

Contents	Page number
1. Scope	5
2. References	5
3. Abbreviations	5
4. Definitions	5
5. Safety considerations	5
6. Introduction	5
7. Producer requirements	5
7.1 Security	5
7.2 Identification	6
7.3 Quality assurance	6
7.4 Degaussing ticket stock	6
8. Ticket material characteristics	6
8.1 Ticket size	6
8.2 Dimensional stability	7
Fig 1 Dimensions	8
8.3 Construction	9
8.4 Quality	9
8.5 Toxicity and chemical reaction	9
8.6 Friction test	9
Fig 2 Friction test	10
8.7 Flexing endurance	11
Fig 3 Flexing endurance	12
8.8 Delamination	13
8.9 Adhesion	13
8.10 Opacity	13
8.11 Colour	13
8.12 Graphics	13
8.13 Tear resistance	13
8.14 Tensile strength	13
8.15 Print surface resolution	13
8.16 Print surface absorbency	13
8.17 Print surface durability	13
8.18 Curvature	13
8.19 Stiffness	13
8.20 Brittleness	14
9. Magnetic stripe characteristics	14
9.1 Dimensions and location	14
Fig 4 Position of magnetic data recorded on ticket	15
9.2 Protrusion	16
9.3 Quality	16
9.4 Surface roughness	16

9.5 Profile	16
9.6 Recording performance	16
Fig 5 Read back signal level	17
9.7 Signal permanence	18
9.8 Signal to noise ratio and DC erasure	18
9.9 Contamination of magnetic heads by tickets	18
Fig 5 Read back signal level	19
9.10 Magnetic surface abrasion resistance	20
10. Packaging	20
10.1 General	20
10.2 Plastic ticket stock	20
11. Pre-encoded tickets	20
Attachments	21
References	21
Diagrams	22

1. Scope

1.1 The purpose of this document is to define London Transport's requirements for plastic ticket stock.

1.2 This document describes the dimensions, size, materials and physical requirements for magnetically encoded plastic tickets to be issued by London Transport and used for travel.

2. References

This document refers to other documents that provide information and guidance. These are cited at appropriate points in the text and are listed in attachment 1. Unless otherwise stated reference should be made to latest editions.

3. Abbreviations

The following special abbreviations are used in this document.

LT	London Transport
LUL	London Underground Limited
AFC	Automatic Fare Collection
Oe	Oersted
Fig	Figure
RH	Relative Humidity
FRPI	Flux reversals per inch
RMS	Root mean square
dB	Decibel
BPMM	Bits per millimetre
g	grammes
mm(2)	Millimetre (squared)
Sec	Second
Kg	Kilogramme

4. Definitions

Specific terms used throughout this document are defined on first use.

5. Safety considerations

Tickets shall be designed so that they present no hazard to those using and handling them (see para 8.5).

6. Introduction

The ticket is a credit card size plastic item. It has pre-printed graphics on one side and a nominal 300 Oe magnetic stripe centrally positioned and parallel to the long edge on the other side, with additional pre-printed graphics above and below the magnetic stripe. In use the ticket will be inserted into ticket issuing machines, which both magnetically encode and print information on the ticket. This information may be subsequently processed by other ticket handling equipment, and it may be used at least 6,000 times, on each occasion being recoded by the processing equipment.

7. Producer requirements

7.1 Security

The tickets are considered to be of value, therefore it will be necessary during the course of manufacture, storage and transportation to adhere to a procedure which will inhibit the theft or misuse of these tickets. This security shall extend to but is not limited to paras 7.1.1, 7.1.2 and 7.1.3.

7.1.1 Scrap material and rejected tickets shall be disposed of in such a manner as to prevent retrieval for further use.

7.1.2 Material, plates and other equipment used in the manufacture of the tickets shall be kept in a secure environment.

7.1.3 Tickets shall be manufactured in secure areas accessible only to personnel involved in the manufacture and/or handling of the tickets and/or raw materials.

