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The Chief Engineer's Group



The Automatic Fare Collection  
Engineer's Department

London Underground Limited

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Standard

AFC-ST-4095-10

Management system

Roll stock and pre-cut card tickets

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improvements to this document, on a marked-up copy.

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Document submitted for validation

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[Redacted]

Document history

Edition	Date	Modification	Writer
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## 1. Scope

1.1 The purpose of this document is to define the London Transport's requirements for tickets made from roll stock and roll stock material.

1.2 This document describes the dimensions, size, materials and configuration for a magnetically encoded passenger ticket made from roll stock material 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	Decibels
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 paper/card document. It has pre-printed graphics on one side and 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. Tickets from roll stock material will be either pre-printed and pre-encoded, or issued by various LT ticket issuing machines. These machines both magnetically encode and print information onto the ticket. In both cases this information may be subsequently processed by other ticket handling equipment, and it may be used at least 20 times; on each occasion being re-encoded 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 documents. This security will extend to, but is not limited to sections 7.1.1, 7.1.2 and 7.1.3.

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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 and will 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 cut to length, one complete code will be legible.

7.2.4 This 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 sufficient to produce 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 of 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.
- 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 subcontractors

### 7.3.3 Encoded information

Manufacturers shall certify where appropriate that the encoded information is consistent with the detail 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.

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#### 7.4 Degaussing of ticket stock

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

### 8. Ticket material characteristics

#### 8.1 Ticket size

8.1.1 The size of tickets produced from rolls of material will conform to that depicted in Fig 1 Dimensions  The 85 + 2/- 1 mm length will be produced by the issuing machine if applicable.

8.1.2 For pre-cut tickets made from roll stock material the following applies 

- a) thickness  $0.25 \pm 0.04$  mm;
- b) width  $53.9 \pm 0.1$  mm;
- c) length  $85 + 2/- 1$  mm;
- d) corners rounded to  $3.5 \pm 0.5$  mm radius;

#### e) edges

1. No irregularities greater than 0.13 mm on sides or trailing or leading edge,
2. all irregularities shall be within the maximum tolerance of the ticket in relation to width, length and thickness;

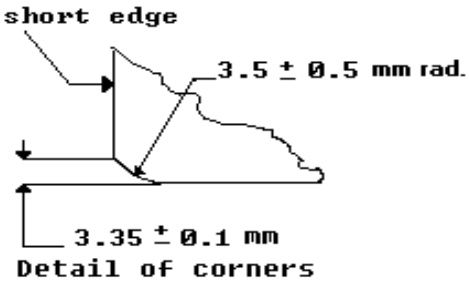
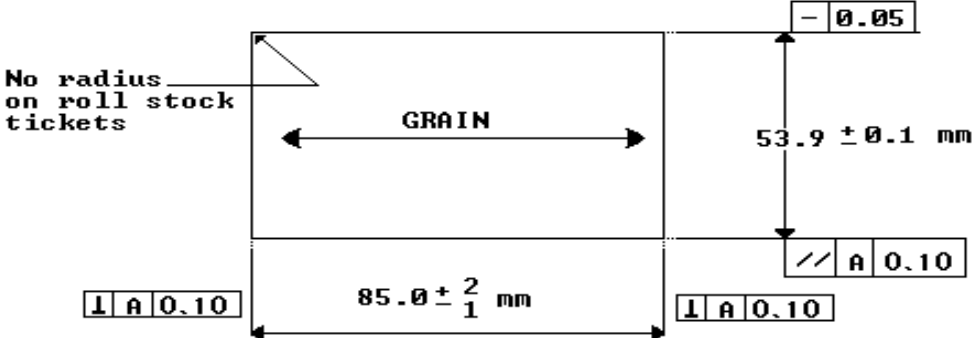
f) squareness sides shall be parallel and perpendicular within  $0.10^\circ$ .

#### 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  $50^\circ\text{C}$  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.

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Fig 1 Dimensions





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### 8.3 Construction

The ticket roll material may be single layered or laminated.

