INTERNATIONAL STANDARD

ISO/IEC 7811-7

Second edition
2014-09-01

Identification cards — Recording technique —

Part 7: Magnetic stripe — High coercivity, high density

Cartes d'identification — Technique d'enregistrement —

Partie 7: Bandeau magnétique — Haute coercitivité, haute densité

Reference number
ISO/IEC 7811-7:2014(E)

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Published in Switzerland

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 17, *Cards and personal identification.*

This second edition cancels and replaces the first edition (ISO/IEC 7811-7:2004) of which it constitutes a major revision with the following changes.

— The primary standard cards held by Q-Card are used to calibrate the manufacture of secondary reference cards. Other primary standard cards held by PTB and Card testing International (CTI) are used as backup to replace cards held by Q-Card as they wear out.

— Delete reference to character sets in the Scope since none are used in this International Standard.

  — List of major differences has been moved from the Introduction to Annex A.

  — The supplier of secondary reference cards has changed from PTB to Q-Card.

ISO/IEC 7811 consists of the following parts, under the general title *Identification cards — Recording technique:*

— *Part 1: Embossing*

— *Part 2: Magnetic stripe — Low coercivity*

— *Part 6: Magnetic stripe — High coercivity*

— *Part 7: Magnetic stripe — High coercivity, high density*

— *Part 8: Magnetic stripe — High coercivity of 51,7 kA/m (650 Oe)*

— *Part 9: Tactile identifier mark*

Notes in this International Standard are only used for giving additional information intended to assist in the understanding or use of the International Standard and do not contain provisions or requirements to which it is necessary to conform in order to be able to claim compliance with this International Standard.

Identification cards — Recording technique —

Part 7:
Magnetic stripe — High coercivity, high density

1 Scope

This part of ISO/IEC 7811 is one of a series of International Standards describing the characteristics for identification cards as defined in the definitions clause and the use of such cards for international interchange.

This part of ISO/IEC 7811 specifies requirements for a high coercivity magnetic stripe (including any protective overlay) on an identification card and encoding technique. It takes into consideration both human and machine aspects and states minimum requirements.

Coercivity influences many of the quantities specified in this part of ISO/IEC 7811 but is not itself specified. The main characteristic of the high coercivity magnetic stripe is its improved resistance to erasure. This is achieved with minimal probability of damage to other magnetic stripes by contact while retaining read compatibility with magnetic stripes as defined in ISO/IEC 7811-2.

This standard provides for a card capacity of approximately 10 times that of a card conforming to ISO/IEC 7811-6. The number of tracks has been increased to six, each track being approximately half the width of tracks conforming to ISO/IEC 7811-6, located so that readers designed to read these high density tracks will also be able to read cards conforming to ISO/IEC 7811-2 and ISO/IEC 7811-6. Data is encoded in 8 bit bytes using the MFM encoding technique. Data framing is used to limit error propagation and error correction techniques further improve reliability of reading.

It is the purpose of this series of International Standards to provide criteria to which cards shall perform. No consideration is given within these International Standards to the amount of use, if any, experienced by the card prior to test. Failure to conform to specified criteria should be negotiated between the involved parties.

ISO/IEC 10373-2 specifies the test procedures used to check cards against the parameters specified in this part of ISO/IEC 7811.

NOTE Numeric values in the SI and/or Imperial measurement system in this part of ISO/IEC 7811 might have been rounded off and therefore are consistent with, but not exactly equal to, each other. Either system can be used, but the two should not be intermixed or reconverted. The original design was made using the Imperial measurement system.

2 Conformance

A prerequisite for conformance with this part of ISO/IEC 7811 is conformance with ISO/IEC 7810. An identification card is in conformance with this part of ISO/IEC 7811 if it meets all mandatory requirements specified herein. Default values apply if no others are specified.

3 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 4287-1, *Surface roughness — Terminology — Part 1: Surface and its parameters*

ISO/IEC 7810, *Identification cards — Physical characteristics*

ISO/IEC 10373-1, *Identification cards — Test methods — Part 1: General characteristics*

ISO/IEC 10373-2, *Identification cards — Test methods — Part 2: Cards with magnetic stripes*

4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 7810 and the following apply.

4.1
primary standard
set of reference cards established by Physikalisch-Technische Bundesanstalt (PTB) and maintained by PTB, Q-Card, and WG1 secretariat that represent the values of UR and IR designated RM7811-6

4.2
secondary standard
reference card designated RM7811-6 that is related to the primary standard as stated in the calibration certificate supplied with each card

Note 1 to entry: Secondary standards can be ordered from Q-Card, 301 Reagan St., Sunbury, PA 17801, USA. The source of secondary standards will be maintained at least until 2018.

4.3
unused un-encoded card
card possessing all the components required for its intended purpose, which has not been subjected to any personalization or testing operation, and which has been stored in a clean environment with no more than 48 h exposure to day-light at temperatures between 5 °C to 30 °C and humidity between 10 % to 90 % without experiencing thermal shock

4.4
unused encoded card
card according to 4.3 that has only been encoded with all the data required for its intended purpose (e.g. magnetic encoding, embossing, electronic encoding)

4.5
returned card
card according to 4.4 after it has been issued to the card holder and returned for the purpose of testing

4.6
flux transition
location of the greatest rate of change with distance of the magnetization

4.7
reference current
$\boldsymbol{I_R}$
minimum recorded current amplitude under the given test conditions that causes, on the reference card, a readback signal amplitude equal to 80 % of the reference signal amplitude U_R, at a density of 20 flux transitions per mm (508 flux transitions per inch) as shown in Figure 6

4.8
reference flux level
$\boldsymbol{F_R}$
flux level in the test head that corresponds to the reference current I_R

4.9
test recording currents
two recording currents defined by: I_{min} = recording current corresponding to 2,2 F_R and I_{max} = recording current corresponding to 2,5 F_R

4.10
individual signal amplitude
U_i
base-to-peak amplitude of a single readback voltage signal

4.11
average signal amplitude
U_A
sum of the absolute values of the amplitude of each signal peak (U_i) divided by the number of signal peaks (n) for a given track over the length of the magnetic stripe area

4.12
reference signal amplitude
U_R
maximum value of the average signal amplitude of a reference card corrected to the primary standard

4.13
physical recording density
number of flux transitions per unit length recorded on a track

4.14
bit density
number of data bits stored per unit of length (bits/mm or bpi)

4.15
bit cell
distance for a data bit nominally the reciprocal of the bit density (see Figure 8)

4.16
average bit cell
B_a
product of bit cell length and sum of the actual distances for all flux transition intervals on a track divided by the sum of the nominal distances for all flux transition intervals on the track

4.17
local average bit cell
B_{a6}
comparison reference for a given flux transition interval equal to the nominal L1 distance multiplied by the sum of the actual distances for the previous six flux transition intervals divided by the sum of the nominal distances for the previous six flux transition intervals

$$L1 \times (\Sigma \text{ actual})/(\Sigma \text{ nominal})$$

4.18
demagnetization current
I_d
D C current value that reduces the average signal amplitude to 80 % of the reference signal amplitude (U_R) on a secondary reference card that has been encoded at a density of 40 ft/mm (1 016 ftpi) at a current of I_{min}

4.19
L_1
short distance between adjacent flux transitions nominally equal to 1 times the bit cell

4.20
L_2
medium distance between adjacent flux transitions nominally equal to 1,5 times the bit cell

4.21
L_3
long distance between adjacent flux transitions nominally equal to 2 times the bit cell

4.22
FSC
frame synchronization character

4.23
CRC
cyclic redundancy check

4.24
CP
column parity

4.25
U_F
magnitude of the individual element at 20 flux transitions per mm frequency of the Fourier spectrum for a given track over the length of the magnetic stripe area

5 Physical characteristics of the identification card

The identification card shall conform to the specification given in ISO/IEC 7810.

