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Information technology — High density digital recording (HDDR) —

Part 2:
Guide for interchange practice

Technologies de l'information — Enregistrement numérique à haute densité (HDDR)

Partie 2: Guide pour l'échange d'information

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Foreword

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

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

International Standard ISO/IEC 8441-2 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

ISO/IEC 8441 consists of the following parts, under the general title *Information technology — High density digital recording (HDDR)*:

— *Part 1: Unrecorded magnetic tape for (HDDR) applications*

— *Part 2: Guide for interchange practice*

Annexes A and B of this part of ISO/IEC 8441 are for information only.

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Information technology — High density digital recording (HDDR) —

Part 2:
Guide for interchange practice

1 Scope

This part of ISO/IEC 8441 specifies the minimum performance levels necessary for the effective interchange of information using High Density Digital Recording (HDDR). It also describes methods of testing for determining these levels. It gives guidance on recorders/reproducer characteristics, modes of recording, and modulation patterns.

The imperial dimensions given in this part of ISO/IEC 8441 are the reference dimensions. The metric and imperial dimensions are, however, given to a sufficient degree of accuracy as to be totally interchangeable.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO/IEC 8441. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO/IEC 8441 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO/IEC 3788:1990, *Information processing — 9-track, 12,7 mm (0,5 in) wide magnetic tape for information interchange using phase encoding at 126 ftpmm (3 200 ftpi), 63 cpmm (1 600 cpi).*

ISO 6068:1985, *Information processing — Recording characteristics of instrumentation magnetic tape (including telemetry systems) — Interchange requirements.*

ISO/IEC TR 6371:1989, *Information processing — Interchange practices and test methods for unrecorded instrumentation magnetic tape.*

3 Definitions

For the purposes of this part of ISO/IEC 8441, the following definitions apply.

3.1 aliasing: The false lower frequency components resulting from an insufficient sampling rate (i.e. less than required by the sampling theorem) when reconstructing an analogue signal from its sampled data representation.

3.2 baseline restorer: A device to restore the d.c. component removed by the record/reproduce process.

3.3 bit error: The incorrect interpretation of a binary bit by a message processing unit.

3.4 bit error rate (BER): The rate at which bit errors occur in a message processing unit, expressed in terms of the number of bit errors divided by the total number of bits processed in a given period of time, or from a given length of tape.

3.5 bit packing density: The number of bits recorded per unit track length, usually expressed in terms of bits per millimetre (bit/mm) or kilobits per inch (kbit/in).

3.6 bit slip: The condition in a message processing unit where the bit rate clock has gained (or lost) more than 180° phasing with respect to synchronism with the binary message bits.

3.7 bit synchronizer: An information processing unit intended to extract the binary message and associated bit rate clock included in a pulse code modulation (PCM) signal.

3.8 cross play: The ability to record and reproduce on the same or a different machine, or record at one speed and reproduce at the same or different speed.

3.9 cross talk: Interference signals that are coupled from adjacent channels into a given processing unit channel, usually expressed in terms of decibels down from full scale amplitude of the unit channel.

3.10 data azimuth: The instantaneous angle in the plane of the tape between a line perpendicular to the reference edge and either of the two parallel lines defining data scatter.

NOTE 1 Data azimuth may be expressed as the sum of static and dynamic components in the form

$$A + Bf(t)$$

where

$$\int_0^t f(t)\mathrm{d}t = 0$$

3.11 data azimuth (dynamic): The maximum angular deviation, over a period of time, of the data azimuth from its mean value as defined by data azimuth (static). For the purpose of this definition, the word "maximum" is interpreted as being at the 95 % probability level. For a Gaussian distribution, this is two standard deviations (2σ).

NOTE 2 Data azimuth (dynamic) is the maximum value of the quantity $Bf(t)$ in 3.10.

3.12 data azimuth (static): The mean value, over a period of time, of the data azimuth.

NOTE 3 Data azimuth (static) is the quantity A in 3.10.

3.13 data scatter: The minimum distance between two parallel lines, in the plane of the tape, enclosing all data transitions recorded simultaneously on all tracks in the same head.

