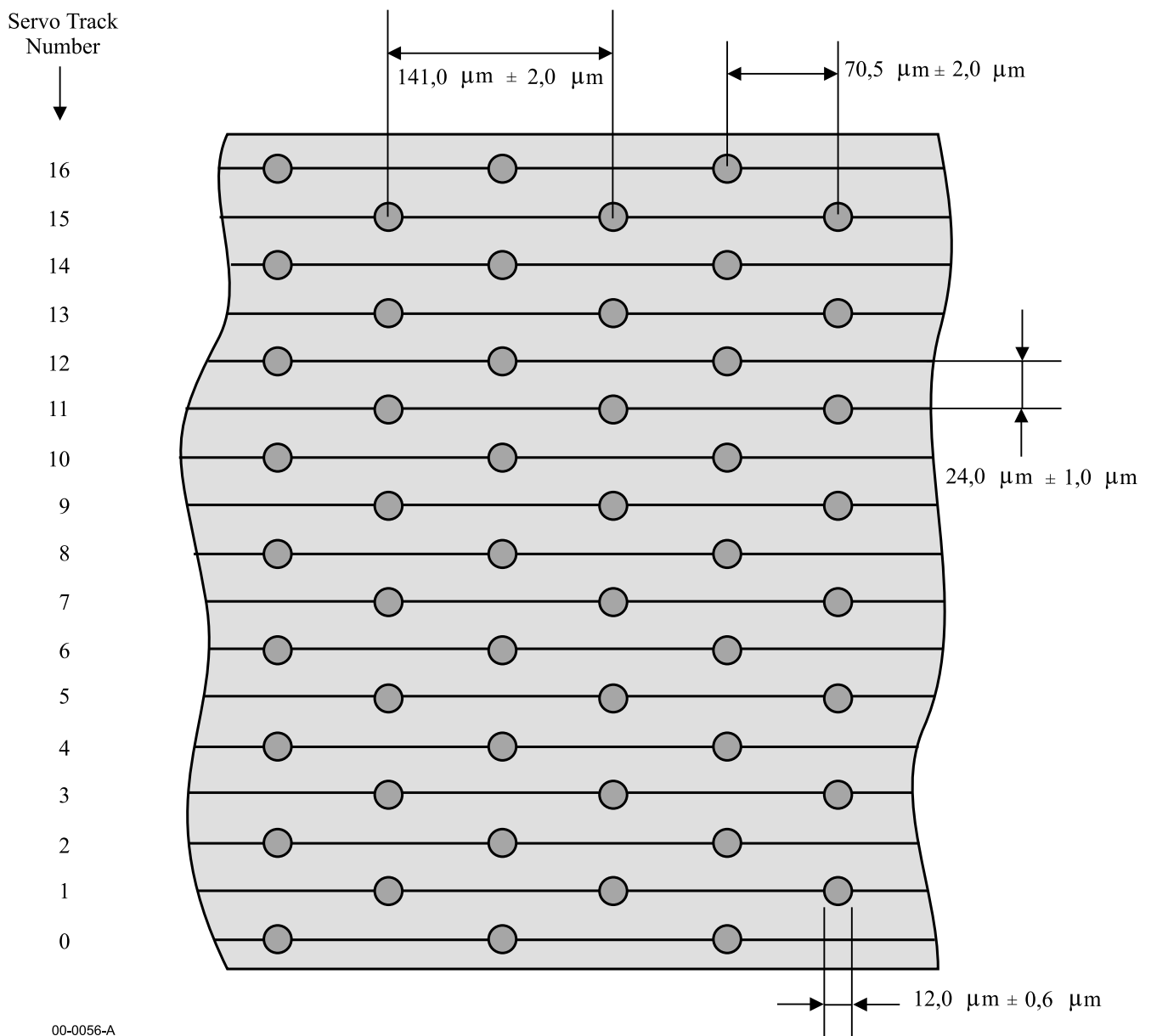
amplitude of the envelope divided by $2\sqrt{2}$ is called the signal. Measurements shall be performed with the incident beam from the spectrometer being perpendicular to the sample surface within 10° . The wavelength of the light beam shall be in the range 250 nm to 1 100 nm.

7.20.4 Signal-to Noise Ratio

When the focussed beam traverses the tape over the non-marked zone, the reflected beam, as seen by the detector contains noise. This noise signal shall be low-pass filtered at a cutoff of 4 kHz at the 3 dB point. The resultant RMS value is called noise. The Signal-to-Noise Ratio shall be $24,5 \text{ dB} \pm 1,5 \text{ dB}$.

7.20.5 Missing servo mark

If the requirement for the Signal-to-Noise Ratio of 7.20.4 is not satisfied by three consecutive servo marks, this is considered to be a missing servo mark. Over 100 consecutive servo marks there shall not be more than one missing servo mark. In the consecutive 100 servo marks following such a missing servo mark, there shall not be any servo mark missing the requirement of 7.20.4. If the tape presents 4 consecutive missing servo marks, it shall be rejected.



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Figure 5 – Servo Tracks

8 Magnetic recording characteristics

The magnetic recording characteristics shall be defined by testing the requirements given below.

When performing the tests, the output or resultant signal shall be measured on the same relative pass for both a tape calibrated to the Master Standard Reference Tape and the tape under test (read-while-write, or on equipment without read-while-write capability, on the first forward-read-pass) on the same equipment.

The following conditions shall apply to the testing of all magnetic recording characteristics, unless otherwise noted.

- Tape condition: a.c. erased to 2 % or less of the Average Signal Amplitude
- Tape speed: 2,946 m/s \pm 0,029 m/s
- Read track: within the written track
- Gap alignment: the read gap and the write gap to be parallel within 2,54 μ m
- Write gap length: 1,00 μ m \pm 0,10 μ m
- Write gap width: 23 μ m \pm 1 μ m
- Read gap length: 0,376 3 μ m \pm 0,037 6 μ m
- Read gap width: 14 μ m \pm 1 μ m
- Tape tension: 0,83 N \pm 0,01 N
- Recording current: Test Recording Current
- Physical recording density: 5 400 ftpmm \pm 100 ftpmm
- Bandwidth of the read amplifier: 25,0 MHz

8.1 Typical Field

The Typical Field shall be between 85 % and 125 % of the Reference Field.

Traceability to the Reference Field is provided by the calibration factors supplied with each Secondary Standard Reference Tape.

8.2 Signal amplitude

The Average Signal Amplitude shall be between 85 % and 115 % of the SRA.

Traceability to the SRA is provided by the calibration factors supplied with each Secondary Standard Reference Tape.

8.3 Resolution

The ratio of the Average Signal Amplitude at 2 700 ftpmm to that at 1 350 ftpmm shall be between 85 % and 125 % of the same ratio for the Master Standard Reference Tape.

Traceability to the resolution of the Master Standard Reference Tape is provided by the calibration factors supplied with each Secondary Standard Reference Tape.

8.4 Overwrite

Overwrite is the ratio of the residual signal of the Average Signal Amplitude recorded at 675 ftpmm after being overwritten at 5 400 ftpmm to the average signal amplitude of the 675 ftpmm signal.

8.4.1 Requirement

The overwrite for the tape shall be less than 110 % of the overwrite for the Master Standard Reference Tape.

Traceability to the overwrite of the Master Standard Reference Tape is provided by the calibration factors supplied with each Secondary Standard Reference Tape.

9 Tape quality

9.1 Missing pulses

A missing pulse is a loss of read signal amplitude. When a base-to-peak read signal amplitude is less than 40% of half the Average Signal Amplitude (See 8.2) for the preceding 25,4 mm of track, then these 25,4 mm constitute a missing pulse. This measurement shall be carried out in steps of 25,4 mm of track.

9.1.1 Requirement

The average missing pulse rate shall be less than 20 missing pulses for any recorded length of track of 100 m.

9.2 Missing pulse zone

A missing pulse zone is a sequence of missing pulses exceeding 100 mm.

9.2.1 Requirement

Missing pulse zones shall not occur.

9.3 Tape durability

This ECMA Standard does not specify parameters for assessing tape durability. However, a recommended procedure is described in annex J.

Section 3 - Mechanical specifications of the tape cartridge

10 General

The tape cartridge shall consist of the following elements

- a case
- a reel for the magnetic tape
- a locking mechanism for the reel
- a magnetic tape wound on the hub of the reel
- a write-inhibit mechanism
- a tape leader

Dimensional characteristics are specified for those parameters deemed mandatory for interchange and compatible use of the cartridge. Where there is freedom of design, only the functional characteristics of the elements described are indicated.

Where they are purely descriptive the dimensions are referred to three reference planes A, B, and C forming a geometrical trihedral. Where the dimensions are related to the position of the cartridge in the drive, they may be referenced to another surface of the cartridge.

In the enclosed drawings a typical implementation is represented.

- Figure 6 shows a general view of the cartridge.
- Figure 7 shows the reference planes A, B, C.
- Figure 8 shows the bottom side of the cartridge.
- Figure 9 shows the right side of the cartridge.
- Figure 10 shows the back side of the cartridge with the door closed.
- Figure 11 shows the left side of the cartridge.
- Figure 12 shows a partial cross-section of the cartridge in locked position.
- Figure 13 shows a partial cross-section of the cartridge in operating position.
- Figure 14 shows the leader-to-tape connection.
- Figure 15 shows the splice of the leader-to-tape connection.
- Figure 16 shows a partial top view at a larger scale of the buckle of the leader.
- Figure 17 shows a perspective view of the relative position of the leader buckle and the take up part before contact.
- Figure 18 shows a partial, enlarged view of figure 17
- Figure 19 shows a perspective view of the relative position of the leader buckle and the take up part after contact

- Figure 20 shows the front side of the cartridge.
Figure 21 shows the position of the door lock on the back side of the cartridge.
Figure 22 shows the back side of the cartridge with the door open.

Figure 6 shows a general view of the cartridge. When it is not in the operating position, the reel of magnetic tape is locked and cannot rotate. When loaded into the drive, the back side is introduced first and the front side remains visible during operation. During the loading process the tape reel is unlocked and the position of the cartridge within the drive is fixed by elements of the drive engaging with corresponding elements of the case.

The position of the case relative to the reference planes A, B and C is shown in figure 7. The top side lies in reference plane A, the right side lies in reference plane B and the back side lies in reference plane C.

10.1 Bottom side and right side (Figures 8 and 9)

The overall dimensions of the cartridge shall be

$$l_1 = 105,79 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_2 = 105,41 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_3 = 25,40 \text{ mm} \pm 0,25 \text{ mm}$$

The bottom side shall have a window the dimensions and the position of which shall be defined by

$$l_4 = 4,85 \text{ mm} \pm 0,05 \text{ mm}$$

$$l_5 = 6,25 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_6 = 83,61 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_7 = 3,81 \text{ mm} \pm 0,05 \text{ mm}$$

This window allows one of the fingers of the drive to penetrate into the case for partially unlocking the reel of tape (See 10.6).

A positioning hole on the bottom side and a guiding notch, followed by a positioning notch in the right side determine the position of the cartridge in the drive.

The dimensions and the position of the positioning hole shall be defined by

$$l_8 = 21,59 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_9 = 4,45 \text{ mm} \begin{matrix} + 0,13 \text{ mm} \\ - 0,00 \text{ mm} \end{matrix}$$

$$l_{10} = 2,79 \text{ mm} \pm 0,05 \text{ mm}$$

$$l_{11} = 44,58 \text{ mm} \pm 0,20 \text{ mm}$$

The dimensions and the position of the positioning notch shall be defined by

$$l_{12} = 5,56 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{13} = 33,60 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_{14} = 5,08 \text{ mm} \pm 0,10 \text{ mm}$$

$$h_1 = 9,02 \text{ mm} \pm 0,10 \text{ mm}$$

$$a_1 = 14^\circ \pm 30'$$

The dimensions and the position of the guiding notch shall be defined by

$$l_{15} = 8,59 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{16} = 24,64 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{17} = 1,50 \text{ mm} \pm 0,05 \text{ mm}$$

$$a_2 = 45^\circ \pm 30'$$

$$a_3 = 17^\circ \pm 30'$$

The right side shall have an indicator connected to the manually operable write-inhibit switch described in 10.5. The dimensions and the position of this indicator shall be defined by

$$l_{18} = 8,64 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{19} = 5,08 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{20} = 86,11 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_{21} = 10,16 \text{ mm} \pm 0,10 \text{ mm}$$

Writing is enabled when the surface of the indicator is substantially flush with the cartridge wall. When this surface is recessed by at least 5,1 mm writing is inhibited. When a force of up to 1,0 N is exerted perpendicularly on the centre of the surface of the indicator, it shall not recede by more than 0,5 mm from reference plane B.

10.2 Back side and left side (Figures 8 and 10 and 11)

The back side shall have a window the dimensions and position of which shall be

$$l_{22} = 8,76 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{23} = 4,25 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{24} = 4,45 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{25} = 8,89 \text{ mm} \pm 0,10 \text{ mm}$$

This window allows a further finger of the drive to penetrate into the case to finally unlock the reel of tape (See also 10.6).

A door shall be rotatably mounted at the corner of the back side and the left side. At a distance

$$l_{73} = 70,65 \text{ mm} \pm 0,20 \text{ mm}$$

from reference plane B, the width of the door is reduced as specified by

$$l_{74} = 0,71 \text{ mm} \pm 0,01 \text{ mm}$$

$$l_{75} = 2,18 \text{ mm} \pm 0,10 \text{ mm}$$

The left side shall have two vertical edges and one horizontal edge the positions and lengths of which shall be

$$l_{26} = 61,47 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_{27} = 9,65 \text{ mm} \begin{matrix} +0,13 \text{ mm} \\ -0,00 \text{ mm} \end{matrix}$$

$$l_{71} = 41,9 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_{72} = 6,18 \text{ mm} \begin{matrix} +0,18 \text{ mm} \\ -0,00 \text{ mm} \end{matrix}$$

$$l_{76} = 47,24 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{77} = 16,35 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{78} = 1,34 \text{ mm} \pm 0,10 \text{ mm}$$

$$l_{79} = 11,22 \text{ mm} \pm 0,10 \text{ mm}$$

NOTE

This horizontal edge is intended to prevent the insertion of the cartridge into a DLT drive.

10.3 Tape reel (Figures 8, 12 and 13)

The bottom side of the case shall have a circular window through which the drive spindle contacts the hub of the reel and transmits torque. The diameter of this window shall be

$$d_1 = 35,05 \text{ mm} \pm 0,08 \text{ mm}$$

The position of its centre shall be defined by

$$l_{69} = 50,42 \text{ mm} \pm 0,31 \text{ mm}$$

$$l_{70} = 52,83 \text{ mm} \pm 0,10 \text{ mm}$$

The interface between the spindle and the hub is provided by 48 evenly spaced teeth in the hub. In the non-operating position, the surface of the hub shall be recessed from the outside surface of the case by

$$l_{28} = 0,38 \text{ mm} \pm 0,05 \text{ mm}$$

The tooth profile consists of straight flanks. The envelope dimensions of the teeth shall be

$$d_2 = 23,88 \text{ mm} \pm 0,13 \text{ mm}$$

$$d_3 = 29,21 \text{ mm} \pm 0,13 \text{ mm}$$

$$d_4 = 34,29 \text{ mm} \pm 0,13 \text{ mm}$$

$$a_4 = 22^\circ \pm 30'$$

$$a_5 = 15^\circ \pm 30'$$

where d_3 is the pitch diameter of the teeth.

In the operating position the surface of the hub shall be at a distance

$$l_{29} = 23,55 \text{ mm} \pm 0,10 \text{ mm}$$

from reference plane A.

10.4 Tape leader (Figures 14, 15 and 16)

The positions of the BOT and EOT relative to the leader/tape connection and to the physical end of the tape shall be as follows.