### 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 relative humidity between 50 to 75% the force required to slide a weighted stack of tickets shall not exceed 950g, measured as detailed in para 8.6.2.

8.6.2 A stack of 100 tickets, lightly fanned to break up any edge bonding,

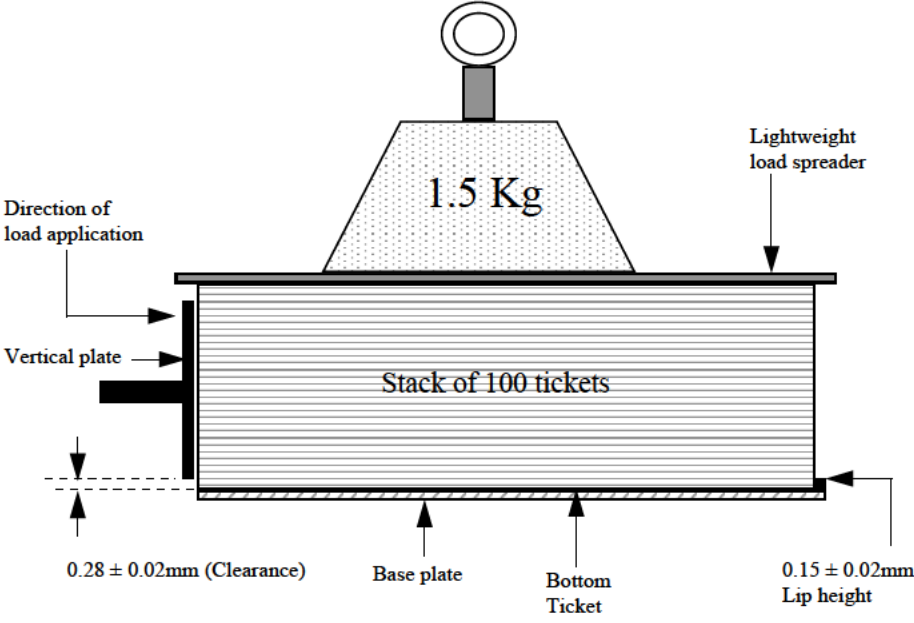
shall be placed on a smooth base plate which has a step (to a depth of  $0.15 \pm 0.02$  mm), so that one end of the bottom ticket in the stack is butted up against the step over its entire length. A 1.5 kg weight shall be placed on top of the stack so that the weight is spread evenly across the top 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  $0.28 \pm 0.02$  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 950g.

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.

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Fig 2 Friction test



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### 8.7 Flexing endurance

This is to be measured by the following method:

A ticket cut from a roll of material, 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 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 and the stripe parallel to the cylinder's length;
- b) the non magnetic side of the ticket against the cylinder and the stripe across the cylinder's length;
- c) the magnetic side of the ticket against the cylinder and the stripe parallel to the cylinder's length.
- d) the magnetic side of the ticket against the cylinder and the stripe across the cylinder length.

### 8.8 Delamination

Neither the ticket paper, nor the magnetic material attached to it shall delaminate during use.

### 8.9 Adhesion

Ten tickets complete with graphics should not adhere to each other when stacked magnetic stripe down on a flat surface for 24 hours in an environment of 60°C and relative humidity of 90% with an applied normal pressure of  $0.7 \pm 0.14 \text{ g/mm}^2$ .

### 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 ticket 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.

8.12.1 The graphics shall be printed and the ticket so wound, that the 'This side up  Not for resale' jingle print reads from the left to the right of the ticket towards the end of the cut edge when unwound from the roll. This is in relation to the roll being viewed from the top with the printed side uppermost and the magnetic stripe below, as shown in Fig 7 Roll stock configuration.

