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UNPUNCHED PAPER CARDS FOR INFORMATION INTERCHANGE

METRIC AND IMPERIAL UNITS



STANDARDS ASSOCIATION OF AUSTRALIA
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Bureau of Census and Statistics

CSIRO Division of Computer Research

Department of Defence

Life Offices Association for Australasia

Manufacturers of data processing equipment

Postmaster-General's Department

Public Service Boards

Qantas Airways

Universities and Colleges

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In order to keep abreast of progress in industry, Australian standards are regularly reviewed. Suggestions for improvements to published standards, addressed to the headquarters of the Association, are welcomed.

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AUSTRALIAN STANDARD SPECIFICATION

UNPUNCHED PAPER CARDS FOR INFORMATION INTERCHANGE

AS 1244 — 1972

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PREFACE

This standard was prepared by the Association's Committee on Computers and Information Processing.

It specifies standard dimensions, materials and characteristics for general purpose paper cards for use with card punching equipment of all kinds.

The standard is technically identical with Recommendation ISO/R 1681—1970 published by the International Organization for Standardization. Reference was also made to ISO R 534 and R 536. Grateful acknowledgment is made of the assistance received from these sources.

This standard requires reference to:

AS P1, Methods of Test for Pulp and Paper.

BS 2925, Methods for Determining the Air Permeability and Air Resistance of Paper.

Tappi T476, Abrasion Loss of Packaging Materials.

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STANDARDS ASSOCIATION OF AUSTRALIA

**Australian Standard Specification
for
UNPUNCHED PAPER CARDS
FOR INFORMATION INTERCHANGE**

1 SCOPE. This standard specifies the dimensions, material, and physical requirements for the general purpose unpunched paper cards to be used for information interchange between different punched card equipments.

2 DETAIL REQUIREMENTS.

2.1 Grain. The grain of the paper shall be in the direction of the card length.

2.2 Defects. Cards shall be free from defects which may cause excessive wear or interfere with the electrical, magnetic, or optical sensing of the data processing equipment.

Among such defects are holes, magnetic particles, electrically conductive particles, dust, fibres protruding from edges or surfaces of the card, abrasive materials, residual chemicals, slime spots, other brittle areas and translucent spots which could cause reading errors in equipment.

2.3 Card Dimensions.

2.3.1 Nominal dimensions (See Fig. 1). The card shall be a nominal rectangle of 187.32 mm \times 82.55 mm (7.375 in \times 3.250 in). (See also Appendix A).

2.3.2 Actual dimensions. All points on the edges of the card except as modified by Clause 2.6 (Corners) shall fall between two concentric, similarly aligned, parallelograms dimensioned as follows:

Outer parallelogram:	Height	82.73 mm (3.257 in)
	Base length	187.45 mm (7.380 in)
Inner parallelogram:	Height	82.47 mm (3.247 in)
	Base length	187.20 mm (7.370 in)
	Angles comprised between	$90^\circ + 5$ minutes and $90^\circ - 5$ minutes (equivalent to 0.12 mm (0.0047 in) projection of the short side on to the long side).

