International Standard 5652

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Information processing — 9-Track, 12,7 mm (0.5 in) wide magnetic tape for information interchange — Format and recording, using group coding at 246 cpmm (6 250 cpi)

Traitement de l'information — Bande magnétique à 9 pistes de 12,7 mm (0,5 in) de large pour l'échange d'information — Format et enregistrement utilisant des codages de groupe à 246 cpmm (6 250 cpi)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 5652 was prepared by Technical Committee ISO/TC 97, *Information processing systems*.

ISO 5652 was first published in 1983. This second edition cancels and replaces the first edition, of which sub-clause B.3.2 of annex B has been technically revised.

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Information processing — 9-Track, 12,7 mm (0.5 in) wide magnetic tape for information interchange — Format and recording, using group coding at 246 cpmm (6 250 cpi)

1 Scope and field of application

This International Standard specifies a format and recording standard for 9-track, 12,7 mm (0.5 in) magnetic tape to be used for data interchange between information processing systems, communication systems, and associated equipment utilizing the 7-bit coded character set (see ISO 646), its extension in ISO 2022 where required, and the 8-bit coded character set (see ISO 4873). Magnetic labelling for use on magnetic tape is the subject of ISO 1001. The magnetic tape and reel to be used shall conform to ISO 1864.

NOTE — Numeric values in the SI and/or Imperial measurement system in this International Standard may have been rounded and therefore are consistent with, but not exactly equal to, each other. Either system may be used, but the two should be neither intermixed nor reconverted. The original design was made using the Imperial measurement system.

2 References

ISO 646, *Information processing — ISO 7-bit coded character set for information interchange.*

ISO 1001, *Information processing — Magnetic tape labelling and file structure for information interchange.*

ISO 1864, *Information processing — Unrecorded* 12,7 mm (0.5 in) *wide magnetic tape for information interchange —* 32 ftpmm (800 ftpi) *NRZ1,* 126 ftpmm (3 200 ftpi) *phase encoded and* 356 ftpmm (9 042 ftpi), *NRZ1.*

ISO 2022, *Information processing — ISO 7-bit and 8-bit coded character sets — Coded extension techniques.* [1]

ISO 4873, *Information processing —* 8-bit *code for information interchange — Structure and rules for implementation.* [2]

3 Definitions

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

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

3.2 reference tape : A tape which has been selected for given properties for use in calibration.

3.3 secondary reference tape : A tape intended for routine calibrating purposes whose performance is known and is stated in relation to that of a reference tape.

3.4 signal amplitude reference tape : A reference tape selected as a standard for signal amplitude.

NOTE — A master standard (computer amplitude reference) has been established at the US National Bureau of Standards (NBS) based on reference tapes and heads. Secondary signal amplitude reference tapes are available from the NBS [3] under the part number SRM 6250.

3.5 typical field : The minimum recording field which, when applied to a magnetic tape, causes a signal output equal to 95 % of the maximum signal amplitude at the specified physical recording density.

3.6 reference field : The typical field of the signal amplitude reference tape at 356 ftpmm (9 042 ftpi).

1) At present at the stage of draft. (Revision of ISO 2022-1982.)

2) At present at the stage of draft. (Revision of ISO 4873-1979.)

3) Office of Standard Reference Materials, Room B 311, Chemistry Building, National Bureau of Standards (NBS), Washington, D.C. 20234, USA.

3.7 standard reference amplitude : The average peak-to-peak signal amplitude derived from the signal amplitude reference tape on the NBS measurement system, or equivalent, under the recording conditions specified in ISO 1864.

3.8 reference edge : The edge furthest from an observer when a tape is lying flat with the magnetic surface uppermost and the direction of movement for recording is from left to right.

3.9 in contact : An operation condition in which the magnetic surface of a tape is in contact with a magnetic head.

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

3.11 row : Nine transversely related locations (one in each track) in which bits are recorded.

3.12 position of flux transition : The point which exhibits the maximum free-space flux density normal to the tape surface.

3.13 physical recording density : The number of recorded flux transitions per unit length of track (ftpmm or ftpi).

3.14 data density : The number of data characters stored per unit length of tape (cpmm or cpi).

3.15 skew : The maximum longitudinal deviation in the placement of bits within a row.

3.16 ECC character : A character used for error detection and correction within a data group.

3.17 auxiliary CRC character : A character used for error detection within the data part of a block.

3.18 CRC character : A character used for error detection within a complete block.

3.19 preamble : A pattern of signals marking the beginning of each storage block, used primarily for electronic synchronization.