The BOT shall be at a distance

$$l_{30} = 13\,260 \text{ mm} \pm 100 \text{ mm}$$

from the leader/tape connection.

The EOT shall be at a distance

$$l_{31} = 7\,620 \text{ mm} \pm 152 \text{ mm}$$

from the physical end of the tape, which is fixed to the hub of the reel. Both the BOT hole and EOT hole shall have a diameter

$$d_5 = 3,60 \text{ mm} \pm 0,10 \text{ mm}$$

Figure 15 shows the relative positions of the tape, the leader and the splice tape. They shall be defined by

$$l_{32} = \begin{array}{l} 11,81 \text{ mm min.} \\ 20,32 \text{ mm max.} \end{array}$$

$$l_{33} = 0,25 \text{ mm max.}$$

$$l_{34} = 0,41 \text{ mm max.}$$

$$l_{35} = 0,00 \text{ mm min.}$$

$$l_{36} = 0,20 \text{ mm max.}$$

Dimensions l_{34} , l_{35} and l_{36} are related to, and depend on, each other. Dimension l_{35} expresses the requirement that the splice tape shall in no case extend beyond the edges of either the tape or the leader.

There shall be no yield of the splice when a force of 22,2 N max. is applied in longitudinal direction across the splice.

A buckle consisting of two arms fixed to an axis is attached at the end of the leader. Figure 16 shows at an enlarged scale this buckle and a perspective view of a buckle arm. The length of these buckle arms shall be

$$l_{80} = 13,51 \text{ mm} \pm 0,13 \text{ mm}$$

when measured between their right-hand end and said axis. The distance of the axis of the buckle arms to the end of the leader below the splice shall be

$$l_{37} = 425,00 \text{ mm} \pm 0,13 \text{ mm}$$

The width of the leader shall be

$$l_{38} = 12,65 \text{ mm} \begin{matrix} +0,00 \text{ mm} \\ -0,10 \text{ mm} \end{matrix}$$

The axis to which the buckle arms are fixed is attached to the leader so as to be able to rotate freely. It has a middle part with a diameter larger than that of its ends fixed to the buckle arms. These diameters shall be

$$d_6 = 0,91 \text{ mm} \pm 0,13 \text{ mm}$$

$$d_7 = 0,71 \text{ mm} \pm 0,25 \text{ mm}$$

The attachment of the axis to the leader shall be as defined by

$$l_{39} = 5,33 \text{ mm} \pm 0,16 \text{ mm}$$

$$l_{40} = 3,65 \text{ mm} \pm 0,09 \text{ mm}$$

The position of the buckle arms relative to the leader shall be as defined by

$$l_{41} = 16,15 \text{ mm} \pm 0,25 \text{ mm}$$

$$l_{42} = 22,76 \text{ mm} \pm 0,11 \text{ mm}$$

$$l_{43} = 5,11 \text{ mm} \pm 0,25 \text{ mm}$$

Figures 17 and 18 are a perspective view showing the leader buckle and the take up part of the drive before contact.

The height of the arm shall be

$$l_{81} = 3,30 \text{ mm} \pm 0,08 \text{ mm}$$

The side opening on the arm shall be

$$l_{82} = 5,71 \text{ mm} \pm 0,13 \text{ mm}$$

The distance between the end of the arm and the edge of the opening shall be

$$l_{83} = 5,76 \text{ mm} \pm 0,13 \text{ mm}$$

Figure 18 show a partial view of the inside of the end of an arm as seen in direction A in figure 17. The inside width of the arm shall be

$$l_{85} = 10,16 \text{ mm} \begin{matrix} +0,05 \\ -0,00 \end{matrix}$$

Within the arm there is an inclined surface having a length

$$l_{86} = 12,70 \text{ mm} \pm 0,08$$

There shall be a free space with a width

$$l_{84} = 16,16 \text{ mm} \pm 0,13 \text{ mm}$$

that allows the take up part of the drive to slide between the wall of the arm and the inclined surface to as to reach its end position shown in figure 19.

10.5 Front side (Figure 20)

The manually operable write-inhibit switch shall have the dimensions

$$l_{58} = 18,29 \text{ mm} \begin{matrix} +0,00 \text{ mm} \\ -0,20 \text{ mm} \end{matrix}$$

$$l_{59} = 26,60 \text{ mm} \pm 0,20 \text{ mm}$$

This switch shall have a detent at its two end positions. The force depends on the design of the write-inhibit indicator.

The front side shall have a slot intended for labels. The dimensions of this slot shall be

$$l_{60} = 54,40 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_{61} = 18,40 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_{62} = 21,40 \text{ mm} \pm 0,20 \text{ mm}$$

$$l_{63} = 0,76 \text{ mm} \pm 0,10 \text{ mm}$$

10.6 Operation of the cartridge (Figures 19 and 21)

When the cartridge is introduced into the drive, the sequence of events is as follows.

- i. The door shall have a movable lock the lower edge of which shall be at a distance

$$l_{64} = 14,50 \text{ mm} \pm 0,20 \text{ mm}$$

from reference plane A. A cam of the drive raises this lock in order to unlock the door, which shall be unlocked when the edge is raised by 1,0 mm min.

The door is then opened 90° by the drive. It shall be able to rotate further up to 105°. In the open position of the door the whole back side shall be accessible except the part limited by

$$l_{65} = 35,79 \text{ mm} \pm 0,20 \text{ mm}.$$

In this position the space along the left side that is delimited by

$$l_{66} = 4,57 \text{ mm} \pm 0,05 \text{ mm}$$

shall be free for a drive element to contact the edge defined by l_{26} and l_{27} (See figure 11).

- ii. A finger of the drive penetrates into the case through the window defined by l_{22} to l_{25} (See figure 10) to partially unlock the reel. The corresponding part of the locking mechanism shall not require a penetration longer than 9 mm nor a force larger than 3,7 N for actuation.
- iii. When the cartridge has been completely introduced into the drive, it is held in position by elements of the drive engaging the positioning notch of the right side (Figures 8 and 9) and the positioning hole in the bottom side (Figure 9).
A second finger of the drive penetrates through the window of the bottom side defined by l_4 to l_7 (See figure 8) and completely unlocks the reel. The requirements for penetration and force are the same as specified in ii. for the first finger.
- iv. The drive spindle engages the teeth of the hub and raises the reel into the operating position (See figure 13). The force with which the tape reel is held against the spindle shall be $6,0 \text{ N} \pm 0,5 \text{ N}$.
- v. When the cartridge is within the drive in the operating position (Figures 13 and 19), the tape is pulled out of the cartridge by a drive leader attached to the hub of a reel within the drive. The tip of this drive leader is designed so as to match the shape of the buckle of the tape leader and to engage it. The case shall have an abutment against which the buckle comes to rest when the tape is completely pulled back into the cartridge.
- vi. The tape leader and the abutment shall withstand the impact of having to stop the full reel when the tape leader is retracted with a speed in the range 152 mm/s to 178 mm/s. Until the reel is fully locked,

i.e. until the cartridge is ejected from the drive, the buckle shall be held against the abutment with a force in the range 1,1 N to 1,7 N.

10.7 Tape winding

The tape shall be wound on the hub with the magnetic coating facing inwards, so that during forward read/write operation the tape is unwound from the cartridge reel in a counterclockwise direction when viewed from the top of the cartridge.

The tape shall be wound with a tension of $1,11 \text{ N} \pm 0,28 \text{ N}$.

10.8 Moment of inertia

A full reel of tape shall have a diameter between 87,45 mm and 91,19 mm.

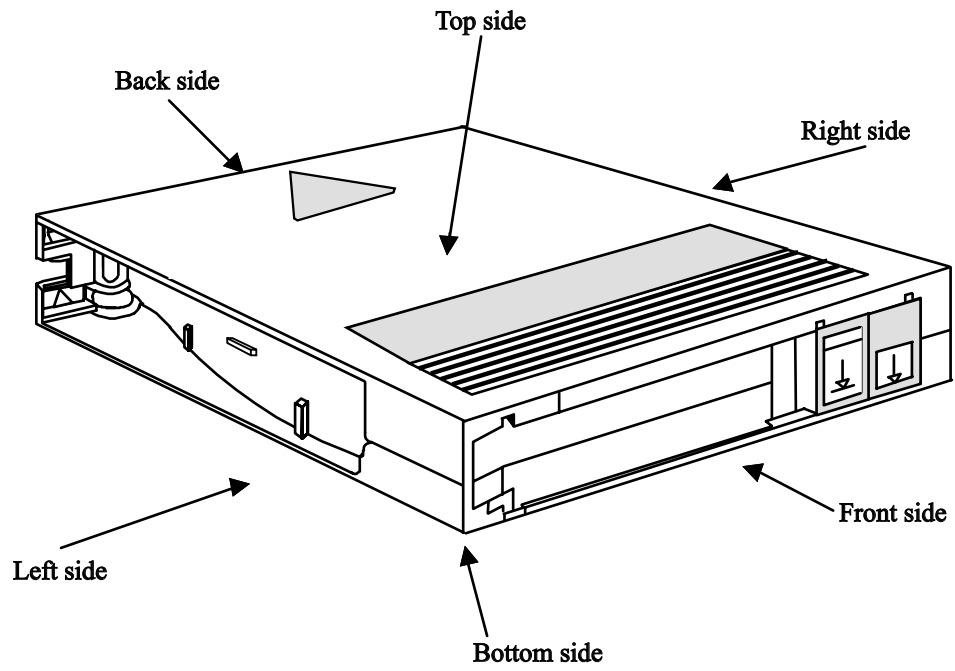
The moment of inertia shall be:

- Full reel: Between $131 \times 10^{-6} \text{ kg} \cdot \text{m}^2$ and $160 \times 10^{-6} \text{ kg} \cdot \text{m}^2$
- Empty reel: Between $19 \times 10^{-6} \text{ kg} \cdot \text{m}^2$ and $23 \times 10^{-6} \text{ kg} \cdot \text{m}^2$

10.9 Material

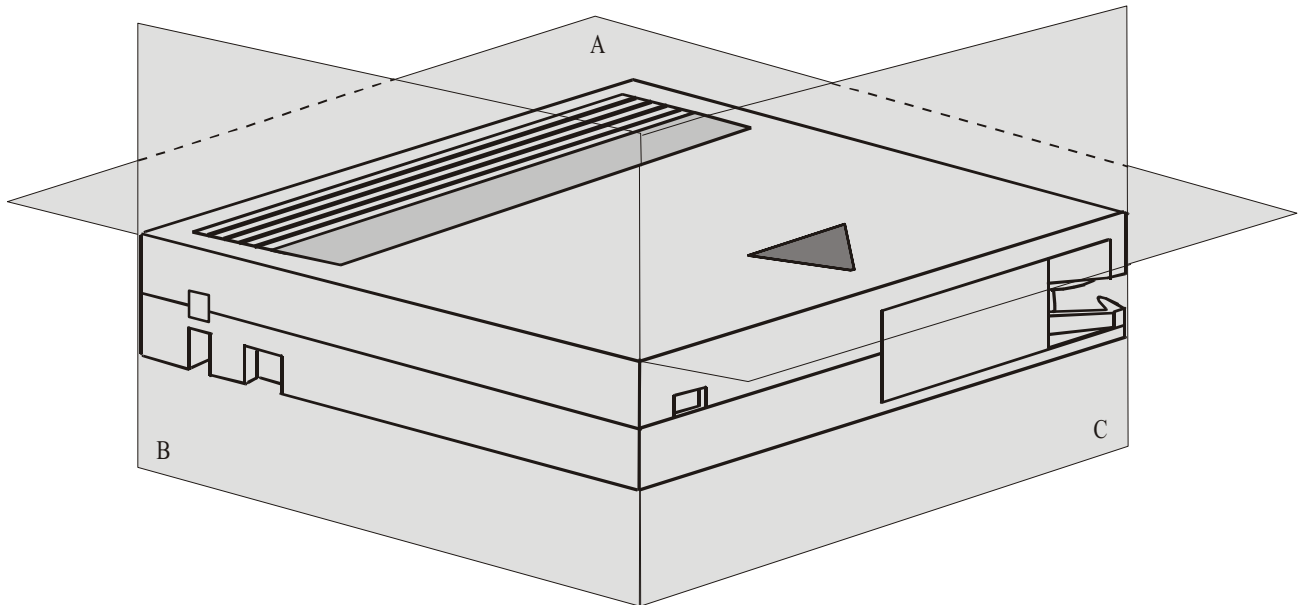
The cartridge can be made of any material as long as the requirements of this ECMA Standard are met. For example, the hub and the case could be made of 10 % glass-filled polycarbonate. A typical wall thickness is 1,5 mm.

The tape leader shall be made of a non-translucent material, for instance pigmented polyethylene terephthalate.



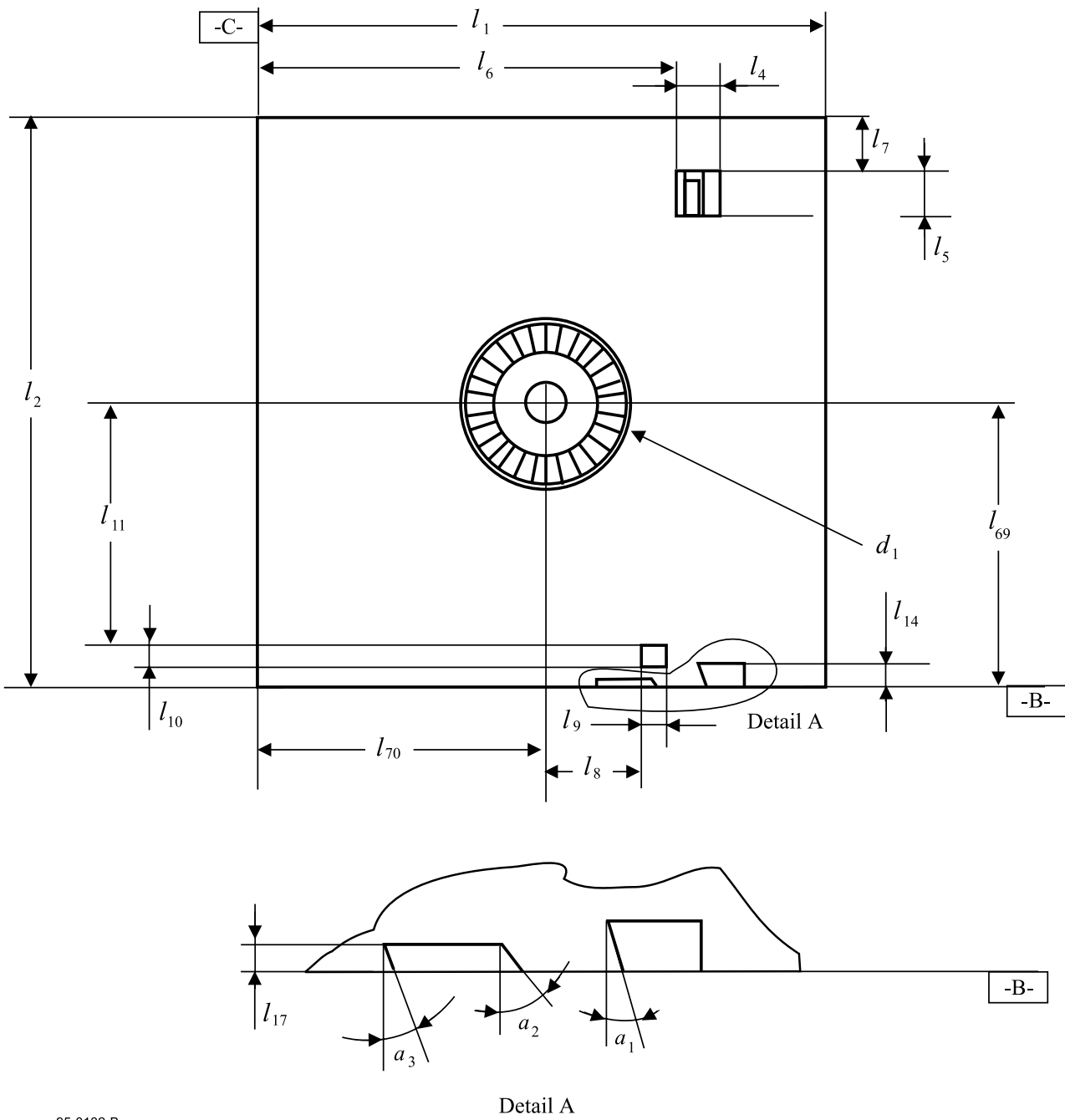
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Figure 6 - General view



