ECMA
EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-120

DATA INTERCHANGE ON 12,7 mm 18-TRACK MAGNETIC TAPE CARTRIDGES

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BRIEF HISTORY

In 1985 ECMA decided to produce an ECMA Standard for a 12,7 mm, 18-Track Magnetic Tape Cartridge. Considerable work was invested in this project so that an urgently needed standard would be produced rapidly.

Three areas in particular have received close attention in order to effect an improvement on earlier standards for magnetic tapes for digital data interchange.

i) The requirements for magnetic properties have previously been defined by relating the performance of the tape under test to that of a Standard Reference Material (SRM). It is desirable that such SRMs are established and maintained by a national laboratory and the industry is indebted to National Bureau of Standards in Washington for those for magnetic tapes. The establishment of such an SRM is protracted and the cost cannot be recouped by the sales of Secondary Standard Reference Tapes.

   In this Standard the need for an SRM has been removed by the incorporation of new and more fundamental tests to measure the performance of the tape in basic units (5.14, 5.15, 5.16 and 5.18).

ii) The signal-to-noise ratio and the amplitudes of the signals from a tape recorded for interchange have previously been measured by comparison with the Standard Reference Amplitude (SRA) read from the SRM. Here more fundamental measurements are specified (7.9).

iii) The timing errors of the interchanged tape have previously been measured using a read head and read amplifier of defined characteristics. Here the performance of the read chain has largely been eliminated by assessing the performance of the write chain via the recorded signals (7.7).

Extensive work is still proceeding in several laboratories to confirm the effectiveness of these new tests in defining the requirements for a tape and a write chain to satisfy the needs of the system. It has been decided to publish the Standard in its present form in order to meet the needs of users and industry; it is intended that these aspects shall be reviewed for the next edition of the Standard.

Upon request of ISO/TC97/SC11 this ECMA Standard has been contributed to ISO for further processing as an international standard under the ISO fast-track procedure.

Adopted as an ECMA Standard by the General Assembly of ECMA on Dec. 11, 1986.

TABLE OF CONTENTS

SECTION I

SCOPE AND CONFORMANCE

REFERENCES

DEFINITIONS

1. SCOPE AND CONFORMANCE

1.1 Scope

This ECMA Standard specifies the physical and magnetic characteristics of a 12,7 mm wide, 18-track magnetic tape cartridge, to enable interchangeability of such cartridges. It also provides a format and recording method, thus allowing, together with Standard ECMA-13 for Magnetic Tape Labelling, full data interchange by means of such magnetic tape cartridges.

1.2 Conformance

A magnetic tape cartridge conforms to this Standard if it satisfies all the requirements of Sections II to IV.

2. REFERENCES

ECMA-6	: 7-bit Input/Output Coded Character Set
ECMA-35	: Code Extension Techniques
ECMA-43	: 8-bit Code - Structure and Rules.
ISO 1302	: Method of indicating surface structure on technical drawings
ISO 683/XIII	: Wrought stainless steels

3. DEFINITIONS

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

3.1 Cartridge

A container holding a supply reel of magnetic tape with an attached leader block.

3.2 Data Density

The number of 8-bit bytes stored per unit length of tape, expressed in bytes per millimetre.

3.3 Flux Transition Spacing

The distance between successive flux transitions.

3.4 Flux Transition Position

That point which exhibits maximum free-space flux density normal to the tape surface.

3.5 Magnetic Tape

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

3.6 Physical Recording Density

The number of recorded flux transitions per unit length of track, expressed in flux transitions per millimetre (ftpmm).

3.7 Track

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

4. 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 equipment.

4.1 Cartridge/Tape Testing Environment

Tests and measurements made on the tape to check requirements of this Standard shall be carried out under the following conditions:

Temperature	: 23 °C ± 2 °C
Relative Humidity	: 40% to 60%
Conditioning before testing	: 24 hours.

4.2 Cartridge Operating Environment

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

Temperature	: 16 °C to 32 °C
Relative Humidity	: 20% to 80%
Maximum Wet Bulb	: 25,6 °C

The temperature of the air immediately surrounding the tape shall not exceed 40,5 °C.

Conditioning before operating: if a cartridge has been exposed during storage and/or transportation to conditions outside the above values, it shall be conditioned for a period of at least 24 hours.

4.3 Cartridge Storage Environment

Cartridges used for data interchange shall be stored under the following conditions.

Temperature	: 5 °C to 32 °C
Relative Humidity	: 5% to 80%
Maximum Wet Bulb	: 27 °C

4.4 Safety Requirements

4.4.1 Safeness

The cartridge and its components shall not constitute any safety or health hazard when used in its intended manner or in any foreseeable misuse in an information processing system.

4.4.2 Flammability

The cartridge and its components shall be made from materials which, if ignited from a match flame, and when so ig-

nited do not continue to burn in a still carbon dioxide atmosphere.

SECTION II

CHARACTERISTICS OF THE TAPE

5. CHARACTERISTICS OF THE TAPE

5.1 Material

The tape shall consist of a base material (oriented polyethylene terephthalate film or its equivalent) coated on one side with a strong yet flexible layer of ferromagnetic material dispersed in a suitable binder. The back surface of the tape may also be coated with a ferromagnetic or non-ferromagnetic material.

5.2 Tape Length

The length of the tape shall not be less than 165 m.

5.3 Tape Width

The width of the tape shall be 12,650 mm ± 0,025 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.

5.4 Tape Discontinuity

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

5.5 Total Thickness of Tape

The total thickness of the tape at any point shall be between 0,0259 mm and 0,0337 mm.

5.6 Base Material Thickness

The thickness of the base material shall be 0,0234 mm nominal.

5.7 Longitudinal Curvature

The radius of curvature of the edge of the tape shall not be less than 33 m.

Procedure

Allow a 1 m length of tape to unroll and assume its natural curvature on a flat smooth surface. Measure the deviation from a 1 m chord. The deviation shall not be greater than 3,8 mm. This deviation corresponds to the minimum radius of curvature of 33 m if measured over an arc of circle.

5.8 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.

5.9 Cupping

The departure across the width of tape from a flat surface shall not exceed 0,3 mm.

Procedure

Cut a 1,0 m ± 0,1 m length of tape. Condition it for a minimum of 3 hours in the test environment by hanging it so that the coated surface is freely exposed to the test environment. From the centre portion of the conditioned tape cut a sample of 25 mm length. Stand the sample on its end in a cylinder which is at least 25 mm high with an inside diameter of 13,0 mm ± 0,2 mm. With the cylinder standing on an optical comparator measure the cupping by aligning the edges of the sample to the reticle and determining the distance from the aligned edges to the corresponding surface of the sample at its centre.

5.10 Dynamic Frictional Characteristics

In the tests of 5.10.1 and 5.10.2 the specified forces of 1,0 N and 1,50 N, respectively, comprise both the force component of the dynamic friction and the force of 0,64 N applied to the sample of tape.

5.10.1 Frictional Drag Between the Recording Surface and the Tape Back Surface

The force required to move the recording surface in relation to the back surface shall not be less than 1,0 N.

Procedure

i) Wrap a sample of tape around a 25,4 mm diameter circular mandrel with the back surface of the sample facing outward.

ii) Place a second sample of tape, with the recording surface facing in, around the first sample for a total wrap angle of 90°.

iii) Apply a force of 0,64 N to one end of the outer sample of tape. Secure its other end to a force gauge which is mounted on a motorized linear slide.

iv) Drive the slide at a speed of 1 mm/s.

5.10.2 Frictional Drag Between the Tape Recording Surface and Ferrite after Environmental Cycling

The force required to move the tape at a point 1,34 m from the leader block of the cartridge shall not be greater than 1,50 N. The force required at a point 4,3 m from the junction of the tape with the cartridge hub shall not exceed the first force by more than a factor of 4.

Procedure

i) Wind a tape on to a spool hub of diameter 50 mm to an outside diameter of 97 mm with a winding tension of 2,2 N nominal.

ii) Repeat the following two steps five times:

a) Store for 48 hours at a temperature of 50 °C and a relative humidity of 10% to 20%.

b) Acclimatize in the testing environment for two hours and rewind with a tension of 2,2 N nominal.

iii) Acclimatize the tape for 48 hours at a temperature of 30,5 °C and a relative humidity of 85%. The tape shall remain in this environment for steps iv) and v).

iv) Apply a force of 0,64 N to one end of a sample taken 1,34 m from the leader block. Pass the sample over a ferrite rod of diameter 25,4 mm with the recording surface in contact with the rod.

The rod shall be made from the ferrite specified in Appendix C. It shall be polished to a roughness value R_a of 0,05 um (roughness grade N2, ISO 1302). Pull the other end of the sample horizontally at 1 mm/s.

v) Repeat step iv) for a sample taken 4,3 m from the junction of the tape with the cartridge hub.

5.11 Coating Adhesion

The force required to peel any part of the coating from the tape base material shall not be less than 1,5 N.

Procedure

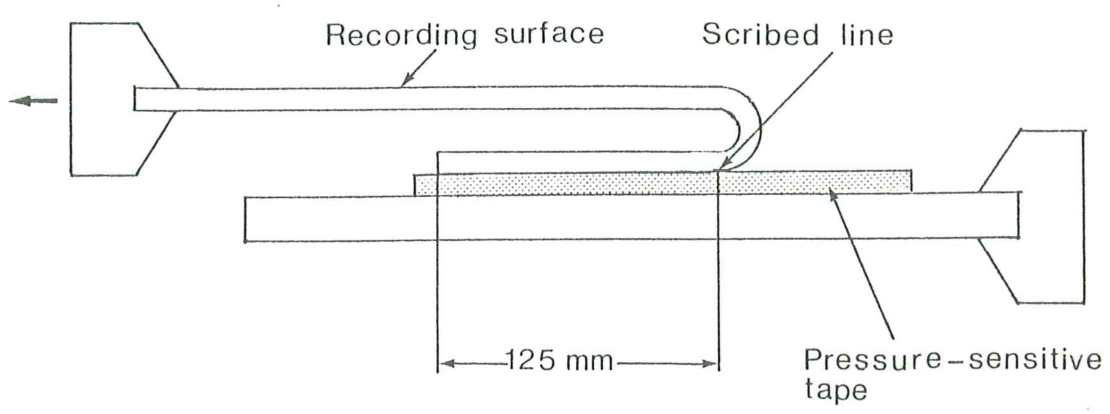
i) Take a sample of the tape approximately 300 mm long and scribe a line through the recording coating across the width of the tape 125 mm from one end.

ii) Using a double-sided pressure sensitive tape, attach the sample to a smooth metal plate, with the recording surface facing the plate, as shown in the figure below.

iii) Fold the sample over 180°, attach the metal plate and the free end of the sample 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 1,5 N, the test has failed. If the sample peels away from the double-sided pressure sensitive tape before the force exceeds 1,5 N, an alternative type of double-sided pressure sensitive tape shall be used.

v) If the back surface of the tape is coated, repeat i) to iv) for the back coating.



5.12 Flexural Rigidity

The flexural rigidity of the tape in the longitudinal direction shall be between 0,06 $N.mm^2$ and 0,16 $N.mm^2$.

Procedure

Clamp a 180 mm sample of tape in a universal testing machine, allowing a 100 mm separation between the machine jaws. Set the jaw separation speed at 5 mm per minute. Plot force against distance. Calculate the flexural rigidity using the slope of the curve between 2,2 N and 6,7 N. The calculation is :

$$E = \frac{\delta F/WT}{\delta L/L}$$

$$I = WT^3/12$$

$$\text{Flexural rigidity} = EI = \frac{\delta FT^2}{12\delta L/L}$$

Where:

δF = change in force in N

T = measured thickness in mm

W = measured width in mm

$\delta L/L$ = change in sample length between the jaws divided by original length between the jaws.

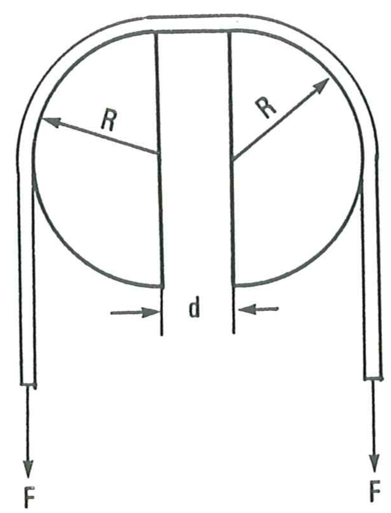
5.13 Electrical Resistance of the Recording Surface

The electrical resistance of any square area of the magnetic surface shall be within the range:

10^5 Ohm to 5.10^9 Ohm

Procedure

Condition a sample of tape to the test environment for 24 hours. Position the sample 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. These electrodes shall be placed parallel to the ground and parallel to each other at a distance d = 12,7 mm between their centres. Apply a force F of 1,62 N to each end of the sample. Apply a DC voltage of 500 V ± 10 V across the electrodes and measure the resulting current flow. From this value, determine the electrical resistance.



When mounting the sample, make sure that no conducting paths exist between the electrodes except those through the magnetic coating. To avoid contamination of the sample or insulating surface, clean lint-free gloves should be used during all measurements.

5.14 Magnetic Coercivity

The coercive force of the recording coating shall be 41,4 kA/m ± 2,4 kA/m when measured in the longitudinal direction.

Procedure

This test should be performed using an EG&G Princeton Applied Research Model 155 Vibrating Sample Magnetometer or equivalent. The magnetometer must be operated in accordance to the manufacturer's operating procedures and calibrated. The following instructions shall be complied with.

i) Cut a sample disk of diameter 10 mm to 12 mm from the parent tape. If the tape has a ferro-magnetic back coating, this shall be removed.

Mount the sample in the magnetometer so that it will be horizontal to the magnetic field, with the direction parallel to the edge of the parent tape (i.e. the longitudinal direction of the sample) parallel to the magnetic field.

ii) Make the time constant of the lock-in amplifier compatible with the cycle time required by iii).

iii) Cycle the sample 0, +350 kA/m, 0, -350 kA/m, 0 for four cycles, with a period of 10 minutes per cycle.

iv) Continue iii) to +350 kA/m, reduce to 0, then, over a period of 2,5 minutes, increase the magnetizing force (H) in the negative direction until the magnetization is reduced to 0.

v) Note the value of this negative field strength. This is the magnetic coercivity.

5.15 Magnetic Particle Orientation

The squareness is the ratio of the residual flux density to the saturation density. The magnetic particle orientation is the ratio of the squareness in the longitudinal direction of the parent tape divided by the squareness in the direction perpendicular to the edge of the parent tape.

The magnetic particle orientation shall not be less than 2,0 and the squareness in the longitudinal direction shall be greater than 0,80.

The test shall be performed using the sample, the equipment and the procedure specified in 5.14.

5.16 Remanence

The remanence is the magnetic flux density of the tape after removal of a magnetizing force.

After subjecting the tape to a magnetizing force of 350 kA/m as in 5.14 and 5.15 during production, the value of the remanence is a maximum.

Before recording as in 7 and before carrying out the tests in 5.19, it is necessary to ensure that the remanence of the tape does not exceed 20% of the maximum value.

Procedure

The remanence shall be measured using a Vibrating Sample Magnetometer (see 5.14).

i) Cut a sample disk of diameter 10 mm to 12 mm from the parent tape. Mount the sample in the magnetometer so that it will be horizontal to the magnetic field, with the direction parallel to the edge of the parent tape (i.e. the longitudinal direction of the sample) parallel to the magnetic field.

ii) Centre the sample between the poles of the magnetometer in accordance with the instructions of the manufacturer of the VSM. The sample shall not be exposed to any stray or ambient magnetic field during preparation or mounting.

iii) Note the remanence of the sample.

iv) Rotate the sample through 180° and repeat steps ii) and iii).

v) Cycle the sample 0, +350 kA/m, 0, -350 kA/m, 0 for four cycles.

vi) Note the positive and negative values of the maximum remanence.

vii) Calculate the ratio of the peak excursion between iii) and iv) to the peak excursion in vi).