WARNING — The attention of card issuers is drawn to the fact that information held on the magnetic stripe may be rendered ineffective through contamination by contact with dirt and certain commonly used chemicals including plasticizers. It should also be noted that any printing or screening placed on top of the magnetic stripe must not impair the function of the magnetic stripe.

5.1 Magnetic stripe area warpage

Application of a 2,2 N (0.5 lbf) load evenly distributed on the front face opposite the magnetic stripe shall bring the entire stripe within 0,08 mm (0.003 in) of the rigid plate.

5.2 Surface distortions

There shall be no surface distortions, irregularities or raised areas on both the front and the back of the card in the area shown in Figure 1 that might interfere with the contact between the magnetic head and magnetic stripe.

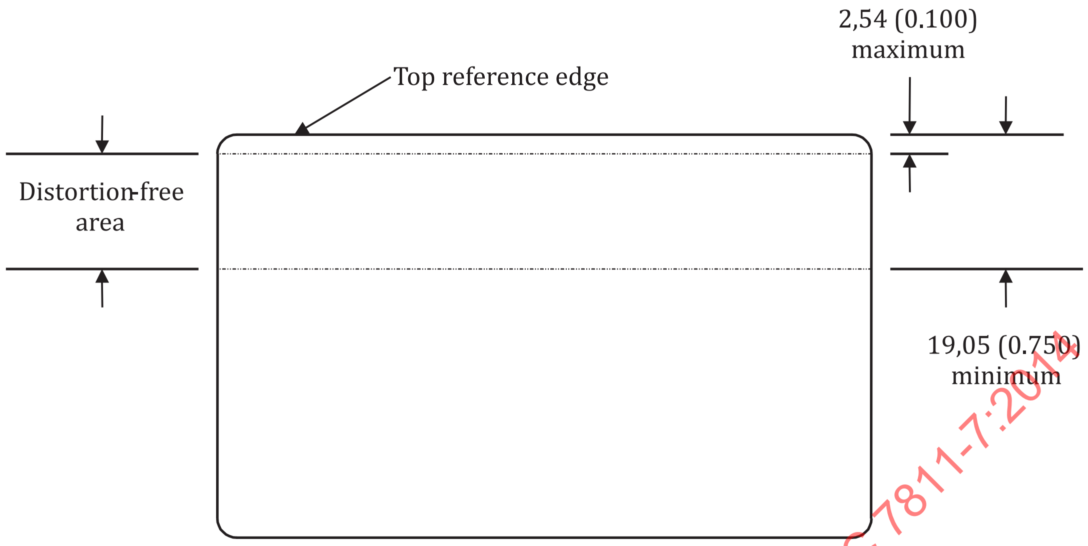


Figure 1 — Distortion-free area on card with magnetic stripe

If a raised signature panel area is located on the front or back of the card, then it shall be no closer to the top edge of the card than 19,05 mm (0.750 in).

NOTE Raised areas and distortions on other areas of the card may cause card transport problems with magnetic stripe processing equipment resulting in reading or writing errors.

6 Physical characteristics of the magnetic stripe

6.1 Height and surface profile of the magnetic stripe area

The magnetic stripe area is located on the back of the card as shown in Figure 2.