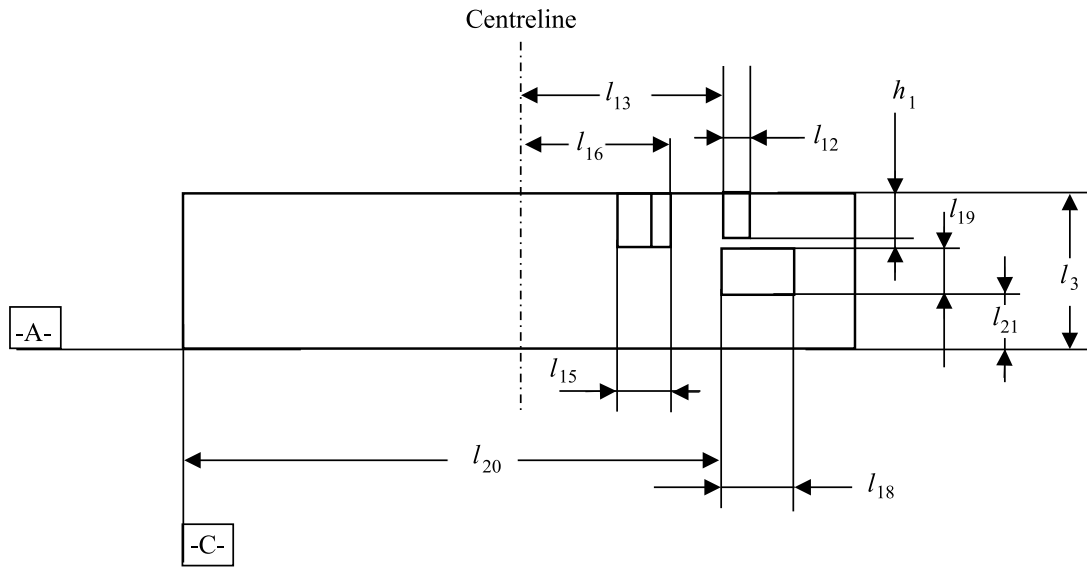
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Figure 7 - Reference planes