2.4 Card Edges.

2.4.1 Condition. All edges shall be smooth and free from burrs and loose ends of fibres.

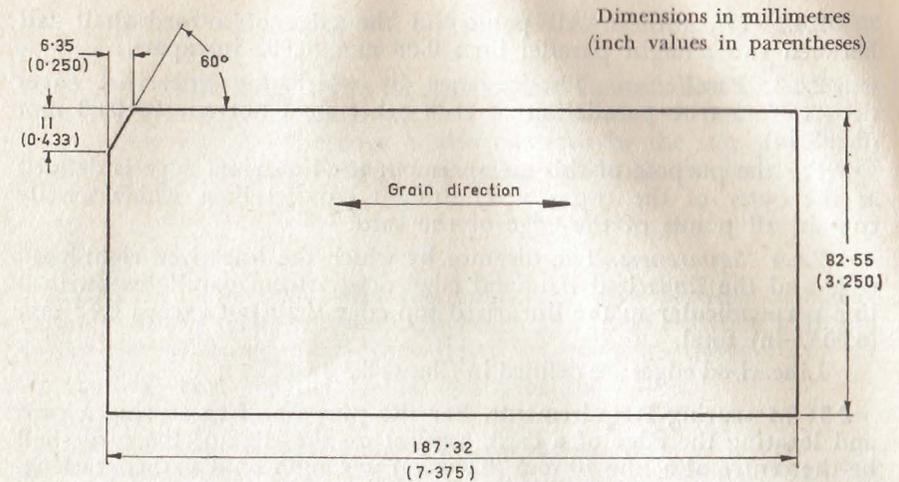


Fig. 1. NOMINAL DIMENSIONS

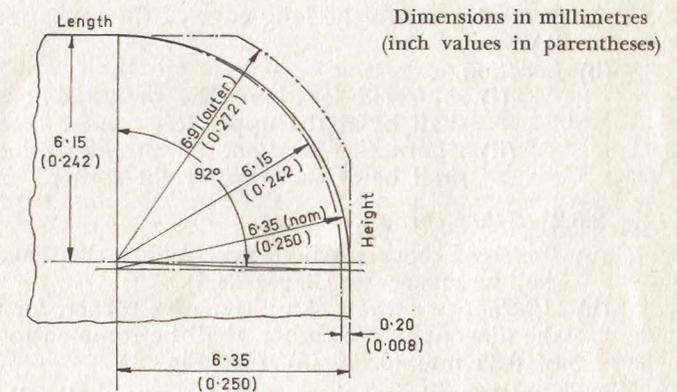


Fig. 2. ROUNDED CORNERS

2.4.2 *Straightness*. All points on the edge of a card shall fall between two straight parallel lines 0.08 mm (0.003 in) apart.

2.4.3 *Parallelism*. The distance by which the linearized edges depart from true parallelism to each other shall not exceed 0.08 mm (0.003 in).

For the purpose of this measurement the linearized edge is defined as the outer of the two closest, straight parallel lines which wholly contain all points of the edge of the card.

2.4.4 *Squareness*. The distance by which the linearized right-hand edge and the linearized left-hand edge depart from parallelism with a line perpendicular to the linearized top edge shall not exceed 0.12 mm (0.0047 in) total.

Linearized edges are defined in Clause 2.4.3.

2.5 *Measuring Requirements*. For the purpose of measuring a card and locating the edge of a card, a point on the edge of the card shall be the centre of a line 10 mm (0.375 in) in length on a flat, contacting, metal surface at least 10 mm (0.375 in) long which is being pressed against the edge of the card with a force of approximately 50 mN per millimetre of its length in contact with the card*.

NOTE: The method of measuring physical dimensions is not specified in this standard. However, any measurement of physical dimensions is made by using the appropriate apparatus that can measure adequately the physical dimensions within the specified tolerances.

2.6 Corners.

2.6.1 Diagonal corner cut.

(a) *Dimensions*. The corner cut shall remove 6.35 ± 0.4 mm (0.250 \pm 0.016 in) from the long edge and 11 ± 0.4 mm (0.433 \pm 0.016 in) from the short edge of the card (at a reference angle of 60 degrees to the long edge of the card). (See also Appendix B.)

(b) *Location*.

(i) *Preferred location*. The preferred location for the cut shall be at the upper left corner. (See Fig. 1.)

(ii) *Alternative location*. An alternative location for the cut shall be at the upper right corner.

2.6.2 Other corners.

(a) *Preferred corners*. All corners, except the diagonally cut corner, shall be square (see Clause 2.4.4).

(b) *Alternative corners*. An alternative corner, for all corners except the diagonally cut corner, shall be rounded to a nominal radius of 6.35 mm (0.250 in). (See Fig. 2.)

The edge of the rounded corner shall fall between two concentric arcs. The centre of the arcs is located 6.15 mm (0.242 in)

* In common practice, this value is equivalent to 5 gf/mm.

from the long edge and 6.35 mm (0.250 in) from the short edge of the card.

The inner arc is 92 degrees and has a radius of 6.15 mm (0.242 in); the outer arc has a radius of 6.91 mm (0.272 in) (see Fig. 2). The edge is also bounded by the line parallel to the top linearized edge and passing through the lower end of the 92 degrees arc.