5.17 Tape Abrasivity

Tape abrasivity is the tendency of the tape to wear the tape transport. The length of the wear pattern on a wear bar shall not exceed 56 um when measured as specified in Appendix C.

5.18 Magnetic Recording Characteristics

The magnetic recording characteristics shall be as follows.

5.18.1 Effective magnetic separation

The EMS is a measure of the density response after read-gap-loss correction.

The EMS of the tape shall not be greater than 0,41 um.

Procedure

Test conditions

- The tape shall be initially AC erased.
- The tape speed shall be 0,76 m/s.
- The width of the write track shall not be less than that of the read track.
- The length of the write gap shall be 1,0 um ± 0,2 um.
- The resonant frequency of the read-head shall not be less than 4 MHz.
- The tape tension shall be 2,2 N ± 0,2 N.
- The read-gap loss function shall be known.
- The write current shall be that producing the maximum read-signal amplitude at 1944 ftpmm.

Using a spectrum analyzer, measure the signal amplitude at 1944 ftpmm and at 972 ftpmm over the same length of tape and compensate for the gap loss effect.

Compute the EMS as follows:

$$EMS = \frac{10^3 \ln \frac{E_1}{E_2}}{972 \pi}$$

where:

E_1 is the average signal amplitude at 972 ftpmm compensated for gap loss.

E_2 is the average signal amplitude at 1944 ftpmm compensated for gap loss.

5.18.2 Narrow band signal-to-noise ratio (NB-SNR)

The ratio of the average signal amplitude power to the average integrated (side band) noise power shall not be less than 27 dB .

Procedure

Test conditions

- The tape shall be initially AC erased.
- The tape speed shall be 0,76 m/s.
- The width of the read track shall be 410 um.
- The width of the write track shall not be less than that of the read track.
- The length of the write gap shall be 1,0 um ± 0,2 um.
- The resonant frequency of the read head shall not be less than 4 MHz.
- The tape tension shall be 2,2 N ± 0,2 N.
- The write current shall be that producing the maximum read signal amplitude at 972 ftpmm.
- The spectrum analyzer shall have a resolution bandwidth of 1 kHz and a video bandwidth of 10 Hz.

i) Measure the read-signal amplitude at 972 ftpmm of at least 150 samples over a 46 m length of the tape, using the spectrum analyzer.

ii) Measure the noise power at least ten times over the same 46 m of tape and integrate it over the range from 332 kHz to 366 kHz.

iii) The read-signal amplitude shall not be compensated for gap loss.

5.18.3 Broad band signal-to-noise ratio (BB-SNR)

The ratio of the average signal amplitude power to the average integrated broad band floor noise power shall not be less than 36 dB when normalized to a track width of 410 um.

Procedure

Test conditions

- The tape shall be initially AC erased.
- The tape speed shall be 0,76 m/s.
- The width of the write track shall not be less than that of the read track.
- The length of the read gap shall not exceed 0,5 um.
- The length of the write gap shall be 1,0 um ± 0,1 um.
- The resonant frequency of the read head shall not be less than 4 MHz.
- The tape tension shall not exceed 2,4 N.
- The write current shall be that producing the maximum read signal amplitude at 972 ftpmm.
- The spectrum analyzer shall have a resolution bandwidth of 3 kHz and a video bandwidth of 30 Hz.

i) Measure the read-signal amplitude at 972 ftpmm of at least 150 samples over a 46 m length of the tape, using the spectrum analyzer.

ii) Measure the noise power at least ten times over the same 46 m of tape and integrate it over the range from 37 kHz to 330 kHz.

iii) The read-signal amplitude shall not be compensated for gap loss.

5.19 Tape Quality

The conditions for the following tests shall be:

- The tape speed shall be 2 m/s.
- The physical recording density shall be 972 ftpmm.
- The length of the write gap shall be 1,0 um ± 0,2 um.
- The write current shall be the current that produces the maximum read signal amplitude at 972 ftpmm.
- The track layout shall be as specified in 8.
- The width of the read track shall be 410 um.

5.19.1 Missing pulses

A missing pulse is a loss of read-back signal amplitude. A missing pulse exists when the read-back signal amplitude is less than 25% of the average read-back signal amplitude measured over the preceding consecutive 25000 flux transitions, exclusive of missing pulses.

5.19.2 Missing pulse zones

A missing pulse zone begins with a missing pulse and ends when 64 consecutive flux transitions are detected or a length of 1 mm of tape has been measured.

i) The missing pulse zone rate shall be less than one in 8×10^6 flux transitions recorded.

ii) The total length of all zones shall not exceed 50 mm on each track.

5.19.3 Coincident missing pulse zones

There are two 9-track groups in the 18-track format. One group comprises the odd-numbered tracks, the other group comprises the even-numbered tracks. A simultaneous missing pulse zone condition on two or more tracks of a 9-track group is a coincident missing pulse zone.

If a coincident missing pulse zone occurs at the same time in both groups of tracks, it shall be considered as a single coincident missing pulse zone. Its length shall begin with the start of the earliest coincident missing pulse zone and terminate with the end of the latest coincident missing pulse zone.

There shall not be more than 10 coincident missing pulse zones per cartridge.

No coincident missing pulse zone shall exceed 50 mm.

SECTION III

CARTRIDGE

6. DIMENSIONAL AND MECHANICAL CHARACTERISTICS OF THE CARTRIDGE

The cartridge shall consist of the following elements:

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

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. In the enclosed drawings a typical implementation is represented in third angle projection.

Where they are purely descriptive the dimensions are referred to three Reference Surfaces A, B and C forming a geometrical trihedral (see Fig. 1). Where the dimensions are related to the position of the cartridge in the drive, they may be referred to another surface of the cartridge. Fig. 2 to 8 show the dimensions of the empty case.

Fig. 1 is a general view of the whole cartridge.

Fig. 2 shows the front side of the case which lies on Reference Surface A,

Fig. 3 shows the top side of the case,

Fig. 4 shows the rear side of the case,

Fig. 5 shows the bottom side of the case which lies in Reference Surface C,

Fig. 6 shows the side of the case which lies in Reference Surface B,

Fig. 7 shows an enlarged view of a part of Fig. 2,

Fig. 8 shows an enlarged cross-section of a location notch,

Fig. 9 shows an enlarged cross-section of a detail of the opening of the case,

Fig. 10 shows an enlarged partial cross-section of the cartridge in hand,

Fig. 11 shows the same cross-section as Fig. 9 but of the cartridge in the drive,

Fig. 12 shows schematically the teeth of the toothed rim,

Fig. 13 shows two views and an enlarged cross-section of the leader block,

Fig. 14 shows the fixation of the tape to the leader block, and

Fig. 15 shows the leader block inserted in the case.

6.1 Overall Dimensions (Fig. 2-4)

The overall dimensions of the case shall be

L_1 = 125,00 mm ± 0,32 mm

L_2 = 109,00 mm ± 0,32 mm

$$L_3 = 24{,}50\ \text{mm} \begin{cases} +\ 0{,}50\ \text{mm} \\ -\ 0{,}32\ \text{mm} \end{cases}$$

The corners of the case shall be rounded off as specified by

R_1 = 3,00 max.

R_2 = 4,00 max.

R_3 = 3,00 min.

6.2 Write-inhibit Mechanism (Fig. 2, 3)

The write-inhibit mechanism shall have a flat surface identified by a visual mark, e.g. a white spot, when in the position in which writing is inhibited. This Standard does not prescribe the actual implementation of the write-inhibit mechanism. For example, it can be a rotatable or a slidable element.

The front side of the case shall have a window specified by

L_4 = 11,80 mm ± 0,25 mm

L_5 = 15,60 mm ± 0,25 mm

L_6 = 7,40 mm ± 0,25 mm

L_7 = 12,00 mm ± 0,25 mm

In the write-inhibit position the flat surface of the write-inhibit mechanism shall be behind this window at a distance

L_8 = 2,55 mm min.

from the front side of the case.

In the write-enable position this surface shall be within 0,25 mm of the front side of the case.

The force required for the operation of the write-inhibit mechanism shall be in the range

2 N to 9 N

when applied tangentially to the surface of the case.

6.3 Label Area of the Rear Side (Fig. 3-4)

On the rear side of the case there shall be a label area specified by

L_9 = 7,00 mm ± 0,25 mm

$$L_{10} = 80{,}00\ \text{mm} \begin{cases} +\ 0{,}30\ \text{mm} \\ -\ 0{,}16\ \text{mm} \end{cases}$$

L_{11} = 12,30 mm ± 0,25 mm

L_{12} = 0,50 mm ± 0,25 mm

R_4 = 1,00 max.

6.4 Label Area of the Top Side (Fig. 3)

On the top side of the case there shall be a label area specified by L_9, L_{10}, L_{12} and in addition by

L_{13} = 31,00 mm ± 0,25 mm

$$L_{14} = 75{,}00\ \text{mm} \begin{cases} +\ 0{,}30\ \text{mm} \\ -\ 0{,}16\ \text{mm} \end{cases}$$

6.5 Opening of Case (Fig. 2, 3, 5 and 7)

The case shall have an opening for the tape in which the leader block can be inserted (see also Fig. 14). This opening shall be specified by

L_{15} = 4,70 mm ± 0,25 mm

L_{16} = 14,90 mm ± 0,32 mm

L_{17} = 7,50 mm ± 0,25 mm

L_{18} = 87,10 mm ± 0,25 mm

L_{19} = 4,00 mm ± 0,25 mm

R_5 = 4,00 mm ± ',25 mm

α = 50° ± 1°

Moreover, Fig. 7 shows at a larger scale the details of the configuration of the case opening as seen at the right-hand side of Fig. 2.

L_{61} = 3,40 mm ± 0,50 mm

L_{62} = 17,70 mm ± 0,50 mm

L_{63} = 3,00 mm ± 0,50 mm

ω_1 = 1° ± 30'

ω_2 = 20° ± 2°

6.6 Locating Notches (Fig. 5, 6 and 8)

There shall be two locating notches open toward the bottom side. These location notches shall be specified by

L_{20} = 106,00 mm ± 0,25 mm

L_{21} = 5,00 mm ± 0,25 mm

L_{22} = 7,00 mm ± 0,25 mm

L_{23} = 104,00 mm ± 0,25 mm

L_{24} = 2,50 mm ± 0,25 mm

β = 1°30' ± 30'

γ = 2° ± 30'

6.7 Locating Areas (Fig. 5)

The bottom side of the case shall have three circular locating areas a_1, a_2 and a_3 which shall lie in the same horizontal plane within 0,25 mm.

Areas a_1 and a_2 shall have a diameter of 10,00 mm ± 0,25 mm. The position of their centre shall be specified by

L_{25} = 108,50 mm ± 0,25 mm

L_{26} = 3,50 mm ± 0,25 mm

L_{27} = 105,00 mm ± 0,25 mm

Area a_3 shall have a diameter of 14,00 mm ± 0,25 mm. The position of its centre shall be specified by

L_{28} = 31,25 mm ± 0,25 mm

L_{29} = 54,50 mm ± 0,25 mm

6.8 Inside Configuration of the Case around the Case Opening (Fig. 5 and 9)

Fig. 5 and 9 show the inside configuration of the case around the opening of the case. This configuration shall be defined as follows (see also 6.10)

L_{30} = 3,30 mm ± 0,25 mm

L_{31} = 18,40 mm ± 0,25 mm

R_6 = 1,50 mm ± 0,25 mm

R_7 = 1,50 mm ± 0,25 mm

The oblique edge of the case shall be tangential to the arc of circle defined by R_6 at an angle

λ = 40° ± 30'

6.9 Other External Dimensions of the Case (Fig. 6)

The external form of the case shall be further specified by

L_{32} = 113,20 mm ± 0,30 mm

L_{33} = 26,00 mm ± 0,25 mm

R_8 = 145,50 mm ± 0,25 mm

R_9 = 145,50 mm ± 0,25 mm

δ = 30° ± 30'

6.10 Central Window (Fig. 5)

The bottom side of the case shall have a central window. The location of its centre shall be specified by L_{29} and

L_{34} = 61,00 mm ± 0,25 mm

Its diameter shall be

d_1 = 43,50 mm ± 2,00 mm

The angle with its apex at the centre of this window and formed by the two lines tangential to the parts shown in Fig. 5 in cross-section shall be

θ = 16° ± 30'

6.11 Stacking Ribs

The bottom side of the case shall have two parallel stacking ribs. Their dimensions shall be

L_{35} = 5,00 mm ± 0,25 mm

L_{36} = 1,00 mm ± 0,16 mm

L_{37} = 74,50 mm ± 0,25 mm

Their locations shall be

L_{38} = 31,00 mm ± 0,25 mm

L_{39} = 7,50 mm ± 0,32 mm

L_{40} = 79,50 mm ± 0,25 mm

6.12 Tape Reel (Fig. 10 and 11)

Fig. 10 and 11 show the tape reel mounted within the case. Fig. 9 specifies the different dimensions of the reel when the cartridge is in hand, Fig. 11 when it is within the drive. For the sake of clarity of the drawing the stacking ribs are not shown in Fig. 10 and 11.

6.12.1 Locking mechanism (Fig. 11)

This Standard does not specify the actual implementation of the locking mechanism. It only specifies the material and the position of its button.

This button shall be made of nylon 6/6 with 2% ± 1% molybdenum disulphide.

Its dimensions shall be

d_9 = 2,00 mm ± 0,50 mm

d_{10} = 10,00 mm ± 0,20 mm

ρ = 15° ± 2°

6.12.2 Axis of rotation of the reel

The axis of rotation of the reel shall be perpendicular to Plane P (see 6.12.7) and pass through the centre of the central window as specified by L_{29} and L_{34}.

6.12.3 Metallic insert

The reel shall have a metallic insert made of stainless steel (ISO 683/XIII, type 10 or 16). It shall withstand a pull out force of 300 N min. Its dimensions shall be

$$d_2 = 35{,}00 \text{ mm} \begin{cases} + 0{,}20 \text{ mm} \\ - 1{,}20 \text{ mm} \end{cases}$$

d_3 = 11,15 mm ± 0,05 mm

e_1 = 1,50 mm ± 0,10 mm

Its central opening (diameter d_3) shall be concentric with the axis of rotation of the reel within 0,15 mm.

6.12.4 Toothed rim

Furthermore, the reel shall have a toothed rim accessible through the central window, and having the dimensions

$$d_4 = 36{,}00 \text{ mm} \begin{cases} + 0{,}50 \text{ mm} \\ - 0{,}00 \text{ mm} \end{cases}$$

d_5 = 41,00 mm ± 0,25 mm

ψ = 11°3' ± 5'

6.12.5 Hub of the reel

The hub of the reel shall have a diameter

$$d_6 = 50{,}00 \text{ mm} \begin{cases} + 0{,}00 \text{ mm} \\ - 0{,}20 \text{ mm} \end{cases}$$

Further dimensions of the hub shall be

$$L_{41} = 13{,}05 \text{ mm} \begin{cases} + 0{,}20 \text{ mm} \\ - 0{,}10 \text{ mm} \end{cases}$$

when measured at the hub surface, and

R_{10} = 0,08 mm max.

The hub shall meet the following requirements:

- the straightness of the hub surface shall be within 0,04 mm,
- the perpendicularity to the plane P through the pitch line of the teeth of the rim (see 6.12.7) shall be within 0,07 mm,
- the ratio of the difference in the diameters d_6 of any two sections (perpendicular to the axis) to the distance between these sections shall not exceed 0,0038,
- the rate of change across the width of the hub surface shall not exceed 0,025 mm per mm,
- the total runout of the hub related to the cylinder perpendicular to the circular pitch line (see 6.12.7) of the teeth of the toothed rim shall not exceed 0,2 mm total indicator reading (TIR).