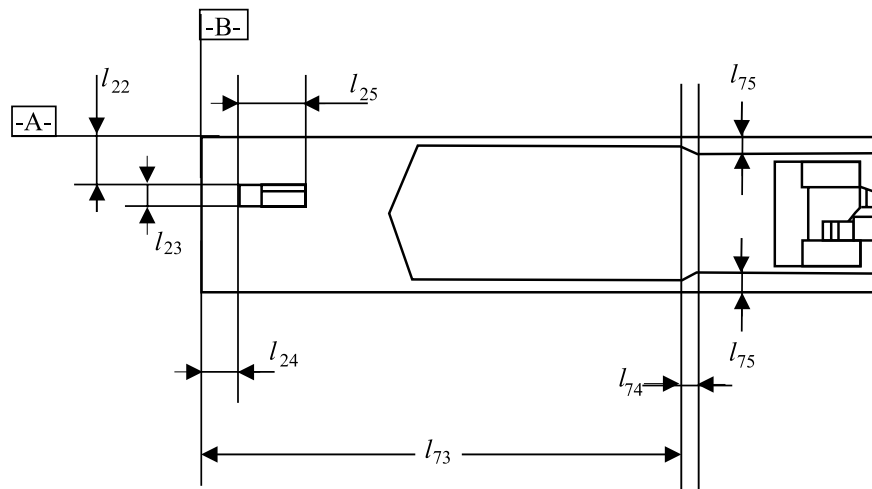
95-0132-B

Figure 8 - Bottom side



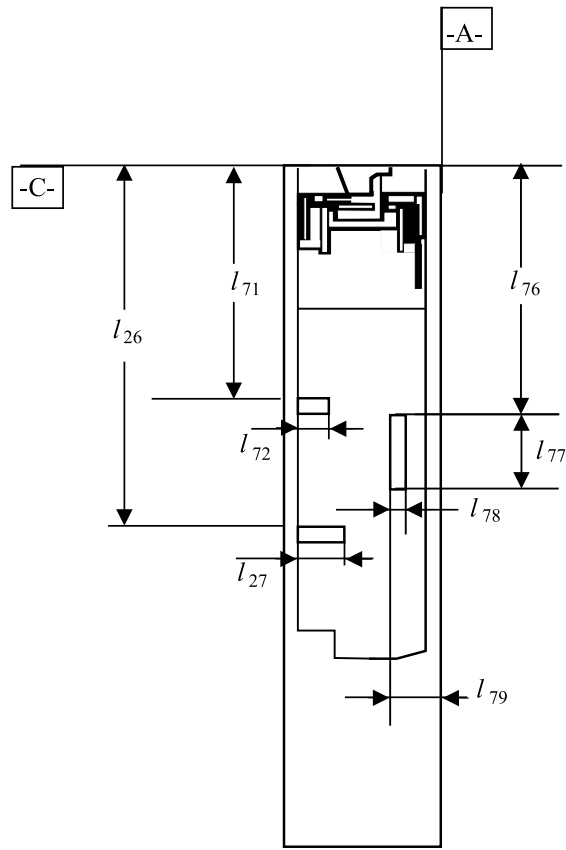
95-0133-A

Figure 9 - Right side



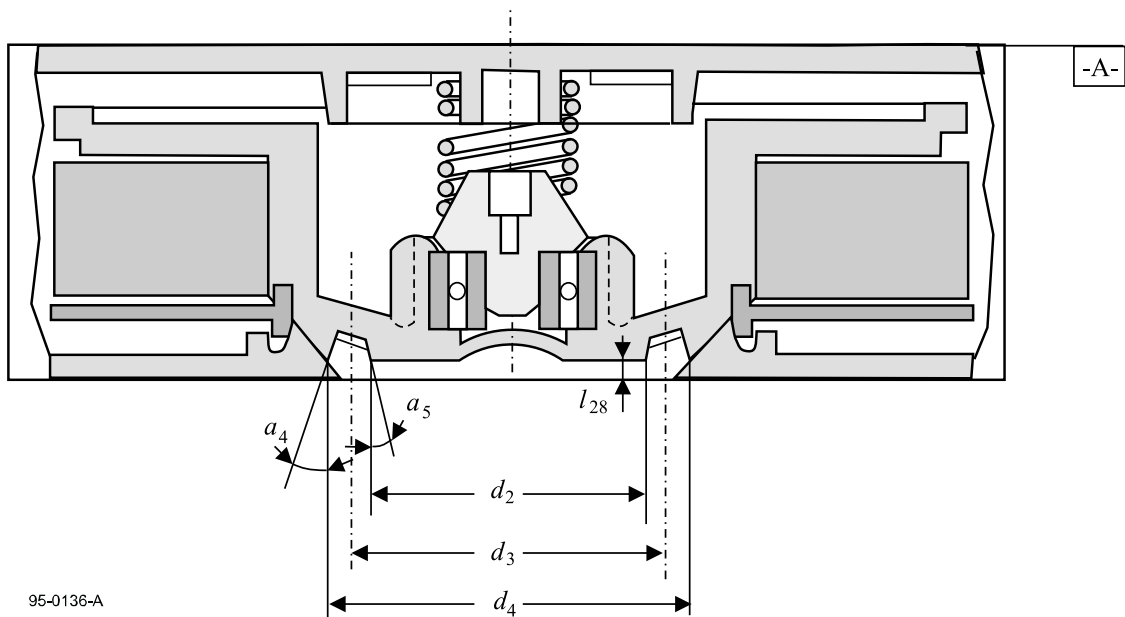
99-0079-A

Figure 10 - Back side



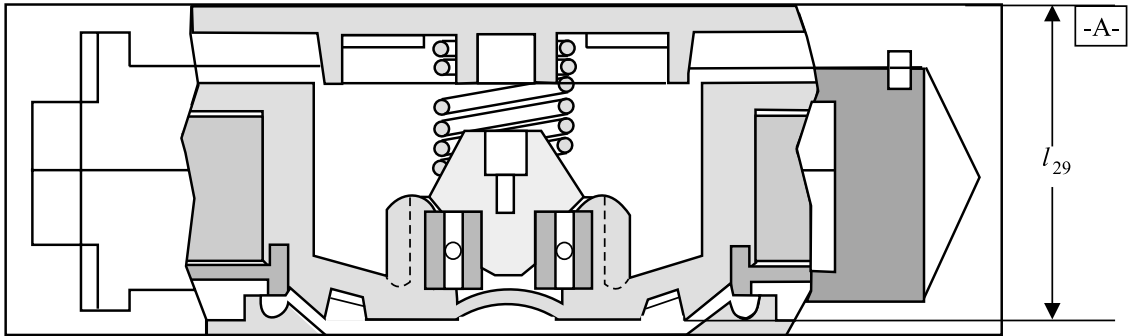
99-0080-A

Figure 11 - Left side



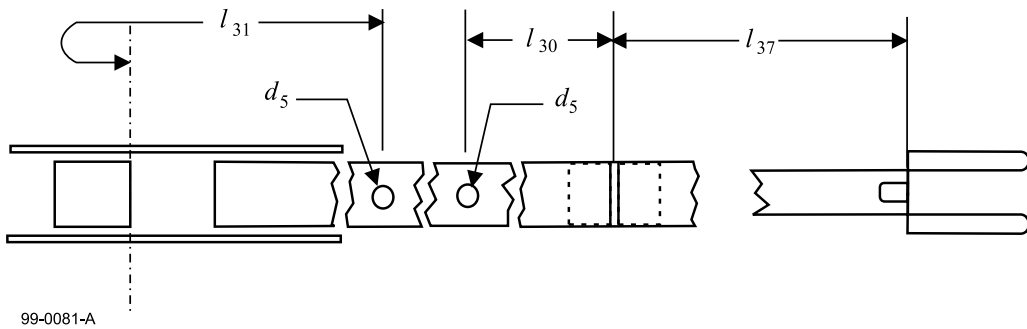
95-0136-A

Figure 12 - Cross section, non-operating position



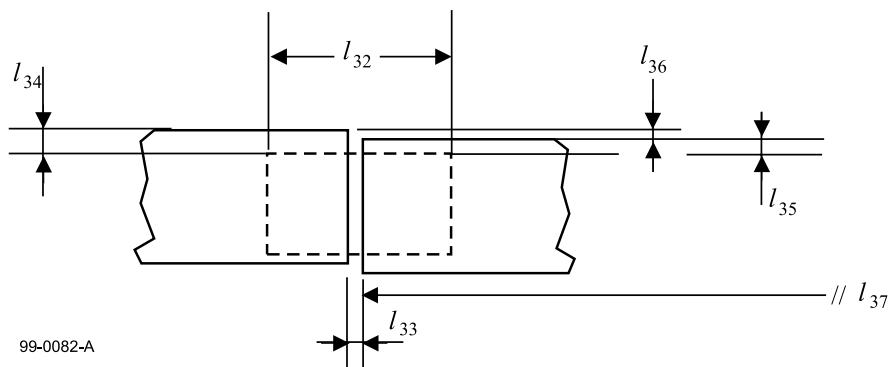
95-0137-A

Figure 13 - Cross section, operating position



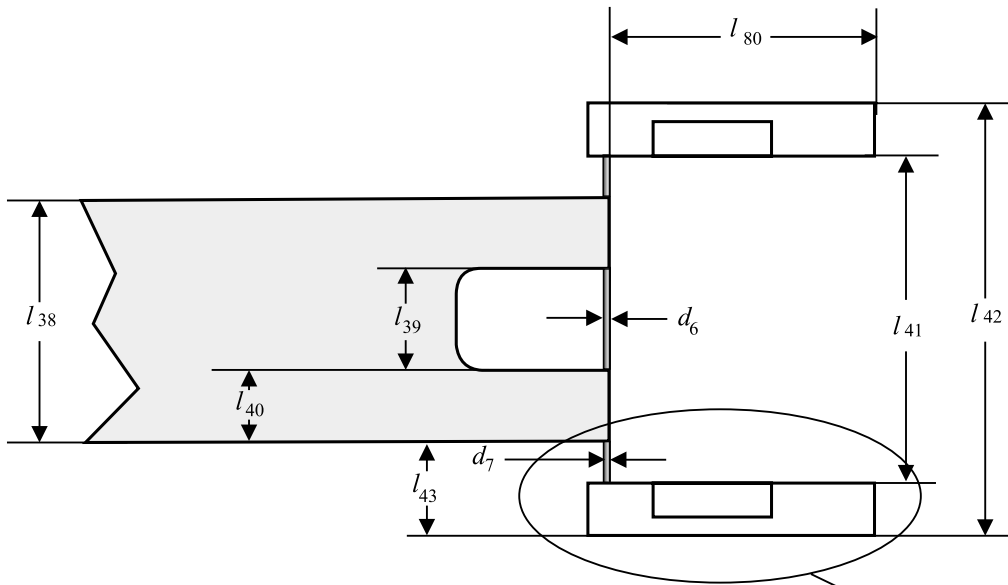
99-0081-A

Figure 14 - Leader/tape connection



99-0082-A

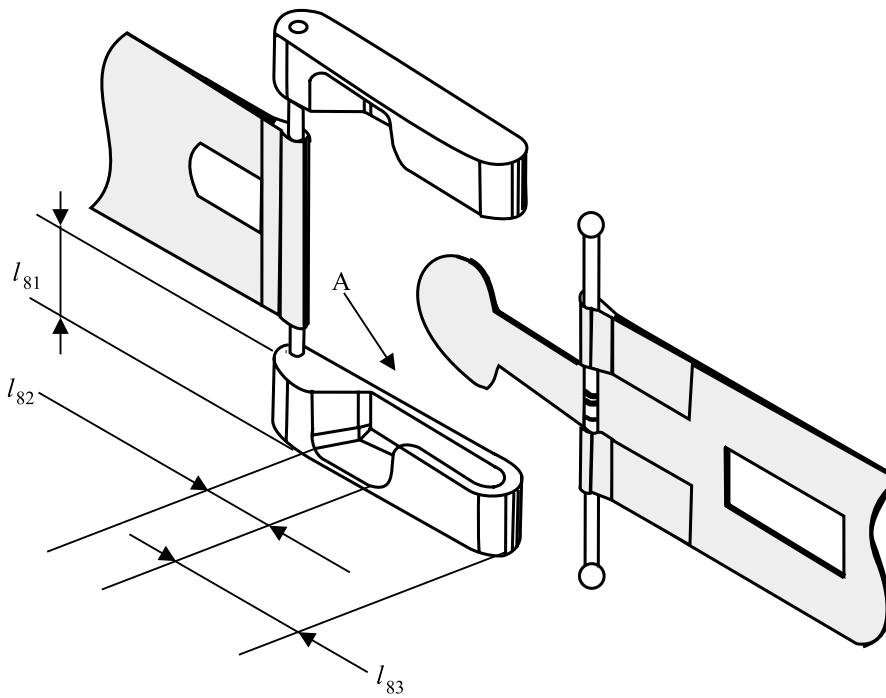
Figure 15 - Position of the splice tape



99-0084-C

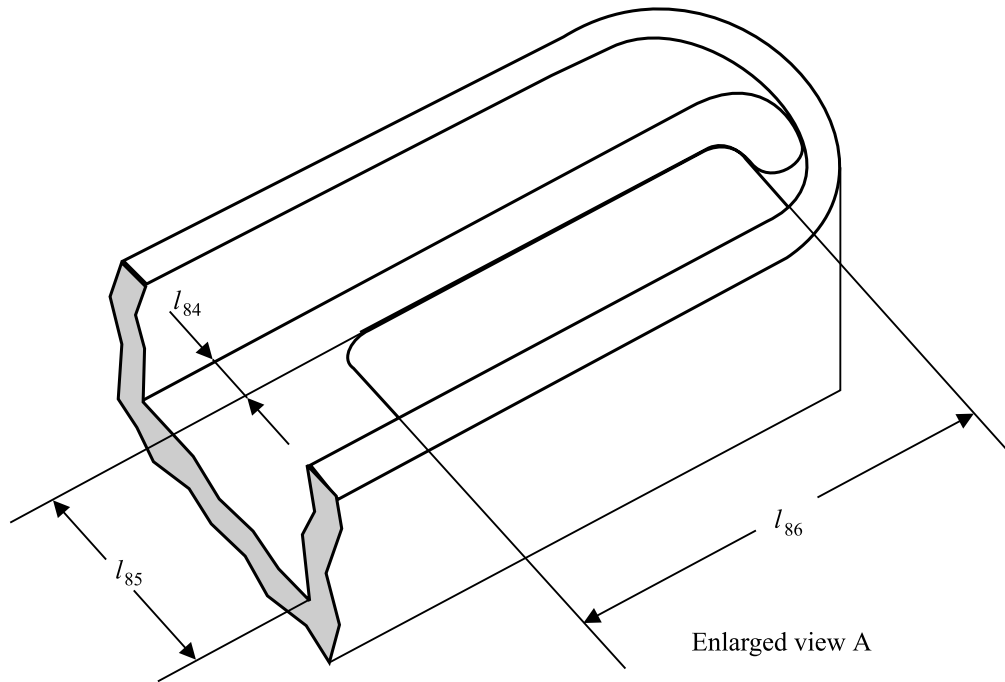
See figure 17

Figure 16 - Enlarged top view of the buckle



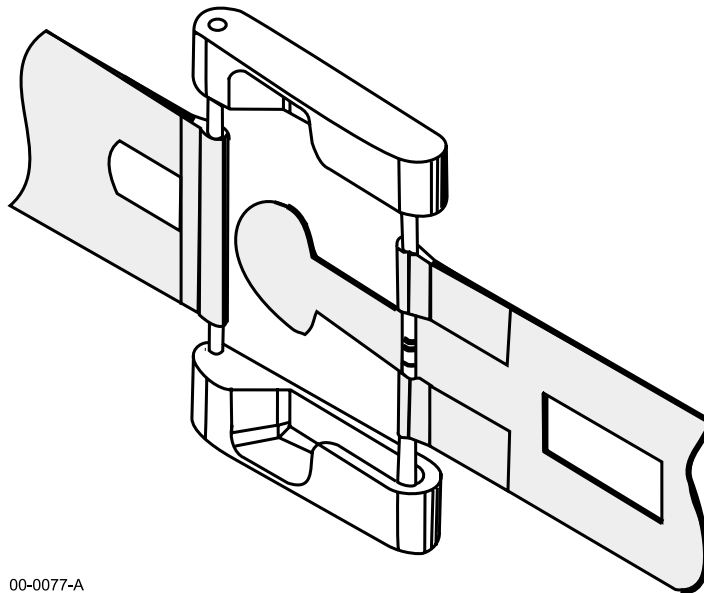
00-0076-B

Figure 17 - Perspective view of the leader buckle and of the take up part before contact



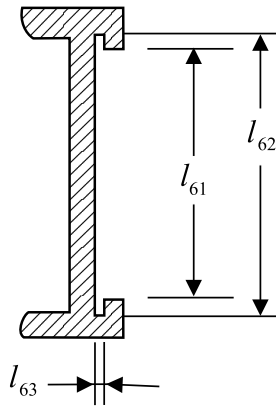
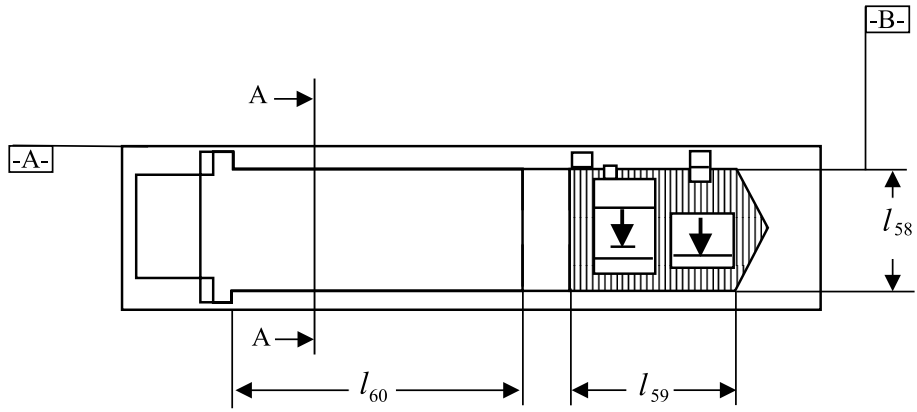
01-0001-A

Figure 18 – Partial enlarged view of figure 17



00-0077-A

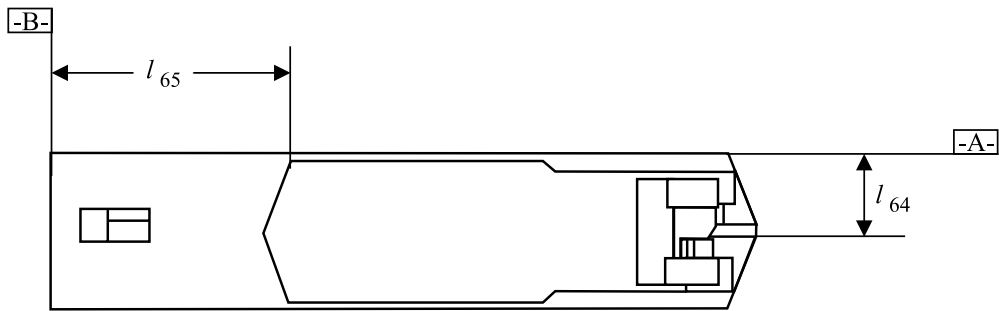
Figure 19 - Perspective view of the leader buckle and of the take up part after contact



Section A-A

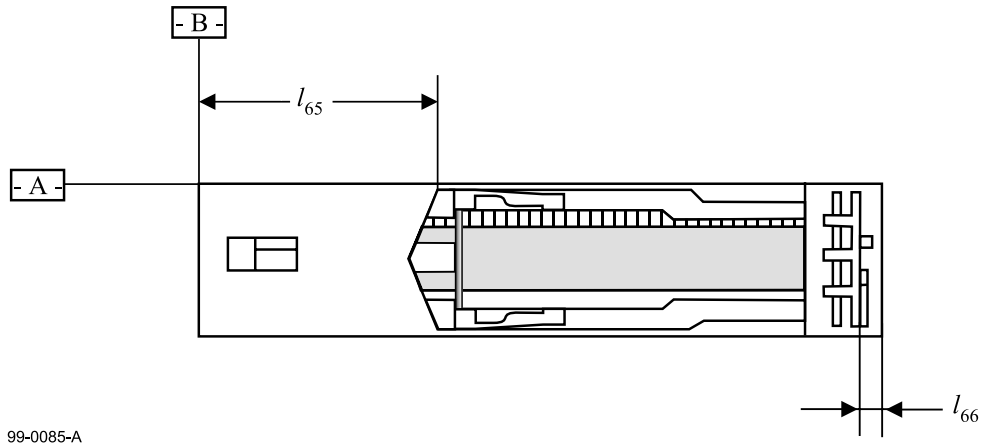
95-0141-A

Figure 20 - Front side



99-0083-A

Figure 21 - Back side, position of the door lock



99-0085-A

Figure 22 - Back side with the door open

Section 4 - Requirements for an interchanged tape

11 Tape format

11.1 Reference Edge

The Reference Edge shall be the bottom edge when viewing the magnetic coating of the tape with the BOT to the left and the EOT to the right of the observer.

11.2 Direction of recording

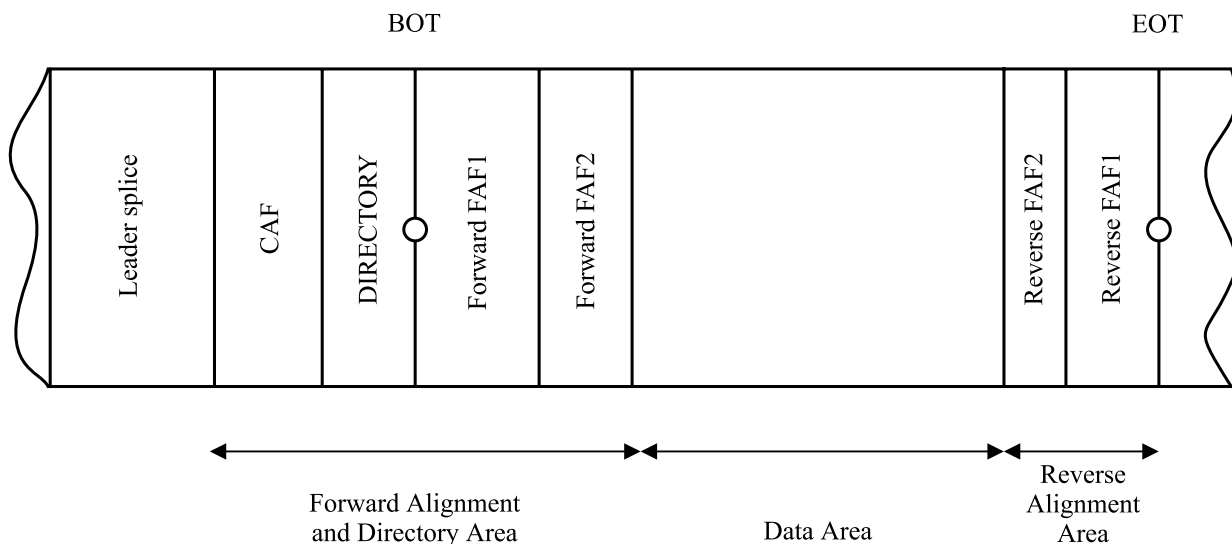
Recording shall take place in two directions:

- forward: from BOT to EOT
- reverse: from EOT to BOT

11.3 Tape layout

The tape shall be partitioned into three areas:

- the Data Area
- the Forward Alignment and Directory Area,
- The Reverse Alignment Area



00-0058-A

Figure 23 – Tape Layout

11.3.1 Data Area

The Data Area shall contain data that is transmitted by the host to the drive and recorded according to the format specified in clause 12. The quantity of recorded data may be such that the total capacity of the maximum number of physical tracks, viz., 448, is required in order to contain it. It may, under other circumstances, be less in which case fewer than 448 physical tracks will be required. The following specification is based on the former case.

11.3.1.1 Physical tracks

There shall be 448 physical tracks in the Data Area, each identified by a Physical Track Number from 1 to 448. Physical Track 448 shall be that farthest from the Reference Edge and Physical Track 1 shall be that nearest to the Reference Edge. The physical tracks are grouped into 4 Recording Bands of 112 physical tracks each.

11.3.1.2 Width of the physical tracks

The width of a physical track shall be $0,023 \text{ mm} \pm 0,001 \text{ mm}$.

11.3.1.3 Positions of the physical tracks

In each band the centreline of the first forward physical track shall be at $1,906\ 5\ \text{mm} \pm 0,002\ 0$ from centreline of the 9th servo track in each band.

The distance between the centrelines of all adjacent forward and all adjacent reverse tracks in all bands shall be $0,024\ \text{mm} \pm 0,001\ \text{mm}$.

The distance between the last forward track and the following reverse track in all bands shall be $0,026\ \text{mm} \pm 0,001\ \text{mm}$.

The distance between the physical tracks of each logical track shall be $0,343\ \text{mm} \pm 0,010\ \text{mm}$.

11.3.1.4 Forward tracks (Figure 25)

The physical tracks with an odd Physical Track Number shall be recorded in the forward direction, i.e. from BOT to EOT, The recording shall start at $8\ 458\ \text{mm} \pm 50\ \text{mm}$ from the BOT and continue until $1\ 525\ \text{mm}$ max. before the EOT.

11.3.1.5 Reverse tracks (Figure 26)

The physical tracks with an even Physical Track Number shall be recorded in the reverse direction, i.e. from EOT to BOT. The recording shall start at $8\ 458\ \text{mm} \pm 50\ \text{mm}$ from the EOT and continue until $1\ 525\ \text{mm}$ max. before the BOT.

11.3.1.6 Logical tracks

A logical track shall consist of eight physical tracks recorded and read simultaneously.

Logical tracks are identified by a Logical Track Number from 0 to 55. They are recorded in ascending order of their Logical Track Numbers, starting with Logical Track No. 0.

Logical tracks with an even Logical Track Number shall be recorded in the forward direction on physical tracks with an odd Physical Track Number.

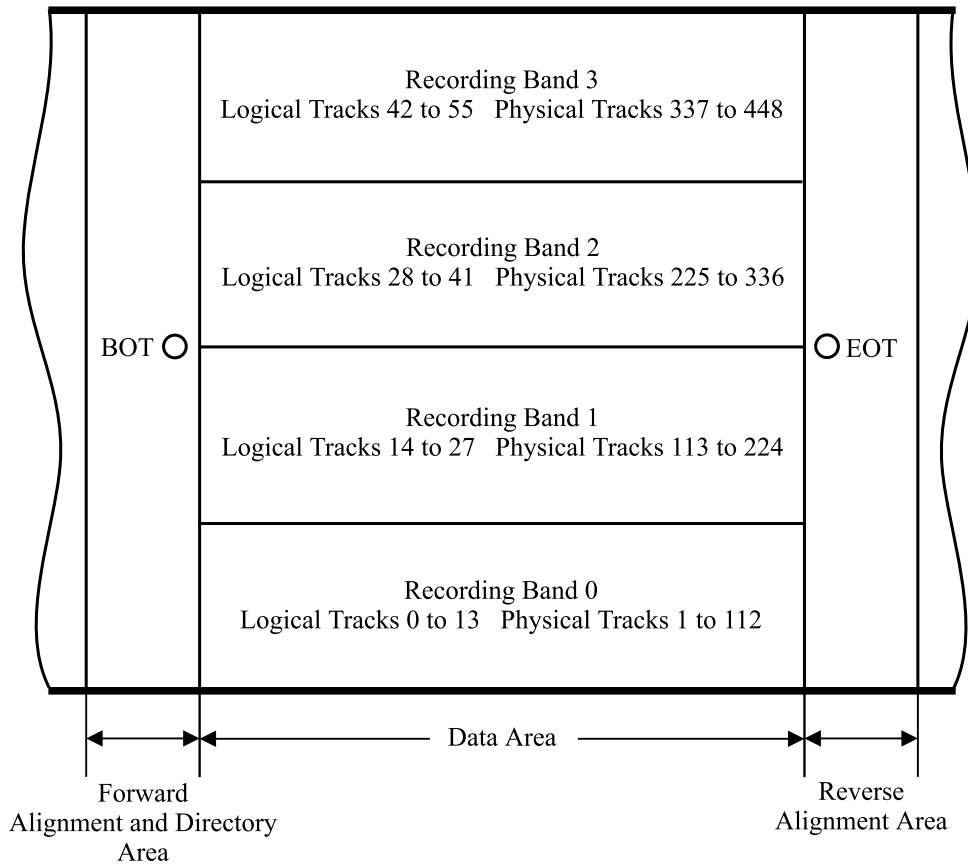
Logical tracks with an odd Logical Track Number shall be recorded in the reverse direction on physical tracks with an even Physical Track Number.