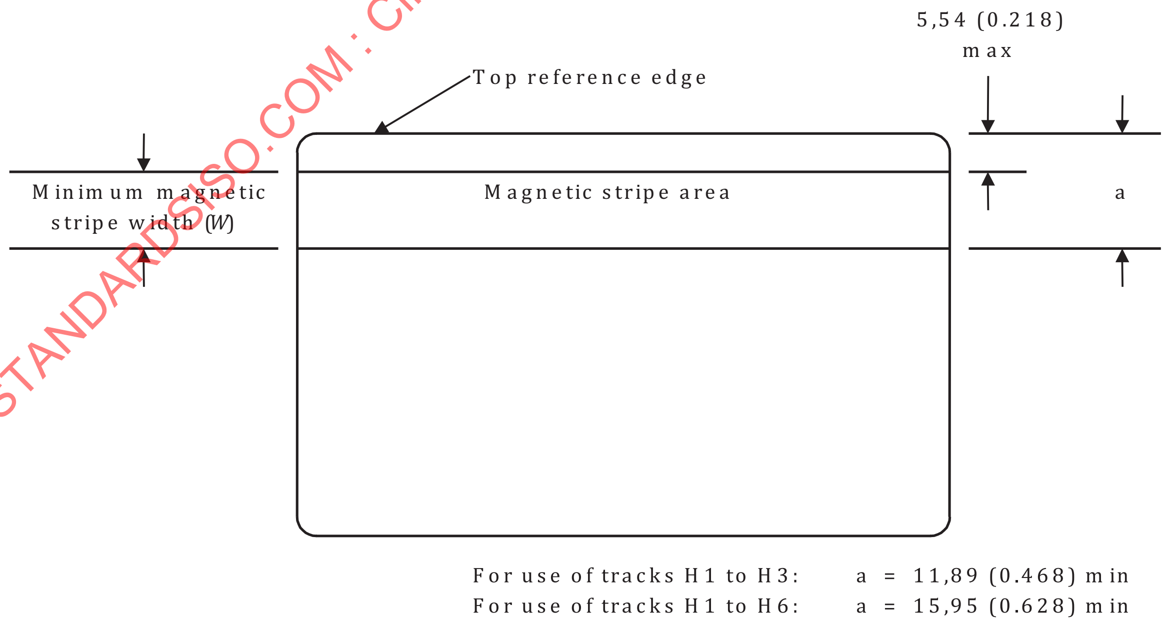


Figure 2 — Location of magnetic material

6.1.1 Surface profile of the magnetic stripe area

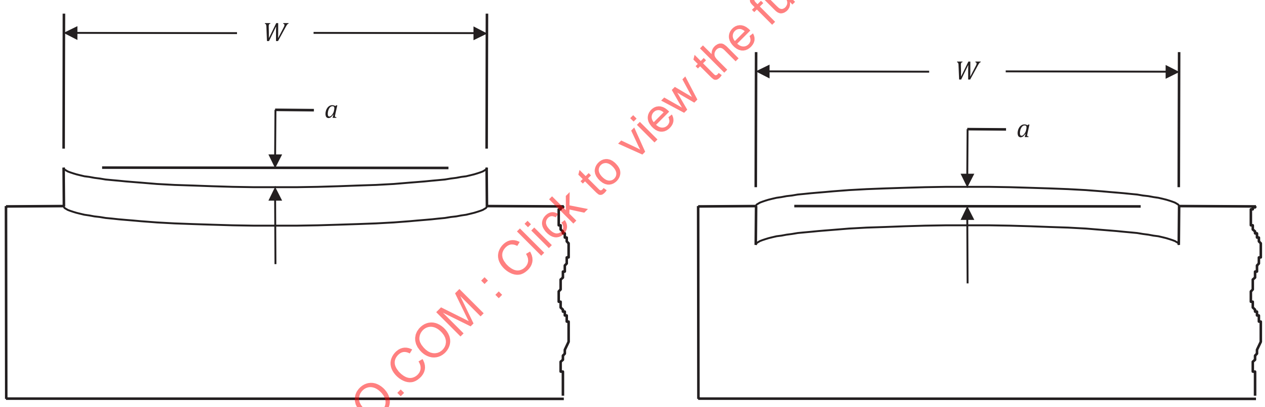
The maximum vertical deviation (*a*) of the transverse surface profile of the magnetic stripe area is shown below. See Figures 3, 4 and 5. The slope of the surface profile curve shall be limited to: -4a/W < slope < 4a/W.

When the bending stiffness value (see ISO/IEC 7810) for the card is 20 mm or more then the surface profile limits are:

Minimum stripe width	**As shown in Figure 3A**	**As shown in Figure 3B**
W = 6,35 mm (0,25 in)	a ≤ 9,5 µm (375 µin)	a ≤ 5,8 µm (225 µin)
W = 10,28 mm (0,405 in)	a ≤ 15,4 µm (607 µin)	a ≤ 9,3 µm (365 µin)

When the bending stiffness value (see ISO/IEC 7810) for the card is less than 20 mm then the surface profile limits are:

Minimum stripe width	**As shown in Figure 3A**	**As shown in Figure 3B**
W = 6,35 mm (0,25 in)	a ≤ 7,3 µm (288 µin)	a ≤ 4,5 µm (175 µin)
W = 10,28 mm (0.405 in)	a ≤ 11,7 µm (466 µin)	a ≤ 7,3 µm (284 µin)



A B

Figure 3 — Surface profile

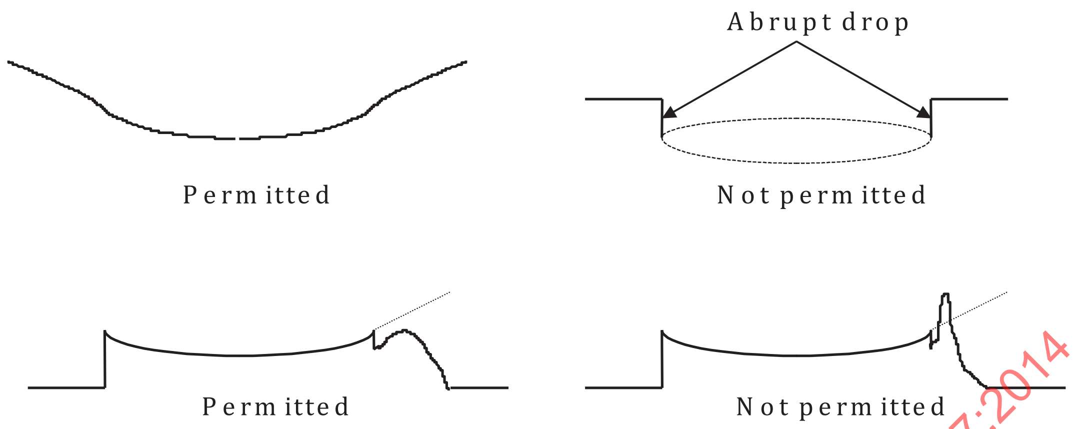


Figure 4 — Surface profile examples

Irregular profiles as shown may result in poor quality encoding.

Figure 5 — Irregular surface profile examples

6.1.2 Height of the magnetic stripe area

The vertical deviation (h) of the magnetic stripe area relative to the adjacent surface of the card shall be:

-0,005 mm (- 200 µin) ≤ h ≤ 0,038 mm (1500 µin)

Spiking in the profile caused by the material “squirt out” in hot stamping is not part of the stripe. It shall not extend above the magnetic stripe area height (h) as defined above.

6.2 Surface roughness

The average surface roughness (R_a) of the magnetic stripe area shall not exceed 0,40 µm (15.9 µin) in both the longitudinal and transverse directions. Refer to ISO/IEC 4287 Part 1.

6.3 Adhesion of stripe to card

The stripe shall not separate from the card under normal use.

6.4 Wear of magnetic stripe from read/write head

Average signal amplitude (U_A) and individual signal amplitude (U_i) are measured before and after 2 000 wear cycles and shall result in:

$U_{A\ after} \geq 0{,}60\ U_{A\ before}$ and $U_{i\ after} \geq 0{,}80\ U_{A\ after}$

6.5 Resistance to chemicals

Average signal amplitude (U_A) and individual signal amplitude (U_i) are measured before and after short term exposure (as defined in the referenced Test Method document) shall result in:

$U_{A\ after} \geq 0{,}90\ U_{A\ before}$ and $U_{i\ after} \geq 0{,}90\ U_{A\ after}$

Average signal amplitude (U_A) and individual signal amplitude (U_i) are measured before and after long term exposure (24 hours) to acid and alkaline artificial perspiration, as defined in the referenced Test Method document.

$U_{A\ after} \geq 0{,}90\ U_{A\ before}$ and $U_{i\ after} \geq 0{,}90\ U_{A\ after}$

7 Performance characteristics for the magnetic material

The purpose of this section is to enable magnetic interchangeability between card and processing systems. Media coercivity is not specified. The media's performance criteria, regardless of coercivity, is specified in clause 7.3.

7.1 General

This method uses a reference card whose material is traceable to the primary standard (see Clause 4). All signal amplitude results from the use of the secondary reference card must be corrected by the factor supplied with the secondary reference card.

7.2 Testing and operating environment

The testing environment for signal amplitude measurements is 23 °C ± 3 °C (73 °F ± 5 °F) and 40 % to 60 % relative humidity. When tested under otherwise identical conditions, the average signal amplitude measured at 40 ft/mm (1 016 ftpi) shall not deviate from its value in the above test environment by more than 15 % after 5 minute exposure over the following operating environment range:

temperature	-35 °C to 50 °C (-31 °F to 122 °F)
relative humidity	5 % to 95 %

7.3 Signal amplitude requirements for magnetic media

The requirements for recording characteristics of the card are shown in Table 1, and Figures 6 and 7. The media's performance requirements specified in section 7.3 shall be met in order to achieve improved resistance to erasure, and to enable magnetic interchange between card and processing systems. The properties in Annex C are intended as guidelines for magnetic material. Annex C is informative and shall not be used as performance criteria for cards.