7.2 Identification

7.2.1 Manufacturers shall retain records for at least two years to enable a ticket serial/batch number to be traced with respect to the date of production and the names of personnel responsible for production and product checking.

7.2.2 An identification code (batch number) is to be printed on the rear (magnetic stripe) side of each ticket, and shall identify the manufacturer and particular production batch from which it originated.

7.2.3 The code shall contain 4 digits and shall be printed in accordance with LT artwork in such a manner that irrespective of how the ticket is produced at least one complete code shall be legible.

7.2.4 The requirement is superseded wherever the artwork supplied by the authorised LT source is contrary to the standard.

7.2.5 A 'batch' is defined under this standard as a quantity of ticket stock produced at any one time, with the same graphics, totalling no more than 1.5 million individual tickets. The actual number may vary from batch to batch but shall be clearly indicated on all relevant test documents.

7.2.6 When a contract is awarded by London Underground, new commencing batch numbers will be specified by an authorised source.

7.3 Quality assurance

7.3.1 Test procedures/methods

The manufacturer shall develop and make available procedures (including sampling methods) for testing all the specified parameters. No testing shall start until the written procedures have been reviewed by LT.

7.3.2 Certification

a) No tickets shall be delivered until the corresponding Certificate of Conformity has been supplied to LT;

b) LT reserve the right to request full test results for any production batch;

c) LT reserve the right to carry out inspection at any stage of the manufacturing process and to monitor the testing carried out by the manufacturer or any of their sub-contractors.

7.3.3 Encoded information

Manufacturers shall certify where appropriate that the encoded information is consistent with the details printed on the face of the ticket

7.3.4 Audit

LT reserves the right to carry out audits as appropriate to ensure that the quality system is maintained.

7.4 Degaussing ticket stock

All tickets shall be degaussed prior to either delivery or encoding as applicable.

8. Ticket material characteristics

8.1 Ticket size

(see Fig 1 Dimensions)

a) thickness 0.25 ± 0.04 mm;

b) width 53.9 ± 0.1 mm;

c) length $85 + 2/-1$ mm;

d) corners rounded to 3.5 ± 0.5 mm radius;

e) edges

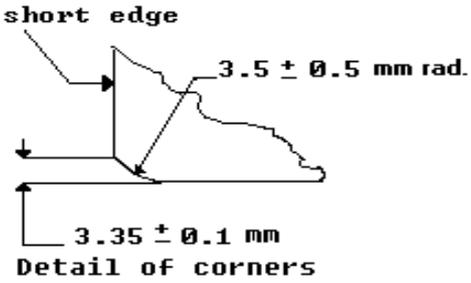
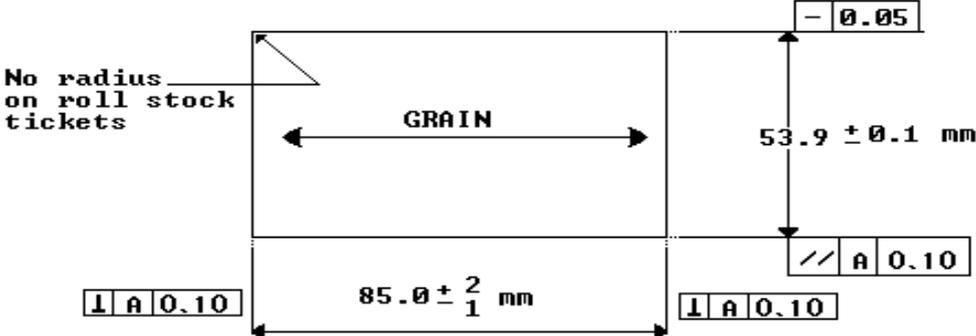
1. no irregularities greater than 0.13 mm on side or trailing or leading edge;

2. all irregularities shall be within the maximum tolerance of the ticket in relation to width, length and thickness;
- f) squareness Sides shall be parallel and perpendicular within 0.10° .