NOTE 4 The errors in location and angular relation among transient data recorded simultaneously on all odd or even tracks are defined by the terms: data azimuth, data scatter, and individual track data azimuth difference. These are approximately equivalent to the terms: head azimuth, gap scatter, and head segment gap azimuth difference; however, guiding misalignment is included in the data location error definition.

3.14 data spacing: The distance on the tape between simultaneous events recorded on odd and even numbered tracks when interlaced heads are used.

NOTE 5 When recording, this is equal to the head spacing, but on reproducing it is equal to head spacing only when the record and reproduce tensions and head spacing are equal.

3.15 decoder: Information recovery device that accepts digital signals from the tape reproducer and converts them into a form suitable for the output interface.

3.16 digital recording code: The on-tape digital coding of the recorded binary message.

3.17 dropout: Reduction in the reproduce signal amplitude severe enough to cause bit errors.

3.18 duty factor (of a pulse): The ratio of pulse duration to pulse period, often expressed as a percentage.

3.19 edge margin (M): The distance between the outside edge of the highest numbered track and the tape edge (see figure 3).

3.20 edge margin, minimum (M_m): The minimum value of the edge margin.

NOTE 6 This value places an additional constraint on track configurations since, in general, the simultaneous application of all worst-case tolerances for track width, track location, and tape width will result in a value of edge margin less than M_m.

3.21 encoder: A processing device that accepts a data stream at its input and converts it to appropriate digital signals to be recorded on tape.

3.22 error detection: The process of detecting bit errors.

3.23 error correction: The process of correcting detected bit errors.

3.24 eye pattern: The pattern as displayed on an oscilloscope, that results from the superpositioning of the waveforms of the different symbols in a digital data sequence. It is used for assessing the quality of the replayed digital signal.

3.25 flaw: An imperfection in the tape oxide coating due to oxide or slitting debris, foreign particulate matter, absence of coating, etc.

NOTE 7 Such imperfections are the major source of dropouts. Other imperfections such as failure to maintain slitting tolerances and other physical nonuniformities can cause poor tracking which results in reproduce signal fluctuations similar to dropouts.

3.26 flutter: Tape speed errors at frequencies above 0,5 Hz.

3.27 flux transition: A 180° change in the flux pattern in a magnetic medium, brought about by the reversal of the magnetic poles within the medium.

3.28 flux transition density: The number of flux transitions (i.e. flux reversals) per unit track length.

3.29 frame synchronizer: A processing device to detect and synchronize frames and subframes of a pulse code modulation bit stream.

3.30 gap length: Distance from the leading edge to the trailing edge of head gap measured perpendicular to the track width (see figure 1).

3.31 gap scatter: The minimum distance between two parallel lines, in the plane of the tape, between which all the gap trailing edges of a record head are embraced (see figure 1).

3.32 head: A group of individual head segments in a fixed assembly.

3.33 head azimuth: The angle formed in the plane of the tape, between a line passing through the gap centres of the two outside head segments and a line perpendicular to the head reference plane (see figure 1).

3.34 head 1: The first record or reproduce head over which an element of tape passes when moving in the normal operating direction (see also 3.39).

3.35 head reference plane: A plane, which may be imaginary, that is parallel to the reference edge of the tape and perpendicular to the plane of the tape.

NOTE 8 For the purpose of this definition the tape is considered as perfect (see figure 1).

3.36 head segment: A single transducer that records or reproduces one track (see figure 1).

3.37 head segment gap azimuth: The angle, formed in the plane of the tape, between a line perpendicular to the head reference plane and a line parallel to the trailing edge of the gap in a record head segment (see figure 1).

3.38 head segment gap azimuth difference: The angular deviation of the azimuth of a head segment gap from the head azimuth.

3.39 head segment number: The number of the head segment corresponding to the track number on the magnetic tape on which that head segment normally operates (see figure 2).

NOTE 9 Head 1 of a pair contains all odd-numbered segments, while head 2 contains all even-numbered segments (see figure 1 and figure 2).

3.40 head spacing (S): The distance along the tape path between the gap centrelines of head 1 and head 2, when interlaced heads are used (see figure 2).

3.41 head tilt: The angle between the plane tangent to the front (active) surface of the head at the centreline of the head segment gaps, and a line perpendicular to the head reference plane (see figure 1).