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### 8.13 Edge strength

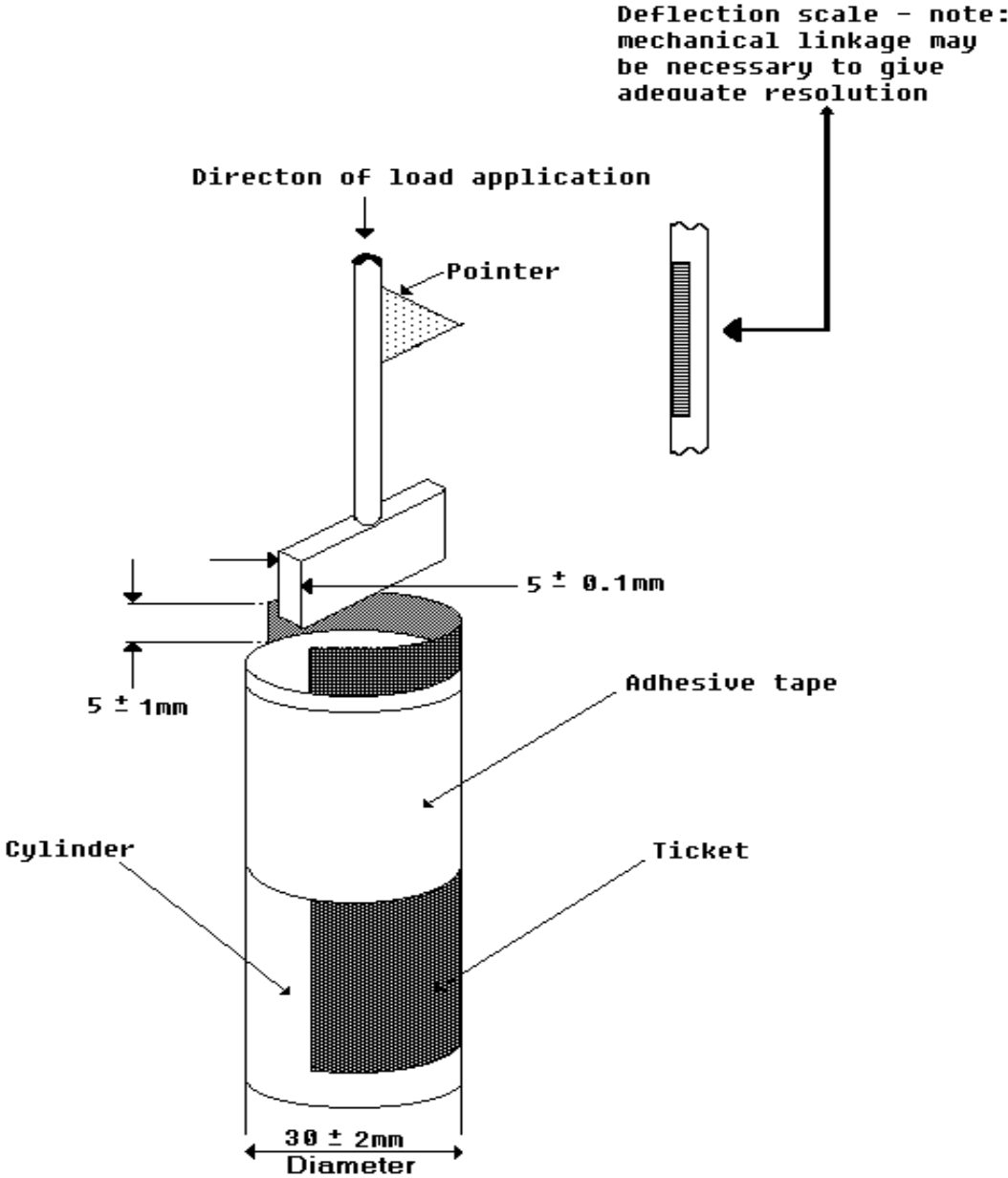
8.13.1 Any edge of a ticket shall be capable of withstanding a specified static load applied in the plane of the ticket, perpendicular to the edge and distributed evenly over an arc of that edge.