8.2 Dimensional stability

The dimensional tolerances detailed in para 8.1 apply at $23 \pm 1^\circ\text{C}$ and $50 \pm 2\%$ RH. Over the temperature and humidity range of 0 to 50°C and 25 to 90% RH the width shall not exceed 54.5 mm and not be less than 53.7 mm. The ticket width shall not be less than 53.3 mm at 15% RH.

Fig 1 Dimensions



8.3 Construction

The ticket material shall be plastic.

8.4 Quality

The tickets shall be free of dirt, debris and defects.

8.5 Toxicity and chemical reaction

The ticket shall present no hazard from contact or inhalation. Equally the ticket, i.e. material, print and magnetic stripe, shall be resistant to normal handling and use.

8.6 Friction test

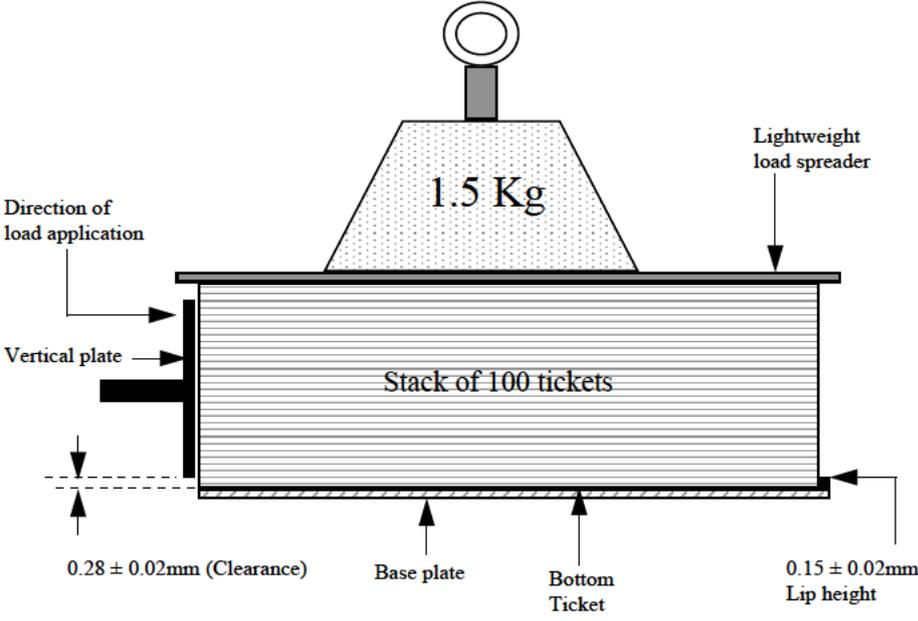
8.6.1 At a temperature of $23 \pm 1^\circ\text{C}$ with a relative humidity between 50 and 75%, the force required to slide a weighted stack of tickets shall not exceed 950 g, measured as detailed in para 8.6.2.

8.6.2 A stack of 100 tickets, lightly fanned to break up any edge bonding, shall be placed on a smooth base plate which has a step (to a depth of 0.15 ± 0.02 mm), so that one end of the bottom ticket in the stack is butted up against the step over its entire length. A 1.5 kg weight shall be placed on top of the stack so that the weight is spread evenly across the top ticket. A force is to be applied to the stack on the edge directly opposite the step, by means of a vertical plate perpendicular to the stack and with a clearance of 0.28 ± 0.02 mm from the bottom of the base plate (see Fig 2 Friction test). The force required to push the stack across the bottom ticket shall not exceed 950 g.

8.6.3 The equipment and test tickets shall be conditioned within the test environment for at least 24 hours prior to the test being carried out.

8.6.4 This test need only be carried out once per purchase of material.

Fig 2 Friction test



8.7 Flexing endurance

This is to be measured by the following methods:

8.7.1 A ticket is to be wrapped around a 10 mm diameter cylinder. It is then to be reformed to a flat state. The magnetic stripe or ticket shall not have deteriorated physically or in its ability to be accurately coded and decoded along the full length and width of the magnetic stripe. The signal to noise ratio shall not be less than detailed in para 9.8.