The allocation of physical tracks to logical tracks shall be as specified in annex F.

There shall be Track ID Start Blocks (See 15.2.1) written at the start of each logical track. These blocks shall be recorded over $1\ 000\ \text{mm} \pm 100\ \text{mm}$, starting at the beginning of the Data Area, viz. at $8\ 458\ \text{mm} \pm 50\ \text{mm}$ from the BOT or the EOT.

There shall be a minimum of one complete Envelope of Track ID End Blocks (See 15.2.5) recorded immediately after the Track ID Start Blocks.

Data blocks containing data from the host and processed as described in clause 12 shall be recorded immediately after the Track ID End Blocks.



00-0059-A

Figure 24 – Data Area

11.3.2 Forward Alignment and Directory Area

The Coarse Alignment Field (CAF) shall be recorded on Logical Track 6, i.e. eight physical tracks, recorded in the forward direction.

The CAF field shall start at 9 150 mm ± 0,50 mm from the BOT and shall end at 2 440 mm ± 50 mm from the BOT. This field shall consist of flux transitions at 1 350 ftpmm.

The Directory Area shall be recorded in the same physical tracks as the CAF.

The Directory Area shall start from 915 mm ± 50 mm from the BOT and end at 76 mm ± 15 mm from the BOT. Its content is not specified by this ECMA Standard and shall be ignored in interchange.

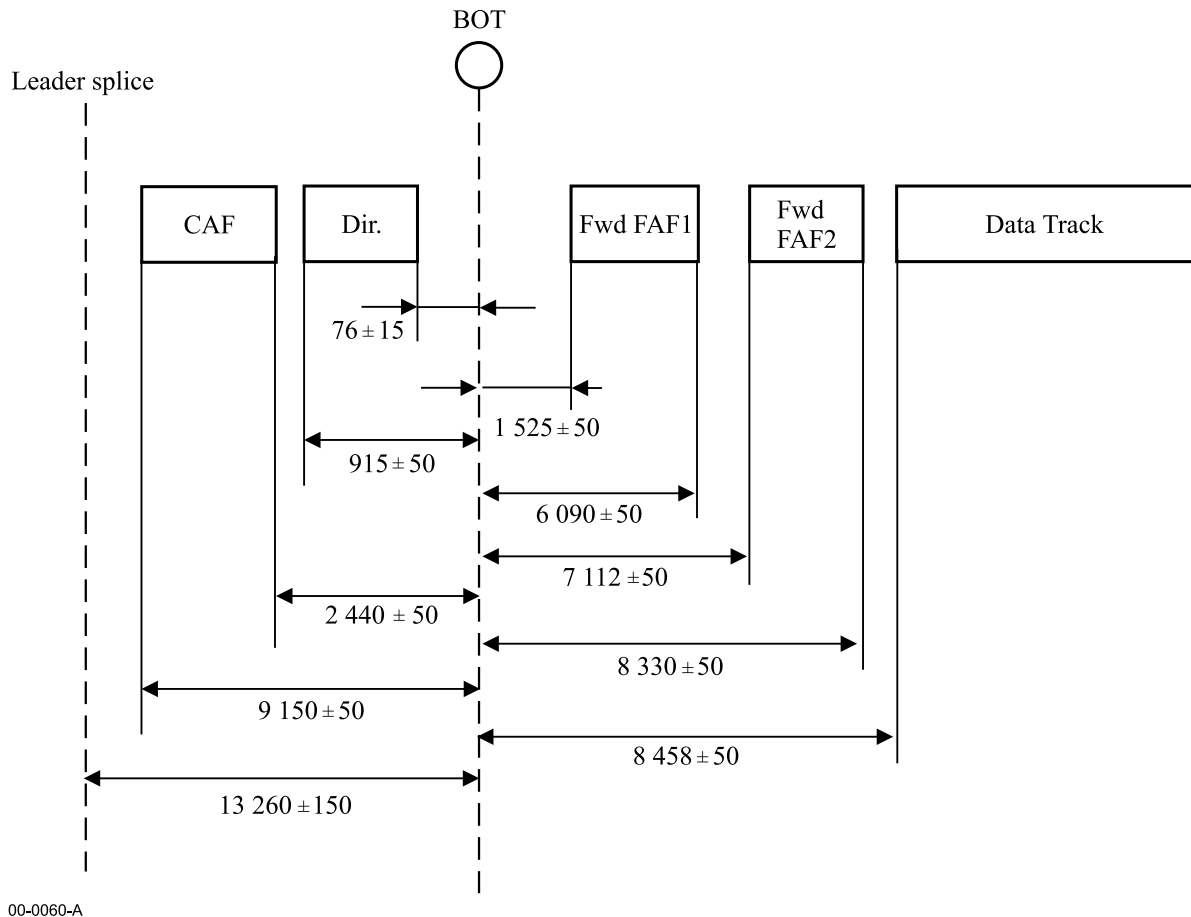
The Forward Fine Alignment Field 1 (FAF1) shall be recorded on the four Logical Tracks 6, 20, 34 and 48, i.e. 32 physical tracks, recorded in the forward direction after the BOT.

The FAF1 shall start at 1 525 mm ± 50 mm from the BOT, and shall end at 6 090 mm ± 50 mm from the BOT. This field shall consist of flux transitions at 1 350 ftpmm.

The Forward Fine Alignment Field 2 (FAF2) shall be recorded on all physical tracks.

The Forward FAF2 shall start at 7 112 mm ± 50 mm from the BOT, and shall end at 8 330 mm ± 50 mm from the BOT.

The FAF2 field shall consist of Track ID Start Blocks (See 15.2.1) and Track ID End Blocks (See 15.2.5).



00-0060-A

Figure 25 – Forward Alignment and Directory Area

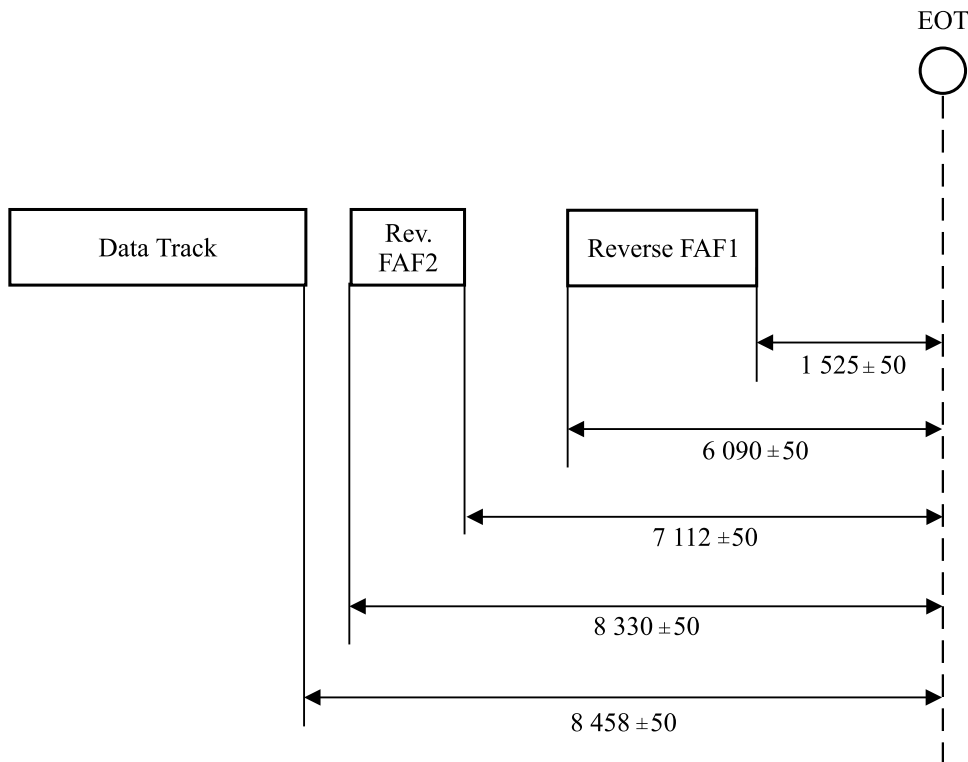
11.3.3 Reverse Alignment Area at EOT

The Reverse FAF1 shall be recorded on the four Logical Tracks 7, 21, 35 and 49, i.e. 32 physical tracks, recorded in the physically reverse, logically forward, direction from the EOT.

The recording of the Reverse FAF1 shall start at 1 525 mm ± 50 mm from the EOT, and shall end at 6 090 mm ± 50 mm from the EOT.

The Reverse FAF2 shall be recorded in the physically reverse, logically forward, direction in all physical tracks.

The Reverse FAF2 shall start at 7 112 mm ± 50 mm from the EOT, and shall end at 8 330 mm ± 50 mm from the EOT. It shall consist of Track ID Start Blocks (See 15.2.1) and Track ID End Blocks (See 15.2.5).



00-0061-A

Figure 26 – Reverse Alignment Area

12 Data format

12.1 Record

The host transmits to the drive data in form of records, each comprising one or more bytes. The interpretation of these bytes is outside the scope of this ECMA Standard and a matter of agreement between the interchange parties.

If the number of bytes of a record received from the host is not a multiple of 4, it is completed by 1, 2 or 3 Pad Bytes, as appropriate. A 32-bit CRC is computed over the bytes of the record or completed record according to annex D and appended to the record or completed record. A record or completed record together with its CRC shall be referred to as a Record. The maximum size of a Record shall be $(2^{24}-1)$ bytes.

12.2 Data Bytes

Data Bytes shall be

- The bytes of a Record
- 8-byte MAP entries (See 12.3.4)
- Pad Bytes, as required (See 12.3.2)

12.3 Data Field

Records shall be arranged in groups of 4 096 Data Bytes to form a Data Field structured as shown in figure 27.

Byte position	Number of bytes	Field
1 to ...	Variable	Page 1: Record 1 and CRC
*	Variable	Page 2: Record 2 and CRC
*	*	*
*	*	*
*	*	*
*	Variable	Page (<i>n</i> -1): Record (<i>n</i> -1) and CRC
*	Variable	Page <i>n</i> : Record <i>n</i> and CRC
*	Variable	Pad Bytes as required
*	8	MAP of page <i>n</i>
*	8	MAP of page (<i>n</i> -1)
*	*	*
*	*	*
*	*	*
4 084 to 4 077	8	MAP of page 2
4 092 to 4 085	8	MAP of page 1
4 096 to 4 093	4	EDC

Figure 27 – Data Field

12.3.1 Pages

A page shall contain a Record or a part of a Record of variable length.

12.3.2 Pad Bytes

Pad Bytes shall be set to all ZEROs. After the last page, the Data Field shall be completed with Pad Bytes. There shall be no MAP Entry (See 12.3.4) for these bytes. The Page Type shall be Filler (See figure 25). No new page shall start if 16 bytes or less remain in the Data Field. There shall be no MAP entry for these bytes.

12.3.3 Page layout

The number of bytes in a page shall always be a multiple of 4.

- a) In each page a Record shall be followed by an additional 32-bit Record CRC (See annex D), except as specified below.
- b) If the total number of Data Bytes of a Record and its CRC in a page is a multiple of 4, this page is followed by the next page, if any.
- c) If a Record or part of a Record comprises 4 096 bytes, its CRC shall be recorded in the first page of the next Data Field. The content of this first page shall consist of this CRC.

12.3.4 MAP entries

Each MAP entry shall consist of 8 bytes. It specifies attributes of a page. The content of each MAP entry shall be as specified in figure 28. The MAP entry for Record 1 is recorded in the byte positions 4 092 to 4 085 of the Data Field, that of Record 2 in positions 4 084 to 4 077 and so on, i.e "upward" as seen in figure 27.

Bit positions	Field	Setting
1	C Bit	ZERO = The data of the Record is not compressed ONE = The data of the Record is compressed.
2 to 4	Page Type 3 bits	001 Filler 010 Data 100 Set Mark 011 Tape Mark
5	N Bit	ZERO = The Record ends in this Data Block ONE = The Record continues in the next Data Block
6	P Bit	ZERO = The Record starts in this Data Block ONE = The Record does not start in this Data Block
7	L Bit	ZERO = There is a further MAP ONE = This is the last MAP
8 to 16	9 bits	These bits shall be set to ZERO
17 to 32	Page Byte Count 16 bits	Number of User Bytes and/or Pad Bytes of the page
33 to 64	Record Byte Count 32 bits	Total number of bytes in the Record

Figure 28 - Content of MAP entries

If the Page type is Filler, Tape Mark or Set Mark, the Page Byte Count shall specify the number of Pad Bytes in the Data Field, and the content of the Record Byte Count shall be ignored.

12.3.5 EDC

The 32-bit EDC shall be recorded in bytes 4 096 to 4 093 of the Data Field. It shall be computed over the previous 4 092 bytes of the Data Field as follows.

Each EDC shall be a 32-bit word computed over 1 023 32-bit Data Words formed from the previous 4 094 bytes of the Data Field. The first Data Byte constitutes the least significant part of the first Data Word, the second Data Byte constitutes its most significant part, and so on. With these 1 023 Data Words identified by $1 \leq i \leq 1\,023$, the EDC word is obtained by the following algorithm.

Set EDC_0 to (FFFFFFFF)

Set EDC_i to $EDC_{i-1} \oplus (\text{Data Word})_i$

Shift EDC_i leftwards by one bit position, with the most significant bit moved to the least significant bit position.

where: \oplus stands for Exclusive OR.

12.4 Data Blocks

Each Data Field shall be completed with the following elements to form a Data Block of 4 144 bytes.

- a Control Field CF1
- a Control Field CF2
- a 64-bit CRC

Number of Bytes	Field
4096	Data Field
16	CF1
24	CF2
8	CRC

Figure 29 – Data Block

12.4.1 Control Field 1 (CF1)

CF1 is a 128 - bit field. It specifies attributes of a block.

The content of CF1 shall be as shown in figure 30

Bit positions	Field name	Length in bits
1 to 16	Logical Block Number or Sequential File Mark Offset	16
17 to 28	Sequential File Mark Number	12
29	Logical Block Number Valid	1
30 to 32	These bits shall be set to ZERO	3
33 to 56	Set Mark Number	24
57 to 64	Compression	8
65 to 88	Tape Mark Number	24
89 and 90	These bits shall be set to ZERO	2
91 to 96	Format	6
97 to 128	Object Number	32

Figure 30 - Content of Control Field 1

This format is not applicable to ECC Blocks (See 15.2.4).

12.4.1.1 Logical Block Number / Sequential File Mark Offset

The contents of this field specify either the Logical Block Number or the Sequential File Mark Offset. The selection depends on the setting of the LBN Valid bit (See 12.4.1.3).

The Logical Block Number shall specify in binary notation the ordinal number of the blocks in each Record starting with 1 for the first block and incremented by 1 for each subsequent block recorded in the same Record.

Each block may contain data and/or a File Mark. In a block no page shall follow the File Mark. If there are subsequent File Marks in this group, they shall be recorded one File Mark per block in sequential blocks.

The Sequential File Mark Offset field shall specify in binary notation the number of File Marks within such a group of sequential File Marks.

12.4.1.2 Sequential File Mark Number

This field is a count of the number of sets of at least two or more consecutive blocks (See 15.1) having pages of type Tape Mark starting with 1 and incremented by 1 for each such set. These sets may be separated by one or more Data Blocks having no page of type Tape Mark.