2.7 Curl.

2.7.1 *Requirements*. The maximum curl of cards, when at equilibrium with any relative humidity between 20 and 75 per cent, shall not exceed the following values when tested according to Clause 2.7.2:

Axis of curl parallel to the grain of the paper	3.04 mm (0.12 in)
Axis of curl at right angles to the grain of the paper	6.35 mm (0.25 in)
Axis of curl diagonal to the grain of the paper	6.35 mm (0.25 in)

2.7.2 *Measuring procedure*. This test shall be performed at 20 ± 2 per cent relative humidity and 75 ± 2 per cent relative humidity. In each case, the temperature shall be maintained at $23 \pm 2^\circ\text{C}$ ($73 \pm 3.5^\circ\text{F}$).

A deck of ten cards shall be laid on a smooth, horizontal surface with the wire side of the paper up.

A similar deck shall be laid on a smooth, horizontal surface with the felt side of the paper up.

After 24 hours, the cards shall be examined and, if necessary, the deck shall be turned so that the concave side of the deck is up. A straightedge, weighing 2.5 ± 0.1 g, shall be placed across the two high points of the deck of cards. The amount of curl is then measured from the bottom of the straight edge to the low point of the top card of the deck. The test shall be preferably performed with separate decks at 20 per cent and at 75 per cent relative humidity, though the deck used at 20 per cent relative humidity may later be used at 75 per cent relative humidity. The cards tested at 75 per cent relative humidity may not, however, later be tested at 20 per cent relative humidity.

2.8 *Characteristics of Pre-printing*. If printing is required, it shall be legible without excess ink, and cause no embossment or distortion of the card. The ink shall be non-abrasive, non-conductive and non-blocking when dry, and shall not transfer to feed rolls, contact rolls, or brushes of data processing machines, and shall not change the physical properties of the cards so that they fall outside the specified limits.

3 PAPER REQUIREMENTS.

3.1 **Furnish.** The paper shall be 100 per cent chemical pulp; no ground wood is allowed.

3.2 **Substance.** The paper shall have a mass of $161 \text{ g/m}^2 \pm 5$ per cent ($99 \text{ lb} \pm 5$ per cent per ream of five hundred $24 \text{ in} \times 36 \text{ in}$ sheets).

Mass shall be determined by the method given in Appendix C.

3.3 **Thickness.** The thickness shall be $0.178 \pm 0.01 \text{ mm}$ ($0.0070 \pm 0.0004 \text{ in}$).

Thickness shall be determined by the method given in Appendix D.

3.4 **Bursting Strength.** The minimum bursting strength shall be 390 kPa^* (55 lbf/in^2).

3.5 **Stiffness.** The minimum stiffness in the machine direction parallel to the grain shall be $16 \times 10^{-4} \text{ N.m}^\dagger$ and in the cross direction shall be $7.8 \times 10^{-4} \text{ N.m}^\dagger$.

3.6 **Retention of Folding Endurance after Accelerated Ageing.** After accelerated (heat) ageing for 72 hours at 105°C , the folding endurance retention in the direction parallel to the grain shall not be less than 25 per cent of the original average folding endurance and never less than 25 double folds.

3.7 **Internal Tearing Resistance.** The minimum resistance to tear in each direction shall be 1.225 N^\ddagger .

3.8 **Ash.** The ash content shall not exceed 2 per cent.

3.9 **pH Value.** The pH value of the card stock obtained by the hot extraction method shall be not less than 5.0 and not greater than 7.5.

3.10 Frictional Characteristics.

3.10.1 *Static coefficient of friction.* The static coefficient of friction shall be between 0.30 and 0.45.

3.10.2 *Kinetic coefficient of friction.* The kinetic coefficient of friction shall not be less than 75 per cent of the static coefficient of friction.

3.10.3 *Test instrument.* The instrument for performing the test shall consist of—

- a smooth, level, metal plate to support the cards, dimensions $76 \text{ mm} \times 76 \text{ mm}$ ($3 \text{ in} \times 3 \text{ in}$), mass 1000 g;
- a 1000 g capacity Chatillon push-pull gauge calibrated for horizontal use;
- a motor-driven mount for the gauge which can advance the gauge horizontally and steadily at the rate of 90 cm/min (3 ft/min).