This test is to be carried out with 4 tickets, one in each of the following manners:

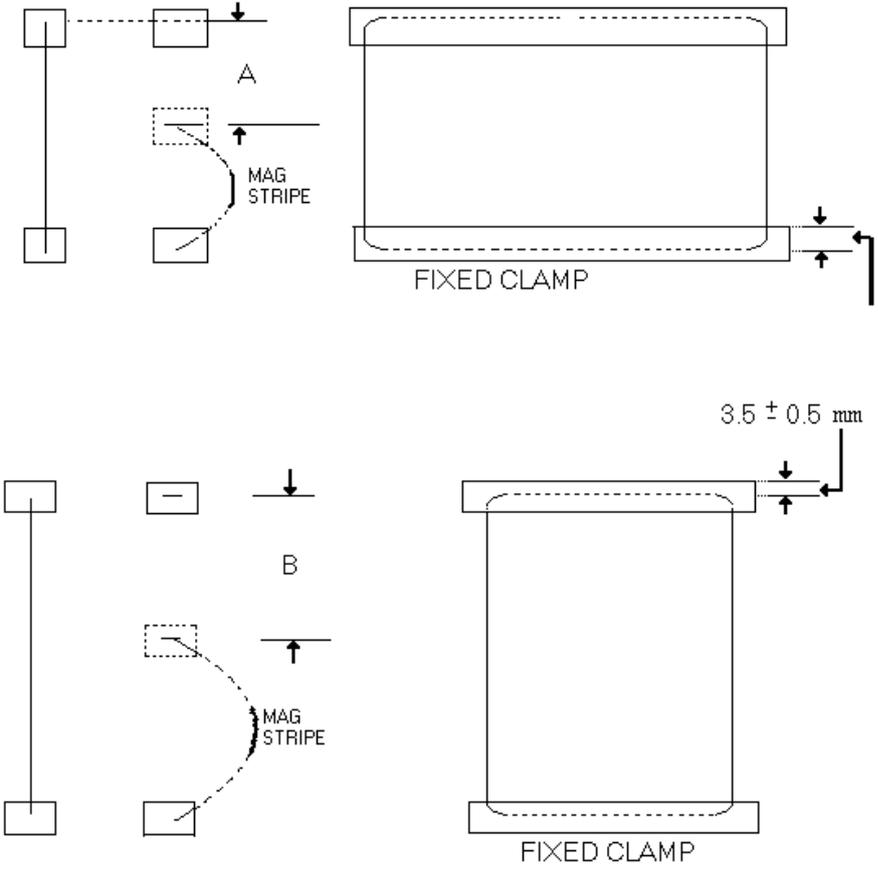
- a) the non-magnetic side of the ticket against the cylinder with the stripe parallel to the cylinder's length;
- b) the non-magnetic side against the cylinder with the stripe across the cylinder's length;

c) the magnetic side against the cylinder with the stripe parallel to the cylinder's length;

d) the magnetic side against the cylinder with the stripe across the cylinder's length.

8.7.2 A ticket is to be clamped in the manner shown in Fig 3 Flexing endurance. The moveable clamp is then to be driven in the manner indicated with the magnetic stripe forming the convex face. This cycle is to be repeated five hundred times at a rate of not less than 30 or more than 60 cycles per minute. On completion of the test there should be no physical damage to either the stripe or ticket including delamination. Neither shall the magnetic stripe fail the signal to noise test detailed in para 9.8. The test is to be repeated using a different ticket with the long side of the ticket clamped.

Fig 3 Flexing endurance



A (TICKET WIDTH) = 14 ± 0.2 mm
B (TICKET LENGTH) = 23 ± 1 mm

8.8 Delamination

Neither the ticket nor the magnetic material attached to it shall delaminate during use over the temperature and humidity range of 0 to 50°C and 25 to 90% RH.