3.20 postamble : A pattern of signals marking the end of each storage block.

3.21 density identification area (ID burst) : A burst of recording at the beginning of a tape identifying the use of the group-coded-recording method.

3.22 Automatic Read Amplification (ARA) burst : A burst of recording at the beginning of a tape which may be used for setting the gain of the read amplifiers.

3.23 error: The detection of a missing pulse or an extra pulse in a track. Missing pulse and extra pulse are as defined in ISO 1864 sub-clauses 5.16.1 c) and 5.16.2 respectively.

4 Operating and transportation conditions

4.1 Operating environment

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

— temperature : 16 to 32 °C (60 to 90 °F);

— relative humidity: 20 to 80 %;

— wet bulb temperature : not greater than 26 °C (78 °F).

Conditioning before operating : If a tape has been exposed during storage and/or transportation to conditions outside the above values, it should be conditioned for a period of 2 to 12 h, depending on the extent of exposure.

4.2 Transportation

Responsibility for ensuring that adequate precautions against damage are taken during shipment shall lie with the sender (see annex A).

4.3 Wind tension

For interchange, the tape winding tension shall be between 2 N and 3,6 N (7 to 13 ozf).

5 Recording

5.1 Method of recording

The "non return to zero mark" (NRZ1) method of recording shall be used where a ONE is represented by a change of direction of longitudinal magnetization.

5.2 Density of recording

The nominal density shall be 356 ftpmm (9 042 ftpi). Other nominal densities used hereafter for specific measurements shall be

178 ftpmm (4 521 ftpi)

119 ftpmm (3 014 ftpi).

5.3 Average flux transition spacings

The following measurements shall be made after interchange using a tape recorded at a density of 178 ftpmm (4 521 ftpi). The nominal flux transition spacing at this density shall be 5,618 µm (221.2 µin) subject to the following variations.

5.3.1 The long term average (static) flux transition spacing shall be within ± 4 % of the nominal spacing. This average shall be measured over a minimum of 5×10^5 successive flux transitions.

5.3.2 The short term average (dynamic) flux transition spacing, when referred to a particular flux transition spacing, is the average of that flux transition spacing and the preceding flux transition spacing.

The short term average flux transition spacing shall be within the limits of ± 6 % of the long term average flux transition spacing.

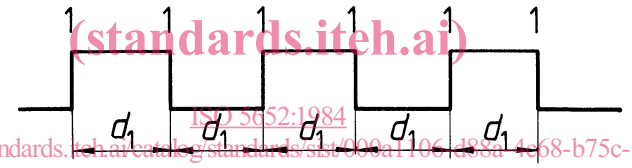
In addition, the rate of change of the short term average flux transition spacing shall not exceed 0,2 % per flux transition spacing.

5.4 Instantaneous flux transition spacings

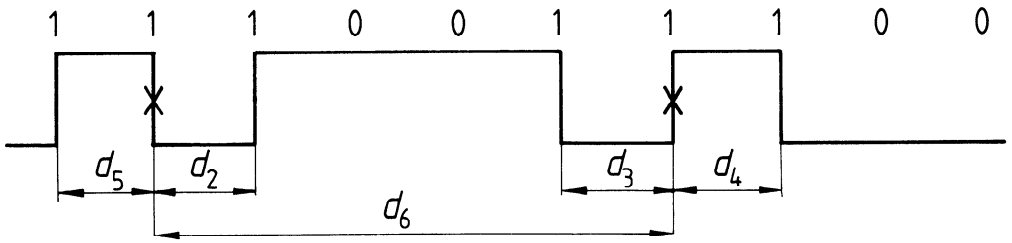
The instantaneous spacing between flux transitions may be influenced by the reading and writing processes, the pattern recorded (pulse crowding effects) and other factors.

Instantaneous spacings between flux transitions shall meet the following conditions, when tested on the reference read chain (see annex B).

5.4.1 At the nominal maximum density of 356 ftpmm (9 042 ftpi) the spacing d_1 between successive flux transitions shall be between 48 % and 52 % of the corresponding short term average flux transition spacing determined at 178 ftpmm (4 521 ftpi).



5.4.2 In a sequence of flux transitions defined by the bit pattern 1110011100..., the average displacement of the spacing of the flux transitions on either side of a reference transition, from that reference transition, shall be not more than ± 28 % from the average spacing of flux transitions at 356 ftpmm (9 042 ftpi).



Crosses denote reference transitions.