* In common practice, this value is equivalent to 3.9 kgf/cm^2 .

† In common practice, these values are equivalent to 17 gf/cm and 8.0 gf/cm .

‡ In common practice, this value is equivalent to 125 gf .

The bottom of the weight shall have a smooth, clean, rubber surface.

3.10.4 *Test procedure.* In performing the test, eleven properly conditioned $187.32 \text{ mm} \times 82.55 \text{ mm}$ ($7.375 \text{ in} \times 3.250 \text{ in}$) cards, which have been handled by their edges only, shall be laid flat on the metal plate with the left end of the cards against a stop.

The top card shall be advanced to the right about 50 mm (2 in) and the weight placed on the cards, near the right end, so that it is supported by all cards. The gauge shall then be advanced toward the left so that it pushes against the weight in the direction of the long axis of the card. A reading shall be taken when the weight and the top card begin to move. This reading, in grams, divided by 1000, is the static coefficient of friction.

Ten successive readings shall be taken by sequentially placing the top card on the bottom of the deck and repeating the procedure. If, as the movement of the weight and top card continues, there is a change in the reading, the new reading, in grams, divided by 1000, is the kinetic coefficient of friction.

3.11 Expansion and Contraction.

3.11.1 *Requirements.* Maximum expansion and contraction with 20 per cent to 75 per cent and 75 per cent to 20 per cent changes in relative humidity shall be as follows:

Parallel to the grain:	0.25 per cent
At right angles to the grain:	0.70 per cent

3.11.2 *Test procedure.* Expansion and contraction tests shall be made by exposing cards sequentially to 20 per cent, 75 per cent and 20 per cent relative humidity at 23°C . Tolerances for humidity and temperature control are ± 2 per cent and $\pm 2^\circ\text{C}$ respectively.

The cards shall be allowed to remain fully exposed for at least 2 hours at each humidity. At the end of 2 hours, the cards shall be measured with a precision of 0.01 mm (0.0005 in), to check their conformity to the specified tolerances.

3.11.3 *Calculations.* The percentage expansion shall be calculated from the difference between the original measurement at 20 per cent relative humidity and the final measurement at 75 per cent relative humidity.

The percentage contraction shall be calculated from the difference between the measurement at 75 per cent relative humidity and the final measurement at 20 per cent. If the relative humidity, as measured with a wet and dry bulb psychrometer, is not exactly 20 per cent and 75 per cent but within the specified tolerances, corrections shall be applied assuming a straight line relationship between relative humidity and card dimensions.

3.12 Smoothness (Roughness). The roughness on either side of the paper shall not be greater than 125 Sheffield Units or less than 30 Sheffield Units, and the ratio of the smoothness one side to the other shall not exceed 1.3 : 1.

3.13 Abrasion Loss. The loss of mass from each side of the paper shall not exceed 50 mg.

The card stock shall be tested by the method of TAPPI, T476m: Procedure 1, Dry Abrasion, except that the turntable of the instrument shall make exactly 100 revolutions.

3.14 Electrical Resistance and Conductivity.

3.14.1 Requirement. The electrical resistance of a card, determined under the conditions and the method of measurement described below, shall be between 30 and 200 megohms.

3.14.2 Conditioning. The measurements shall be made at 23°C (73°F) and 50 per cent relative humidity.

3.14.3 Apparatus.

(a) **Contact plates.** The lower plate, which rests on a rubber sheet, shall have a length of at least 190 mm (7.385 in) and a width of at least 85 mm (3.257 in).

The upper plate shall be a rectangle of 178 mm × 76 mm (7 in × 3 in). Its thickness shall be about 10 mm (0.375 in). A supplementary weight is added, if necessary, to bring the total mass to 3400 g (7.5 lb).

(b) **Measuring apparatus.** The measuring apparatus is a voltmeter of about 100-megohm internal resistance.

(c) **Current source.** The current source is provided by a 45 V battery.