3.42 high density digital recording (HDDR): Recording of digital data on a magnetic medium, having a flux transition density in excess of 590 transitions per millimetre (15 000 transitions per inch) per track.

3.43 individual track data azimuth difference: The angular deviation of the data azimuth of individual odd or even recorded tracks from the data azimuth of other odd or even tracks.

NOTE 10 The difficulty in making direct optical angular measurements requires this error to be expressed as a loss of signal amplitude when the tape is reproduced with an ideal head, whose gap is aligned to coincide with the data azimuth of all odd or even tracks, as compared to the maximum signal amplitude obtainable by optimizing the reproduce head azimuth for the individual tracks (see figure 1).

3.44 in-line heads: An arrangement in which all record or all reproduce gaps are in line on a single head stack.

3.45 interlaced heads: An arrangement whereby pairs of head stacks are mounted so that alternate tracks are contained in separate head stacks of a pair (see figure 2).

3.46 jitter amplitude: The variation in the timing of one clock transition relative to that of the preceding transition, expressed as a percentage of the mean interval between the clock transitions.

3.47 jitter rate: The rate of change of the jitter amplitude expressed in hertz.

3.48 overbias: When the bias current is continuously increased from an initial low level while recording a relatively long wavelength signal on tape, the reproduce output first increases with increasing bias until it reaches a maximum, after which further increases in bias cause a reduction in output. A typical bias adjustment procedure involves finding the level corresponding to maximum (or peak) output and then increasing the bias to cause a specified reduction in reproduce amplitude where the amount of this reduction, usually expressed in decibels, is known as the amount of overbias.

3.49 overhead bits: Bits added to the bit stream to facilitate the transmission and recovery of the bit

stream (e.g. frame synchronization words, check bits).

3.50 parallel HDDR: The recording of multiple PCM data streams that are synchronous to a common clock on multitrack recorders/reproducers so that synchronization can be restored at playback.

3.51 pseudorandom sequences/patterns: Repeating sequences exhibiting many of the statistical properties of uniformly distributed random number sequences.

3.52 pulse code modulation (PCM): A modulation method in which information to be recorded is encoded into digital symbols (see 3.21 and figure A.1).

3.53 reference edge: The edge of the tape nearest to track 1 (see figure 3).

3.54 reference track location (G): Location of the centreline of track 1 relative to the reference edge of the tape (see figure 3).

3.55 signal-to-noise ratio (SNR): The ratio of signal power to noise power, expressed in decibels.

3.56 single track serial HDDR: The recording of one or more digital data streams on to a single recording track.

3.57 synchronization word: A fixed pattern of bits inserted in a digital bit stream to synchronize the frame synchronizer.

3.58 synchronous: Having the same rate and phase.

3.59 tape skew: Motion of tape such that the tape tracks are not perpendicular to the gap centre line. Skew can have both static and dynamic components (see 3.10, 3.11 and 3.12).

3.60 tape speed, actual (v_{act}): The tape speed during recording and reproducing.

NOTE 11 In general, the actual tape speed will not be equal to the nominal tape speed (see 4.2.1).

3.61 tape speed, effective (v_{eff}): The tape speed corrected for the effects on the tape of operating conditions, i.e. tensile force, tape materials, thickness, and environment (temperature and humidity).

3.62 tape speed, nominal (v): A set of defined nominal tape speeds for tapes operating at the reference tensile force (see 4.4.7), and in standard test environmental conditions of 23 °C ± 3 °C (+ 73 °F ± 5 °F) and relative humidity 45 % to 55 %.

3.63 tape speed error: Departure of the average speed from the nominal value.

3.64 tape tensile force: The tensile force applied to the tape during operation.

NOTE 12 The value of this tensile force is not necessarily equal to the reference tensile force.

3.65 track location (H_n): The distance from the centreline of the reference track to the centreline of the recorded track location, (n) (see figure 3).

3.66 track numbering: The consecutive numbering of tracks, starting with track 1, from top to bottom, when viewing the magnetic surface on the tape with the earlier portion of the recorded signal to the observer's right (see figure 3).

3.67 track spacing (D): The centre-to-centre distance between adjacent recorded tracks (see figure 3).

3.68 track width (W): The mechanical width of the common interface of the record head segment at the gaps (see figure 1).