8.9 Adhesion

Ten tickets complete with graphics shall not adhere to each other when stacked magnetic side down on a flat surface for 24 hours at a temperature of 40°C and relative humidity of 90% with an applied normal pressure of 0.7 ± 0.14 g/mm².

8.10 Opacity

A minimum opacity to infra-red light is required. Specifically, attenuation of light in passing through the thickness of the ticket (exclusive of the magnetic stripe area) shall be 85% minimum over a wavelength range of 500 to 1,020 nanometres.

8.11 Colour

The colour(s) of the base and the printed ink of the finished product shall conform to those stipulated in the artwork and/or samples provided by LT. Whatever method is used to colour the surface of the ticket stock, it must not impair the surface absorbency characteristics in para 8.16 or the magnetic stripe characteristics in section 9.

8.12 Graphics

Graphics to be pre-printed on both sides shall conform to those stipulated in the artwork provided by LT and are subject to change. Proofs shall be submitted to LT for approval prior to production. Tolerances shall be clearly indicated. The printed graphics shall be clearly legible and shall not smear, transfer or be easily erasable during normal use.

8.13 Tear resistance

This shall be at least 5.0 kg when tested in accordance with ASTM D-1004. An approved equivalent standard may be used.

8.14 Tensile strength

The minimum tensile strength shall be 16.5 kg/15 mm both across and along the document when measured in accordance with BS 4415.

8.15 Print surface resolution

The quality of the print surface shall be adequate for legible printing of dot matrix characters printed with needles 0.35 mm in diameter applied by means of an impact needle printer and ink fabric ribbon.

8.16 Print surface absorbency

The print surface shall be sufficiently absorbent to ensure that impact printed information shall not smear after 2 seconds drying time.

8.17 Print surface durability

Printed samples are to be submitted to LT for approval of print durability on any new or proposed stock.

8.18 Curvature

The inherent curvature of the ticket may be only concave into the magnetic stripe. The curvature shall be less than 2 mm at any point beneath the ticket, neither shall any corner when placed on a level surface, magnetic stripe down, be above the level surface by more than 1 mm. These criteria remain throughout its storage life which could be up to 18 months.

8.19 Stiffness

The stiffness when measured in accordance with ISO 2483 shall be between 35-50 mn.

8.20 Brittleness

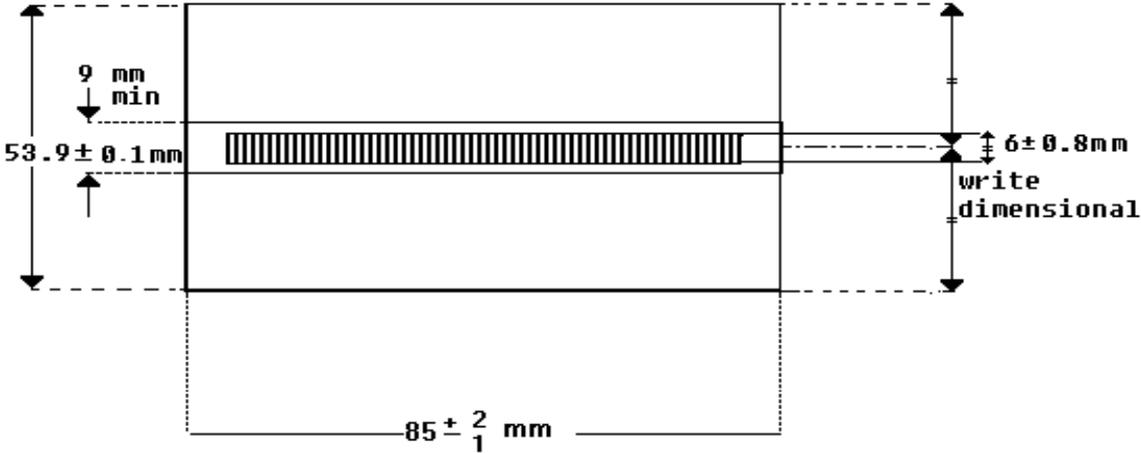
This is to be determined by the impact strength when measured to ASTM 1822. The minimum strength shall be 600 kJ/m².