3.14.4 Test Procedure. The card shall be inserted between the two plates lying horizontally. It shall be centred between edges of the contact plates so that the card surface to be measured is equal to that of the upper plate.

The current source, the voltmeter, the contact plates, and the card shall be connected in series.

The reading on the voltmeter dial shall be converted to megohms by the formula:

$$R = \frac{(E - V)M}{V}$$

where

R = card resistance, in megohms

E = source voltage, in volts

V = reading of the voltmeter, in volts

M = internal resistance of the voltmeter, expressed in megohms.

3.15 Moisture Content. The moisture content of the card stock shall be 6 ± 1 per cent.

3.16 Air Permeability. The air permeability shall be not less than 60 nor greater than 200 ml/min when tested by the method of BS 2925.

3.17 Optical Properties. The light transmitted through any part of a card shall not exceed 3 per cent of the light transmitted through the ambient air with no card present.

The method of test shall be by the application of a light to the card in the form of a perpendicular beam 1.6 mm in diameter from a tungsten filament lamp suitably positioned from the card and with controlled power supply to maintain a filament temperature of 2870 K. The light transmitted through the card shall be measured by a vacuum photocell 50 mm from the surface of the card and having a caesium oxide/silver cathode of peak response in the range of 800 to 900 nm. The operations shall be carried out in favourable ambient lighting conditions and with appropriate shielding of the photocell.

3.18 Sizing Degree. When tested in accordance with the following procedure, the card shall be dry to the touch within 10 seconds of having been written upon and the lines and intersections shall be clear cut and legible, without excessive feathering, spreading or penetration through the card:

The symmetrical pattern (Fig. 3) shall be drawn on both sides of a clean, unhandled sample of the card stock, using a ruling pen and suitable ink. A suitable ink can be prepared by dissolving 5 grams per litre of both CI 7180 (phthalocyanine) and CI 42025 (triphenylmethane) in distilled water at a temperature not exceeding 80°C, and as an antiseptic 1 gram per litre of phenol is added. The ruling pen with a blade gap of 0.6 mm (0.025 in) and filled to a height of 10.00 mm (0.4 in) at the beginning of each set of three lines shall be drawn across the paper under its own weight, parallel to its blades and at an angle of 45 degrees to the paper. Patterns on opposite sides of the sample shall not overlap and each set of three lines must be dry before the intersecting set is drawn.

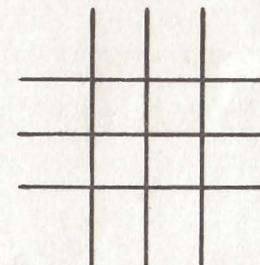


Fig. 3. PATTERN FOR SIZING TEST

4 TESTING.

4.1 Methods. Except where otherwise specified test methods shall be those specified in Australian Standard P1, Methods of Test for Pulp and Paper. Where no method of test is given in AS P1, a suitable test shall be chosen by agreement between manufacturer and purchaser.

4.2 Conditions. Unless otherwise specified, tests for physical requirements shall be performed on cards conditioned at 50 ± 2 per cent relative humidity and $23 \pm 2^\circ\text{C}$ ($73 \pm 3.5^\circ\text{F}$).

The paper shall be brought into equilibrium from a drier state.

APPENDIX A

STORAGE AND USE OF PAPER CARDS

INTRODUCTION. Cards should be stored and used under the following conditions:

- (a) *Storage**: Relative humidity between 30 and 65 per cent; temperature between 5 and 50°C (41 and 122°F).
- (b) *Use**: Relative humidity 50 ± 10 per cent; normal temperature of use between 18 and 24°C (65 and 75°F).

Recommendations are classified under the three following sections:

A1. Climatic conditions:

A1.1 Importance of climate for cards

A1.2 Ambient conditions for working and storage areas

A1.3 Acclimatization of cards.

A2. Storage procedures.

A3. Card handling.

It is strongly recommended that the procedures listed below should be followed.

A1 CLIMATE CONDITIONS.

A1.1 Importance of Climate for Cards. Without proper precautions cards will be affected by heat, cold and, most significantly, by humidity. Variations in the humidity will alter the card's size and weight by changing its moisture content, and may cause warping, the most frequency source of card trouble in data processing installations.