6.12.6 Relative positions

6.12.6.1 With the cartridge in hand (Fig. 10):

- the distance of the tip of the button of the locking mechanism to Reference Surface C shall be

$$L_{42} = 1{,}90 \text{ mm} \begin{cases} + 1{,}40 \text{ mm} \\ - 0{,}90 \text{ mm} \end{cases}$$

- the distance from the bottom surface of the metallic insert to Reference Surface C shall be

$$L_{43} = 0{,}40 \text{ mm} \begin{cases} + 1{,}00 \text{ mm} \\ - 0{,}50 \text{ mm} \end{cases}$$

6.12.6.2 Whether the cartridge is in hand or in the drive (Fig. 10 and 11):

- the distance from the bottom surface of the metallic insert to plane P shall be

  L_{44} = 2,27 mm + 0,12 mm

- the distance of the inside of the lower flange of the reel to plane P shall be

  L_{45} = 0,65 mm ± 0,09 mm

6.12.6.3 With the cartridge in the drive (Fig. 11):

- the distance from the tip of the button of the locking mechanism to Reference Surface C shall be

  L_{46} = 8,10 mm ± 0,16 mm

- the force required to move the button into this position shall not exceed 12,25 N,
- the distance from the centreline of the tape to Reference Surface C shall be

  L_{47} = 12,25 mm nominal.

- the distance from the Reference Surface C to Plane P (see 6.12.7) shall be:

  L_{60} = 6,00 mm ± 0,16 mm

6.12.7 Characteristics of the toothed rim

The toothed rim shall comprise 60 teeth spaced at an angle of

6° ± 5' non-cumulative

The teeth are specified at the pitch diameter d_5 by

L_{48} = 4 mm nominal

L_{49} = 2 mm nominal

φ = 30° nominal

The pitch line is the circumference of the teeth taken at the distance L_{49}. The plane in which it lies is the plane P mentioned above.

The blend radius at the bottom of the teeth shall be

R_{11} = 0,25 mm max.

The blend radius at the tip of the teeth shall be

0,10 mm $\leqslant R_{12} \leqslant$ 0,30 mm

6.13 Leader Block (Fig. 13)

The leader block shall have the following dimensions.

L_{50} = 31,80 mm ± 0,04 mm

L_{51} = 6,80 mm ± 0,10 mm

L_{52} = 21,80 mm ± 0,20 mm

$L_{53} = 10{,}93\ \text{mm} \begin{cases} +\ 0{,}06\ \text{mm} \\ -\ 0{,}08\ \text{mm} \end{cases}$

L_{54} = 5,46 mm ± 0,10 mm

L_{55} = 6,00 mm ± 0,25 mm

$L_{56} = 16{,}50\ \text{mm} \begin{cases} +\ 0{,}00\ \text{mm} \\ -\ 0{,}20\ \text{mm} \end{cases}$

L_{57} = 5,20 mm ± 0,20 mm

R_{13} = 25,00 mm ± 0,25 mm

R_{14} = 1,40 mm ± 0,20 mm

d_7 = 7,00 mm ± 0,20 mm

d_8 = 4,00 mm ± 0,20 mm

μ_1 = 90° ± 2°

$\mu_2 = 8° \begin{cases} +\ 0° \\ -\ 3° \end{cases}$

$\mu_3 = 44° \begin{cases} +\ 0° \\ -\ 3° \end{cases}$

6.14 Fixation of the Tape to the Leader Block (Fig. 14)

There shall be a cylindrical insert for fixing the tape to the leader block. It shall cover the full width of the tape and not protrude beyond the surfaces of the leader block.

In zone Z the bottom edge of the tape (as seen in Fig. 14) shall be parallel to the edge of the leader block within 0,12 mm and shall be at a distance

L_{58} = 1,90 mm ± 0,26 mm

from it, when measured while the tape is under tension.

When fixed to the leader block the end of the tape shall not protrude above the surface of the leader block by more than

L_{59} = 2,50 mm

The leader block shall remain attached to the tape when a force of 10 N is applied at an angle

μ_4 = 38° ± 2°

as shown in Fig. 14.

6.15 Latching Mechanism (Fig. 15)

This Standard does not specify the actual implementation of the latching mechanism for the leader block. It specifies only the forces required to pull out and to insert the leader block.

The pull-out force, i.e. the force required to pull the leader block and the tape attached to it out of the cartridge shall satisfy both following conditions:

- to be in the range 3,0 N to 7,5 N, and
- the product of the maximum value of the pull-out force and the displacement distance shall be less than 13 Nmm.

The insertion force shall be measured at the same angle and jaw separation speed as the pull-out force.

Procedure

Clamp the cartridge in a universal testing machine that can extract the leader block at the angle μ_5 starting at the pickup point (see Fig. 14). The leader-block pickup point is located by the intersection of the centre lines positioned by dimensions L_{17}, L_{18}. Set the jaw separation speed to 10 mm/min, pull the leader block allowing it to pivot on the pulling pin as it exits the cartridge. Measure the distance between the point where the force first exceeds 0,5 N and the point where the maximum pull-out force is observed. The force shall be measured with a pin that fits into diameters d_7 and d_8 (see Fig. 12).

The insertion force, i.e. the force required to push the leader block into latched position in the cartridge shall not be greater than 12 N when measured at an angle

μ_5 = 48° ± 3°.

6.16 Tape Wind

When the cartridge is viewed from the top, the tape shall be wound counter-clockwise and with the recording surface toward the hub.

6.17 Wind Tension

The tape shall be wound with a tension of:

2,2 N ± 0,2 N

6.18 Diameter of the Tape Reel

When the tape is wound around the reel hub at the winding tension specified in 6.17, the reel shall have a diameter between 89 mm and 98 mm.

6.19 Reel Moment of Inertia

The moment of inertia of the empty reel shall be

$$0{,}03300\ \mathrm{gm}^2 \pm 0{,}00363\ \mathrm{gm}^2.$$

The moment of inertia of the reel loaded with tape shall be within

$$0{,}166\ \mathrm{gm}^2 \text{ to } 0{,}216\ \mathrm{gm}^2.$$

Procedure

Tortionally oscillate the reel on an inertial dynamics unit. The oscillation period shall be measured electronically with a universal counter. The oscillation time shall then be converted to its rotational inertial value.

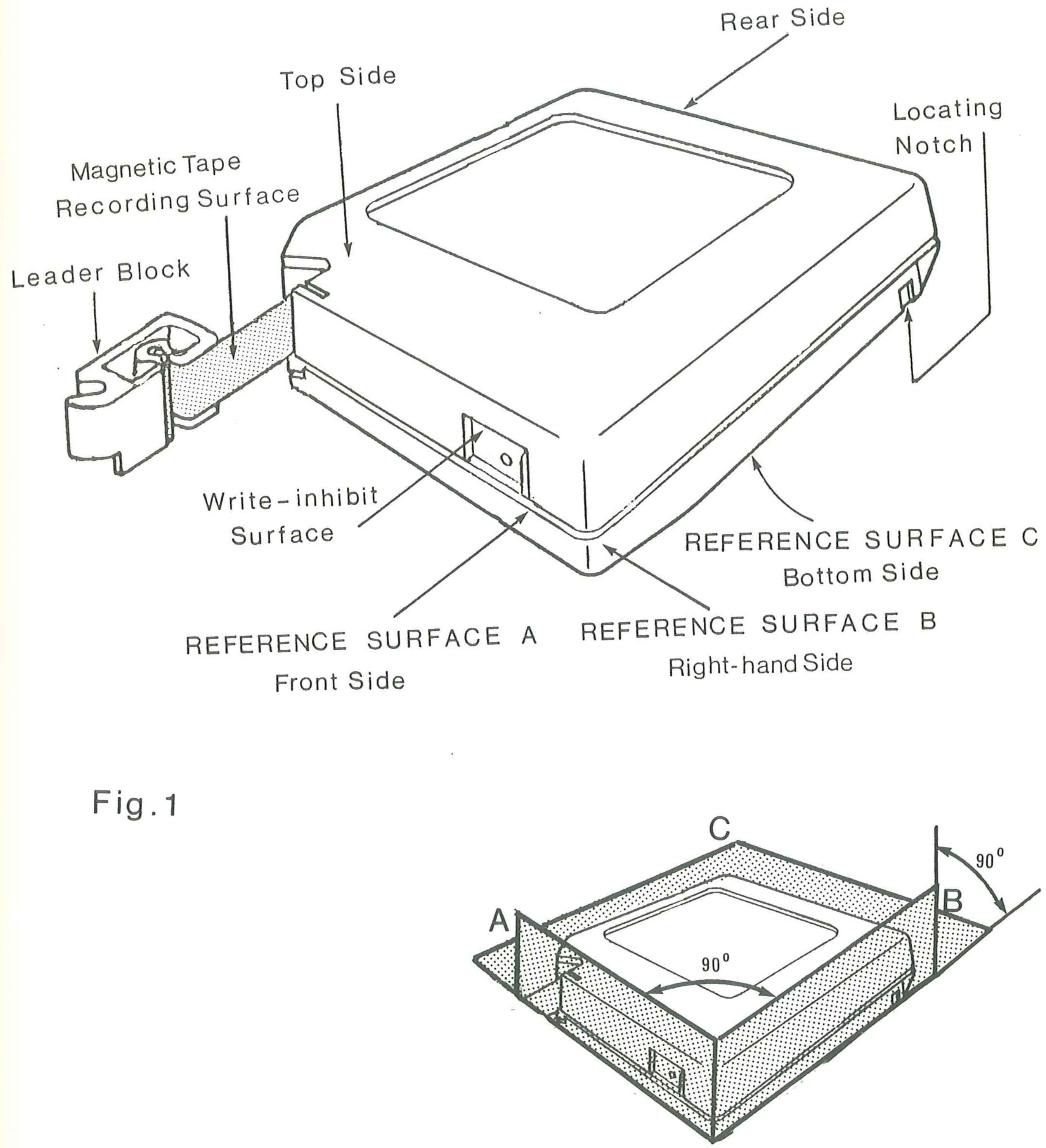


Fig.1

Fig. 2

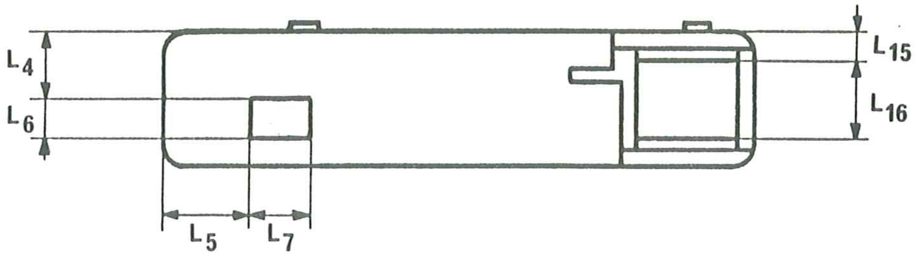


Fig. 3

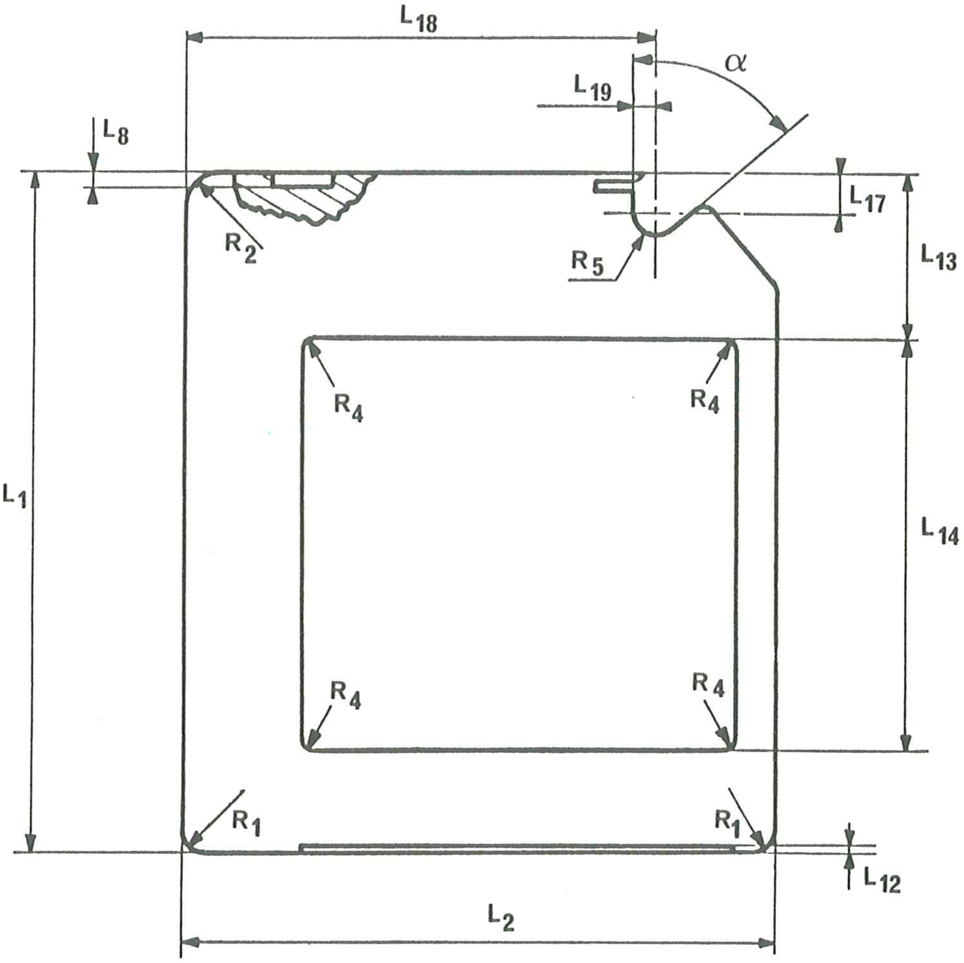
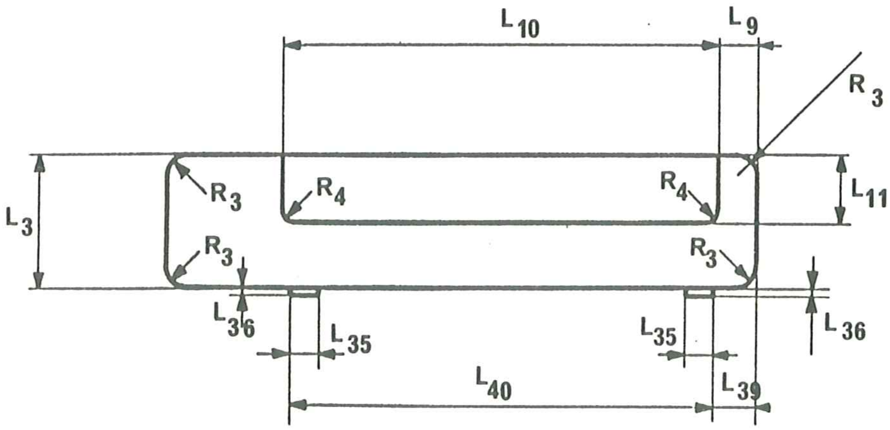