1,28 d_1 ⩾ average d_5 ⩾ 0,72 d_1

1,28 d_1 ⩾ average d_2 ⩾ 0,72 d_1

1,28 d_1 ⩾ average d_3 ⩾ 0,72 d_1

1,28 d_1 ⩾ average d_4 ⩾ 0,72 d_1

The tolerances of long term average spacing and short term average spacing (see 5.3.1 and 5.3.2) are included in this deviation.

The average distance d_6 between actual consecutive reference flux transitions in a sequence defined by the bit pattern 1110011100... and the calculated distance $5d_1$, of six flux transitions at nominal maximum density of 356 ftpmm (9 042 ftpi) shall not differ by more than 6 % of d_1.

5,06 d_1 ⩾ average d_6 ⩾ 4,94 d_1

5.5 Skew

No flux transition shall be displaced by more than 16,86 µm (664 µin) from any other flux transition in the same row. This displacement shall be measured as the distance between perpendiculars to the reference edge through the said flux transitions.

5.6 Signal amplitude

5.6.1 Standard reference amplitude

The standard reference amplitude is the average peak-to-peak signal amplitude derived from the signal amplitude reference tape on the qualified measurement system at the density of 356 ftpmm (9 042 ftpi) and the recording current $I_R = k \times I_f$ (see ISO 1864).

The signal amplitude shall be averaged over a minimum of 4 000 flux transitions and shall be measured on the read-while-write pass.

The reference current I_f is the current which produces the reference field (see 3.6).

5.6.2 Average signal amplitude

5.6.2.1 The average peak-to-peak signal amplitude of the interchanged tape at 356 ftpmm (9 042 ftpi) shall not deviate by more than ± 50 % from the standard reference amplitude.

5.6.2.2 The average peak-to-peak signal amplitude at 119 ftpmm (3 014 ftpi) shall be less than five times the standard reference amplitude.

5.6.2.3 Averaging shall be done over a minimum of 4 000 flux transitions, which for the interchange tape may be segmented into blocks. Averaging shall be done on the first-read pass after interchange.

5.6.3 Minimum signal amplitude

A tape to be interchanged shall contain no flux transition in more than one track since the last MARK 1 control sub-group, the base-to-peak amplitude of which is less than 15 % of half the standard reference amplitude.

5.7 Erasure

5.7.1 When erased, the rim end of the erased area of the tape shall be magnetized so that it is a North-seeking pole.

5.7.2 The full width of the tape shall be DC erased in the direction specified in 5.7.1.

5.7.3 The tape shall be erased so that the residual signal shall not exceed 4 % of the standard reference amplitude.

6 Tracks

6.1 Number of tracks

There shall be nine tracks.

6.2 Track identification

Tracks shall be numbered consecutively beginning at the reference edge with track 1.

6.3 Track positions

The distance from the centrelines of the tracks to the reference edge shall be :

Track 1 : 0,74 ± 0,08 mm (0.029 ± 0.003 in)
Track 2 : 2,13 ± 0,08 mm (0.084 ± 0.003 in)
Track 3 : 3,53 ± 0,08 mm (0.139 ± 0.003 in)
Track 4 : 4,93 ± 0,08 mm (0.194 ± 0.003 in)
Track 5 : 6,32 ± 0,08 mm (0.249 ± 0.003 in)
Track 6 : 7,72 ± 0,08 mm (0.304 ± 0.003 in)
Track 7 : 9,12 ± 0,08 mm (0.359 ± 0.003 in)
Track 8 : 10,52 ± 0,08 mm (0.414 ± 0.003 in)
Track 9 : 11,91 ± 0,08 mm (0.469 ± 0.003 in)

6.4 Track width

The width of a written track shall be :

1,09 mm min. (0.043 in min.)

7 Data representation

The characters shall be represented by means of the 7-bit coded character set (see ISO 646) or the 8-bit coded character set (see ISO 4873) or, where required, of an extension of the 7-bit coded character set (see ISO 2022).

The bit-to-track allocation shall be as follows :

7.1 7-bit coded characters

Binary weight	2^0	2^1	2^2	2^3	2^4	2^5	2^6	—	—
Bit designation	b_1	b_2	b_3	b_4	b_5	b_6	b_7	—	P
Track	2	8	1	9	3	5	6	7	4

Track 7 shall always be recorded with bit ZERO.

7.2 8-bit coded characters

Binary weight	2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7	—
Bit designation	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	P
Track	2	8	1	9	3	5	6	7	4

Bit P in track 4 shall be the parity bit. The parity shall be odd.