More precise indications of the affects of humidity are as follows:

- (a) *Dimensions.* When humidity is high, moisture is absorbed by cards, usually causing them to swell in length, width and thickness. When humidity is low, cards lose moisture and shrink in all dimensions. For example, a variation of relative humidity from 20 to 75 per cent or from 75 to 20 per cent may cause variations of card dimensions up to 0.45 mm (0.018 in) in length and 0.58 mm (0.023 in) in width.

A new card does not return to its original dimensions when brought back to the initial conditions of measurement after exposure to a wide variation or a high level of relative humidity. For example, a card exposed to a relative humidity higher than 70 per cent may become permanently deformed, causing the card to be out of tolerance. It is therefore recommended to maintain relative humidity below 65 per cent for storage.

* It must be stressed that the relative humidity and the temperature values given above apply only to the storage and the use areas. They have no influence on the values required for conditioning and tests given in Clause 4.

- (b) *Warp*. A card exposed to a relative humidity beyond the extremes of 40 to 60 per cent may become temporarily, or even permanently, warped; it has a tendency to warp, in particular, when the relative humidity is low. Even when keeping it within these limits, an abrupt change in relative humidity may cause a temporary warp. In this case, the stresses that cause warp will usually disappear as soon as the card has reached a moisture balance with its new surroundings.

NOTE: Inherent warp on cards may be found, but very rarely; it cannot be corrected and is even increased when the cards have been exposed to extreme humidity levels. However, when the recommended ambient conditions for the storage and use have been complied with, the dimensional changes and the distortion of cards at their time of use are comparatively minor.

A1.2 Ambient Conditions for Storage and Working Areas. From what has been stated above, it results that—

- (a) The relative humidity levels and the temperatures of working and storage areas must be taken into account; it is recommended that they should be recorded.
- (b) It would be desirable that the relative humidity to which cards are exposed be maintained constant; abrupt changes are particularly to be avoided.

In fact, it is possible to maintain to the desirable levels the humidity of almost every working area, except perhaps when the outside temperature is extreme or the humidity very high; great care must be exercised in regulating thermostats and hygrometers.

- (c) In winter, a favourable relative humidity in the machine room is more easily maintained at lower temperatures. Continuous high heat dries the air and may cause a drop in recommended humidity levels.
- (d) In summer, an excessive relative humidity may be reduced by the use of de-humidifiers.

It must be pointed out, however, that there are often very great variations in the atmosphere of one room, particularly near pipes, radiators, or open windows, and cards should not be stored near any of these. Care must be exercised in opening and closing windows. The cards should not be placed directly on the floor, particularly if the floor is other than a wooden one, or against a wall, as local conditions of cold and high humidity often occur at such a point. The method of heating is immaterial provided that systems are not used which put noxious fumes and water vapour into the air.

The following points should be taken into account:

- (i) Moving cards from the storage area to the working area may cause warp especially if there is a sharp difference in relative humidity and cards are not protected during transportation.
- (ii) Cards transferred from a cold room to a warm room may collect moisture in much the same way as the outside of a glass of iced water.

A1.3 Acclimatization of Cards. Even when the recommendations concerning the storage have been observed, cards should be given ample time to achieve a moisture balance with the machine room atmosphere, in order to perform properly.

This time depends primarily on the difference between the relative humidity of the machine room and the cards, on the manner in which cards are packed (in full cartons, in open-trays, etc) and the extent of air circulation around them (open or closed cartons, etc).

Although there are no precise data, the following values may give an approximation of this time:

- (a) Card alone: 2 hours
- (b) Cards in opened cartons:
 - for a difference in relative humidity of ± 10 per cent: 1 day
 - for a difference in relative humidity of ± 20 per cent: 10 days
 - for a difference in relative humidity of ± 30 per cent or greater: 15 days

In all circumstances, a carton of cards should not be opened before equilibrium of temperature is reached with the working area. Where space permits, storage facilities should be set up in the working area for a five to ten day supply.