Table 1 — Signal amplitude requirements for unused unencoded cards

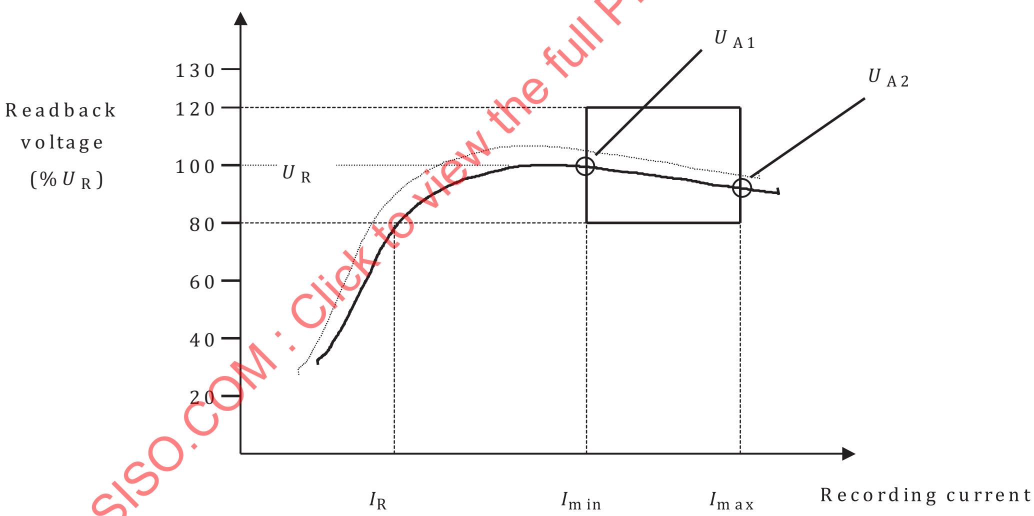
Description	Density ft/mm (ftpi)	Test recording current	Signal amplitude result	Requirement
Signal amplitude	20 (508)	I_{min}	U_{A1}	$0{,}8\ U_R \leq U_{A1} \leq 1{,}2\ U_R$
Signal amplitude	20 (508)	I_{min}	U_{i1}	$U_{i1} \leq 1{,}26\ U_R$
Signal amplitude	20 (508)	I_{max}	U_{A2}	$U_{A2} \geq 0{,}8\ U_R$
The slope of the saturation curve shall never be positive between I_{min} and I_{max}.				
It is not permissible to combine the above requirements mathematically.				

Table 1 *(continued)*

Description	Density ft/mm (ftpi)	Test recording current	Signal amplitude result	Requirement
Signal amplitude	40 (1016)	I_{max}	U_{i2}	$U_{i2} \geq 0{,}65\ U_R$
Resolution	40 (1016)	I_{max}	U_{A3}	$U_{A3} \geq 0{,}8\ U_{A2}$
Erasure	0	I_{min}, DC	U_{A4}	$U_{A4} \leq 0{,}03\ U_R$
Extra pulse	0	I_{min}, DC	U_{i4}	$U_{i4} \leq 0{,}05\ U_R$
Demagnetisation	0	I_d, DC	U_{A5}	$U_{A5} \geq 0{,}64\ U_R$
Demagnetisation	0	I_d, DC	U_{i5}	$U_{i5} \geq 0{,}54\ U_R$
Overwrite	20 (508)	I_{max}	U_{F6}	$U_{F7} \leq 0{,}03\ U_{F6}$
	40 (1016)	I_{min}	U_{F7}	
The slope of the saturation curve shall never be positive between I_{min} and I_{max}.				
It is not permissible to combine the above requirements mathematically.				

NOTE 1 The density of 20 ftpmm converts to 508 ftpi in this standard and to 500 ftpi in ISO/IEC 7811 part 2 and part 6. These 2 are not different in principle. To ensure compatibility at the higher recording density the more accurate conversion is used in this part of the standard.

NOTE 2 It has been observed that low resolution as measured per Table 1 can correlate with high flux transition spacing variation as measured per Table 2.



Key

······ example curve

—— reference card curve corrected to the primary standard

Figure 6 — Saturation curve example showing tolerance area

NOTE The curve defines the primary standard response (on a card). The window parameters define a card that will be functional in the machine readable environment.