NOTE 13 This does not include the effects of fringing fields which will tend to increase the recorded track width by a small amount (see figure 1 and figure 3).

4 Recording and reproducing characteristics

4.1 General

This clause defines those tape and recorder/reproducer characteristics required to ensure successful interchange, so that tapes recorded on one machine at one facility may be successfully reproduced on another machine of like design at another facility. Test procedures for magnetic tape recording/reproducing equipment are given in ISO 6068:1985, annex A.

The physical properties of the tape are specified in ISO/IEC 8441-1.

4.2 Tape speeds

4.2.1 Tape speed

The record tape speed shall be in the range of 23,8 mm/s (15/16 in/s) to 6 096 mm/s (240 in/s). It shall be appropriate for the input data rate so that the flux transition density on tape is within the limit imposed by table A.1 for the performance category of the system concerned. The reproduce tape speed may be adjusted to obtain the desired output data rate. Tape speed should be a matter of agreement between the interchange parties. Table 7 lists nominal recording tape speeds and the associated flux transition density limits.

4.2.2 Effective tape speed

The effective tape speed (v_{eff}) throughout a reel (in the absence of tape-derived servo speed control) shall be within ± 0,5 % of each of the nominal tape speeds given in table 7 which are provided for by the recorder/reproducer.

4.2.3 Pulse-to-pulse jitter

4.2.3.1 Intratrack. On any track, the pulse-to-pulse jitter (0 to peak units) plotted against pulse-to-pulse interval (in the absence of tape-derived speed control) shall have a slope less than 0,2 % at every speed listed in table 7 which is provided for by the recorder/reproducer.

NOTE 14 Recommended methods for measuring pulse-to-pulse jitter are given in ISO 6068:1985, annex A.

4.2.3.2 Intertrack. Between any pair of adjacent tracks on the same head, the intertrack pulse-to-pulse jitter (0 to peak units) plotted against pulse-to-pulse interval (in the absence of tape-derived speed control) shall have a slope less than 0,4 % at all effective tape speeds as 4.2.2. The effects of skew can be added, provided dynamic skew and static skew limits in this part of ISO/IEC 8441 are not exceeded.

4.2.3.3 With tape-derived speed control. With tape-derived speed control, the intertrack and intratrack pulse-to-pulse jitter values shall not exceed twice the values given in 4.2.3.2 and 4.2.3.1, respectively.

4.3 Track configurations

Head mechanical parameters shall be as shown in figure 1. Track configurations shall be as shown in figure 2 for an n-track interlaced head, and the recorded tape format shall be as shown in figure 3 with dimensions given in the applicable table 1 to table 6.

NOTE 15 Although a tape reference edge is stated, edge guiding of the tape is not an implied requirement of the recorder/reproducer.

The head spacing for adjustable heads refers to equipment having facilities for adjusting the azimuth of reproduce heads; these facilities are required for high density digital recorders/reproducers in category C and possibly category B (see annex A).

NOTE 16 For cross-play enhancement, it may be beneficial to adjust the record head azimuth against a recorded reference tape aligned to the reproduce systems.

4.4 Recorder/reproducer characteristics

4.4.1 Data scatter

The maximum data scatter shall be as follows:

Tape width	Maximum data scatter
12,7 mm (0,5 in)	2,54 µm (100 µin)
25,4 mm (1,0 in)	5,08 µm (200 µin)
50,8 mm (2,0 in)	10,16 µm (400 µin)

4.4.2 Data azimuth (static)

Data azimuth (static) shall not be greater than ± 0,3 mrad (± 1′).

4.4.3 Data azimuth (dynamic)

Data azimuth (dynamic) shall not be greater than ± 0,3 mrad (± 1′) as determined from measurements of the dynamic interchannel time displacement error (ITDE) between outer tracks on the same head. The method for the measurement of ITDE shall be in accordance with ISO 6068.

4.4.4 Individual track data azimuth difference

The maximum signal loss due to the individual track data azimuth differences shall not be greater than 1 dB (excluding reproduce head error) at the shortest wavelength specified by the manufacturer of the equipment. The overall record/reproduce error shall not be greater than 2 dB.

4.4.5 Head tilt

Head tilt shall not be greater than ± 0,3 mrad (± 1′) (see figure 1).