Fig. 4



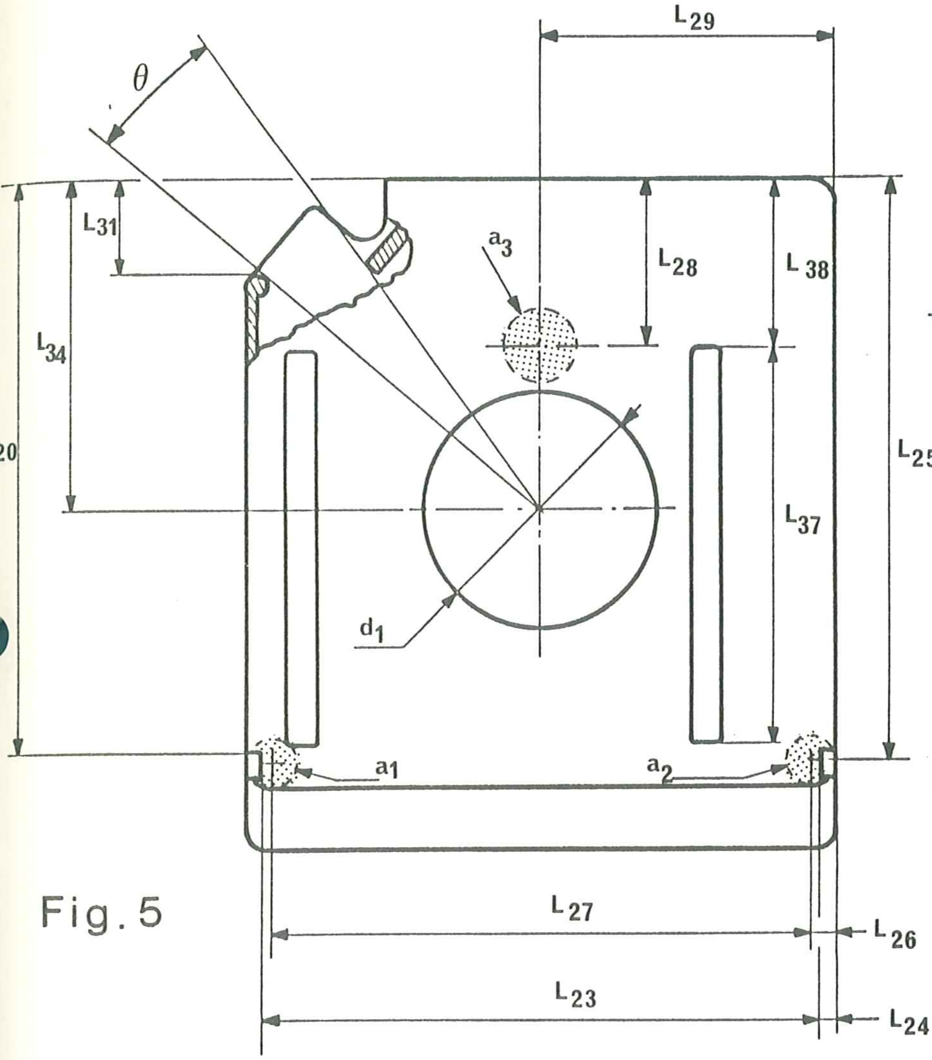


Fig. 5

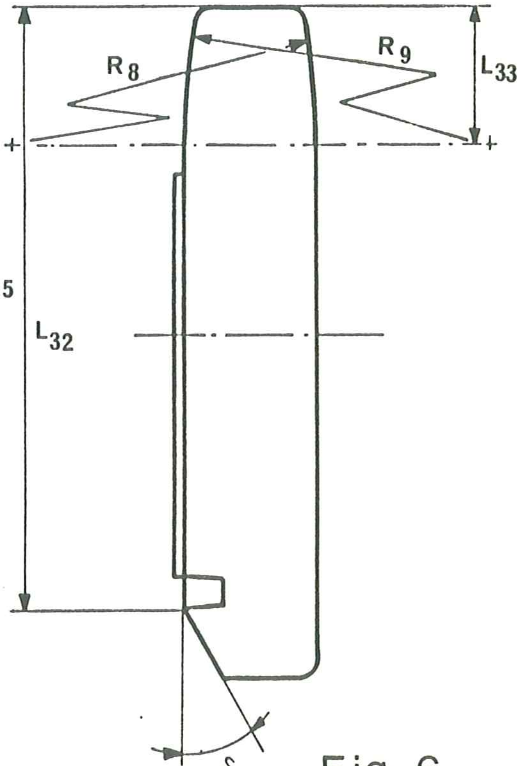


Fig. 6

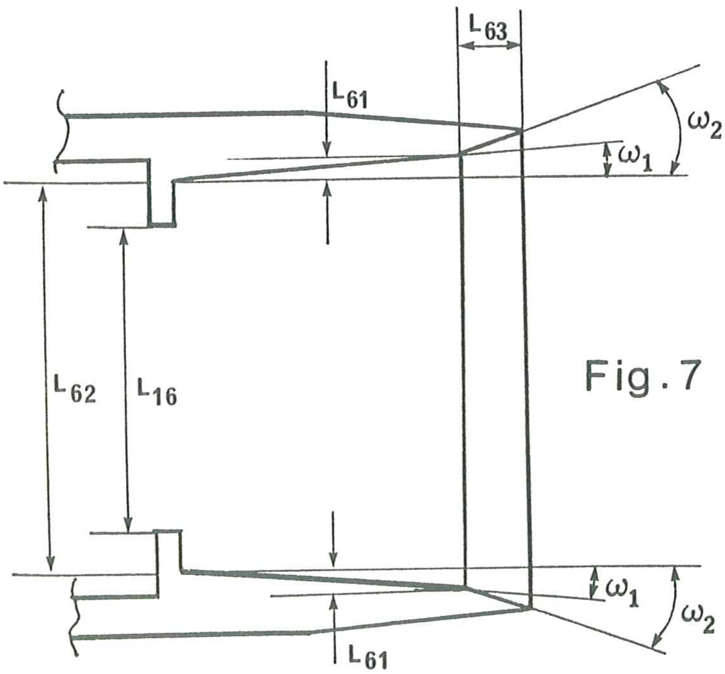


Fig. 7

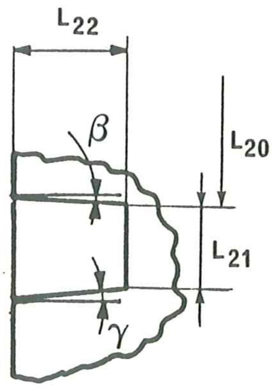


Fig. 8

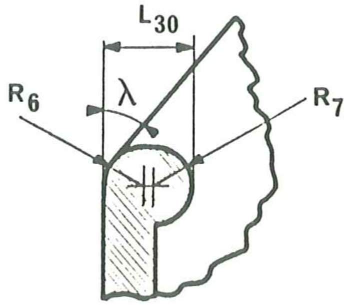


Fig. 9

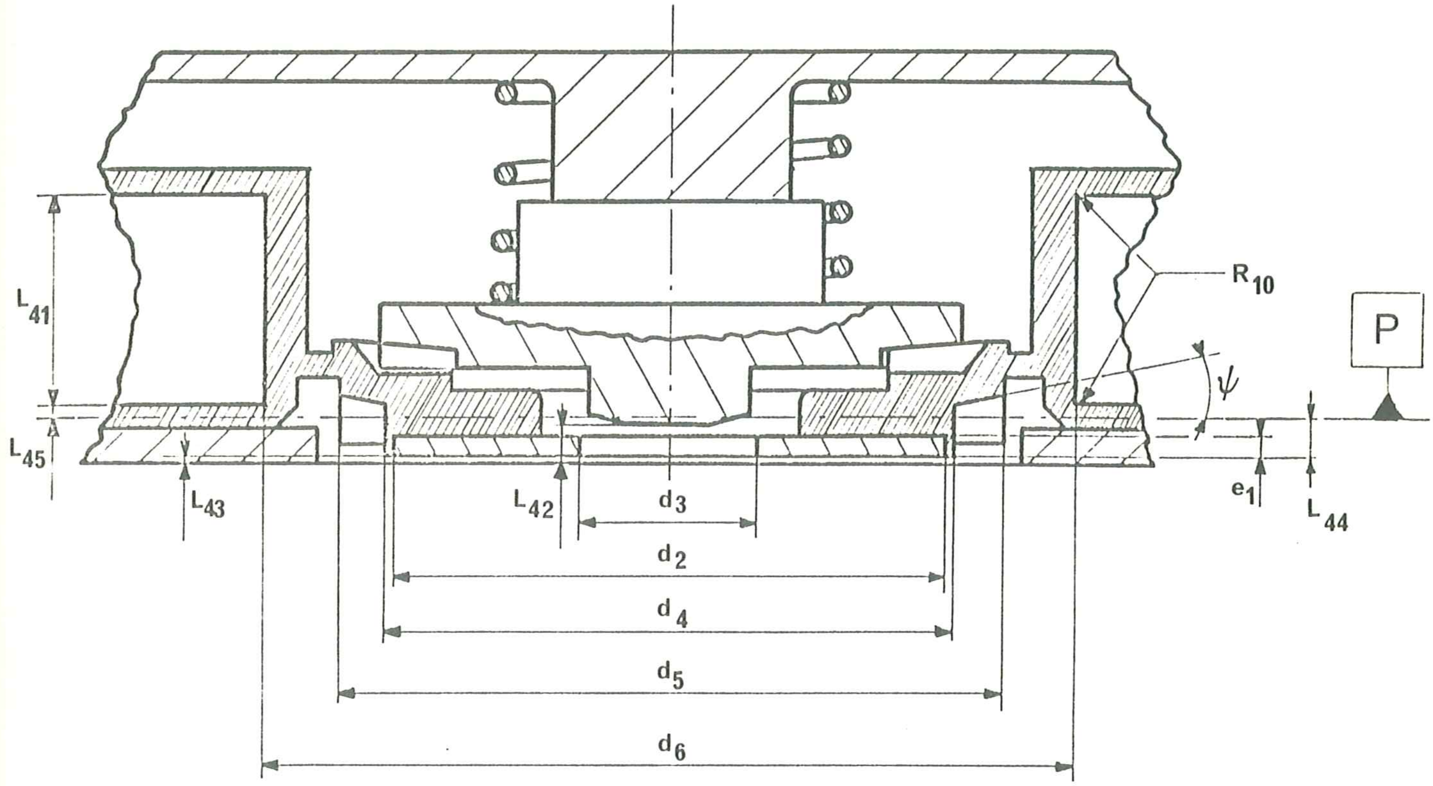


Fig.10

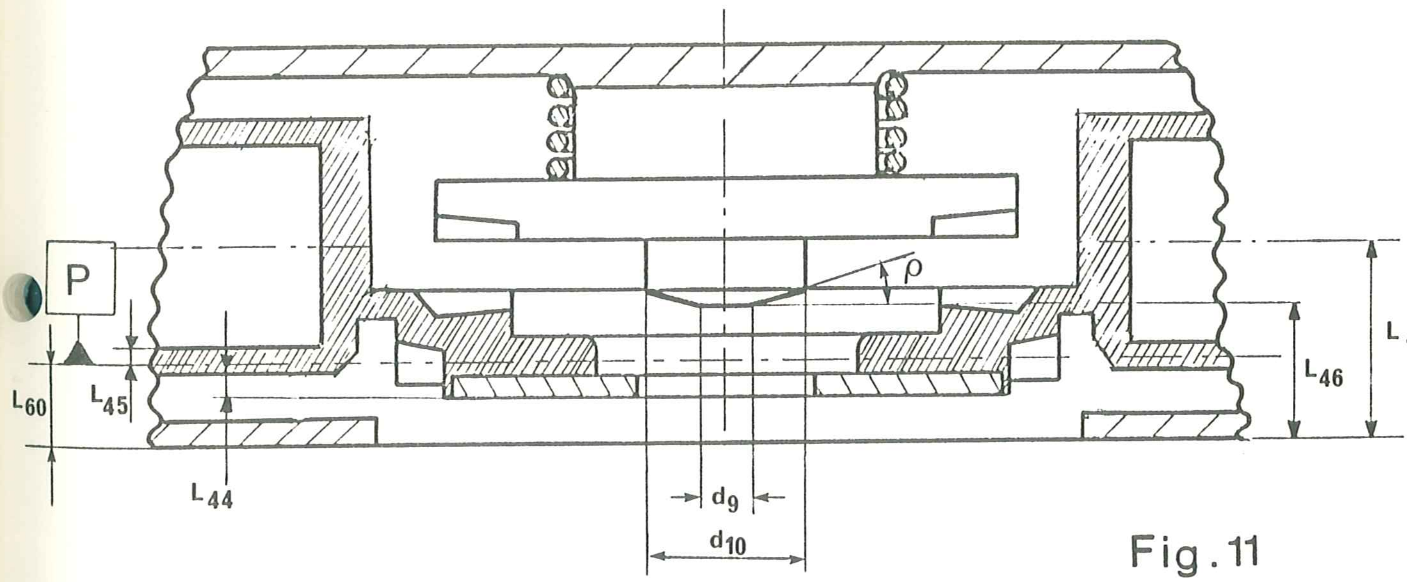


Fig.11

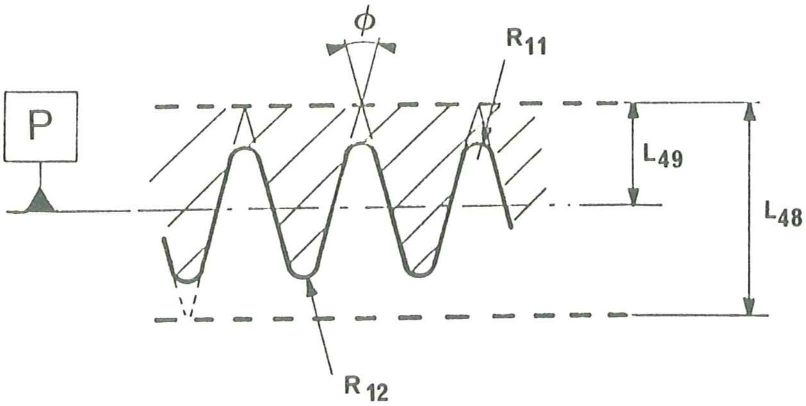


Fig.12

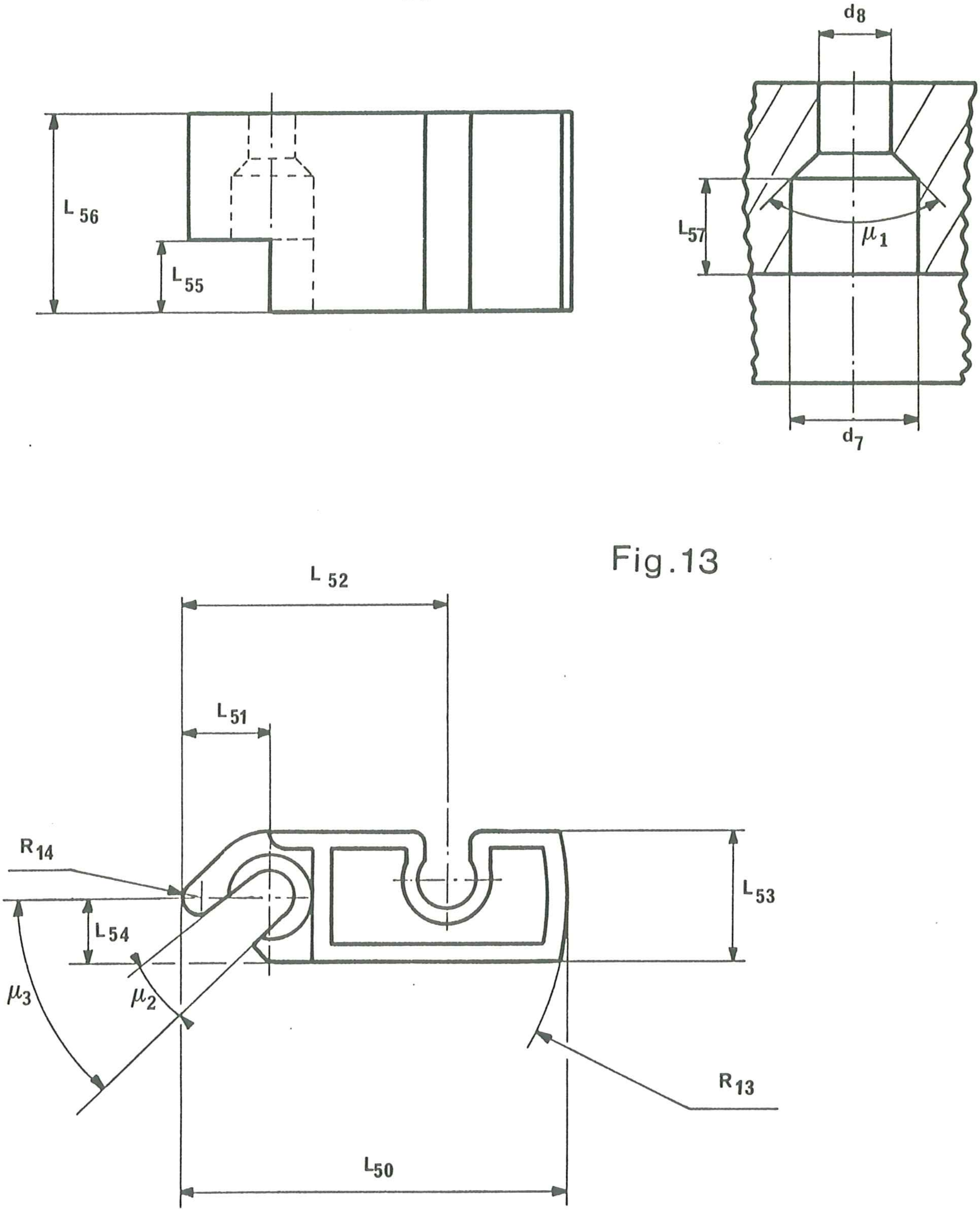


Fig.13

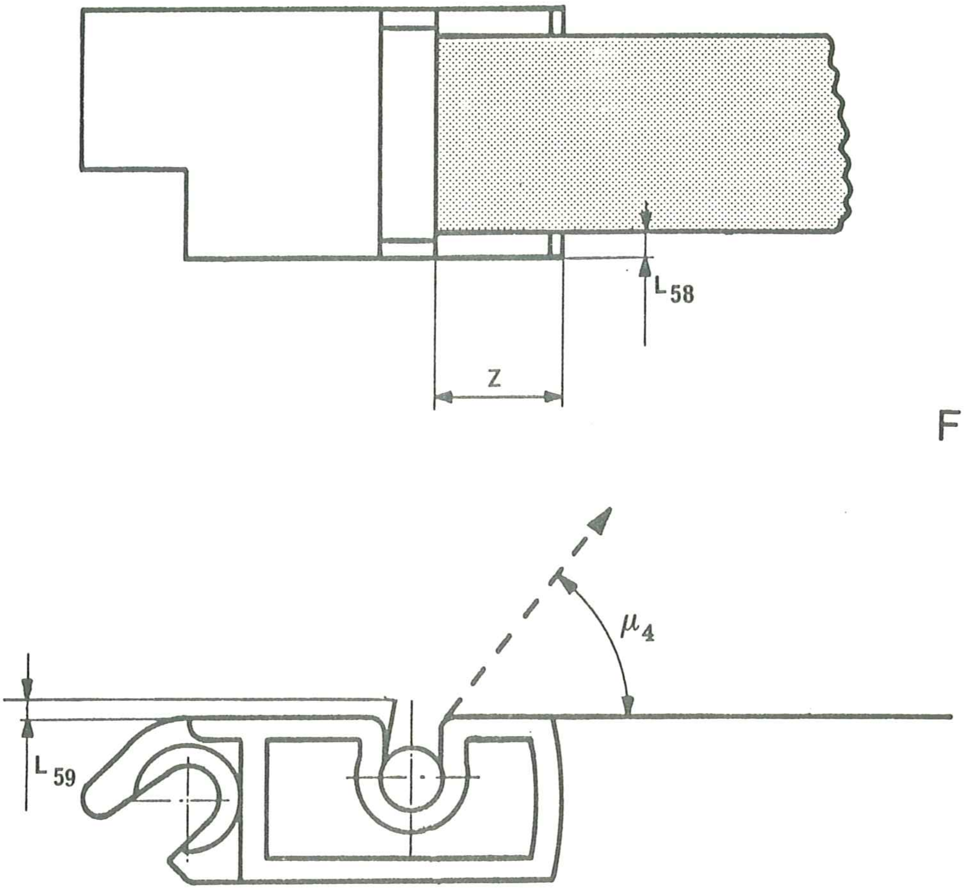


Fig. 14

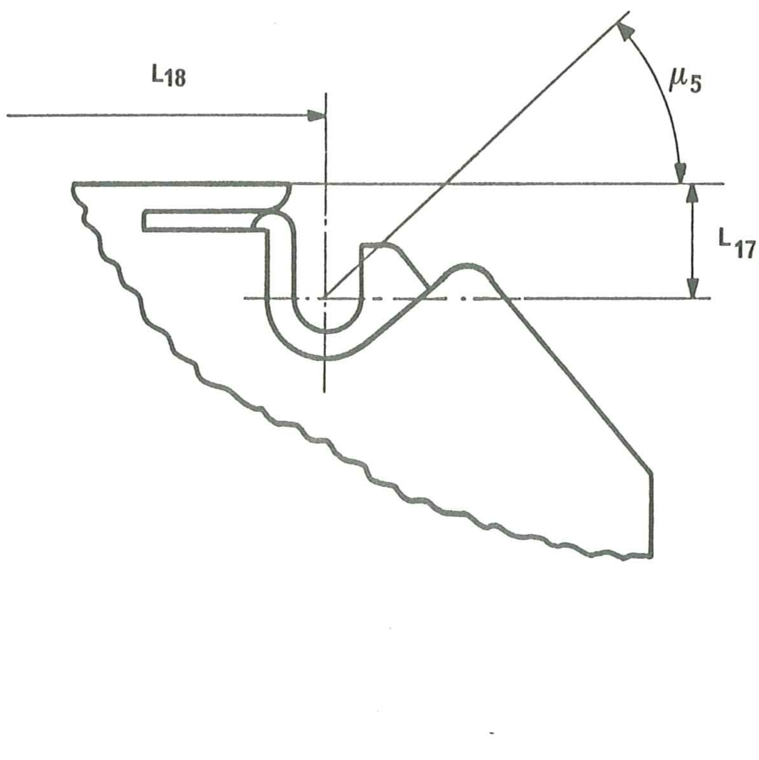


Fig. 15

SECTION IV

RECORDING METHOD

DATA FORMAT

LAYOUT OF THE TAPE

7. METHOD OF RECORDING

The method of recording shall be Inverted Frequency Modulation (IFM) defined as follows:

- a ONE is represented by a flux transition at the beginning of a bit cell,
- a ZERO is represented by flux transition at the beginning of a bit cell followed by a flux transition at the centre of the bit cell.

7.1 Physical Recording Density

The physical recording density shall be:

- for all ZEROs: 1944 ftpmm
- for all ONEs : 972 ftpmm

7.2 Bit Cell Length

The resulting nominal bit cell length is 1,029 µm.

7.3 Average Bit Cell Length

The average bit cell length shall be the sum of n bit cell lengths divided by n.

7.4 Long-Term Average Bit Cell Length

The long-term average bit cell length shall be the average bit cell length taken over a minimum of 972 000 bit cells. The long-term average bit cell length shall be within ± 4% of the nominal bit cell length.

7.5 Short-Term Average Bit Cell Length

The short-term average bit cell length (STA) shall be the average taken over 16 bit cells. The short-term average bit cell length shall be within ± 7% of the nominal bit cell length.

7.6 Rate of Change

The rate of change of the short-term average bit cell length shall not exceed 1,6%.

$$100 \cdot \frac{\left| STA_n - STA_{n+1} \right|}{STA_n} \leq 1,6\ \%$$

7.7 Write Phase

The intercept of the write phase curve shall be between -9° and -29°. The error between the data and the fitted curve shall not exceed 4° over the 3rd, 5th, 7th, 9th and 11th harmonics. See Appendix E for the test procedure and curve definition.

7.8 Total Character Skew

No bit belonging to the same written transverse column shall be displaced by more than 19 bit cell lengths when measured in a direction parallel to the Reference Edge (8.2) of the tape.

7.9 Signal-To-Noise Ratio

The broad-band signal-to-noise ratio at 972 ftpmm normalized to a read-track width of 410 um shall be in the range 34 dB to 46 dB.

Procedure

Test conditions:

- The tape speed shall be 0,76 m/s.
- The resonant frequency of the read head shall not be less than 4 MHz.
- The tape tension shall be 2,2 N ± 0,2 N.
- The spectrum analyzer shall have a resolution bandwidth of 3 kHz and a video bandwidth of 30 Hz.

i) Measure the read-signal amplitude at 972 ftpmm of at least 150 samples over a 46 m length of the tape, using the spectrum analyzer.

ii) Measure the noise power at least 10 times over the same 46 m of tape and integrate it over the range 37 kHz to 330 kHz.

iii) The read-signal amplitude shall not be compensated for gap loss.

8. TRACK FORMAT

8.1 Number of Tracks

There shall be 18 tracks.

8.2 Reference Edge

The Reference Edge of the tape is its bottom edge when viewing the recording surface of the tape with the hub end of the tape to the observer's right (see 10.8.2).

8.3 Track Positions

The distance from the centrelines of the tracks to the Reference Edge shall be:

Track 1	:	11,68 mm
Track 2	:	11,05 mm
Track 3	:	10,42 mm
Track 4	:	9,79 mm
Track 5	:	9,16 mm
Track 6	:	8,53 mm
Track 7	:	7,90 mm
Track 8	:	7,27 mm
Track 9	:	6,64 mm
Track 10	:	6,01 mm
Track 11	:	5,38 mm
Track 12	:	4,75 mm
Track 13	:	4,12 mm
Track 14	:	3,49 mm
Track 15	:	2,86 mm
Track 16	:	2,23 mm
Track 17	:	1,60 mm
Track 18	:	0,97 mm

The tolerance shall be ± 0,04 mm for all tracks.

8.4 Track Width

The width of a written track shall be 0,540 mm ± 0,017 mm.

8.5 Azimuth

On any track the angle that a flux transition across the track makes with a line perpendicular to the Reference Edge shall not be greater than 3 minutes of arc.

Note 1:

At the time of writing the tape, the azimuth should be less than 1 minute of arc. The remaining 2 minutes of arc is the allowance for tape distortion caused by environmental conditions and aging.

9. DATA FORMAT

Prior to recording, the data shall be arranged in groups completed with computed check characters. These data groups shall be in turn arranged in a given sequence together with additional groups of bytes having a prescribed bit pattern. The so arranged data bytes and additional bytes shall then be recorded on the tape according to a specific coding scheme.

9.1 Types of Bytes

The format specified by this Standard distinguishes three types of bytes:

- data bytes,
- pad bytes,
- Block-ID bytes.

9.1.1 Data bytes

Data Bytes are 8-bit bytes available for the recording of the information to be interchanged and/or stored.

9.1.1.1 Coded Representation of characters in data bytes

Characters shall be represented by means of the 7-bit Coded Character Set (Standard ECMA-6) and, where required, by its 7-bit or 8-bit extensions (Standard ECMA-35) or by means of the 8-bit Code (Standard ECMA-43).

i) Recording of 7-bit Coded Characters

Each 7-bit coded character shall be recorded in bit positions B_1 to B_7 of a byte; bit-position B_8 shall be recorded with ZERO. The relationship shall be as follows:

Binary weight	-	64	32	16	8	4	2	1
Bit designation	-	b_7	b_6	b_5	b_4	b_3	b_2	b_1
Bit-positions in the byte	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1

ii) Recording of 8-bit Coded Characters

Each 8-bit coded character shall be recorded in bit positions B_1 to B_8 of a byte. The relationship shall be as follows:

Binary Weight	128	64	32	16	8	4	2	1
Bit designation	b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1
Bit-position in the byte	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1

Note 2:

If each character has a coded representation consisting of one single 7-bit or 8-bit byte, the number of characters is equal to the number of data bytes. Code extension techniques allow multiple-byte representation. In this case the number of characters is equal to the number of data bytes divided by the number of bytes of the coded representation of a single character.

9.1.1.2 Representation of binary data in data bytes

When the coding method requires it, the coded representations to be recorded in data bytes shall be regarded as an ordered sequence of bit positions, each containing a bit, which can be either a ZERO or a ONE.

The binary weights, bit designations and bit positions shall be as given in 9.1.1.1 ii).

9.1.2 Pad bytes

Pad bytes are 8-bit bytes having a bit pattern consisting of eight ZEROs.

9.1.3 Block-ID bytes

There shall be four 8-bit bytes for the representation of the Block-ID. These four bytes shall follow the last data byte. The 32 bits are numbered from 1 (most significant) to 32 (least significant). These bits shall have the following values:

Bit 1 shall be ZERO.

Bits 2 to 8 shall express in binary notation the value of a Physical Position Indicator. This value shall be the largest positive integer satisfying the condition:

$$1 \leqslant \left[\frac{62{,}5 \sqrt{625 + R_0^2 - R^2}}{R} - 31 \right] \leqslant 91$$

where:

R_0 is the initial radius of the fully loaded reel of tape,

R is the current radius of the reel of tape.

Note 3:

The purpose of the Physical Position Indicator is to provide a coarse, fast indication of the location of the data without having to read the data or all Block-ID bytes.

Bits 9 to 12 shall be ZEROs.

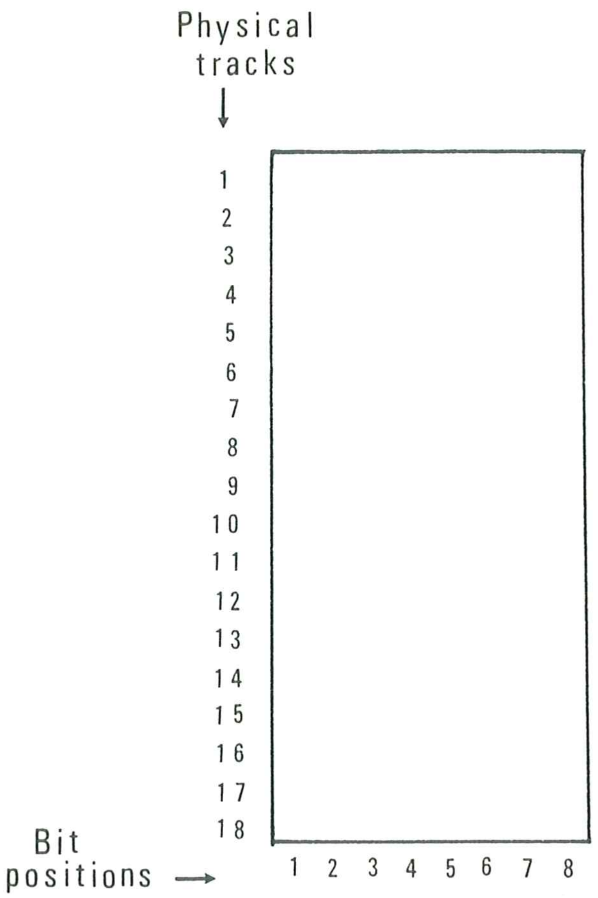
Bits 13 to 32 shall express in binary notation a Count which is increased by 1 for each Data Block (see 9.3) and each Tape Mark (see 10.5). The Count is set to 0 for the first Recorded Data Block (see 9.6) or Tape Mark following the initial Interblock Gap (see 10.3).

These 32 bits shall be assigned to the following positions.

Byte sequence	1	2	3	4
Bits	1 to 8	9 to 16	17 to 24	25 to 32
Bit position in the byte	8 to 1	8 to 1	8 to 1	8 to 1

9.2 Frame

A frame shall be a logical section across all 18 tracks containing logically related 8-bit bytes. Each byte in a frame is recorded along a track.



9.3 Data Block

A Data Block shall comprise at least 1 and at most 32768 data bytes.