8.13.2 For the purpose of measurement, the ticket shall be secured by means of adhesive tape to a cylinder of diameter  $30 \pm 2$  mm so that the edge upon which measurements are to be made forms an arc  $5 \pm 1$  mm above and parallel to one end of the cylinder. An initial pre-load of

100g is applied to the ticket, the position of the indicating pointer is then read from the scale and noted. The load shall then be increased at a rate of 100 g/s or in 50g steps (as shown in Fig 3 Edge strength measurement) until the pointer has displaced a further 0.5mm. the total applied load for this deflection must be greater than 340g.

8.13.3 This test is to be carried out once per purchase of material.

Fig 3 Edge strength measurement



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#### 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 Printed surface durability

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

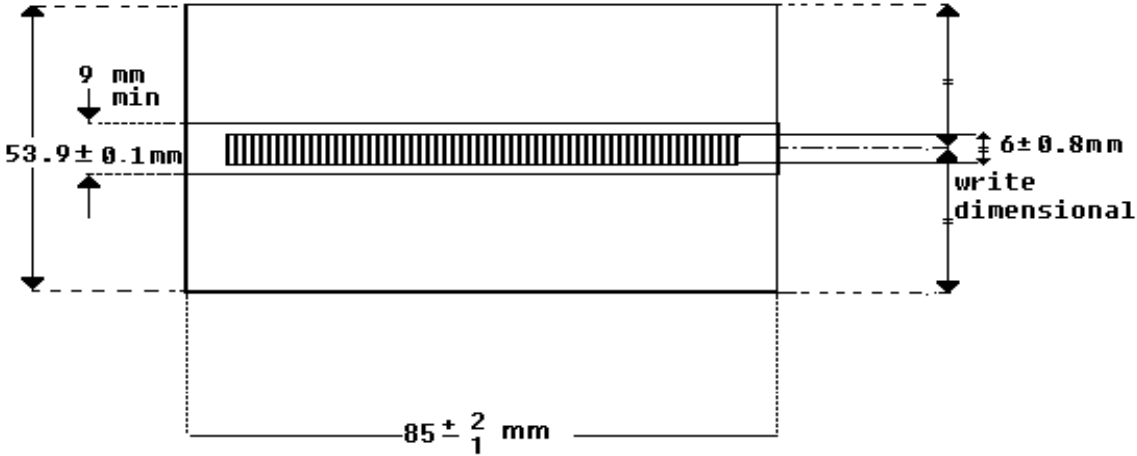
### 9. Magnetic stripe characteristics

#### 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 stripe 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.

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Fig 4 Position of magnetic data recorded on document



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## 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 0.0038 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 0.005mm.