9. Magnetic stripe characteristics

9.1 Dimensions and location

The size and position of the magnetic stripe shall be as shown in Fig 4 Position of magnetic data recorded on ticket. Magnetic material can be applied either by coating or by the transfer of magnetic tape providing all of the above parameters are satisfied. If a stripe is transferred it shall be impossible to separate the stripe from the ticket stock without visually degrading the ticket surface or the magnetic stripe itself. Normal use in LT equipment shall not cause any part of the stripe to lift.

Fig 4 Position of magnetic data recorded on ticket



9.2 Protrusion

The magnetic stripe at any point along its length or width shall not protrude by more than 0.015mm nor be less than 0.005 mm above the surface of the ticket.

9.3 Quality

There shall be no joins or splices in the magnetic material applied to the ticket.

9.4 Surface roughness

The average peak to peak irregularity for determining surface roughness of the magnetic stripe will not exceed 0.0013 mm centre line average in both longitudinal and transverse directions, using a cut off wavelength of 0.25 mm when using a stylus of 0.0025 mm minimum radius.

9.5 Profile

The surface profile of the magnetic stripe when measured across the width of an area of the stripe extending a minimum of 3.8 mm either side of the lateral centre line with a probe of 2.54 mm radius, shall not show a deviation from the high point of more than 0.011 mm across the measured distance, subject to the provisions of meeting the minimum stripe protrusion of 0.005 mm.