It shall have the following structure:

- First 2 frames:
  Prefix
- Further frames up to 2340 frames grouped in clusters:
  Data Frames
- Next frames, up to 2 frames:
  Residual Frames 1 and/or Residual Frame 2
- Last 2 frames:
  Suffix.

Prefix	1st Data Cluster	2nd Data Cluster	//	last Data Cluster	Res.1	Res.2	Suffix
2 frames	69 frames	71 frames		up to 71 frames	1 frame	1 frame	2 frames

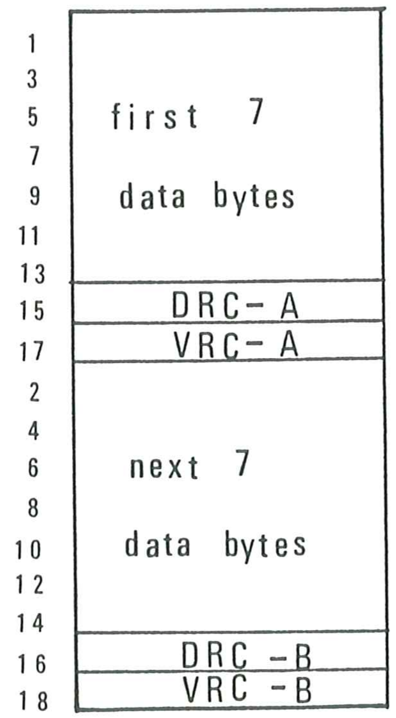
9.3.1 Prefix

The prefix shall consist of two frames containing pad bytes in each track.

9.3.2 Data Frames

Each Data Frame shall consist of:

- the first 7 data bytes recorded in odd tracks 1 to 13,
- the next 7 data bytes recorded in even tracks 2 to 14,
- a Diagonal Redundancy Character (DRC-A) recorded in track 15 (see 9.4.1),
- a Vertical Redundancy Character (VRC-A) recorded in track 17 (see 9.4.2),
- a Diagonal Redundancy Character (DRC-B) recorded in track 16 (see 9.4.1),
- a Vertical Redundancy Character (VRC-B) recorded in track 18 (see 9.4.2).



The Data Frames are grouped in clusters as follows:

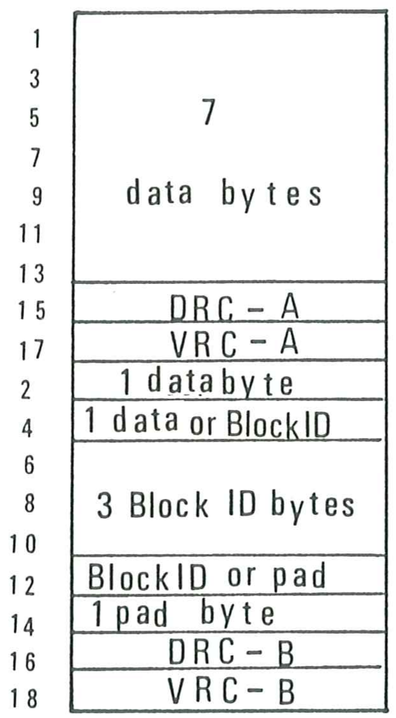
- the first cluster shall comprise up to 69 frames of data bytes,
- the next clusters, if provided, shall each comprise 71 frames of data bytes,
- the last cluster shall comprise up to 71 frames of data bytes.

9.3.3 Residual Frame 1

If after the last Data Frame of the last Data cluster 8 or 9 data bytes remain to be recorded, there shall be a Residual Frame 1. If the number of remaining data bytes is less than 8 there shall be no Residual Frame 1.

The structure of the Residual Frame 1 shall be:

- 8 or 9 data bytes,
- four Block-ID bytes,
- 1 or 2 pad bytes, depending on the number of remaining data bytes,
- in Tracks 15 and 17 the DRC-A and the VRC-A, respectively,
- in Tracks 16 and 18 the DRC-B and the VRC-B, respectively.



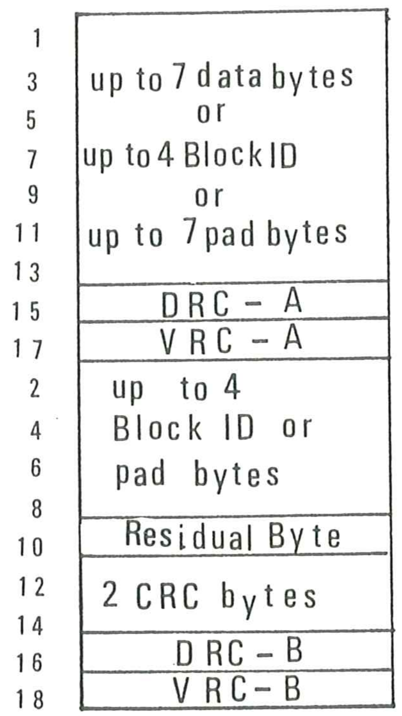
9.3.4 Residual Frame 2

If there is no Residual Frame 1, i.e. if there are 7 or less remaining data bytes, these data bytes followed by the 4 Block-ID Bytes followed by pad bytes shall be recorded in odd tracks 1 to 13 and even tracks 2 to 8. If there are no remaining data bytes, the 4 Block-ID bytes shall be recorded in odd tracks 1 to 7, followed by pad bytes in odd tracks 9 to 13 and even tracks 2 to 8.

If there is a Residual Frame 1, odd tracks 1 to 13 and even tracks 2 to 8 shall be recorded with pad bytes.

In either case:

- Track 10 shall be recorded with the Residual Byte (see 9.3.4.1)
- Track 12 and 14 with the CRC Byte 1 and the CRC Byte 2, respectively (see 9.3.4.2)
- Tracks 15 and 17 with the DRC-A and the VRC-A, respectively (see 9.4.1 and 9.4.2)
- Tracks 16 and 18 with the DRC-B and the VRC-B respectively (see 9.4.1 and 9.4.2).



9.3.4.1 Residual Byte

The Residual Byte shall be recorded in track 10 of the Residual Frame 2. Its bits are numbered from 1 (most significant) to 8 (least significant).

Bits 1 and 2	shall be unspecified, they can be a ONE or a ZERO.
Bits 3 and 4	shall be ONEs.
Bits 5 to 8	shall express in binary notation the total number of pad bytes in the Residual Frame(s).

The allocation of bits to the bit positions in the Residual Byte shall be:

Bit	1 to 8
Bit position	8 to 1

9.3.4.2 CRC Bytes

The 16-bit Cyclic Redundancy Check Character (CRC) shall be represented by two bytes recorded in tracks 12 and 14 of the Residual Frame 2. The CRC character shall be computed from the generator polynomial.

$$x^{16} + x^{15} + x^{8} + x + 1$$

The CRC is computed over the data, the Block-ID and the pad bytes. It does not include the ECC bytes.

The bits of the bytes of the CRC shall be processed starting with bit 1, i.e. the least-significant bit and ending with bit 8, i.e. the most significant bit.

Note 4:

As this polynomial is symmetrical it yields the same value when read in either direction.

The allocations of bits to bit positions in the two CRC bytes is:

	CRC Byte 1	CRC Byte 2
Bits	9 to 16	1 to 8
Bit position	8 to 1	8 to 1

9.3.5 Suffix

The suffix shall consist of two frames containing:

- in odd track 1 to 13 : pad bytes
- in track 15 : DRC-A (see 9.4.1)
- in track 17 : VRC-A (see 9.4.2)
- in even track 2 to 14 : pad bytes
- in track 16 : DRC-B (see 9.4.1)
- in track 18 : VRC-B (see 9.4.2)

9.4 Error Correcting Code

The error correcting code yields two check characters:

- the Diagonal Redundancy Check (DRC)
- the Vertical Redundancy Check (VRC).

Computation of the DRCs and VRCs starts with the Prefix and ends with the Suffix.

In 9.4.1 and 9.4.2 the following notation is used:

Tn_m = the m-th bit of the n-th track

9.4.1 Diagonal Redundancy Check (DRC)

The two DRCs shall be recorded in tracks 15 and 16, respectively. The bits in each of these tracks shall be computed from the bits in all other tracks, except tracks 17 and 18. The m-th bit in each of these tracks is specified by:

$$\text{m-th bit of track 15} = \left\{ \sum_{n=0}^{6} T(2n+1)_{m-n-1} + \sum_{n=1}^{8} T(2n)_{m-n-7} \right\} \quad (\text{modulo } 2)$$

$$\text{m-th bit of track 16} = \left\{ \sum_{\substack{n=0\\ i=7}}^{\substack{i=1\\ n=6}} T(2n+1)_{m-n-2i} + T15_{m-15} + \sum_{n=1}^{7} T(2n)_{m+n-8} \right\}$$

$$(\text{modulo } 2)$$

9.4.2 Vertical Redundancy Check (VRC)

The two VRCs shall be recorded in tracks 17 and 18, respectively. The bits in each of these tracks shall be computed from the bits of the eight other tracks having the same index parity. The m-th bit in each of these tracks is specified by:

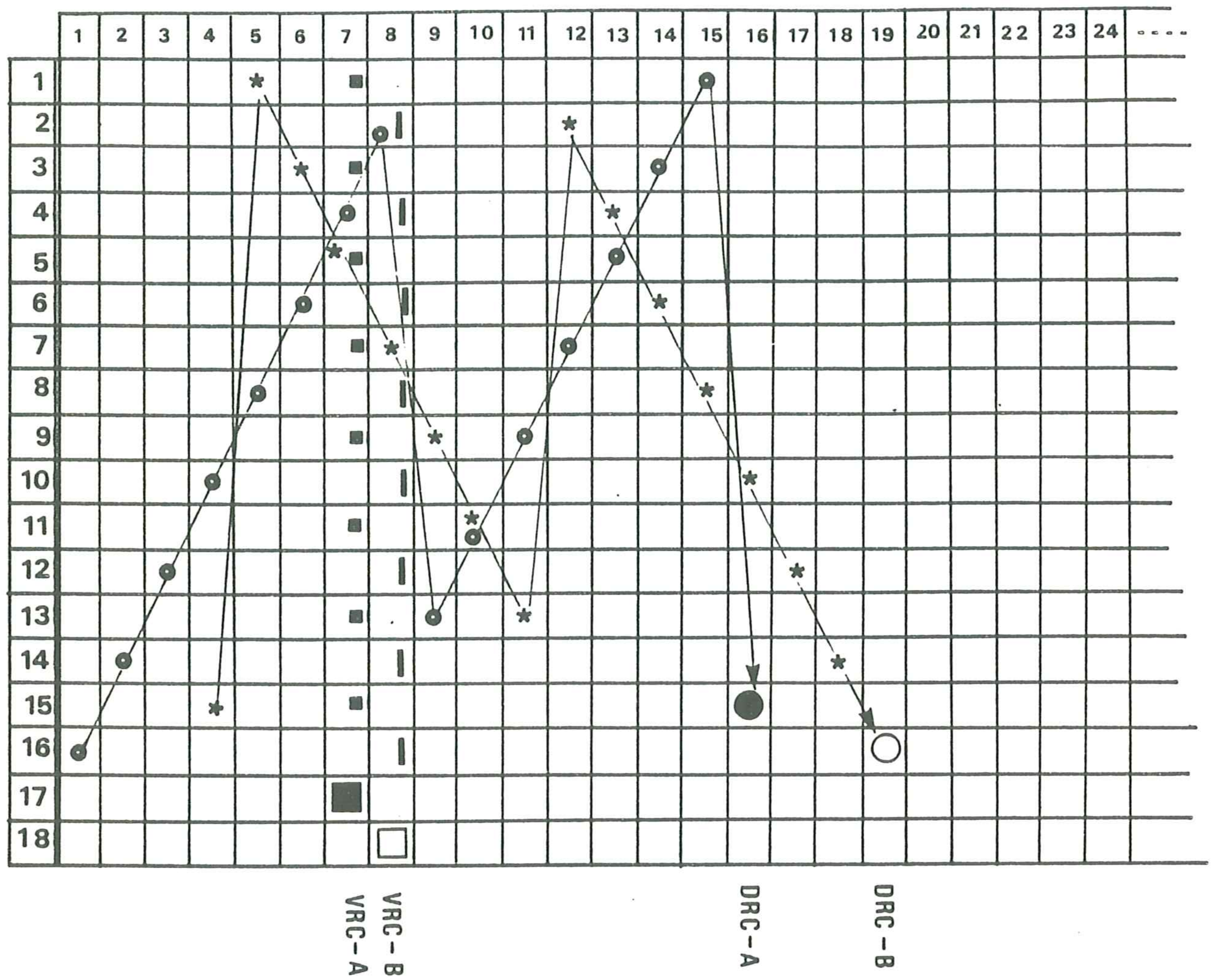
$$\text{m-th bit of track 17} = \left\{ \sum_{n=0}^{7} T(2n+1)_m \right\} \quad (\text{modulo } 2)$$

$$\text{m-th bit of track 18} = \left\{ \sum_{n=1}^{8} T(2n)_m \right\} \quad (\text{modulo } 2)$$

9.4.3 ECC Format

In each frame eight bits of the DRCs and the VRCs shall be considered as an 8-bit byte.

9.4.4 Summary of ECC



- ● bit of the DRC-A
- ■ bit of the VRC-A
- ○ bit of the DRC-B
- □ bit of the VRC-B

BIBLIOGRAPHY

For a complete description of this ECC scheme, see A.M. PATEL: Adaptive cross parity (AXP) code for a high-density magnetic tape subsystem, in IBM Journal of Research and Development, Vol. 29, Number 6 of November 1985.

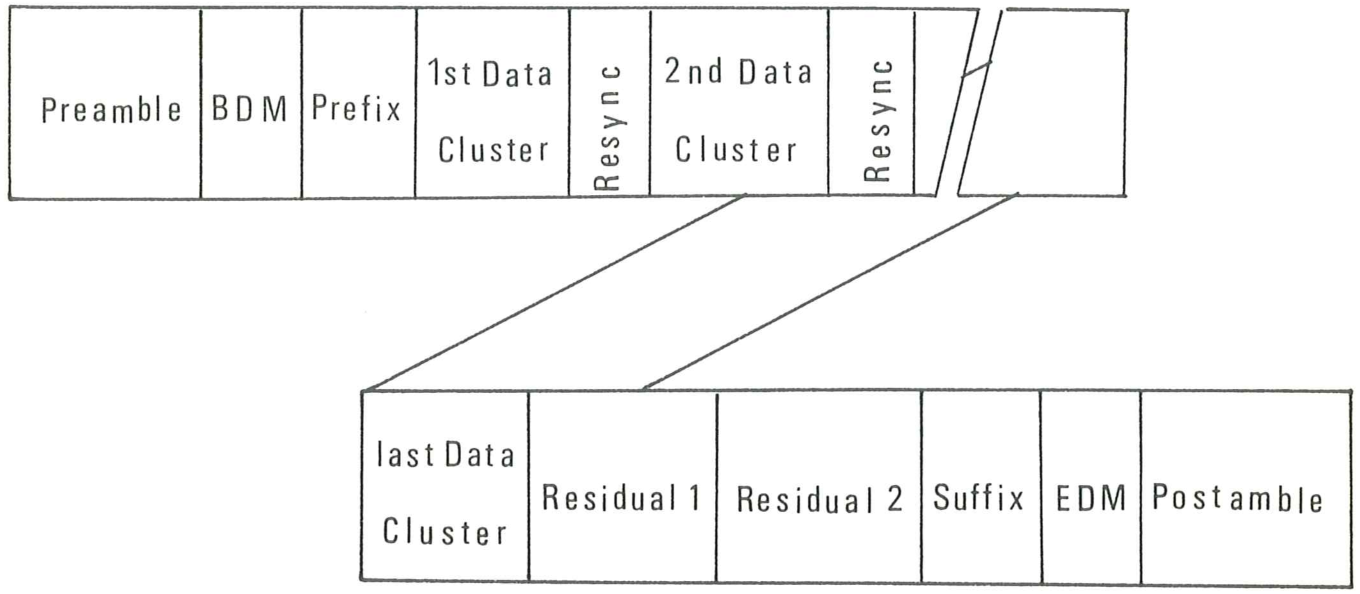
9.5 Recording of 8-bit bytes on the tape

Each 8-bit byte in the Prefix, in the Data Frames, in the Residual Frame(s) and in the Suffix shall be represented by a 9-bit pattern on the tape.