12.4.1.3 LBN Valid

This bit shall be set to ZERO to indicate that the bytes specified in 12.4.1.1 represent the Sequential File Mark Offset. This bit shall be set to ONE to indicate that these bytes represent the Logical Block Number.

For EOTR and EOD Blocks (See 15.2.2 and 15.2.3), this bit shall be set to ZERO.

12.4.1.4 Set Mark Number

This field shall be set to all ZEROs for all blocks prior to the first one containing a page of type Set Mark. In this first block containing a page of type Set Mark, this field shall also be set to all ZEROs.

For Data Blocks this field shall specify in binary notation the ordinal number of the previous Data Block containing a page of type Set Mark.

For EOTR and EOD Blocks, this field shall be set to all ZEROs.

12.4.1.5 Compression Type

This field shall specify in binary notation a numerical identifier of the compression algorithm, where applicable, else it shall be set to all ZEROs (See ISO/IEC 11576).

12.4.1.6 Tape Mark Number

This field shall be set to all ZEROs for all blocks prior to the first one containing a page of type Tape Mark.

For Data Blocks this field shall specify in binary notation the ordinal number of the previous Data Block containing a page of type Tape Mark.

For EOTR and EOD Blocks, this field shall be set to all ZEROs.

12.4.1.7 Format

This field shall be set to 001010.

12.4.1.8 Object Number

This field is a count of all Records and pages of type Tape Mark on the tape, starting with 1 and incremented by 1 for each Record and each page of type Tape Mark.

The content of this field in EOTR and EOD Blocks shall be set to all ZEROs.

12.4.2 Control Field 2 (CF2)

CF2 is a 192-bit field. It specifies further attributes of a block, of the Entity and of the Envelope in which it is recorded. The content of CF2 shall be as shown in figure 31.

Bit positions	Field name	Length in bits
1 to 8	Track Number	8
9	K Bit	1
10 to 32	Envelope Instance Tag	23
33 to 64	Physical Block Number	32
65 to 96	Back Link, Physical Block Number	32
97 to 101	Entity Offset	5
102 to 104	Block Type	3
105	Logical Block 0	1
106 to 128	Back Link Instance Tag	23
129 to 133	Entity Number	5
134 to 138	Entity Size	5
139 to 143	Envelope Size	5
144	This bit shall be set to ZERO	1
145 to 160	Envelope Number	16
161 to 192	Envelope First Object Number	32

Figure 31 - Content of Control Field 2

12.4.2.1 Track Number

This field shall specify in binary notation the Logical Track Number (from 0 to 55) of the logical track on which the block is recorded.

12.4.2.2 K bit

In the first eight blocks of an Envelope, this bit shall be set to ONE if any block in the preceding Envelope is in error. Once the erroneous block(s) of the preceding Envelope has been re-written, these K Bits shall be re-set to ZERO.

12.4.2.3 Envelope Instance Tag

This field shall specify in binary notation a pseudo-random number. This number provides an additional check capability by comparing the value obtained by the read-while-write process with the pseudo-random number generated. This field shall be ignored in interchange.

12.4.2.4 Physical Block Number

This field shall specify the physical block number. This number shall be set to the value 1 for the first physical block written on the physical track, and shall be incremented by 1 for each successive physical block.

12.4.2.5 Back Link Physical Block Number

This field shall specify the block number of the last physical block written in the previous Envelope.

12.4.2.6 Entity Offset

This field shall specify the ordinal number of the block within the Entity.

12.4.2.7 Block Type

This field shall specify the types of block as a 3-bit pattern.

Bit pattern	Type of the block
001	Data Block
010	Track ID Start Block
011	End of Track Block
100	End of Data Block
101	ECC Block
110	Track ID End Block

12.4.2.8 Logical Block 0

This bit shall be set to ONE if the block is the first logical block of the entity. Otherwise, it shall be set to a ZERO.

12.4.2.9 Back Link Instance Tag

This field shall specify the number of the last completed Envelope of the logical track.

12.4.2.10 Entity Number

This field shall specify the ordinal number of an Entity within an Envelope. The least significant four bits specify this number. The most significant four bits specify the number 0 for the first Envelope on logical track No. 0. This number is incremented by 1 (mod 16) for each following Envelope on the tape.

12.4.2.11 Entity Size

This field shall specify the number of blocks recorded within the Entity.

12.4.2.12 Envelope Size

This field shall specify the number of Entities in the Envelope (See clause 17).

12.4.2.13 Envelope Number

This field shall specify the ordinal number of the Envelopes of a logical track, starting with 1 for the first Envelope and incremented by 1 for each subsequent Envelope of this logical track.

12.4.2.14 Envelope First Object Number

This field shall specify the Object number of the first block of the Envelope.

12.4.3 CRC

This field shall contain the 64-bit CRC. The CRC is computed over the 4 096 bytes of the Data Field, CF1 and CF2. The algorithm for the CRC shall be as specified in annex C.

13 Method of recording

The method of recording shall be as follows:

- When the data to be recorded change from a ONE to a ZERO, or a ZERO to a ONE, a flux transition shall be recorded at 20% to 25% from the leading boundary of the bit cell.
- When the data to be recorded do not change, a transition shall be recorded at the leading boundary of the bit cell and another transition shall be recorded at 20% to 25% from the leading boundary of the bit cell.

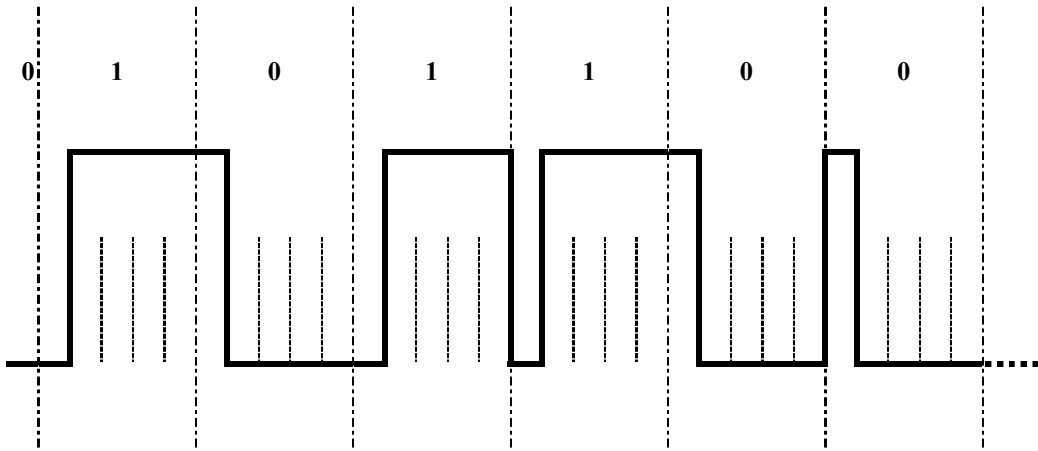


Figure 32 – Method of Recording

13.1 Physical recording density

The recording density averaged over two bit cells shall be in the range 675 ftpmm to 5 400 ftpmm.

13.2 Channel bit cell length

The nominal Channel bit cell length is 0,185 2 μm .

13.2.1 Average Channel bit cell length

The average Channel bit cell length is the overall length of n Channel bit cells divided by n .

13.2.2 Long-term average Channel bit cell length

The long-term average Channel bit cell length shall be the average Channel bit cell length taken over a minimum of 1 000 000 Channel bit cells. It shall be within 2,25 % of the nominal Channel bit cell length.

13.2.3 Short-term average Channel bit cell length

The short-term average Channel bit cell length shall be the average taken over 10 Channel bit cells. It shall be within 5 % of the nominal Channel bit cell length.

13.3 Read signal amplitude

The signal amplitude shall be measured at a point in the read channel where the signal is proportional to the rate of change of flux in the read head.

The Average Signal Amplitude of an interchanged cartridge shall be between 75 % and 125 % of the SRA.

Averaging for the interchanged cartridge may be segmented into blocks. No missing pulses shall occur within the measured area.

Traceability to the SRA is provided by the calibration factors supplied with each Secondary Standard Reference Tape.

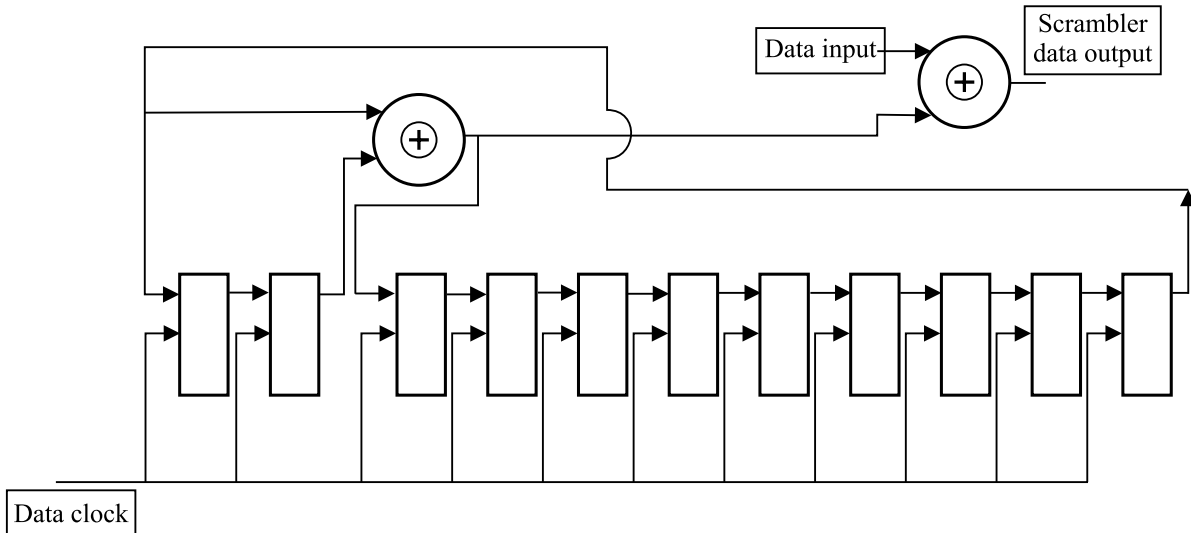
13.4 Channel skew

The deviation between corresponding Channel bits on the physical tracks of a logical track (See 11.3.1.6) shall not exceed 200 Channel bit cell lengths for any pair of such physical tracks.

14 Block Recording Format

14.1 Scrambler

The 4 144 bytes of each Data Block (Figure 29) shall be scrambled bit-by-bit by the circuit shown in figure 33. As a result each original Data Block is transformed into a Scrambled Data Block of 4 144 bytes. In the initial condition, the circuit shall be set to all ONES. All stages are D Type flip flop.



00-0062-A

Figure 33 – Circuit of the Scrambler

14.2 Modulation

The 4 144 bytes of the Scrambled Data Blocks are 8-bit bytes. They shall be modulated so that, after modulation, these 4 144 bytes are represented by 34 188 bits, grouped in 1 036 groups of 33 bits each.

14.2.1 Modulation process

These 4 144 bytes shall be operated on in groups of 4 at a time. Each group of 4 bytes shall be split into 8 nibbles of 4 bits each identified by N0 to N7, N0 being the least significant nibble. The bits of each nibble are identified by $N_{00}, N_{01}, N_{02}, N_{03}, N_{10} \dots N_{70}, N_{71}, N_{72}$ and N_{73} . At the end of the process 33 encoded bits are produced. At the end of the modulation process 8 N nibbles are transformed into seven 4-bit nibbles M0 to M4, M6 and M7 and one 5-bit nibble M5 (Figure 31). The bits of these M 4-bit nibbles are identified by M_{00}, M_{01}, M_{02} and $M_{03} \dots$ etc.; those of the 5-bit nibble M5 by M_{50} to M_{54} . At the start of the process the M nibble shall be set to the same pattern as the N nibbles, i.e $N0/M0, N1/M1, \dots, N7/M7$. The bits N_{50}, N_{51}, N_{52} and N_{53} of nibble N5 shall be placed in bit positions 4, 3, 2, and 1 of nibble M5, the setting of bit M_{50} in bit position 0 is initially undetermined.

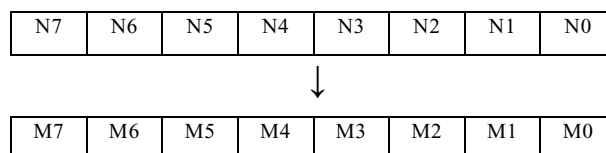


Figure 34 – Transformation of 32 bits into 33 bits

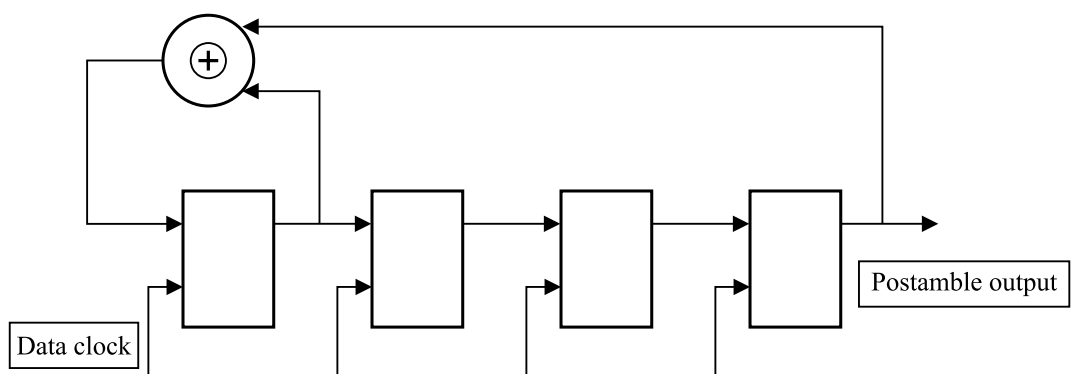
The algorithm to obtain the M nibbles shall as follows.

- i. If none of the N nibbles is set to all ZEROS, Bit M_{50} shall be set to ONE, all other bits remain unchanged.

- ii. If one N nibble is set to all ZEROs, Bits M_{50} shall be set to ZERO, Bit M_{52} shall be set to ONE, Bit M_{54} , M_{53} and M_{51} shall specify the ordinal number of the N nibble set to all ZEROs, all other bits remain unchanged. Unless nibble N5 is set to all ZEROs, the data from this nibble N5 shall be written into the M nibble having the same ordinal number as the N nibble set to all ZEROs.
- iii. If two N nibbles are set to all ZEROs, Bits M_{50} and M_{52} shall be set to ZERO, bit M_{43} shall be set to ONE, Bits M_{51} , M_{53} and M_{55} shall specify the ordinal number of one of the N nibbles that is set to all ZEROs. Bits M_{42} , M_{41} and M_{40} shall specify the ordinal number of the other N nibble that is set to all ZEROs. The setting of all other bits shall remain unchanged. The data from the N5 nibble shall be written into the left-hand side M nibble corresponding to the N nibble set to all ZEROs. The data from the N4 nibble shall be written into the M nibble corresponding to the second N nibble set to all ZEROs to the right-hand side of the second N nibble set to all ZEROs.
- iv. If 3 or more N nibble are set to all ZEROs, Bits M_{51} and M_{33} shall be set to ZERO, Bits M_{54} and M_{53} , M_{42} , M_{41} , M_{40} , M_{32} , M_{31} and M_{30} shall be set to ONE for each of the N nibble set to all ZEROs. All N nibbles not set to all ZEROs shall be assigned to the corresponding M nibbles as required. Where there are 4 or more nibbles set to all ZEROs, the M nibbles that are still set to all ZEROs, shall be set to ONE. Nibbles N3, N4 and N5 are assigned to M nibbles known to have been set to all ZEROs.