8 Data formatting

Prior to recording, the data shall be arranged in groups completed with computed check characters (see 8.4). These data groups shall be in turn arranged in a given sequence together with groups of control characters. The data and control character groups so arranged are then recorded on the tape according to a specific coding scheme (see clause 9).

8.1 Data groups

A data group shall comprise 8 bytes as follows :

— in positions 1 to 7, seven data bytes;

— in position 8, an ECC character.

8.2 Residual group

A residual group shall be a group comprising

— in positions 1 to 6, the remaining data bytes, if any;

— in positions 1 to 6, not occupied by a data byte, a padding character [byte (00) with odd parity];

— in position 7, an auxiliary CRC character;

— in position 8, an ECC character.

8.3 CRC group (see figure below)

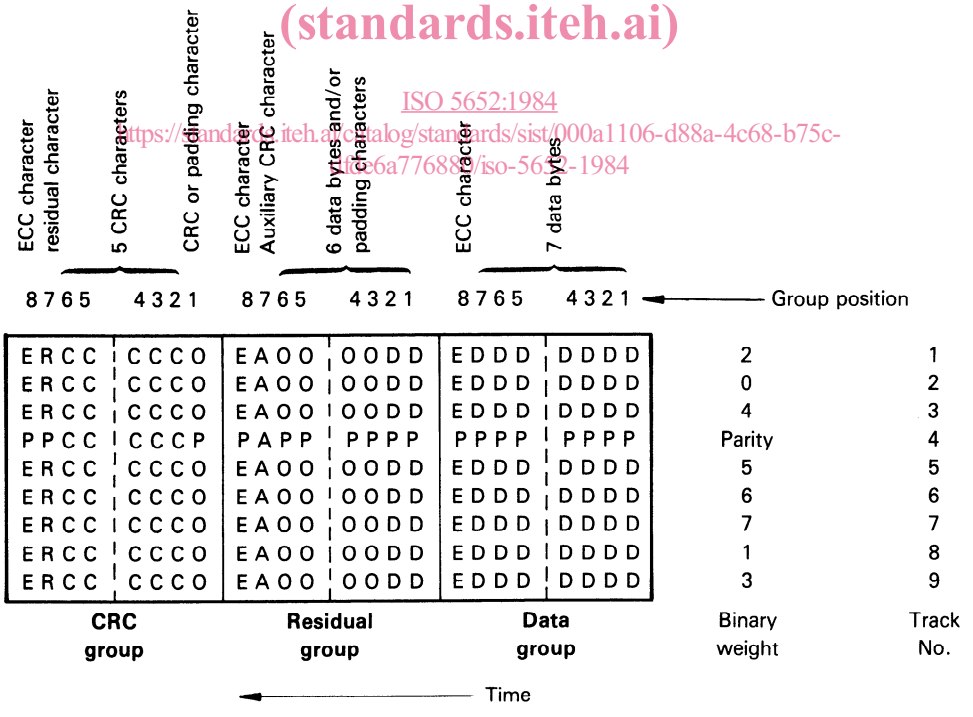
After the residual group, a CRC group shall be formed comprising

— in position 1 : byte (00) with odd parity if the number of preceding data groups is even, or the CRC character if the number of preceding data groups is odd;

— in positions 2 to 6, the CRC character;

— in position 7, the residual character;

— in position 8, an ECC character.



NOTE — The line of bits corresponding to each track number shown will then be group coded (see clause 9), and the resulting bit stream will then be recorded on the tape in the corresponding track.

8.4 Check characters

8.4.1 ECC character

The ECC character shall be calculated separately for each group (data group, residual group and CRC group). In each case, 7 polynomials D_1 to D_7 shall be formed, the coefficients of which shall be the 8 bits of each byte in positions 1 to 7. The coefficients of polynomial D_1 shall be the bits in position 1, those of polynomial D_2 shall be the bits in position 2, etc. The parity bit in track 4 shall not be part of the ECC character generation.

These bits shall be allocated to the polynomials as follows :

Bit from track	is coefficient of
7	x^0
1	x^1
8	x^2
5	x^3
2	x^4
9	x^5
6	x^6
3	x^7
–	–

The ECC character shall be obtained from the coefficients of polynomial E computed as follows :

$$E = \Sigma\ (x^i D_j) \text{ (mod } G)$$

where

i = 7 to 1

j = 1 to 7

$G = x^0 + x^3 + x^4 + x^5 + x^8$

All arithmetic operations shall be (mod 2).

The bits of the ECC character shall be the coefficients of the resulting polynomial :

In track	the coefficient of
1	x^1
2	x^4
3	x^7
4	P
5	x^3
6	x^6
7	x^0
8	x^2
9	x^5

In track 4, an odd parity bit P shall be inserted.