Appendix F specifies the 9-bit pattern representing each 8-bit byte. The bit of the 9-bit pattern in the lowest bit position shall be recorded first.

9.6 Recorded Data Block

When recorded in the tape each Data Block shall have the following structure and be called a Recorded Data Block.



9.6.1 Preamble

The Preamble shall consist of 9 to 13 frames recorded with the 9-bit pattern 111111111 in all tracks.

9.6.2 Beginning of Data Mark (BDM)

The BDM shall consist of two frames recorded with the 9-bit pattern 100010001 in all tracks.

9.6.3 Resync Control Frame

A Resync Control Frame shall have the 9-bit pattern 100010001 in all tracks. A Resync Control Frame shall be recorded after each Data Cluster, but not after the last one.

9.6.4 End of Data Mark (EDM)

The EDM shall consist of two frames recorded with the 9-bit pattern 100010001 in all tracks.

9.6.5 Postamble

The Postamble shall consist of 9 to 13 frames recorded with the 9-bit pattern 111111111 in all tracks.

9.7 Data Density

Due to the EEC bytes, the 8-bit to 9-bit conversion and to the Resync Control Frames the maximum density of user bytes is:

$$14 \cdot 972 \cdot \frac{1}{8} \cdot \frac{8}{9} \cdot \frac{71}{72} = 1491 \text{ user bytes per mm}$$

where:

14 : the number of bytes per frame,

972 : the number of flux transitions per mm for the all ONEs density,

1/8 : the inverse value of the number of bits per byte,

8/9 : corresponds to the GCR mode,

71/72 : corresponds to the RESYNC Control Frames.

10. TAPE FORMAT

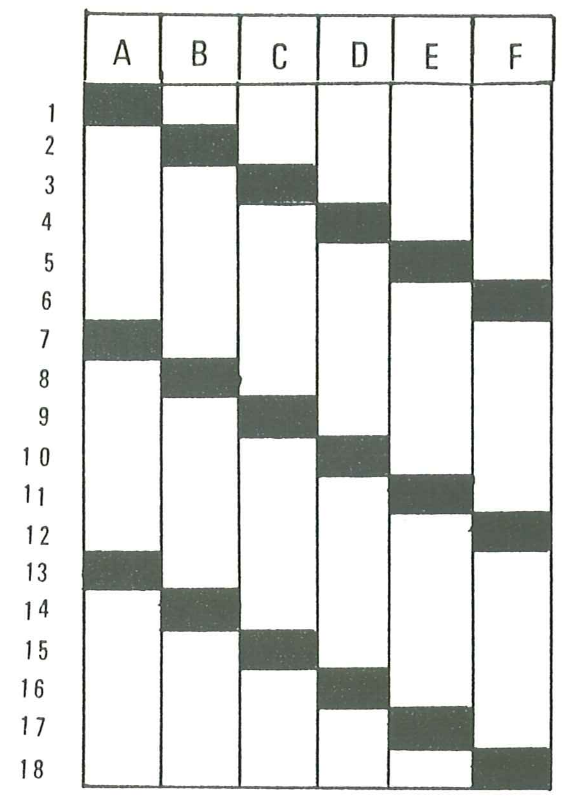
The format of the tape is defined by the following control blocks separating and/or qualifying the Recorded Data Blocks.

- the Density Identification Burst,
- the ID Separator Burst,
- Interblock Gaps,
- Erase Gaps,
- Tape Marks.

The five control blocks have the following recording characteristics.

i) The 18 tracks are divided in six zones:

- zone A : Tracks 1, 7, 13
- zone B : Tracks 2, 8, 14
- zone C : Tracks 3, 9, 15
- zone D : Tracks 4, 10, 16
- zone E : Tracks 5, 11, 17
- zone F : Tracks 6, 12, 18



ii) The tracks of each zone are recorded either with the all ONEs pattern or with the repeated 6-bit pattern 100000 called tone.

10.1 Density Identification Burst

The Density Identification Burst shall be characterized by:

- all ONEs in zones A, C, F
- tone in zones B, D, E

Its length shall be:

Nominal : 2375 mm
Minimum : 2250 mm
Maximum : 3060 mm

The Density Identification Burst shall be the first recording on the tape.

10.2 ID Separator Burst

The ID Separator Burst shall be characterized by:

- all ONEs in all zones.

Its length shall be:

Nominal : 2,0 mm
Minimum : 1,9 mm
Maximum : 2,1 mm

10.3 Interblock Gaps

The Interblock Gaps shall be characterized by:

- all ONEs in zones A, D, F
- tone in zones B, C, E.

The length of each Interblock Gaps shall be:

Nominal : 2,0 mm
Minimum : 1,6 mm
Maximum : 3,0 mm

Any discontinuity across all tracks in an Interblock Gap (e.g. due to start/stop mode) shall not be greater than 0,03 mm. Such discontinuity shall not occur less than 0,5 mm before the Preamble of a Recorded Data Block or within 0,5 mm after the Postamble of such a block.

An Interblock Gap shall be recorded immediately after the ID Separator Burst. These shall be an Interblock Gap recorded before and after each Recorded Data Block, each Erase Gap (see 10.4) and each Tape Mark (see 10.5), except after the last Tape Mark on the tape (see 10.7).

10.4 Erase Gaps

Erase Gaps shall be characterized by:

- all ONEs in zones B, C, F
- tone in zones A, D, E.

Erase Gaps shall be recorded over a length of tape where an unsuccessful write operation occurred or upon an erase instruction.

10.4.1 Normal Erase Gaps

The length of a Normal Erase Gap shall be:

Nominal : 7,8 mm
Minimum : 7,4 mm
Maximum : 8,2 mm

Up to 20 successive Normal Erase Gaps, separated by Interblock Gaps, are permitted to be written to cover a defect area.

10.4.2 Elongated Erase Gaps

The length of an Elongated Erase Gap shall be:

Maximum : 200 mm

Elongates Gap shall be recorded in the case that a Normal Erase Gap and/or the following Interblock Gap are not recognized as such. Within an Elongated Erase Gap partial Interblock Gaps of not more than 1 mm are permitted to appear.

10.5 Tape Marks

Tape Marks are control blocks characterized by:

- all ONEs in zones B, D, E
- tone in zones A, C, F.

The length of each Tape Mark shall be:

Nominal : 1,0 mm
Minimum : 0,7 mm
Maximum : 1,3 mm

One or more Tape Marks may be used to delimit sequences of Recorded Data Blocks.

10.6 Relation between Interblock Gaps, Erase Gaps and Tape Marks

Where an Interblock Gap precedes or follows an Erase Gap or a Tape Mark, respectively, in six of the nine tracks the prescribed tone pattern shall be preceded or followed by 18 ONE bits.

10.6.1 Interblock Gap followed by a Tape Mark

On tracks 1, 6, 7, 12, 13 and 18:

- the tone pattern of the Tape Mark is preceded by 18 ONE bits.

On tracks 2, 5, 8, 11, 14 and 17:

- the tone pattern of the Interblock Gap ends with ONE bits.

10.6.2 Tape Mark followed by an Interblock Gap

On tracks 1, 6, 7, 12, 13 and 18:

- the tone pattern of the Tape Mark ends with 18 ONE bits.

On tracks 2, 5, 8, 11, 14 and 17:

- the tone pattern of the Interblock Gap is preceded by 18 ONE bits.

10.6.3 Interblock Gap followed by an Erase Gap

On tracks 1, 4, 7, 10, 13 and 16:

- the tone pattern of the Erase Gap is preceded by 18 ONE bits.

On tracks 2, 3, 8, 9, 14 and 15:

- the tone pattern of the Interblock Gap ends with 18 ONE bits.

10.6.4 Erase Gap followed by an Interblock Gap

On tracks 1, 4, 7, 10, 13 and 16:

- the tone pattern of the Erase Gap ends with 18 ONE bits.

On tracks 2, 3, 8, 9, 14 and 15:

- the tone pattern of the Interblock Gap is preceded by 18 ONE bits.

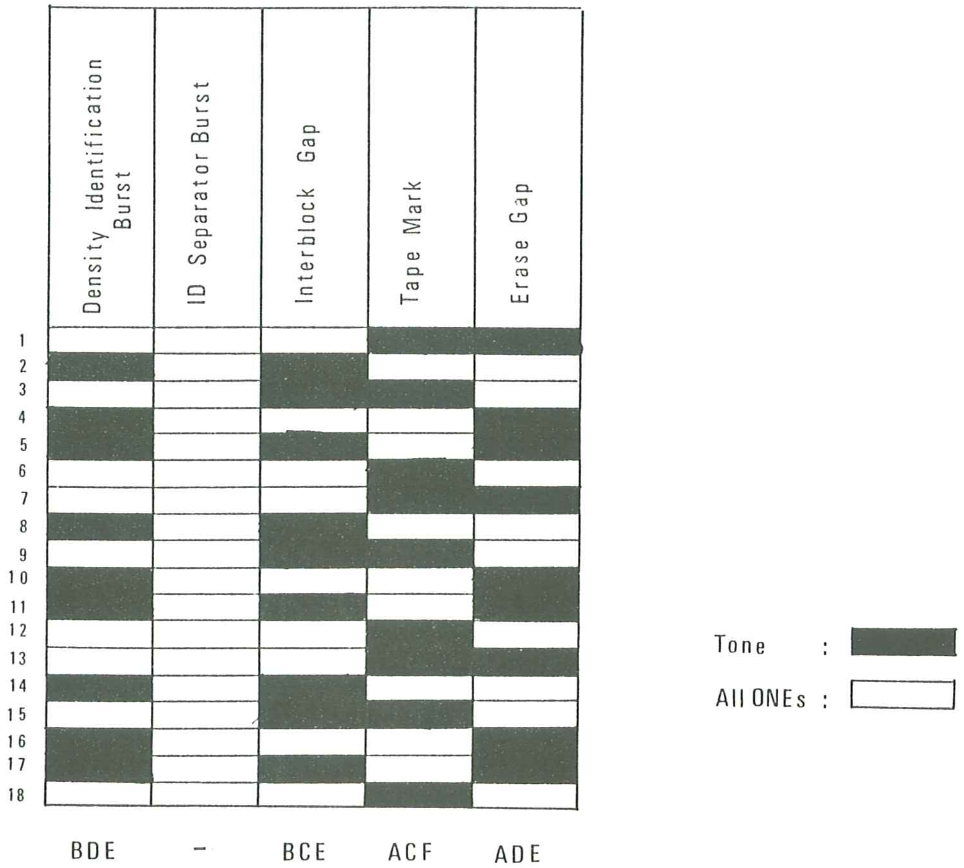
10.7 First and Last Recording on the Tape

The first recording on the tape shall be a Density Identification Burst. It shall begin not more than 1,34 m from the leader block of the cartridge and end not less than 3,28 m from it.

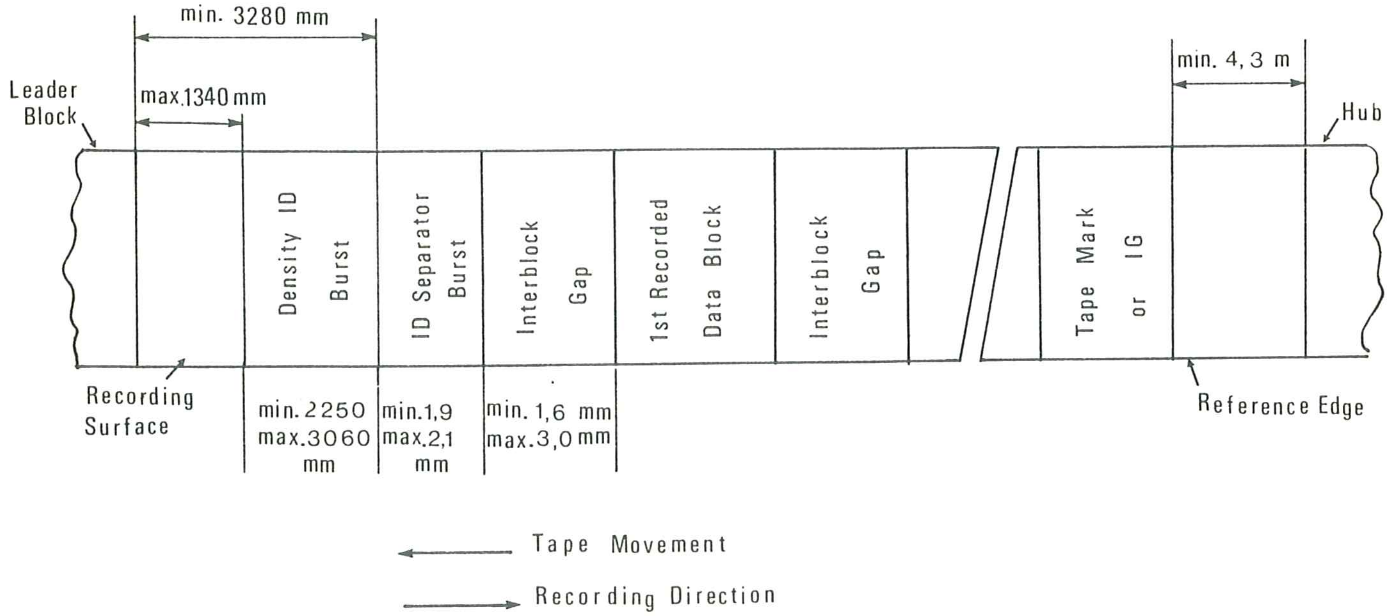
The last recording on the tape shall be a Tape Mark optionally followed by an Interblock Gap. It shall end not less than 4,3 m from the junction of the tape to the hub of the cartridge.

10.8 Summary of the Tape Format

10.8.1 Characteristics of Recording other than Recorded Data Blocks



10.8.2 Arrangement of Recording on the Tape



SECTION V

APPENDICES

APPENDIX A

RECOMMENDATIONS FOR TRANSPORTATION

A.1 ENVIRONMENT

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

A.1.1 Unrecorded Cartridges

Temperature	:	-23 °C to 48 °C
Relative Humidity	:	5% to 100%
Wet Bulb Temperature	:	27 °C
Duration	:	10 days max.

There shall be no condensation in or on the cartridge.

A.1.2 Recorded Cartridges

Temperature	:	5 °C to 32 °C
Relative Humidity	:	5% to 80%
Wet Bulb Temperature	:	27 °C
Duration	:	10 days max.

There shall be no condensation in or on the cartridge.

A.2 HAZARDS

Transportation of recorded cartridges involves three basic potential hazards.

A.2.1 Impact Loads and Vibration

The following recommendations should minimize damage during transportation.

i) Avoid mechanical loads that would distort the cartridge shape.

ii) Avoid dropping the cartridge more than 1 m.

iii) Cartridges should be fitted into a rigid box containing adequate shock-absorbant material.

iv) The final box must have a clean interior and a 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 their axes are horizontal.

vi) The final box should be clearly marked to indicate its correct orientation.

A.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 hours.

A.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 minimize the risk of corruption.

APPENDIX B

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 abrasiveness, 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.

APPENDIX C

TAPE ABRASIVITY MEASUREMENT PROCEDURE

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

Wind a minimum of 520 m of new and unused tape onto a supply reel. Install a clean ferrite wear bar made as shown in Fig. C1 on a holding fixture similar to that shown in Fig. C2. The test edge facing upward shall be unworn and free of chips or voids greater than 1 um in size. The radius of the test edge must not be greater than 13 um.