## 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 ins/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.

### 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.

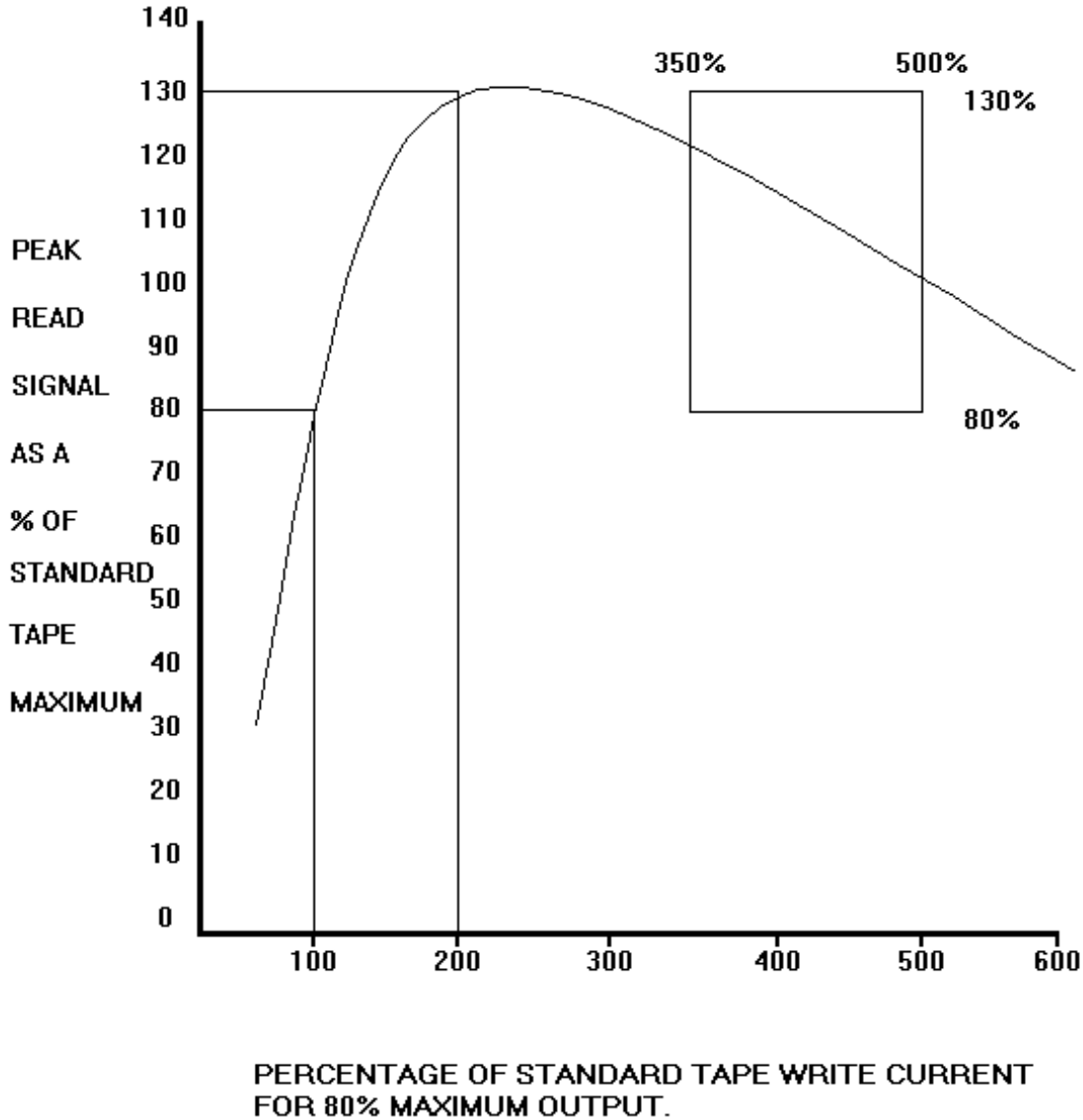
### 9.6.3 Signal uniformity

The uniformity of the materials and method of application shall be such that, excluding areas within 1 mm of a stripe edge or within 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 signal level requirements given above.

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Fig 5 Read back signal level



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## 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  $50 \pm 2$  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 (defined 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.

# 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 shall be wrapped with waterproof material.

## 10.2 Roll stock

Each roll shall contain at least 2000 tickets. The number of rolls to a carton shall be 5, unless agreed otherwise by LT. Cartons shall be of sufficient strength to permit stacking them six high without damage to the tickets or the cartons during a storage period of 18 months. Cartons shall be clearly labelled with:

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

Packaging of pre-cut tickets made from roll stock material will be as specified by the authorised LT source.

## 10.3 Reduced length rolls (12.6 also refers)

10.3.1 All reduced length rolls shall be packaged separately from, and in a manner which clearly distinguishes them from full length rolls. Packaging shall be labelled to provide the same information as in para 11.2 and clearly indicate the approximate number of tickets on each reduced length roll.

# 11. Pre encoded tickets

See E2062 Ticket encoding specification

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## 12. Ticket stock type

### 12.1 General roll stock

The roll shall be continuous without any breaks or splices. The surfaces either side of the roll shall be flat within 1 mm. The roll shall be cleanly cut without ridges or cutting debris between the windings. The roll shall be wound in such a manner that the magnetic stripe does not adversely distort. The magnetic stripe shall be on the inside surface of the roll.