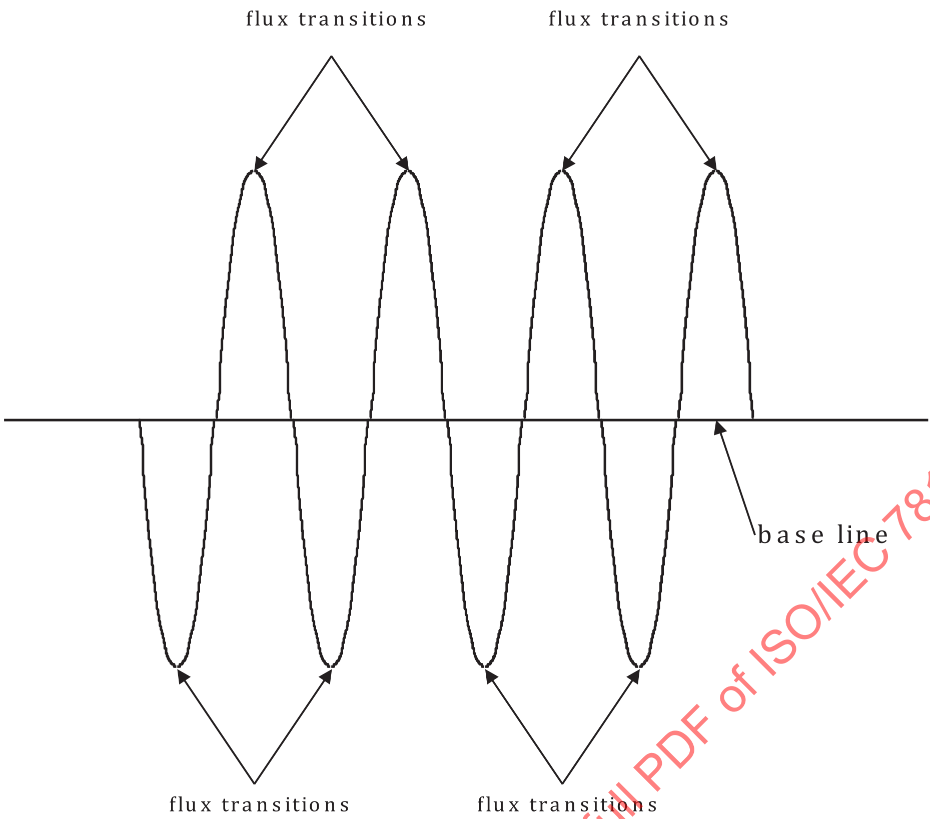


Figure 7 — Waveform example

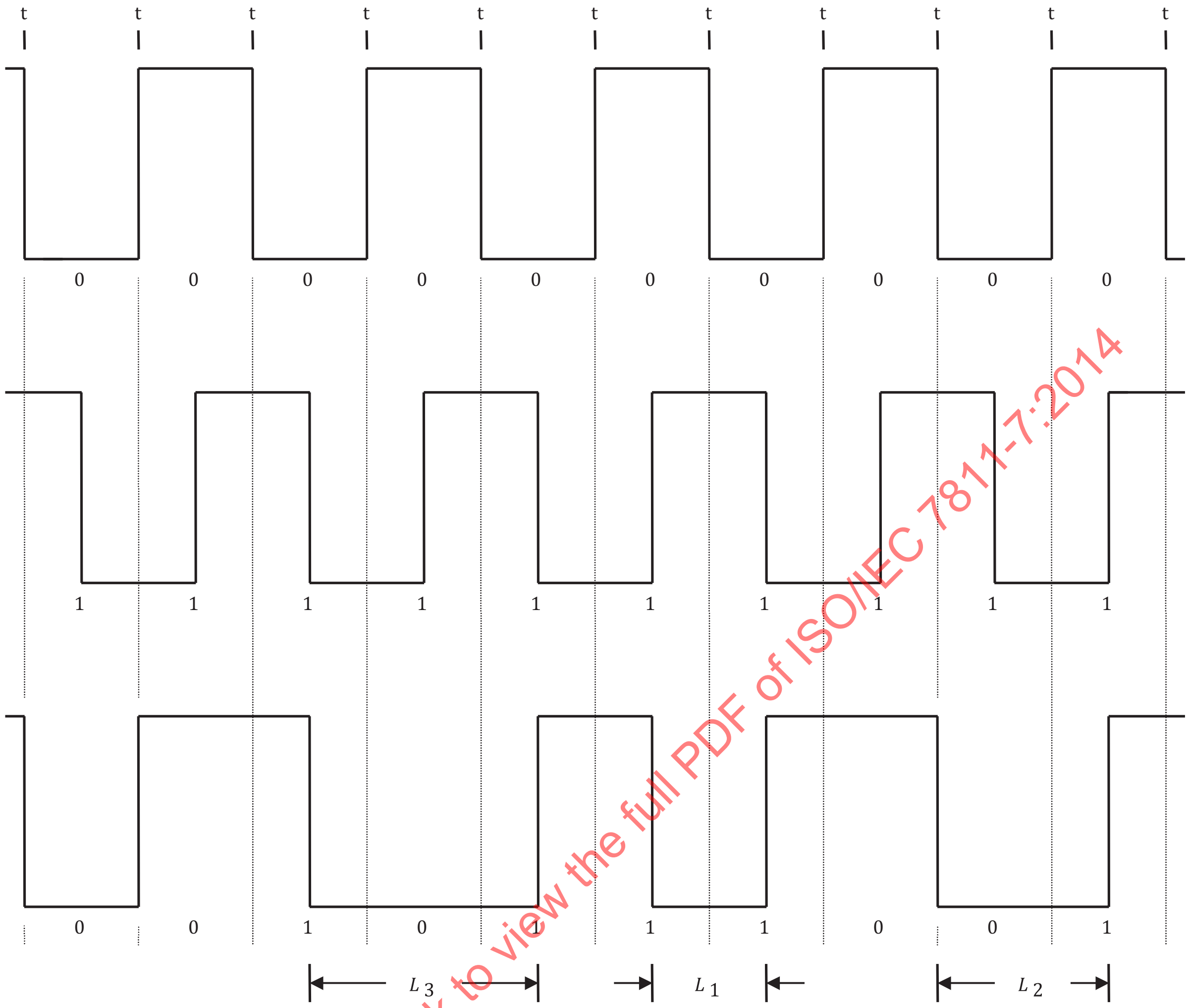
8 Encoding technique

The encoding technique for each track shall be Modified Frequency Modulation (MFM) recording for which the conditions are:

— a flux transition shall be written at the centre of each bit cell containing a ONE,

— a flux transition shall be written at each cell boundary between adjacent bit cells containing ZEROS.

See Figure 8.



Key

t indicates bit cell boundaries

Figure 8 — Examples of MFM encoding

The data shall be recorded as a synchronous sequence of characters without intervening gaps.

NOTE 1 Recording with a write current which is less than Imin may result in poor quality encoding.

NOTE 2 MFM is the same as the FM technique described in ISO/IEC 7811-6 except that clocking flux transitions for 1 bits have been removed. This results in a loss of some of the self-clocking feature with FM encoding and requires more accuracy for flux transition intervals. With this technique there may not be a flux transition at the bit cell boundary.

9 Encoding specification

9.1 Angle of recording

The angle of recording shall be normal to the nearest edge of the card parallel to the magnetic stripe with a tolerance of ± 20 minutes. The angle of recording (α) is determined by measuring the angle of the head gap when the reading amplitude is maximum (see Figure 9).

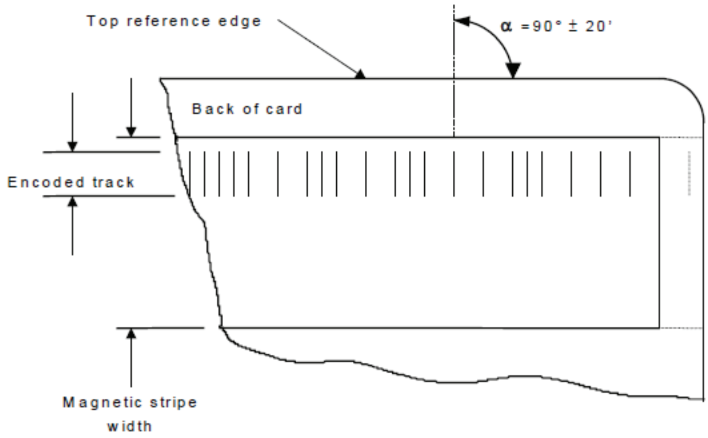


Figure 9 — Angle of recording

9.2 Nominal bit density

The nominal bit density for each of the tracks shall be 40 bits/mm (1016 bpi).

9.3 Flux transition spacing variation

Flux transition spacing variations for all tracks are given in Table 2.

Table 2 — Flux transition spacing variation

Term	Description	Requirement	Variation
B_a	Average bit cell	23 µm (906 µin) ≤ B_a ≤ 25,3 µm (994 µin)	−8 % to +1 %
B_{a6}	Local average bit cell	0,92 $B_a \leq B_{a6} \leq$ 1,08 B_a	±8 % of B_a
L_1	Short interval	0,80 $B_{a6} \leq L_1 \leq$ 1,20 B_{a6}	±20 % of B_{a6}
L_2	Medium interval	1,30 $B_{a6} \leq L_2 \leq$ 1,70 B_{a6}	±13,3 % of 1,5B_{a6}
L_3	Long interval	1,80 $B_{a6} \leq L_3 \leq$ 2,25 B_{a6}	±10 % of 2B_{a6}

NOTE It has been observed that low resolution as measured per Table 1 can correlate with high flux transition spacing variation as measured per Table 2.