The material of the ferrite bar shall be single-phase polycrystaline ferrite. It shall have the following weight percentages:

ZnO	22%
NiO	11%
Fe_2O_3	67%

Its average grain size shall be 7,2 um ± 2 um. Its density shall not be less than 5,32 g/cm^3.

Note:

Such material should be available as "Sumitomo H4R3" from Sumitomo Special Metals Div. in Torrance (California), USA.

The surface finish on all four sides of the bar shall be at least of roughness grade N2 (ISO 1302).

Install the test fixture 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 1 m/s, make one pass of the tape over the wear bar. The length of tape passing over the wear bar shall be 520 m ± 2,5 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 300 times or higher is recommended.

Measurements should be taken across the 1/4, 1/2 and 3/4 points of the 12,65 mm width of the wear pattern. The three readings are averaged and the average length is used. Fig. C3 shows a typical wear pattern and the points of measurements.

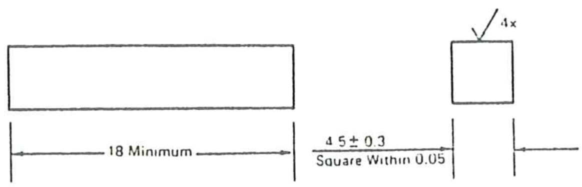


Fig. C1 - Ferrite Wear Bar

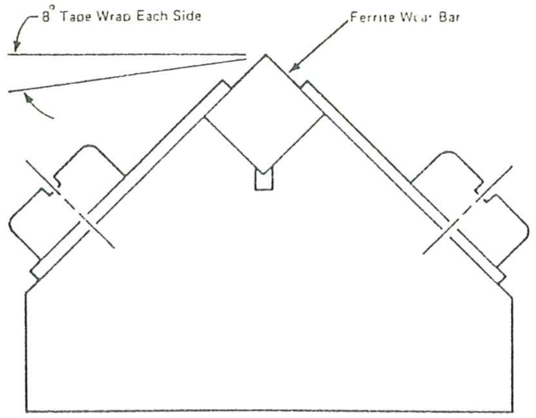


Fig. C2 - Wear Bar Holding Fixture

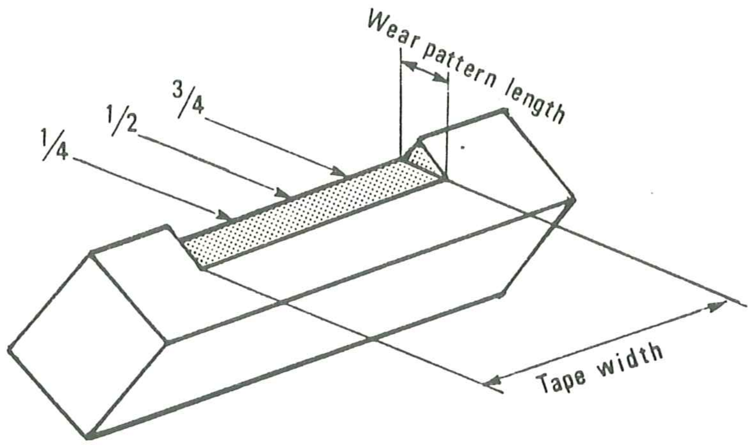


Fig. C3 - Typical Wear Pattern. Ferrite Bar following abrasivity test illustrating three locations for wear length measurement (the amount of wear is exaggerated for clarity).

APPENDIX D

RECOMMENDATIONS ON TAPE DURABILITY

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 operating environment (see 4.2) for the tape and the tape drive.

D.1 SHORT-LENGTH DURABILITY/RELIABILITY

D.1.1 The short-length durability/reliability is the ability of the tape to withstand the wearing action encountered during repeated accesses to a short file of data.

D.1.2 No permanent read errors are permitted for a minimum of 40000 read forward passes. In addition, no more than one permanent read error is permitted on the average for each 80000 read forward passes.

D.1.3 Procedure

Ensure the tape drive is clean before starting this test.

As a test sample, use a minimum of four cartridges, written in the area of the tape free of coincident missing pulse zones, to be cycled during the test. The area to be tested on each cartridge should be approximately 500 data blocks of 25000 bytes each past the tape load point. The test area should consist of 50 such data blocks.

Each test cycle consists of starting at the beginning of the test area and accessing each data block in the test area before returning, using backspace file, to the beginning of the test area. For a complete test, 80000 cycles should be made on each cartridge. Ten attempts to read forward should be made for each error before a permanent error is logged.

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

D.2 LONG-LENGTH DURABILITY/RELIABILITY

D.2.1 The long-length durability/reliability is the ability of the tape to resist the wearing action encountered while cycling full-length passes on a tape drive. This is not a test for end of life for the tape.

D.2.2 The cartridges should meet the following requirements.

i) The coincident missing pulse zones for the first 200 full length passes should not be more than 10 write errors per cartridge.

ii) There should not be more than 16 coincident missing pulse zones on any single pass and no permanent errors.

D.2.3 Procedure

Clean the tape drive before starting this test. The data written should consist of data blocks of at least 16000 bytes.

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

APPENDIX E

WRITE-PHASE MEASUREMENTS

A specification of the write transfer function is required to complete the set of constraints for an interchange tape. The phase of this transfer function, together with the minimum SNR, constitute a sufficient set of nominal signal constraints for interchange. The following procedure describes a method for measuring the write transfer function phase and a method for describing the shape of this phase.

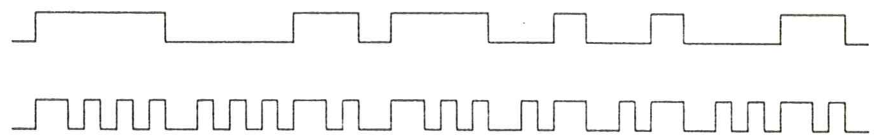
E.1 PROCEDURE

The first step in obtaining the write transfer function phase consists of taking amplitude samples of the 26-bit sequence (10001000101100101101100101) that appears in every track at the beginning of each recorded block. The sequence starts with the first bit of the frame of the BDM (9.6.2) and ends with the 8th bit of the second frame of the Prefix (9.3.1). This sequence will always be preceded and succeeded by ONES. For purposes of later references the waveform that would be generated by NRZ1 encoding (that is, a single transition at ONEs and no transition at ZEROs) of this sequence is called the NRZ1 waveform. As described in 7, the actual flux changes written on the tape are obtained using a write waveform that is generated by Inverted Frequency Modulation.

18-bit sequence 1 0 0 0 1 0 0 0 1 0 1 1 0 0 1 0 1 1 0 1 1 0 0 1 0 1

Equivalent NRZ1 pattern

Ideal write waveform



In order to separate the phase of the read and write transfer functions, the recorded sequence is read using both forward and backward direction tape motion. In each case the resulting read-back signals are sampled in the time domain using a minimum of four samples per bit and a total number of samples which spans exactly 26 bits. All succeeding phase calculations are then performed numerically. At least 100 repetitions of the sampled 26-bit period are time-averaged to obtain smoothed estimates of the output waveform. A forward transfer function is computed by dividing the Fourier series for the averaged forward read waveform by the Fourier series for the ideal write waveform, where both transforms are computed over exactly one 26-bit period. Because the phase of the transfer function is of interest, the time reference position of the output waveform must be selected to be nearly coincident with that of the write waveform in order to avoid problems associated with "phase wrapping". The latter occurs because the arc tangent function is evaluated in the range -180° to +180°. Time misalignment introduces a linear phase term which then "wraps" into the range of the arc tangent function. Time coincidence can readily be accomplished by comparing the NRZ1 waveform with the observed output. Similarities during long period portions of the waveforms serve as useful indicators for this purpose. Although exact alignment is not required, sufficient care should be taken to ensure that the time references coincide within one bit period.

Transfer-function calculations are carried out using harmonics 7 to 16 for a total of ten frequency points. The Fourier series coefficients for the 26-bit ideal write waveform are:

Harmonic Number	Fourier Series Coefficient	
	real	imaginary
7	-0,0227	-j 0,1402
8	0,0624	j 0,0270
9	0,0256	-j 0,0028
10	-0,0482	-j 0,1596
11	0,0568	-j 0,0211
12	0,0079	-j 0,0366
13	0,0	j 0,0490
14	-0,0086	-j 0,0400
15	-0,0678	-j 0,0253
16	0,0633	-j 0,2094

Once the forward-transfer function has been computed in this manner, it is further normalized for time delay by adding a linear-phase term, which forces the 13th harmonic (corresponding to the all-ONEs frequency) to 90°. The phase of this transfer function then consists of the sum of the write and read phases.

An analogous procedure is employed to compute the backward transfer function by dividing the transform of the averaged waveform obtained through reading the backward direction by the Fourier series for the time-reversed write waveform (i.e. the complex conjugate of the series used in the forward transfer function calculation). Because the read occurred in a direction opposite to that used to write the pattern, the phase of the resulting backward transfer function consists of the difference between the write phase and the read phase. Because the read transfer function is identical for both the forward and backward read measurements, the write phase can be extracted by taking one half of the difference between the forward and backward transfer function phases.

E.2 WRITE-PHASE CURVE DEFINITION

The phase of the write transfer function obtained using the procedure in E.1 is denoted by $\varphi(n)$, where n is the harmonic number (7 to 16). This measurement is approximated by the linear function $\Theta(n)$ given by,

$$\Theta(n) = a_0 + a_1 \cdot n$$

where a_0 and a_1 are constants chosen to minimize the sum-squares error ε^2,

$$\varepsilon^2 = \sum_n \{\varphi(n) - \Theta(n)\}^2$$

where the sum Σ is taken over n = 7, 8, ..., 16.

The intercept a_0 of this function at n = 0, is used to specify acceptable write-phase performance, as described in 7.7.

APPENDIX F

REPRESENTATION OF 8-BIT BYTES BY 9-BIT PATTERNS

	8-bit byte	9-bit pattern
	00000000	011001011
	00000001	011001001
	00000010	001001101
	00000011	101100011
	00000100	011001010
	00000101	101100101
	00000110	101100110
	00000111	101100111
	00001000	011001111
	00001001	101101001
	00001010	101101010
	00001011	101101011
	00001100	011001110
	00001101	101101101
	00001110	101101110
	00001111	101101111
	00010000	001001011
	00010001	001001001
	00010010	011001101
	00010011	100100011
	00010100	001001010
	00010101	100100101
	00010110	100100110
	00010111	100100111
	00011000	001001111
	00011001	100101001
	00011010	100101010
	00011011	100101011
	00011100	001001110
	00011101	100101101
	00011110	100101110
	00011111	100101111
	00100000	101001111
	00100001	101001101
	00100010	001010010
	00100011	001010011
	00100100	101001110
	00100101	001010101
	00100110	001010110
	00100111	001010111
	00101000	101001011
	00101001	001011001
	00101010	001011010
	00101011	001011011
	00101100	101001010
	00101101	001011101
	00101110	001011110
	00101111	001011111
Bit position	8 1	9 1

	8-bit byte	9-bit pattern
	00110000	011100011
	00110001	001100011
	00110010	001110010
	00110011	001110011
	00110100	010100011
	00110101	001110101
	00110110	001110110
	00110111	001110111
	00111000	111100011
	00111001	001111001
	00111010	001111010
	00111011	001111011
	00111100	110100011
	00111101	001111101
	00111110	001111110
	00111111	001111111
	01000000	010001011
	01000001	010001001
	01000010	010010010
	01000011	010010011
	01000100	010001010
	01000101	010010101
	01000110	010010110
	01000111	010010111
	01001000	010001111
	01001001	010011001
	01001010	010011010
	01001011	010011011
	01001100	010001110
	01001101	010011101
	01001110	010011110
	01001111	010011111
	01010000	011100101
	01010001	001100101
	01010010	010110010
	01010011	010110011
	01010100	010100101
	01010101	010110101
	01010110	010110110
	01010111	010110111
	01011000	111100101
	01011001	010111001
	01011010	010111010
	01011011	010111011
	01011100	110100101
	01011101	010111101
	01011110	010111110
	01011111	010111111
Bit position	8 1	9 1

	8-bit byte	9-bit pattern
	01100000	011100110
	01100001	001100110
	01100010	011010010
	01100011	011010011
	01100100	010100110
	01100101	011010101
	01100110	011010110
	01100111	011010111
	01101000	111100110
	01101001	011011001
	01101010	011011010
	01101011	011011011
	01101100	110100110
	01101101	011011101
	01101110	011011110
	01101111	011011111
	01110000	011100111
	01110001	001100111
	01110010	011110010
	01110011	011110011
	01110100	010100111
	01110101	011110101
	01110110	011110110
	01110111	011110111
	01111000	111100111
	01111001	011111001
	01111010	011111010
	01111011	011111011
	01111100	110100111
	01111101	011111101
	01111110	011111110
	01111111	011111111
	10000000	111001011
	10000001	111001001
	10000010	100010010
	10000011	100010011
	10000100	111001010
	10000101	100010101
	10000110	100010110
	10000111	100010111
	10001000	111001111
	10001001	100011001
	10001010	100011010
	10001011	100011011
	10001100	111001110
	10001101	100011101
	10001110	100011110
	10001111	100011111
Bit position	8 1	9 1

	8-bit byte	9-bit pattern
	10010000	011101001
	10010001	001101001
	10010010	100110010
	10010011	100110011
	10010100	010101001
	10010101	100110101
	10010110	100110110
	10010111	100110111
	10011000	111101001
	10011001	100111001
	10011010	100111010
	10011011	100111011
	10011100	110101001
	10011101	100111101
	10011110	100111110
	10011111	100111111
	10100000	011101010
	10100001	001101010
	10100010	101010010
	10100011	101010011
	10100100	010101010
	10100101	101010101
	10100110	101010110
	10100111	101010111
	10101000	111101010
	10101001	101011001
	10101010	101011010
	10101011	101011011
	10101100	110101010
	10101101	101011101
	10101110	101011110
	10101111	101011111
	10110000	011101011
	10110001	001101011
	10110010	101110010
	10110011	101110011
	10110100	010101011
	10110101	101110101
	10110110	101110110
	10110111	101110111
	10111000	111101011
	10111001	101111001
	10111010	101111010
	10111011	101111011
	10111100	110101011
	10111101	101111101
	10111110	101111110
	10111111	101111111
Bit position	8 1	9 1

	8-bit byte	9-bit pattern
	11000000	110001011
	11000001	110001001
	11000010	110010010
	11000011	110010011
	11000100	110001010
	11000101	110010101
	11000110	110010110
	11000111	110010111
	11001000	110001111
	11001001	110011001
	11001010	110011010
	11001011	110011011
	11001100	110001110
	11001101	110011101
	11001110	110011110
	11001111	110011111
	11010000	011101101
	11010001	001101101
	11010010	110110010
	11010011	110110011
	11010100	010101101
	11010101	110110101
	11010110	110110110
	11010111	110110111
	11011000	111101101
	11011001	110111001
	11011010	110111010
	11011011	110111011
	11011100	110101101
	11011101	110111101
	11011110	110111110
	11011111	110111111
Bit position	8 1	9 1

	8-bit byte	9-bit pattern
	11100000	011101110
	11100001	001101110
	11100010	111010010
	11100011	111010011
	11100100	010101110
	11100101	111010101
	11100110	111010110
	11100111	111010111
	11101000	111101110
	11101001	111011001
	11101010	111011010
	11101011	111011011
	11101100	110101110
	11101101	111011101
	11101110	111011110
	11101111	111011111
	11110000	011101111
	11110001	001101111
	11110010	111110010
	11110011	111110011
	11110100	010101111
	11110101	111110101
	11110110	111110110
	11110111	111110111
	11111000	111101111
	11111001	111111001
	11111010	111111010
	11111011	111111011
	11111100	110101111
	11111101	111111101
	11111110	111111110
	11111111	111111111
Bit position	8 1	9 1