4.4.6 Head polarity

4.4.6.1 Record side. Some recording codes require that the recording and reproduce polarities bear a known relationship to each other for correct decoding. To maintain signal polarity from record to playback it is required that an isolated false-to-true level transition, followed by a return to the quiescent false level, at the encoder output be recorded as a south-north north-south flux transition sequence on tape. Likewise, the passage of such an isolated south-north north-south flux transition sequence past the reproduce head shall cause a positive-going output pulse to appear at the input to the decoder.

NOTE 17 Details as to how to establish known polarity flux transitions on tape will be found in ISO 6068:1985, annex A.

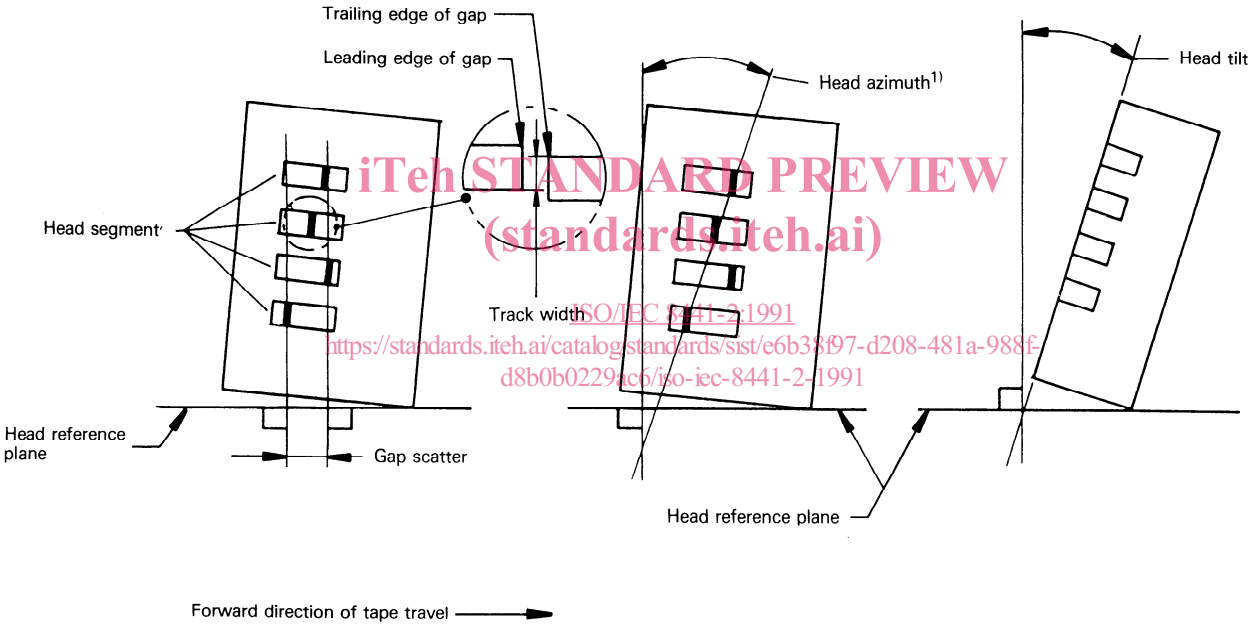
4.4.6.2 Reproduce side. Each reproduce head winding shall be connected to its respective amplifier in such a manner that a segment of tape exhibiting a south-north north-south transition pattern will produce a positive-going pulse, with respect to system ground, at the output of the reproduce amplifier.

4.4.7 Reference tensile force

The reference tensile force shall be 0,109 N/mm (10 ozf/in) of tape width. For ideal interchange, recorder/reproducer operating tape tensile forces should be equal to the reference tensile force; as the operating tensile force departs from the reference tensile force, the corrections applied to make the effective tape speed (v_{eff}) equal to the nominal tape speed (v) become increasingly unreliable due to nonlinearities, etc.