### 12.2 Concavity of roll stock

The manufacturer shall carry out tests to satisfy the following criteria:

- a) the striped area of the ticket must not be concave in relation to the face of the ticket by more than 2 mm. This is to be measured using a sample of stock 170 mm long taken from the middle of a roll which has been conditioned in an environment of  $23 \pm 1^\circ\text{C}$  and  $50 \pm 2\%$  RH for at least 24 hours and repeating the profile test procedure (paragraph 9.5) in 6 equidistant positions along the length of the sample;
- b) the arithmetic mean derived from this procedure must be greater than  $R_t/1.8$  where  $R_t$  is the distance from the maximum peak to the maximum trough.
- c) For pre-cut tickets made from roll stock material the inherent curvature of the document may be only concave into the magnetic stripe face as viewed from the leading or trailing edge of the ticket and also from either long side. In each case, 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.

## 12.3 Roll core

The finished ticket material (including the magnetic stripe and pre-printed graphics) shall be rolled around a core. One end of the roll can be secured to the core with adhesive tape or paste with an adhesion strength on the stock of no more than 300g. If tape or paste is used then all the tape or adhesive must remain attached to the core with no active adhesive material remaining on the ticket. No adhesive material of any kind must adhere to the stripe. The ticket material shall not be folded over on itself as a means, or partial means, of adhering the stock to the hub. The preferred method is for no tape or adhesive to be used to attach the end of the roll to the core.

### 12.4 Roll outside end

12.4.1 The outside end of the roll may be secured with an adhesive tape, or some other means that shall not damage the ticket material when removed.

### 12.5 Dimensions

The dimensions of the roll shall be :

- a) outside diameter 270 mm max.;
- b) inside diameters (of the ticket stock) = 97 mm;
- c) inside diameter of the core (6 mm wall) =  $86 \pm 2$  mm;
- d) width of roll stock material =  $53.9 \pm 0.1$  mm;
- e) thickness of roll stock material =  $0.25 \pm 0.04$  mm

### 12.6 Reduced length rolls (10.3 also refers)

12.6.1 A reduced length roll is acceptable provided that the roll contains no fewer than 1200 tickets and the total number of

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reduced rolls does not exceed 10% of the number of rolls in one production batch. However it should be noted that a number of sites will not accept reduced length rolls. Details of these sites will be provided by the Ticket Procurement section as appropriate.

#### 12.7 Tightness of roll

12.7.1 A complete roll of tickets (2000 at least) is to be placed onto two bars as indicated in Fig 7 Test for tightness of roll. Each bar is to be made of a non-ferrous metal and should measure 9 mm x 15 mm x 150 mm. The bars are to be placed onto a flat level surface with the 9 mm face in contact with the flat surface. The bars are to be placed apart from each other, such that each edge of the ticket roll coincides with the outside edge of each bar.

12.7.2 The ticket roll is to be placed onto the bars such that the length of the bar is equidistant about the ticket roll.

12.7.3 The roll upon the bars is to be left at an environment of  $23 \pm 1^\circ\text{C}$  with a relative humidity in the range of  $50 \pm 2\%$  for a period of 24 hours.

12.7.4 After 24 hours no point on the underside of the ticket roll shall be within 4.5 mm of the level surface below the roll.

12.7.5 For the purpose of this test only, the outside end of the roll shall be adhered to the remainder of the roll, it shall not be secured by elastic bands, shrink-wrap or similar. The means employed must not damage the ticket material when removed.