9.4 Signal amplitude requirements

The requirements for signal amplitude on all tracks shall be as follows:

Unused encoded cards: 0,64 $U_R \leq U_i \leq$ 1,36 U_R

Returned cards: 0,52 $U_R \leq U_i \leq$ 1,36 U_R

NOTE The requirements above specify the interchange signal amplitude limits for each of the encoded track locations at the specified bit densities. Signal amplitude requirements specified in Table 1 reflect the magnetic media limits at the specified recording frequency and recording test currents.

9.5 Bit configuration

Data shall be recorded with the least significant bit (2^0) first.

9.6 Direction of recording

The encoding shall begin from the right-hand side viewed from the side with the magnetic stripe and with the stripe at the top.

9.7 Leading and trailing clock bits

The lead-in up to the first FSC shall be recorded with ones and the space after the last FSC shall also be recorded with ones. Ones encoded from the edge of the card to 3,30 mm (0.130 in) in from the edge of the card are not required to meet the specifications given herein.

10 Data structure

User data to be written on the card shall be divided among the tracks used. Each track used shall be of a fixed length depending on the type of card used requiring the user data to be padded with binary zero bytes if it does not fill the the available space on the track(s) used. Data structure on each track is independent of other tracks. The general process for structuring of the data is shown in Table 3, see also Figure 11.

Table 3 — Data structure process steps

Step	Process
1	Determine number of tracks needed based on data capacity for card type used
2	Divide card data into data for each track and pad end of card data with binary zero bytes if necessary, such that all frames on every track used are filled. Padding can be done before dividing onto tracks or after. More error correction is obtained if data is divided equally among the tracks used and then each track padded.
3	Generate CRC for track data and append to end of track data.
4	Divide track data into frames.
5	Generate reed-solomon column parity.
6	Add frame ID number.
7	Generate CRC for each frame.
8	Arrange for writing on card: add lead/trail clock transitions, convert frame ID from 8 bit to 5 bit string, and add FSC's.

NOTE No coded character set is defined by this standard. Most uses for the high density format will be for non-text applications.

10.1 Track format

10.1.1 Track layout

Each track shall consist of leading clock transitions, a FSC, data frames each separated by a FSC, a FSC, and trailing clock transitions as shown below.

Leading clock transitions
FSC
Frame identifier 1
Data
Frame CRC
FSC
Frame identifier 2

Data
Frame CRC
FSC
Frame identifier 3
Data
Frame CRC
FSC
:
:
:
FSC
Frame identifier 18
Data
Frame CRC
FSC
Trailing clock transitions

10.1.2 FSC

The FSC is used to determine direction and identify the edge of the data frame. A FSC shall occur before and after each data frame but only one FSC shall occur between adjacent data frames. The FSC has the representation shown in Figure 10.

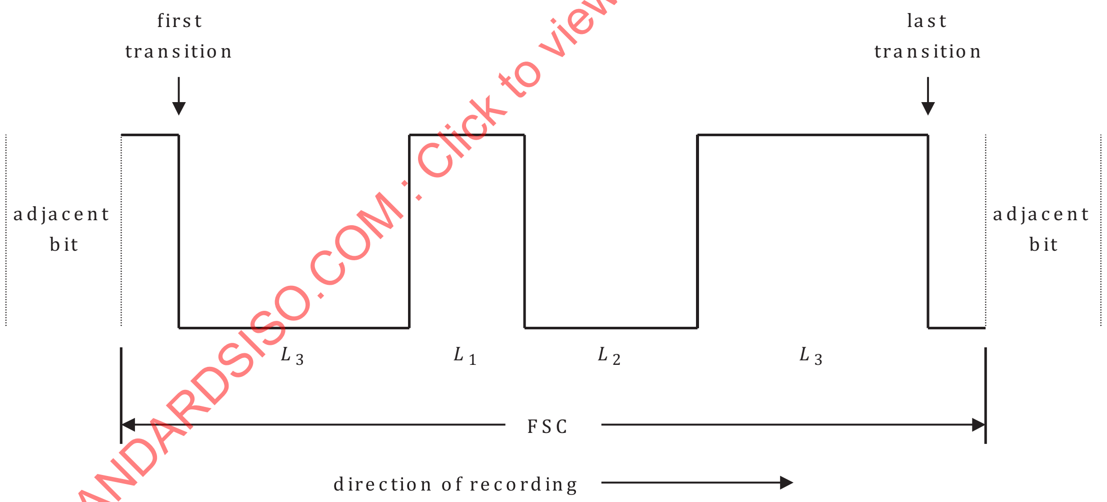


Figure 10 — FSC representation

NOTE The FSC occupies a space of 7,5 bits and is a series of flux transition intervals where the edges are like 1 bits (transition in middle of bit boundary). It is not a series of 1 and 0 bits since this pattern of flux transition intervals is unique and will never occur with MFM encoding rules. Therefore, the FSC can be found even if character synchronisation within the data frame has been lost, and synchronisation begins with the next data frame.

10.1.3 Data frame

Data frames shall consist of a frame number, data and a frame CRC character. The number of frames per track shall be 18.

10.1.3.1 Frame identifier

Each data frame shall be identified with a 5 bit character representing a number. Frames shall be numbered consecutively starting with 1 for the frame nearest the start of encoding and ending with 18 nearest the end of encoding. When performing data operations prior to writing on the card or during the decoding process after reading, the frame identifier shall be represented as an 8 bit string.

10.1.3.2 Data

Data shall be represented in 8 bit bytes and shall be user data, column parity, or track CRC information. The capacity and number of bytes per frame depends on the card size and shall be as shown in Table 4. For each card size all the amounts are fixed (no variable lengths).

Table 4 — Track capacity

Card type	ID-1	ID-2	ID-3
Frame data capacity (bytes per frame)	17	22	28
Frame size (bits per frame)	156,5	196,5	244,5
Track data capacity (bytes per track)	306	396	504
Track size (bits per track)	2824,5	3544,5	4408,5
Column parity (bytes)	68	88	112
Track CRC (bytes)	4	4	4
User data capacity (bytes)	234	304	388

NOTE The user data capacity shown in Table 4 is based on the amount of error correction used. Frame size equals FSC+Frame ID+(bytes per frame*8)+CRC. Track size equals (bits per frame*18)+FSC.

10.1.3.3 Frame CRC character

Each frame shall include one 8 bit CRC character.

10.2 Coding for error detection and correction

Track data shall be located in frames as shown in Figure 11 where N is 2 plus the number of bytes per track as specified in Table 4. When written on the card, byte 1 of frame 1 is nearest the start of encoding and byte N of frame 18 is nearest the end of encoding (left to right, top to bottom).