9.6 Recording performance

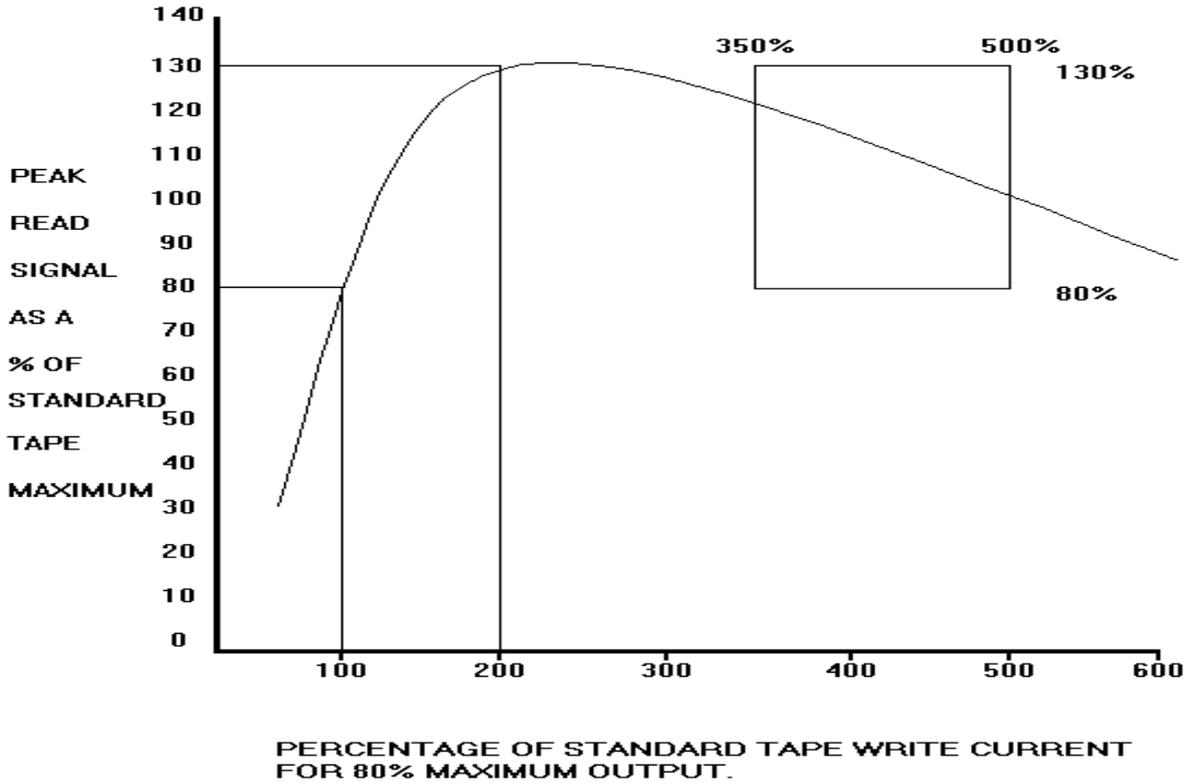
9.6.1 Initial test

a) Signals from the leading and trailing 3 mm segments of the recording track shall not be considered in evaluating the results of these tests. The magnetic material shall be capable of producing peak read-back signals of not less than 80% and not greater than 130% of read head voltage calibration with any current between 350% and 500% of a defined write head calibration (see Fig 5 Read back signal level);

b) The 100% read head voltage calibration is defined as the maximum peak read-back signal obtained from a saturation plot secondary signal amplitude reference tape (SRM 3200 as defined in ISO 1864) written at 200 frpi and transported at a velocity of 1.016 m/sec (40 in/sec) equal to that of the ticket encoder.

c) The 100% write head calibration is defined as that square wave current required to achieve 80% of maximum voltage from the reference tape.

Fig 5 Read back signal level



9.6.2 Wavelength response

The read-back signal for 500 frpi shall not be less than 56% of that obtained at 200 frpi when:

- a) the write current and all other parameters are identical;
- b) the read head gap is less than 0.013 mm;

The overall response of the read-back and measurement equipment is such that, with SRM 3200 tape, the read-back signal of 500 frpi is not less than 95% of that obtained at 200 frpi.

9.6.3 Signal uniformity

The uniformity of the materials and method of application shall be such that, excluding areas within 1 mm of a stripe edge or 2 mm of stripe ends, every pulse in a track of 200 frpi, written and read parallel to the longer edge of the ticket anywhere on the magnetic stripe, shall comply with the above signal level requirements.

9.7 Signal permanence

The signal level as measured above shall be reduced to no less than 72% of read head voltage calibration (i.e. 90% of the minimum signal level), by exposure to a unidirectional longitudinal field of 50 ± 2 Oe.

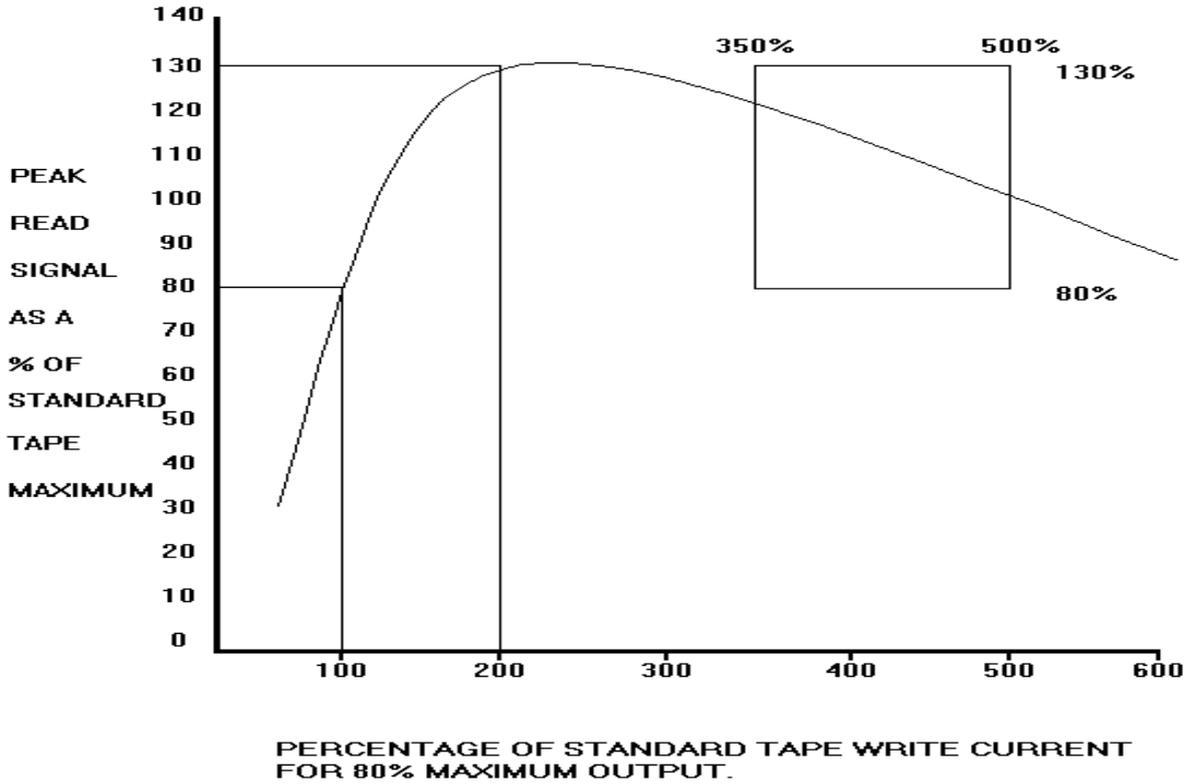
9.8 Signal to noise ratio and DC erasure