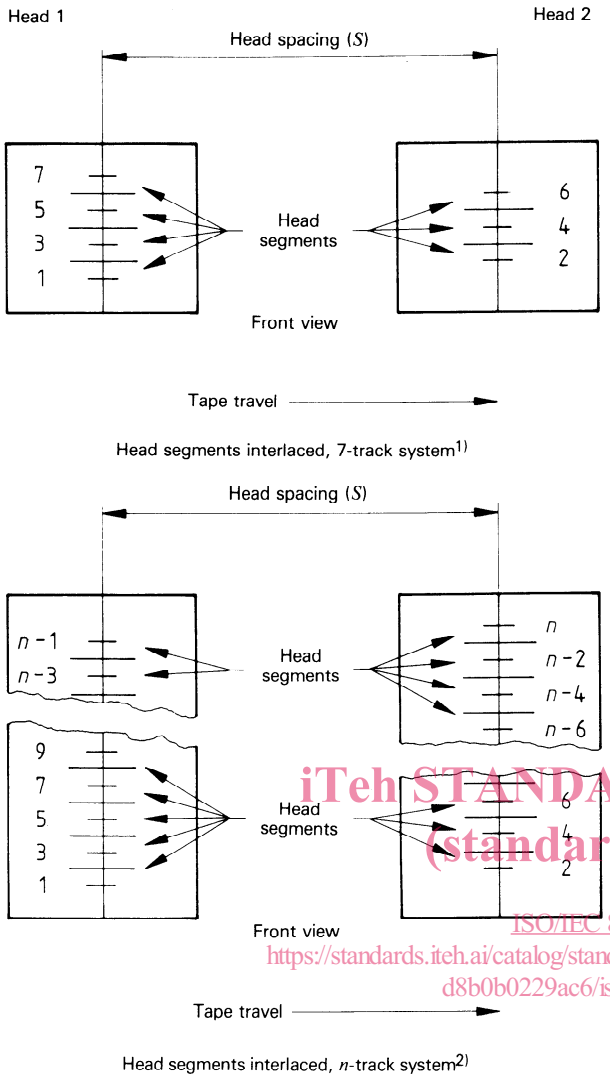
4.5 Other characteristics

Requirements for other characteristics are not stated in this part of ISO/IEC 8441 since they depend on the intended application, but recommended test methods for measuring such characteristics are given in ISO 6068:1985, annex A.



1) The head azimuth line passes through the gap centres of the two outside tracks.

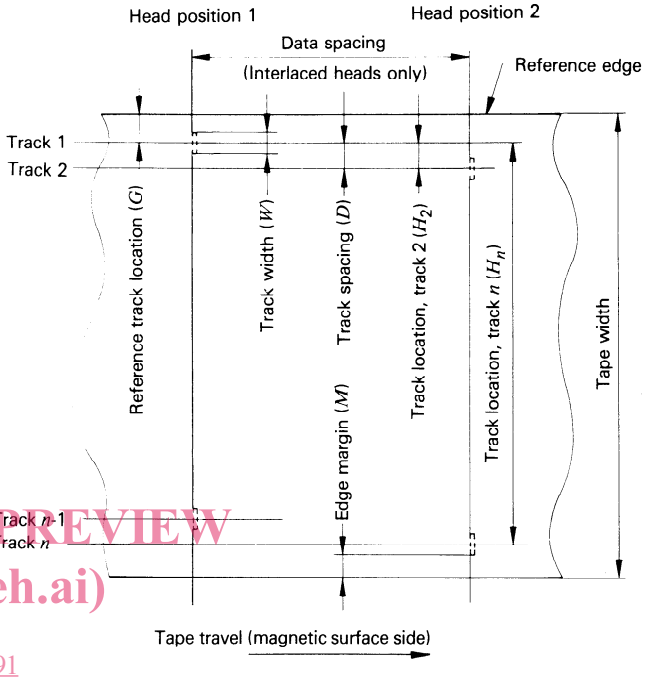
Figure 1 — Head mechanical parameters



1) For 7 track systems, head segments 1, 3, 5 and 7 are in head 1, and head segments 2, 4 and 6 are in head 2.

2) For formats listed in table 3 to table 7, head segments n-1, n-3, etc. are in head 1, and head segments n, n-2, etc. are in head 2.

Figure 2 — 7-track and n-track systems with head segments interlaced



1) For an in-line format all tracks are in head position 1.

2) For interlaced formats, tracks 1 to n-1 are in head position 1, and tracks 2 to n are in head position 2.

3) For 7-tracks (3 + 4) interlaced formats, track 7 is n.

Figure 3 — Recorded tape format