Byte										
1	**2**	**3**	**4**		**N-5**	**N-4**	**N-3**	**N-2**	**N-1**	**N**
Frame ID	**Data area**									**CRC**
1	CP	CP	CP		CP	CP	CP	CP	CP	CRC_1
2	CP	CP	CP		CP	CP	CP	CP	CP	CRC_2
3	CP	CP	CP		CP	CP	CP	CP	CP	CRC_3
4	CP	CP	CP		CP	CP	CP	CP	CP	CRC_4
5	Data	Data	Data		Data	Data	Data	Data	Data	CRC_5
6	Data	Data	Data		Data	Data	Data	Data	Data	CRC_6
7	Data	Data	Data		Data	Data	Data	Data	Data	CRC_7
8	Data	Data	Data		Data	Data	Data	Data	Data	CRC_8
9	Data	Data	Data		Data	Data	Data	Data	Data	CRC_9
10	Data	Data	Data		Data	Data	Data	Data	Data	CRC_{10}
11	Data	Data	Data		Data	Data	Data	Data	Data	CRC_{11}
12	Data	Data	Data		Data	Data	Data	Data	Data	CRC_{12}
13	Data	Data	Data		Data	Data	Data	Data	Data	CRC_{13}
14	Data	Data	Data		Data	Data	Data	Data	Data	CRC_{14}
15	Data	Data	Data		Data	Data	Data	Data	Data	CRC_{15}
16	Data	Data	Data		Data	Data	Data	Data	Data	CRC_{16}
17	Data	Data	Data		Data	Data	Data	Data	Data	CRC_{17}
18	Data	Data	Data		Data	Track CRC				CRC_{18}

Figure 11 — Track data structure

NOTE The frame CRC character is used for error detection and column parity is used for error correction.

10.2.1 Track CRC

The track shall include a CRC comprised of four 8 bit bytes generated as follows and added to the end of the track data. Highest order term for track CRC shall be in byte (N-4) frame 18.

$$CRC = [x^4 M(x)] \bmod g(x) \text{ over } GF(2^8)$$

where:

$M(x)$ = all user data for the track in polynomial form (length depends on card type used). Highest order term is in byte 2 frame 5 and lowest order term in byte N-5 frame 18. See Figure 11.

$g(x)$ = $(x-\alpha)(x-\alpha^2)(x-\alpha^3)(x-\alpha^4)$ = generator polynomial for the track CRC

$GF(2^8)$ = a finite Galois field of 256 different 8 bit binary symbols generated by a primitive polynomial

$$\mathbf{p}(x) = 1 + x^2 + x^3 + x^4 + x^8$$

x^i = bit at position i

NOTE 1 The track CRC will allow the detection up to 4 errors with a probability of 1. For more than 4 errors the probability of detecting errors is equal to 1-1/(256)4.

NOTE 2 The track CRC is the remainder of x4M(x) divided by g(x) using modulo operations. For more than 251 bytes of data, the CRC is technically not a cyclical check, it is a simple redundancy check although it is generated in the same way.

NOTE 3 Published tables exist showing the bit representations for the corresponding power for α for GF power of alpha corresponds to the number so that the term alpha raised to it's power is a unique bit pattern (8bit binary string). Each byte of the user data needs to be converted from 8 bit binary into the corresponding power of α before carrying out the modulo operation. The term x is used to denote the position of the bit in the string for example, x2 in the track data would be the third lowest order byte.

10.2.2 Column parity

Column parity shall be generated for each column of byte information across all user data frames on the track using a shortened Reed-Solomon code RS(255-237,251-237), also called RS(18,14). Highest order term for track CP shall be in frame 4 and lowest order term shall be in frame 1.

$$CP = [x^4M(x)] \bmod g(x) \text{ over } GF(2^8)$$

where:

M(x) = user data for a column from frame 5 to frame 18 in polynomial form (length is fixed at 14). Highest order term is in frame 18 and lowest order term in frame 5. See Figure 11.

g(x) = $(x-\alpha)(x-\alpha^2)(x-\alpha^3)(x-\alpha^4)$ = generator polynomial for the Reed-Solomon CP

$GF(2^8)$ = a finite Galois field of 256 different 8 bit binary symbols generated by a primitive polynomial

$\mathbf{p}(x) = 1 + x^2 + x^3 + x^4 + x^8$

x^i = bit at position i

NOTE 1 The CP will allow the correction up to 4 "erasures" with a probability of 1. More than 4 "erasures" on a track cannot be corrected. The term "erasure" is used in RS codes and denotes an area is not readable, the decoding process then treats that sector as "erased" or not there.

NOTE 2 The CP is the remainder of x4M(x) divided by g(x) using modulo operations. The term "shortened" before Reed-Solomon means that there are higher order terms with a value of 0 (237 in this case) which do not need to be considered in modulo operations.

NOTE 3 This code results in 100 %*4/18 = 22.2 % error correction overhead.

10.2.3 Frame CRC

The frame shall include a CRC comprised of one 8 bit byte generated as follows and added to the end of the frame data.

$$CRC = [xM(x)] \bmod g(x) \text{ over } GF(2^8)$$

where:

M(x) = user data for frame and frame ID number from byte 1 to byte N-1 in polynomial form (length depends on card type used). Highest order term is in byte 1 and lowest order term in byte N-1. See Figure 11

g(x) = (x-α) = generator polynomial for frame CRC

$GF(2^8)$ = a finite Galois field of 256 different 8 bit binary symbols generated by a primitive polynomial

$\mathbf{p}(x) = 1 + x^2 + x^3 + x^4 + x^8$

x^i = bit at position i

NOTE 1 The frame CRC will allow the detection up to 1 error with a probability of 1. For more than 1 error the probability of detecting errors is equal to 1-1/256.

NOTE 2 The CRC is the remainder of xM(x) divided by g(x) using modulo operations.

NOTE 3 The frame ID number is an 8 bit byte for all calculations but is written on the card as a 5 bit sequence.

11 Decoding

The general steps to follow for decoding data for each track after reading are shown in Table 5. Specific implementations are left to the user.

Table 5 — Decoding process

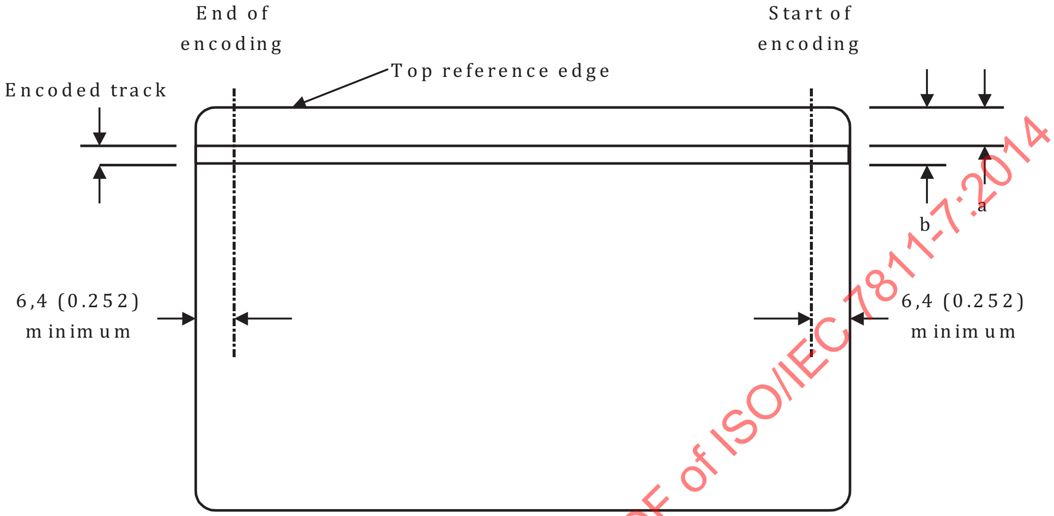
Step	Process
1	Read track data from card.
2	Expand frame ID to 8 bit size.
3	Create data structure as shown in Figure 11.
4	Check track CRC [result of [$x^4M(x)$ + CRC) mod g(x) over $GF(2^8)$], (result 0 = no errors)
	If a track CRC error occurs, begin error correction.
5	Check CRC of each frame. Frame errors indicate an error location for all columns at that byte position.
6	If the quantity of frame errors is beyond the capability of the decoder, post a Media Error and quit. Otherwise, continue to the next steps.
7	Fill the frames at locations indicated by frame CRC errors with hexadecimal zero (00) bytes (data erasure is assumed).
8	Column parity is then used along with frame CRC error locations to reconstruct data byte values [Reed-Solomon code RS (18,14) is used]. These byte values are inserted at column-positions indicated by corresponding frame errors.
9	Check track CRC [result of ($x^4M(x)$ + CRC) mod g(x) over $GF(2^8)$ shall be all 0 bytes for no errors]
10	Process the corrected data for output.
11	Process all tracks in the same manner.