A2 STORAGE PROCEDURES. Cartons protect the characteristics of cards. To a certain extent, they reduce edge damage and slow down the exchange of humidity with the outside.

Therefore, for storage, it is advisable—

- (a) to keep cards in their original cartons or special drawers, until used;
- (b) that the cartons be squarely supported at the bottom to prevent any tendency for the weight to distort the cartons;
- (c) not to put weights on top of the cartons.

If half-full cartons were stacked, cards could actually be distorted. It is possible, however, to put incompletely filled cartons on top of a stack, cards lying then on their faces.

While cards properly stored have a very long and trouble-free life, it is nevertheless recommended, in the best interests of the user, that not more than a few month's supply should be stored by the customer and that cards should be used in rotation, old stock being consumed before newer supplies are opened.

A3 CARD HANDLING. For the purpose of card processing, it is recommended that the cards be fanned lightly before passing them through machines.

Cards should be flat for machine feeding; if they exhibit slight distortion, the machine operator can generally eliminate it by gently manipulating the cards.

APPENDIX B OTHER CORNER CUTS

Corner cuts, different from the standardized one and currently used on other card equipments, are given below:

- (a) Long edge: 4 ± 0.5 mm (0.157 ± 0.020 in)
 Short edge: 9 ± 0.5 mm (0.354 ± 0.020 in)
- (b) Both edges: $6.35 \begin{smallmatrix} +0 \\ -1.5 \end{smallmatrix}$ mm ($0.250 \begin{smallmatrix} +0 \\ -0.060 \end{smallmatrix}$ in)
- (c) Both edges: $7.0 \begin{smallmatrix} +0 \\ -0.9 \end{smallmatrix}$ mm ($0.275 \begin{smallmatrix} +0 \\ -0.035 \end{smallmatrix}$ in)

making an angle of $45 \pm 2^\circ$.

APPENDIX C DETERMINATION OF PAPER SUBSTANCE

C1 DEFINITION. *Substance* is the mass of paper, expressed in grams per square metre, determined under standard test conditions.

C2 PRINCIPLE. The area of the test pieces and their mass are measured and the mass per square metre is calculated, all measurements being made on conditioned test pieces.

C3 APPARATUS.

C3.1 Cutting Device. The cutting device should normally be capable of repeatedly cutting out test pieces whose area, in at least 95 cases out of 100, falls to the nearest 1 per cent of a known area. This should be checked frequently by the method given in Paragraph C3.3.1 below and, provided that the above accuracy is attained, the mean area obtained in these check tests should be used for calculating substance.

With certain types of paper it will be found, after carrying out this determination of area, that test pieces cannot be cut with the accuracy just defined and, in such cases, the area of every test piece should be determined individually (see Paragraph C3.3).

C3.2 Weighing Device. The weighing device should be accurate enough, over the range of mass for which it is used, to measure always to the nearest 0.5 per cent of the actual mass. It should be sensitive enough to detect a change of ± 0.2 per cent of the mass to be weighed; if the device is of the direct-reading type it should be graduated so that readings may be taken to this degree of accuracy. For checking of the weighing device, see Paragraph C3.3.2.

Special sheet-weighing devices, designed to weigh test pieces of a given size and indicating substance in grams per square metre, may be used, provided that the above conditions are fulfilled and that the area of each test piece in a single weighing is not less than 500 cm² (see Paragraphs C6 and C7 (b)).

When in use, the weighing device should be shielded from air currents.

C3.3 Calibration of Apparatus.

C3.3.1 Checking of cutting device. The area cut should be checked frequently by measuring 20 test pieces and calculating their areas (see Paragraph C6 (b)). The cutting accuracy specified in Paragraph C3.1 is attained when the standard deviation of the individual areas is below 0.5 per cent of the mean area, in which case this mean area should be used for calculating substance in subsequent tests. If the standard deviation exceeds this value, the area of every test piece should be determined individually.

C3.3.2 Checking of weighing device. The weighing device should be checked frequently by applying accurately measured masses with both increasing and decreasing loads.

C4 SAMPLING. Samples shall be taken at random from a representative number of units, e.g. reels, bales, bundles, cases, reams, etc. The number of specimens taken shall be at least five and their combined area should be sufficient for at least twenty test pieces.