8.4.2 Auxiliary CRC character

The auxiliary CRC character shall be calculated from all the data bytes within the storage block considered as 9-bit bytes by inclusion of their parity bit P. Polynomials M_j shall be formed.

The coefficients shall be the bits in each data byte.

The coefficients of polynomial M_1 shall be the bits of the byte in position 1 of the first data group, those of polynomial M_2 shall be the bits of the byte in position 2, etc., up to M_n where n is the number of data bytes within the block.

These bits shall be allocated to the polynomials as follows :

Bit from track	is coefficient of
1	x^0
5	x^1
8	x^2
4	x^3
2	x^4
6	x^5
3	x^6
7	x^7
9	x^8

The auxiliary CRC character shall be obtained as follows. An asymmetrical polynomial N shall be computed

$$N = \Sigma\ (x^i M_j) \text{ (mod } H)$$

where

i = n to 1

j = 1 to n

$H = x^0 + x^2 + x^6 + x^9$

All arithmetic operations shall be (mod 2).

A polynomial $(x^0 + x^1 + x^6 + x^7 + x^8)$ shall be combined by means of an exclusive OR operation with N in the corresponding bit positions.

The coefficients of the resulting polynomial shall be the bits of the auxiliary CRC character according to the following allocation :

In track	the coefficient of
1	x^0
2	x^4
3	x^6
4	x^3
5	x^1
6	x^5
7	x^7
8	x^2
9	x^8

The auxiliary CRC character shall have odd parity. If the auxiliary CRC character obtained has even parity, the bit in track 4 shall be inverted to obtain odd parity.

8.4.3 CRC character

The CRC character shall be calculated from all the previous characters within the block (data, padding characters, auxiliary CRC, and the padding character, if any, in position 1 of the CRC group) considered as 9-bit bytes by inclusion of their parity bit, but excluding all the ECC characters in position 8 of the data groups and of the residual group. Polynomials M_j shall be formed, the coefficients of which are the bits in each byte. The coefficients of polynomial M_1 shall be the bits of the byte in position 1 of the first data group, those of polynomial M_2 shall be the bits of the byte in position 2, etc., up to M_n for the n characters to be considered.

These bits shall be allocated to the polynomials as follows :

Bit from track	is coefficient of
4	x^0
7	x^1
6	x^2
5	x^3
3	x^4
9	x^5
1	x^6
8	x^7
2	x^8

The CRC character shall be obtained as follows. A polynomial C shall be computed

$$C = \Sigma\,(x^i M_j) \pmod K$$

where

$i = n$ to 1

$j = 1$ to n

$K = x^0 + x^3 + x^4 + x^5 + x^6 + x^9$

All arithmetic operations shall be (mod 2).

A polynomial $(x^0 + x^1 + x^2 + x^4 + x^6 + x^7 + x^8)$ shall be combined by means of an exclusive OR operation with C in the corresponding bit positions. The coefficients of the resulting polynomial shall be the bits of the CRC character according to the following allocation :

In track	the coefficient of
1	x^6
2	x^8
3	x^4
4	x^0
5	x^3
6	x^2
7	x^1
8	x^7
9	x^5

NOTE — The CRC character will always have an odd parity.

8.4.4 Residual character

The residual character shall be obtained from the number n of data bytes within the block.

$R_1 = n \pmod 7$

$R_2 = n - 1 \pmod{32}$

With R_1 and R_2 expressed in binary notation, the bits of the residual character shall be :

R_1 = bits 0 1 2

R_2 = bits 3 4 5 6 7

These bits shall be allocated to tracks as follows :

	Bit	In track
R_1 0	0	5
1	1	6
2	2	7
R_2 0	3	2
1	4	8
2	5	1
3	6	9
4	7	3

In track 4, an odd parity bit P shall be inserted.

9 Recording of groups on tape

The groups prepared as specified in clause 8 shall be recorded on the tape as follows :

Each 4 consecutive positions on each track shall be translated according to the following table and recorded on the tape as five consecutive bits.

0000 → 11001
0001 → 11011
0010 → 10010
0011 → 10011
0100 → 11101
0101 → 10101
0110 → 10110
0111 → 10111
1000 → 11010
1001 → 01001
1010 → 01010
1011 → 01011
1100 → 11110
1101 → 01101
1110 → 01110
1111 → 01111

After recording, the different fields on the tape are called

— data storage group

— residual storage group

— CRC storage group