NOTE The simplest decode process assumes “data erasure”, but other extended processes are possible. Numerous references are available describing specific decoding implementations. See Annex D.

12 Location of encoded tracks

Each encoded track shall be located between the two lines as shown in Figure 12. The start of encoding is located at the centreline of the first transition of the first FSC. The end of encoding is located at the centreline of the last transition of the last FSC.

Dimensions in millimetres (inches)



Track	Dimension		
Track H1	a b	5,75 (0,226) 6,75 (0,266)	maximum minimum
Track H2	a b	7,45 (0,293) 8,45 (0,333)	maximum minimum
Track H3	a b	9,15 (0,360) 10,15 (0,400)	maximum minimum
Track H4	a b	10,85 (0,427) 11,85 (0,467)	maximum minimum
Track H5	a b	12,55 (0,494) 13,55 (0,.534)	maximum minimum
Track H6	a b	14,25 (0,561) 15,25 (0,601)	maximum minimum

Figure 12 — Location of encoded tracks

Annex A
(informative)

Compatibility of magnetic stripes (ISO/IEC 7811-6 and ISO/IEC 7811-7)

The purpose of this annex is to explain to users the limitations of the term ‘read compatibility’ as mentioned in the scope of this standard, and applied to ISO/IEC 7811-6 and ISO/IEC 7811-7.

The high density tracks specified in ISO/IEC 7811-7 are arranged such that a reader designed to read these tracks will also be able to read the normal tracks defined in ISO/IEC 7811-6. This also allows a combination of normal and high density tracks to coexist on the same magnetic stripe, for example normal tracks 1 and 2 with high density tracks H5 and H6. It is not possible to interchange write heads in the same way that read heads can be.

The increased density specified in ISO/IEC 7811-7 will result in a lower signal amplitude compared to ISO/IEC 7811-6: approximately 40 % $depending on testing of PTB. The exact ratio between these two signal amplitude values will depend on the type of magnetic stripes used.

The following is an overview of the main differences between this International Standard and ISO/IEC 7811-2 and ISO/IEC 7811-6.

a) The bit density has increased from 8,27 bits/mm (track 1,3) and 2,95 bits/mm (track 2) to 40 bits/mm for all tracks which results in 234 bytes of user data per track for an ID-1 size card.

b) The encoding technique referred to as MFM is used in place of F2F. This change doubles the data storage density for the same minimum transition spacing with only a small reduction in the self-clocking ability.

c) The 3 tracks have been replaced by 6 tracks that are approximately half the width so that they occupy the same space on the card. These are located so that readers designed to read the high density tracks will also be able to read cards conforming to ISO/IEC 7811-2 and ISO/IEC 7811-6.

d) Data is distributed in frames with synchronisation characters to aid in error recovery, and there is a CRC for each frame and a track CRC. Data recorded on each track is independent from other tracks (error detection and correction for each track is on the same track), even though it may be only part of the message on the card.

e) Error detection and correction is included using a shortened Reed-Solomon code. The amount of error correction is fixed for all card sizes.

f) The magnetic stripe area extends completely to the left and right edge of the card.

g) In Table 1, test density values have changed, the resolution requirement has changed from 0,7 to 0,8, the test for Waveform has been deleted, and Overwrite has been added to the requirements.

h) The maximum coercivity in Table D.1 of informative Annex C has been changed from 335 kA/m (4200 Oe) to 250 kA/m (3125 Oe).

Annex B
(informative)

Magnetic stripe abrasivity

The purpose of this annex is to explain why the abrasive properties of magnetic stripes as it relates to head life are not among the physical characteristics governed by this standard. The absence of any specification for abrasive properties reflects the difficulty of defining the parameters of abrasive wear and devising an accurate, repeatable test for measuring abrasive properties. Although no repeatable test methods are available, there are known technologies available for extending head life such as improved head materials, magnetic stripe formulation additives, or overcoats on magnetic stripe.

A quantified stripe abrasivity would seem to be an essential prerequisite to any attempt to predict magnetic head lifetimes. However, just as there is considerable variation in the abrasive nature of different magnetic stripes, there are a multitude of magnetic stripe reader/writer environments. The variety of combinations of influences and the complexity of the manner in which these affect abrasivity makes it extremely difficult to predict magnetic head lifetimes even when the environmental, mechanical and magnetic stripe conditions are specified.

Current equipment-specific abrasivity testing is done on a purely comparative basis. It is time consuming and usually expensive in terms of the number of cards used. The results of such tests are simply rankings that show one stripe to be some degree more or less abrasive than others under the specific conditions of test. There are no accurate absolute values and the rankings may change from one set of conditions to another.

Performing a successful read or write operation on a magnetic stripe requires the stripe and magnetic head to be in contact for the whole operation. The relative movement between the magnetic head and magnetic stripe produces wear of both. Initially the abrasivity of the magnetic stripe falls rapidly with the number of head passes, so that the abrasivity of a new unused magnetic stripe may be much greater than that of a magnetic stripe which has only been written once, but as the number of head passes increases the rate of change of abrasivity decreases.

The influences affecting magnetic stripe abrasivity are known to include temperature, humidity, head material (and its state of wear and finish), head pressure, card speed, the specific physical properties of the magnetic stripe surface in contact with the head, surface roughness, and contamination on the magnetic stripe. Under field conditions dust, dirt and grease from the environment are deposited at the head/stripe interface often producing major discrepancies between abrasive wear measured under laboratory conditions and that actually achieved.

It may be seen, therefore, that not only are there difficulties involved in achieving an acceptable level of measurement uncertainty for abrasivity testing but that there are significant doubts regarding the applicability of the results of abrasivity tests on cards under laboratory conditions to predictions of performance in the real world. Unless these problems are resolved, there can be no useful standard specification and test.