C5 CONDITIONING. The test pieces should be conditioned in accordance with the requirements of Clause 4.2.

C6 PROCEDURE.

- At least 20 test pieces in all are taken from at least five conditioned specimens, if possible the same number from each specimen, each test piece having an area of not less than 500 cm².
- The area of a test piece is determined by calculation from measurements taken to the nearest 0.5 mm.
- If the cutting device does not satisfy the accuracy requirements of C3.1, the dimensions of each test piece should be measured.
- Weigh each test piece.

C7 CALCULATION. The results are expressed in grams per square metre to three significant figures.

- Using the procedure in Paragraph C6, the substance of each test piece is calculated according to the following formula:

$$X = \frac{m}{A} \times 10\,000$$

where

X = substance, in grams per square metre
 m = mass of the test piece, in grams
 A = area of the test piece, in square centimetres.

- If a specified sheet-weighing device as described in Paragraph C3.2 is used, then the substance is given by the following formula:

$$X = \frac{A'}{A} \times X'$$

where

X = substance, in grams per square metre
 X' = indicated substance of the test piece, in grams per square metre
 A' = area of test piece for which the device is calibrated, in square centimetres
 A = area of weighed test piece, in square centimetres.

- Calculate the mean of the results.

APPENDIX D

DETERMINATION OF THE THICKNESS OF SINGLE SHEETS OF PAPER

D1 GENERAL. The method is based on the use of a precision dial micrometer to measure the thickness of a single sheet when a static load is applied. The method is suitable for measuring the thickness of single sheets of paper up to a substance of 250 g/m².

D2 EQUIPMENT.

D2.1 Precision Dial Micrometer. This instrument is provided with two parallel plane faces between which the paper can be placed for measurement. One of the faces should be capable of movement in a direction perpendicular to the other, which is fixed. The movable face or pressure foot should be circular. The fixed face or anvil should also be circular and of such size that the whole area of the pressure foot is in contact with the anvil in the zero position.

To ensure that the pressure between the faces is uniform within the limits given, the use of a dead weight rather than a spring is preferred.

The instrument should conform to the requirements of Table D1.

TABLE D1
MICROMETER CHARACTERISTICS

Characteristics	Metric system	Inch system
Diameter of pressure foot	16 ± 0.5 mm	0.63 ± 0.02 in
Area of pressure foot	200 mm ² (nominal value)	0.31 in ² (nominal value)
Pressure exerted by pressure foot	100 ± 10 kPa (1.00 ± 0.10 kgf/cm ²)	14.2 ± 1.5 lbf/in ²
Repeatability of measurement (standard deviation)	≤ 0.002 5 mm or 0.5%	≤ 0.000 1 in or 0.5%
Indication error	± 0.002 5 mm or 0.5%	± 0.000 1 in or 0.5%
Error of parallelism of pressure foot and anvil	≤ 0.005 0 mm or 1%	≤ 0.000 2 in or 1%

D2.2 Calibration. The instrument should be calibrated at reasonable intervals. For instruments in frequent use, it is suggested that the calibration be checked daily for repeatability and accuracy, and monthly for parallelism and foot pressure.

D3 SAMPLING. Not less than twenty test pieces each having a size of 6 cm × 6 cm or larger should be cut from specimens taken at random

and conditioned as in Appendix C. Not more than one test piece should be cut from any one specimen.

D4 TEST PROCEDURE. The tests should be made in the standard test atmosphere stated in Clause 4.2. The test piece should be placed between the jaws of the micrometer. The pressure foot should then be lowered slowly* and very carefully onto the test piece so that all punching effect is avoided; also no stress should be imposed on the instrument or the test piece by the hand, when a reading is being taken and the instrument should not be subjected to any vibration. The reading should be taken when the pointer has ceased to move†.

Make one measurement on each of the test pieces taken. This measurement is made 2 cm or more from any side of the test piece.

D5 RESULTS. Calculate the mean of the twenty (or more) readings: the value obtained is the average thickness of a single sheet.

* Speed of about 1 to 3 mm/s.

† This will usually be in about 2 to 5 seconds.

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