The test specimen will be DC erased with a unidirectional write current equal to a minimum of 250% of the reference 100% write current calibration level determined in para 9.6.1c). The ratio of peak signal level to rms noise level (measured under identical conditions) shall be at least 50 (i.e. better than 34dB).

9.9 Contamination of magnetic heads by tickets

The surface quality of the ticket oxide layer shall be such that any oxide dust or other residue does not accumulate on the magnetic heads in the ticket handling unit. Specifically the average signal amplitude read from a given ticket shall not be reduced by more than 5% upon passing 980 separate tickets through a test ticket handler. The heads are to be cleaned prior to the test, but not during the test. The result is to be based on the average read value for the passing of the same ticket 10 times at the commencement and at the completion of the test.

Fig 5 Read back signal level



9.10 Magnetic surface abrasion resistance

9.10.1 The abrasion test consists of subjecting tickets to a test cycle of 30 revolutions on a Taber "Abrader" using clear CS-10F wheels and a load on each wheel of 500 g. (Taber Instrument Corp, North Tonawanda, NY, USA or an approved equivalent tester).

9.10.2 After being subjected to the abrasion test, the average pulse amplitude read from the abraded portion of a test pass pre-recorded with a density of 240 frpi shall be at least 50% of the average pulse amplitude read from the non-abraded portion of the same pass.

10. Packaging

10.1 General

Ticket stock shall be packaged in such a manner as to inhibit pilferage, prevent damage during shipment and facilitate storage. The contents of each individual carton should be wrapped with waterproof material.

10.2 Plastic ticket stock

Tickets are to be delivered as instructed by the purchase order and where applicable are to be in strict numerical sequence. Cartons shall be clearly labelled with:

- a) manufacturer's name;
- b) purchase order number/contract number as appropriate;
- c) four digit batch identification number printed on ticket;
- d) type of ticket;
- e) quantity;
- f) date of packaging.

Packaging shall be as specified by the authorised LT source.

11. Pre encoded tickets

See E2062 Ticket encoding specification.

References

British standards:

BS 4415 Documentation of tensile properties of paper and board
BS 5132 Embossed credit cards

ISO standards:

ISO 1864 Information processing - Unrecorded magnetic tape

Diagrams

Fig 1 Dimensions page 8 referenced in para 8.1

Fig 2 Friction test page 10 referenced in para 8.6

Fig 3 Flexing endurance page 12 referenced in para 8.7.2

Fig 4 Position of magnetic data recorded on ticket page 15 referenced in para 9.1

Fig 5 Read back signal level page 17 referenced in para 9.6.1 a)