14.2.2 Modulated Data Group

A Postamble of 168 bits shall be added to these 1 036 groups, so that the complete Modulated Data Group consists of 34 356 bits. This Postamble shall be obtained by means of the circuit of figure 35. All stages shall be Type D flip flop. At the start of the computation they shall be set to 1000.

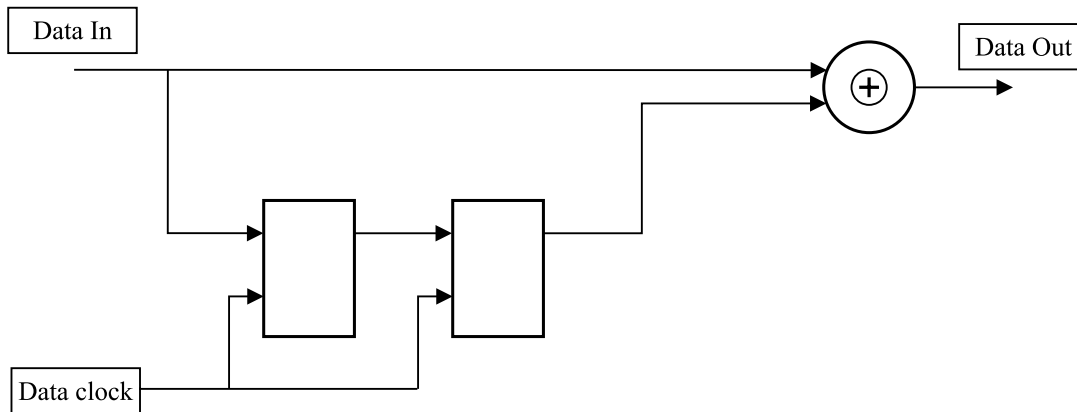


00-0063-A

Figure 35 - Circuit of the Postamble

14.3 Precoder

The Modulated Data Group shall be then processed through the Precoder of figure 36. Both stages shall be Type D flip flop. The corresponding algorithm is $Y_n = X_n \oplus Y_{n-2}$. In the initial state the precoder shall be set to ZERO ZERO.



01-0002-A

Figure 36 – Circuit of the Precoder

14.4 Recording Data Block

The Recording Data Block shall consist of the Precoded Data Block completed with a Preamble and a Sync preceding it. This Preamble and this Sync shall not be processed according to clause 13.

14.4.1 Preamble

The Preamble shall consist of 800 bit cell times. There shall be a flux transition at the end of the gap preceding the Preamble field. The Preamble field shall consist of flux transitions at intervals of 4 bit cell times. This shall be done 200 times.

14.4.2 Sync

The Sync shall consist of 37 bit cell times. A flux transition shall occur at the following bit cell intervals : 9 9 9 2 2 2 2.

Representation	Field
800 bit cells	Preamble
37 bit cells	Sync
34 356 bits	Precoded Data Block

Figure 37 – Recording Data Block

15 Types and Use of Blocks

15.1 Types of Blocks

There shall be six types of blocks.

- Data Blocks
- Track ID Start Blocks
- End of Track Blocks (EOTR)
- End of Data Blocks (EOD)
- ECC Blocks
- Track ID End Blocks

Blocks shall have the format shown in figure 29 (See 12.4). This figure shows a Data Block. All blocks, except ECC Blocks (See 15.2.4) shall have the same structure, but their Data Field shall not contain user data.

15.2 Use of blocks

15.2.1 Track ID Start Blocks

Track ID Blocks shall be located in the FAF2 only.

The Data Field of the Track ID Block is not specified by this ECMA Standard and shall be ignored in interchange. The Physical Block Number in the Control Field 2 of these blocks shall be set to (FFFF). The K Bit in the Control Field 2 of these blocks shall be set ONE.

15.2.2 End of Track Blocks (EOTR)

If the Envelope has been completely written, and there is less than 3 048 mm but more than 1 524 mm left to the BOT or EOT, then at least 74 EOTR Blocks shall be recorded on tape and the recording completed. If the Envelope is not completed, and there is less than 3 048 mm but more than 1 524 mm left to the BOT or EOT, a minimum of 74 EOTR blocks shall be recorded on tape and the recording ended. The completed Envelope is then recorded at the start of the next logical track.

The content of the Data Field of an EOTR Block is not specified by this ECMA Standard and shall be ignored in interchange.

15.2.3 End of Data of Data Blocks (EOD)

At least one Envelope of 120 EOD Blocks shall be recorded to indicate the end of the data recorded on the tape.

The content of the Data Field of an EOD Block is not specified by this ECMA Standard and shall be ignored in interchange.

15.2.4 ECC Blocks

The bytes of the four ECC Blocks shall be computed over the 4 096 bytes of the Data Field and the 16 bytes of CF1 of the preceding blocks of an Entity. The ECC check bytes shall be recorded in byte positions 0001 to 4112, thus the CF1 of ECC Blocks consist only of the 4-byte field.

The CF2 of ECC Blocks shall be as specified in 12.4.2.

The ECC Blocks shall be completed by a CRC computed as specified in 12.4.3.

Annex E specifies how the ECC bytes shall be computed.

15.2.5 Track ID End Blocks

Track ID End Blocks shall be located in the FAF2 only, immediately following the Track ID Start Blocks. The Physical Block Number in the Control Field 2 of these blocks shall be set to ZERO and the K Bit in shall be set to ONE. A minimum of one complete Envelope shall be written.

The content of the Data Field of the Track ID End Block is not specified by this ECMA Standard and shall be ignored in interchange.

16 Format of Entities

All blocks, except EOTR and EOD Blocks, shall be recorded in Entities. An Entity shall be recorded entirely on the same logical track. It shall consist of 20 blocks numbered consecutively from 1 to 20. At least block No. 1 shall be a Data Block. Blocks No. 2 to No. 16 shall be either Data Blocks or repeated Data Blocks.

- Block No. 17 shall be the ECC1 Block
- Block No. 18 shall be the ECC2 Block
- Block No. 19 shall be the ECC3 Block
- Block No. 20 shall be the ECC4 Block.

After computation of the ECC Blocks, the Data Blocks and the ECC Blocks are recorded on the tape. Each block shall be preceded by a gap consisting of a d.c. erased portion of tape of a nominal length of 100 bytes in 57 mm of which the read signal is less than 5 % of the Average Signal Amplitude.

17 Format of Envelopes

Entities shall be grouped in Envelopes. The number of Entities of an Envelope constitutes its size and shall be in the range 1 to 8. Each Entity within an Envelope shall be identified by its Entity Number (12.4.2.10) related to that Envelope. Envelopes shall not span logical tracks. After a write command from the host, recording shall start in a new Envelope immediately after the Envelope to which the append point is targeted. From this point on all existing data shall be overwritten. Within an Envelope, the blocks are recorded in any order on the physical track of the logical track.

18 Error handling

When a block is in error, it shall be re-written on any other physical track of the same logical track until it is written successfully (See also 12.4.2.2).

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.

For the purpose of this ECMA 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 obtained when no test piece is present. The transmittance value is expressed as the percentage ratio of the two readings. The requirement of a value of less than 5 % shall be met for the two wavelengths specified in A.2.1.

A.2 Description of the measuring equipment

The equipment shall comprise:

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

A.2.1 Radiation source

Two infra-red light-emitting diodes (LED) with the following parameters shall be used successively:

LED No. 1

Wavelength at peak emission : 750 nm \pm 50 nm

Half-power bandwidth : \pm 50 nm

LED No. 2

Wavelength at peak emission : 1 050 nm \pm 50 nm

Half-power bandwidth : \pm 50 nm

A.2.2 Radiation receiver

A flat silicon photo diode shall be used. It shall be operated 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 (Figure A.1)

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

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

where α is the angle where the relative intensity of the LED 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 (Figure A.2)

The components of the measuring circuitry are:

E : regulated power supply with variable output voltage

R : current-limiting resistor

LED : light-emitting diode

Di : silicon photo diode

A : operational amplifier

R_{f0} , R_{f1} : feedback resistors

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.

The output voltage of the operational amplifier is given by

$V_0 = I_k \times R_f$ where I_k is the short-circuit current of Di.

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

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

The following ratio applies:

$$\frac{R_{f0}}{R_{f1}} = \frac{1}{20}$$

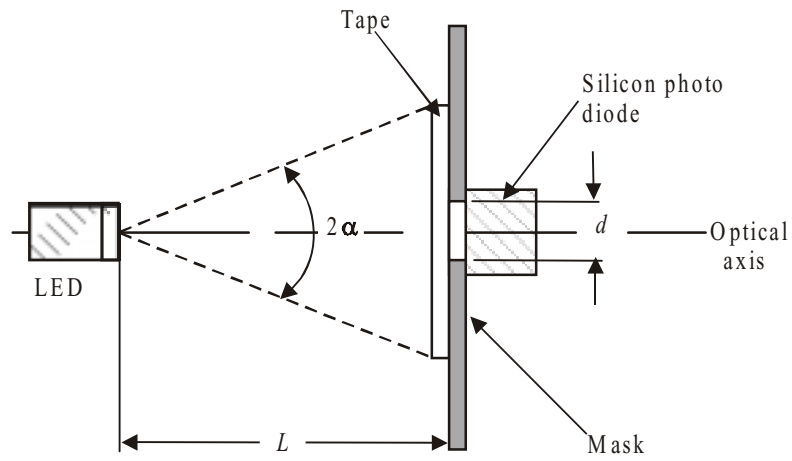
A.3 Measuring method

Set switch S to position 0.

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

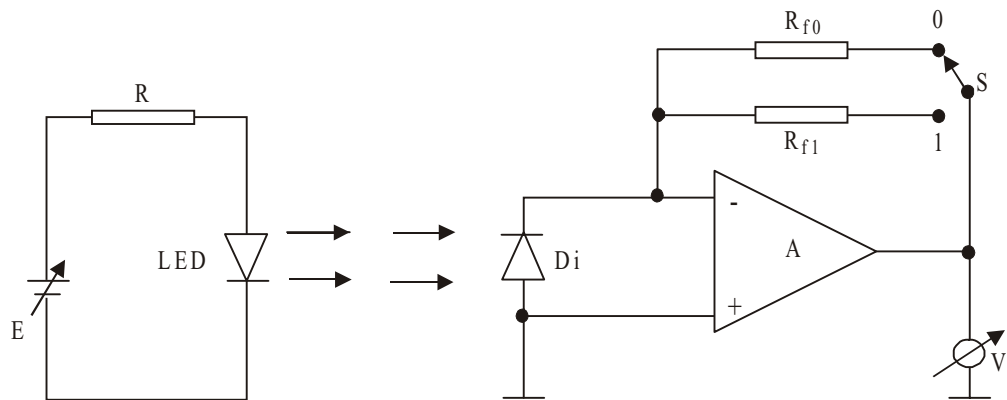
Mount a test piece of magnetic tape on the mask. Set switch S to position 1. Full deflection of the voltmeter now represents a light transmittance of 5 %.

Apply the method twice, once with LED No. 1 and once with LED No. 2.



93-0123-A

Figure A.1 - Optical arrangement



93-0124-B

Figure A.2 - Measuring circuitry

Annex B **(normative)**

Procedure for the measurement of abrasivity

B.1 General

Tape abrasivity is the tendency of the tape to wear the tape transport.

B.2 Test fixture

Install a clean ferrite wear bar made as shown in figure B.1 on a holding fixture similar to that shown in figure B.2. Test edge facing upward shall be unworn and free of chips or voids greater than 1 μm in size. The radius of the test edge shall not exceed 13 μm .

The ferrite bar shall consist of polycrystalline ferrite. It shall have the following weight percentages expressed in mole weight:

MgO	30 %
ZnO	17 %
Fe ₂ O ₃	53 %

It shall be 99 % dense. It shall have a hardness Knoop of 500.

The surface finish on all four sides of the bar shall be at least of roughness grade N2, 0,05 μm .

The wear bar shall be square within 0,05 mm.

NOTE

Such material is available under reference MND5200 from Ceramic Magnetics Inc., 16 Law Drive in Fairfield (NJ 07004).

B.3 Procedure

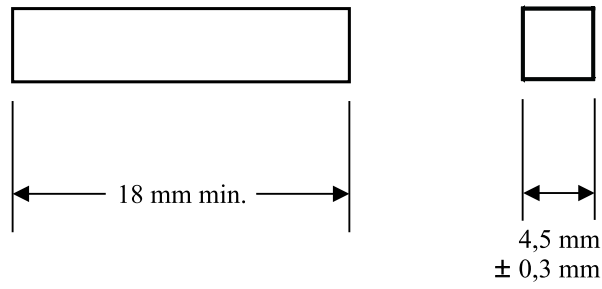
Install the test fixture (clause B.2) on a tape transport so that the wrap angle of the tape over the bar is 8° on each side, for 16° of total wrap;

Set the tape tension at the bar at 1,4 N.

With a tape speed of 2,54 m/s, make 600 passes (300 cycles) of the tape over the wear bar. The length of tape passing over the wear bar shall be 300,0 m \pm 3,0 m.

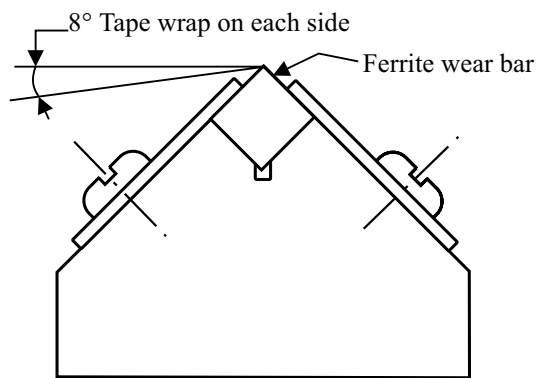
Remove the holding fixture from the transport and measure the length of the flat worn on the wear bar. This measurement is most easily made using a microscope of known magnification, a camera, and a reference reticule. Magnification of 300X or higher is recommended.

Measurements shall be taken at the 1/4, 1/2, and 3/4 points of the 12,65 mm width of the wear pattern. Take the average length calculated from the three readings. Figure B.3 shows a typical wear pattern and the points of measurements.



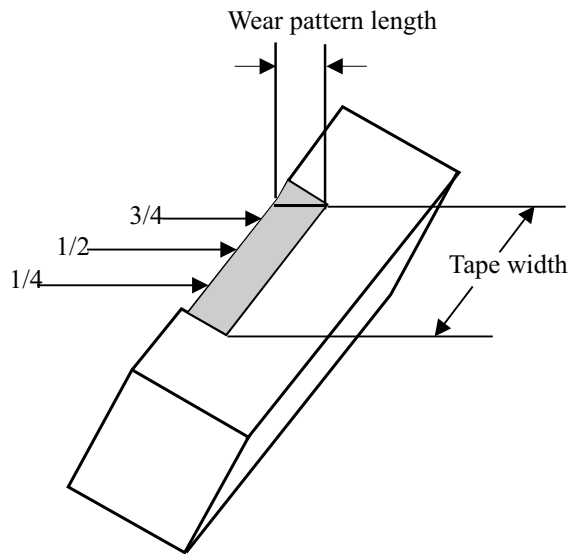
95-0010-B

Figure B.1 - Ferrite wear bar



94-0126-A

Figure B.2 - Wear bar holding fixture



94-0025-A

Figure B.3 - Typical wear bar pattern

Annex C
(normative)

Generation of the Data Block CRCs

The CRC field shall be recorded as a 64-bit check character computed over the 33 088 bits of the first 4 136 bytes of the Data Block, starting with the first byte of the Data Field and ending with the last byte of CF2.