Fig 6 Test for tightness of roll

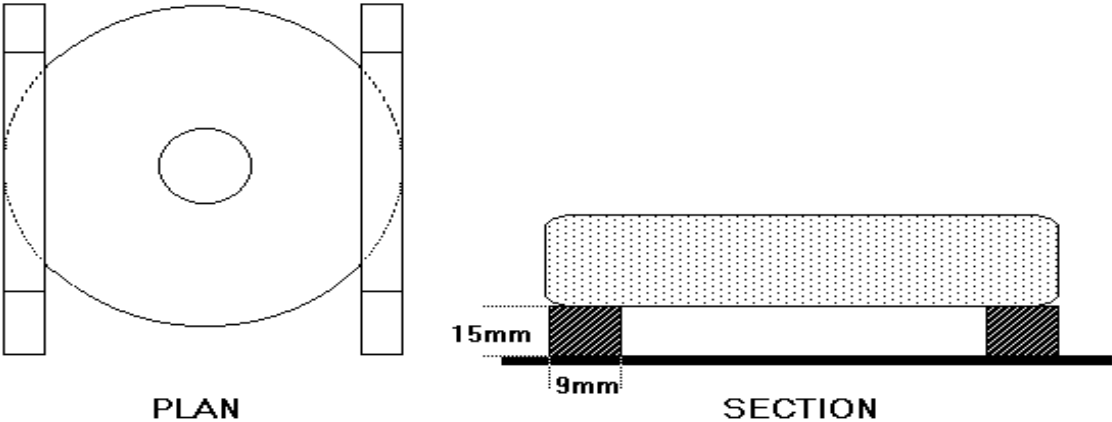
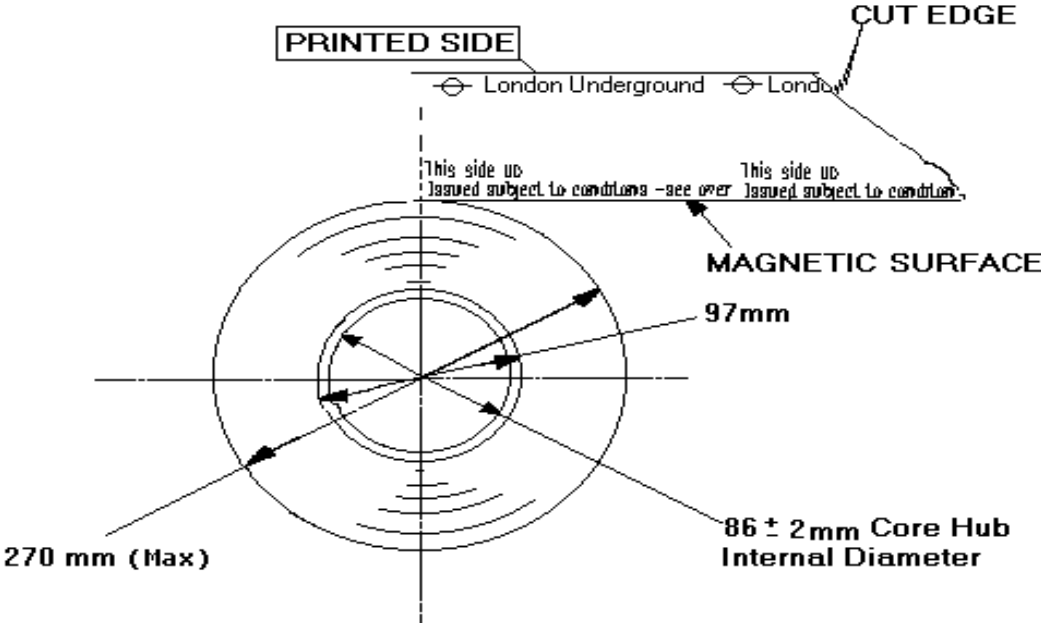


Fig 7 Roll stock configuration



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## References

### British standards:

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

### ISO standards:

ISO 1864

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## Diagrams

Fig 1 Dimensions page 8 referenced in paragraph 8.1.1

Fig 2 Friction test page 10 referenced in paragraph 8.6.2

Fig 3 Edge strength measurement page 13 referenced in paragraph 8.13.2

Fig 4 Position of magnetic data recorded on document page 15 referenced in paragraph 9.1

Fig 5 Read back signal level page 17 referenced in paragraph 9.6.1

Fig 6 Test for tightness of roll page 21 referenced in paragraph 12.7.1

Fig 7 Roll stock configuration page 22 referenced in paragraph 8.12.1

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