These bits, with b_0 being the low-order bit, shall be the coefficients of the polynomial:

$$M(x) = \sum_{i=0}^{i=33088} b_i x^i$$

Let $P(x) = M(x) x^{64}$

The generating polynomial shall be

$$G(x) = x^{64} + x^{62} + x^{57} + x^{55} + x^{54} + x^{53} + x^{52} + x^{47} + x^{46} + x^{45} + x^{40} + x^{39} + x^{38} + x^{37} + x^{35} + x^{33} + x^{32} + x^{31} + x^{29} + x^{27} + x^{24} + x^{23} + x^{22} + x^{21} + x^{19} + x^{17} + x^{13} + x^{12} + x^{10} + x^9 + x^7 + x^4 + x + 1$$

The 64-bit CRC character shall be the remainder of the division of $P(x)$ by $G(x)$.

Annex D
(normative)

Generation of page CRCs

The CRC in each page shall be a 32-bit check character computed over the k bits of the Record or completed Record contained in the page.

These k bits b_0 to b_{k-1} , where b_0 is the low order bit, shall be the coefficient of the polynomial

$$M(x) = \sum_0^{k-1} b_i x^i$$

$$\text{Let } P(x) = M(x)x^{32}.$$

The remainder of the division of $P(x)$ by the generator polynomial

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

shall constitute the 32-bit CRC.

Annex E **(normative)**

ECC generation

E.1 The four ECC Blocks are designated by ECC1, ECC2, ECC3 and ECC4 (See clause 15). Each 8-bit byte of the ECC Blocks is computed over the corresponding bytes in the Data Fields, Pad bytes and CF1 of the first 16 blocks of an Entity. Thus, for each of the ECC Blocks:

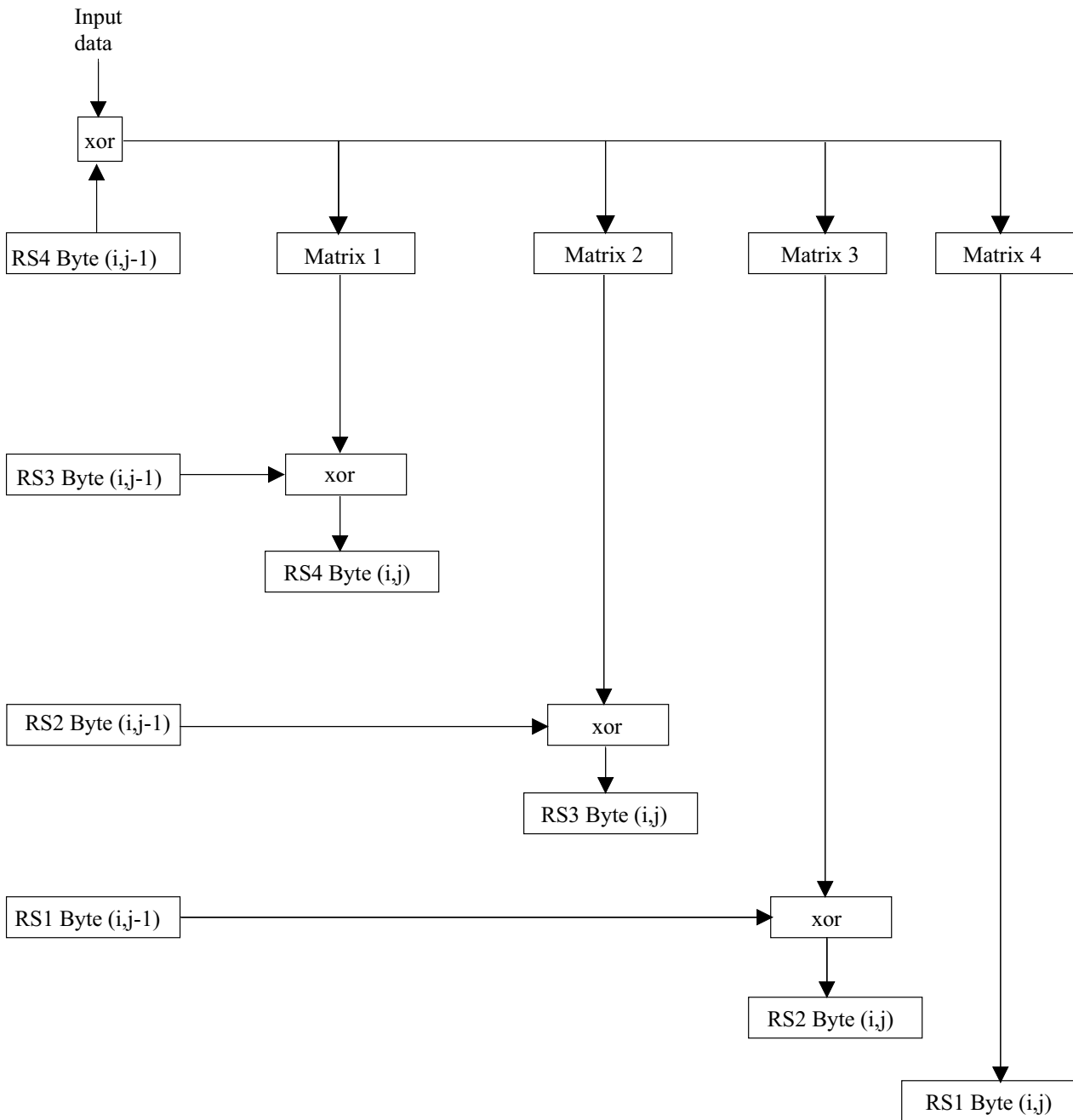
ECC1 (Byte i), ECC2 (Byte i), ECC3 (Byte i) and ECC4 (Byte i) are based on:

Block 1 (Byte i), Block 2 (Byte i), Block 3 (Byte i) ... and Block 16 (Byte i).

E.2 Each byte of the ECC Blocks is computed as follows.

- At the start of each ECC computation RS1 Byte (i,0), RS2 Byte (i,0), RS3 Byte (i,0) and RS4 Byte (i,0) are set to all ZEROs, where i indicates the position of the byte in the block.
- After passing each group of 16 bytes through the Reed-Solomon generator:
 - ECC1 Byte (i) → RS1 Byte (i,16)
 - ECC2 Byte (i) → RS2 Byte (i,16)
 - ECC3 Byte (i) → RS3 Byte (i,16)
 - ECC4 Byte (i) → RS4 Byte (i,16)

E.3 Figure C.1 summarises this process. In this figure i represents the position of the byte and j the Data Block number ($j = 1$ to 16).



94-0095-A

Figure E.1 - ECC Blocks

E.4 The matrices shown in figure C.1 shall be as follows.

- Matrix 4

07 = i7 xor i6 xor i5 xor i1;
06 = i6 xor i5 xor i4 xor i0;
05 = i5 xor i4 xor i3;
04 = i4 xor i3 xor i2;
03 = i6 xor i5 xor i3 xor i2;
02 = i7 xor i6 xor i4 xor i2;
01 = i7 xor i3;
00 = i7 xor i6 xor i2.

- Matrix 3

07 = i7 xor i5 xor i4 xor i3 xor i2 xor i1;
06 = i7 xor i6 xor i4 xor i3 xor i2 xor i1 xor i0;
05 = i6 xor i5 xor i3 xor i2 xor i1 xor i0;
04 = i7 xor i5 xor i4 xor i2 xor i1 xor i0;
03 = i6 xor i5 xor i2 xor i0;
02 = i7 xor i3 xor i2;
01 = i7 xor i6 xor i5 xor i4 xor i3;
00 = i6 xor i5 xor i4 xor i3 xor i2.

- Matrix 2

07 = i5 xor i3 xor i2;
06 = i4 xor i2 xor i1;
05 = i3 xor i1 xor i0;
04 = i2 xor i0;
03 = i5 xor i3 xor i2 xor i1;
02 = i5 xor i4 xor i3 xor i1 xor i0;
01 = i7 xor i5 xor i4 xor i0;
00 = i6 xor i4 xor i3.

- Matrix 1

07 = i7 xor i6 xor i5 xor i4;
06 = i7 xor i6 xor i5 xor i4 xor i3;
05 = i6 xor i5 xor i4 xor i3 xor i2;
04 = i7 xor i5 xor i4 xor i3 xor i2 xor i1;
03 = i5 xor i3 xor i2 xor i1 xor i0;
02 = i6 xor i5 xor i2 xor i1 xor i0;
01 = i7 xor i6 xor i1 xor i0;
00 = i7 xor i6 xor i5 xor i0.

Annex F
(normative)

Allocation of Physical Tracks to Logical Tracks

Band No.	Logical Tracks	Physical Tracks								Logical Tracks	Physical Tracks							
		Odd Forward									Even Reverse							
0	0	1	15	29	43	57	71	85	99	1	8	22	36	50	64	78	92	106
0	2	2	16	30	44	58	72	86	100	3	9	23	37	51	65	79	93	107
0	4	3	17	31	45	59	73	87	101	5	10	24	38	52	66	80	94	108
0	6	4	18	32	46	60	74	88	102	7	11	25	39	53	67	81	95	109
0	8	5	19	33	47	61	75	89	103	9	12	26	40	54	68	82	96	110
0	10	6	20	34	48	62	76	90	104	11	13	27	41	55	69	83	97	111
0	12	7	21	35	49	63	77	91	105	13	14	28	42	56	70	84	98	112
1	14	113	127	141	155	169	183	197	211	15	120	134	148	162	176	190	204	218
1	16	114	128	142	156	170	184	198	212	17	121	135	149	163	177	191	205	219
1	18	115	129	143	157	171	185	199	213	19	122	136	150	164	178	192	206	220
1	20	116	130	144	158	172	186	200	214	21	123	137	151	165	179	193	207	221
1	22	117	131	145	159	173	187	201	215	23	124	138	152	166	180	194	208	222
1	24	118	132	146	160	174	188	202	216	25	125	139	153	167	181	195	209	223
1	26	119	133	147	161	175	189	203	217	27	126	140	154	168	182	196	210	224
2	28	225	239	253	267	281	295	309	323	29	232	246	260	274	288	302	316	330
2	30	226	240	254	268	282	296	310	324	31	233	247	261	275	289	303	317	331
2	32	227	241	255	269	283	297	311	325	33	234	248	262	276	290	304	318	332
2	34	228	242	256	270	284	298	312	326	35	235	249	263	277	291	305	319	333
2	36	229	243	257	271	285	299	313	327	37	236	250	264	278	292	306	320	334
2	38	230	244	258	272	286	300	314	328	39	237	251	265	279	293	307	321	335
2	40	231	245	259	273	287	301	315	329	41	238	252	266	280	294	308	322	336
4	42	337	351	365	379	393	407	421	435	43	344	358	372	386	400	414	428	442
4	44	338	352	366	380	394	408	422	436	45	345	359	373	387	401	415	429	443
4	46	339	353	367	381	395	409	423	437	47	346	360	374	388	402	416	430	444
4	48	340	354	368	382	396	410	424	438	49	347	361	375	389	403	417	431	445
4	50	341	355	369	383	397	411	425	439	51	348	362	376	390	404	418	432	446
4	52	342	356	370	384	398	412	426	440	53	349	363	377	391	405	419	433	447
4	54	343	357	371	385	399	413	427	441	55	350	364	378	392	406	420	434	448

Annex G

(informative)

Recommendations for transportation

G.1 Environment

It is recommended that during transportation the cartridges be kept within the following conditions:

G.1.1 Unrecorded cartridges

Temperature	: 23 °C to 48 °C
Relative humidity	: 5 % to 100 %
Duration	: 10 consecutive days max.

There shall be no condensation in or on the cartridge.

G.1.2 Recorded cartridges

Temperature	: 5 °C to 32 °C
Relative humidity	: 5 % to 80 %

There shall be no condensation in or on the cartridge.

G.2 Hazards

Transportation of recorded cartridges involves three basic potential hazards.

G.2.1 Impact loads and vibration

The following recommendations should minimise damage during transportation.

- i. Avoid mechanical loads that would distort the cartridge shape.
- ii. Avoid dropping the cartridge more than 1,0 m.
- iii. Cartridges should be fitted into a rigid box containing adequate shock-absorbent material.
- iv. The final box must have a clean interior and construction that provides sealing to prevent the ingress of dirt and water.
- v. The orientation of the cartridges within the final box should be such that the axes of the hubs are horizontal.
- vi. The final box should be clearly marked to indicate its correct orientation.

G.2.2 Extremes of temperature and humidity

- i. Extreme changes in temperature and humidity should be avoided whenever possible.
- ii. Whenever a cartridge is received it should be conditioned in the operating environment for a period of at least 24 h.

G.2.3 Effects of stray magnetic fields

A nominal spacing of not less than 80 mm should exist between the cartridge and the outer surface of the shipping container. This should minimise the risk of corruption.

Annex H
(informative)

Inhibitor tape

Any tape that reduces the performance of the tape drive or other tapes is called an inhibitor tape. Certain tape characteristics can contribute to poor tape drive performance. These characteristics include: high abrasivity, high static friction to tape path components, poor edge conditions, excessive tape wear debris, 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. Tapes that have these characteristics may not give satisfactory performance and can result in excessive errors.

Tapes to be used in this cartridge should not be inhibitor tapes.

Annex J

(informative)

Recommendations on tape durability

The durability/reliability test assesses the ability of the tape to resist the wearing action encountered while cycling the tape on a tape drive. This is not a test for end of life for the tape or for the ability of the drive to recover data from erroneous blocks.

When delivered from the supplier the tape of a new cartridge should meet the following requirements.

Testing and measurements performed on the cartridge using an appropriate drive are described below. The test must be performed in the operating environment (See 6.2) for the tape and the tape drive.

- J.1** The durability/reliability is the ability of the tape to withstand the wearing action encountered during repeated access to a file of data. A permanent missing pulse is one that persists for ten consecutive read passes.
- J.2** If after 20 000 passes, 3 blocks of one of 10 Entities are found in error, the tape is considered as having failed to pass the test. An error means that all three blocks have had at least one missing pulse each.
- J.3** If after 250 000 passes, 5 blocks of one of 10 Entities are found in error, the tape is considered as having failed to pass the test. An error means that all 5 blocks have had at least one missing pulse each.

J.4 Procedure

Ensure the tape drive is clean before starting this test.

As a test sample, use a minimum of four cartridges. The test area should consist of at least 1 m of tape or 10 Entities.

Each test cycle consists of starting at the beginning of the test area and accessing each record in the test area before returning to the beginning of the test area. Seven attempts to read should be made for each missing pulse before a missing pulse zone is logged.

Tape path cleaning between passes is not permitted for this test.

Annex K
(informative)

Handling guidelines

K.1 General

- K.1.1** Do not carry cartridges loosely in a container that would submit cartridges to unnecessary physical shock.
- K.1.2** Leave cartridges in protective case until ready for use in tape unit.
- K.1.3** Avoid unnecessary opening of cartridge lid exposing tape to possible contamination or physical damage or both. Do not allow direct contact with tape.
- K.1.4** Do not expose the tape cartridge to moisture or direct sunlight.
- K.1.5** Maintain a clean operating, working and storage environment.
- K.1.6** Do not place cartridges on or near devices that may produce a magnetic field.

K.2 Labels

- K.2.1** Use labels provided by the cartridge supplier. Other labelling techniques may interfere with normal cartridge operation.
- K.2.2** Do not use graphite pencils, water soluble felt pens, or other debris-producing writing instruments on labels. Never erase a label - replace it.

K.3 Storage

The protective case containing the cartridge is to be stored vertically.

Free printed copies can be ordered from:

ECMA

114 Rue du Rhône

CH-1204 Geneva

Switzerland

Fax: +41 22 849.60.01

Email: documents@ecma.ch

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ECMA
114 Rue du Rhône
CH-1204 Geneva
Switzerland

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