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Indian Standard

METHODS OF PHYSICAL TESTING OF LEATHER

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NEW DELHI 110002

July 1971
[Page 13, clause 7.1 (c)] - Add the following new notes after 7.1 (c):

'NOTE 1 - No single value shall be outside the specified limits where range is stipulated.

NOTE 2 - No single value shall be below or above the specified value where minimum or maximum value is specified.'

(CDC 16)

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Indian Standard

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Indian Standard

METHODS OF PHYSICAL TESTING OF LEATHER

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 7 January 1970, after the draft finalized by the Leather Sectional Committee had been approved by the Chemical Division Council.

0.2 This standard is the amalgamated revision of all physical methods of test specified in IS: 582-1954* and IS: 1016-1960†. These methods of test were originally based on B.S. 1309 : 1956 Methods of sampling and analysis of vegetable tanned and chrome tanned leathers. British Standards Institute, and 'Official methods of sampling and test' adopted by the Society of Leather Trades' Chemists (SLTC) (1954). Since then, both BSI and SLTC have revised their methods of test. The International Union of Leather Chemists' Society which came into existence in the meantime has from time to time published a number of standards on testing of leather. So far, they have evolved 20 methods of test of which 17 have been adopted by the SLTC. All such methods have been fully adopted in this standard. The technical committee, set up in 1966 under the auspices of International Organization for Standardization, namely, ISO/TC 120 Leather, has in principle decided to base all its standards on methods of test published by SLTC and IULCS. India being a 'P' member of ISO/TC 120 has the necessary obligation to adopt these methods of test as far as practicable. Alignment of this standard with well established methods would also facilitate international trade in the field of leather in which India occupies a unique position. Besides these, certain methods of test have also been adopted from American Society for Testing and Materials, USA standard methods, such as the double hole stitch tear resistance test, measurement of area, width and thickness of leather units.

0.3 The Committee while prescribing the Kubelka method for water absorption which is presently being recommended in IUP methods felt that a number of standards have been formulated prescribing gravimetric method. It, therefore, decided to continue for sometime the gravimetric method as prescribed in LP : 11 and to amend immediately all material specifications prescribing Kubelka method so that gravimetric method could be withdrawn in due course.

---

*Methods of sampling and test for vegetable and chrome tanned leathers.
†Methods of sampling and test for oil tanned leathers.
0.4 At present facilities may not exist for carrying out all the tests specified in this standard by the quality control and testing laboratories in this country. The committee took note of this fact but decided that it should proceed with the publication of this standard aligning it with the methods of tests of SLTC and IULCS hoping that leather laboratories in this country would progressively equip themselves with the necessary testing instruments. The instruments prescribed in this standard are simple enough to be either fabricated in this country or could be procured easily.

0.5 In the formulation of this standard, assistance has been drawn from the following publications:

- B.S. 1309 : 1956 Methods of sampling and analysis of vegetable tanned and chrome tanned leathers. British Standards Institution.
- ALCA Methods of analysis. 1957. American Leather Chemists Association, USA.

0.6 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

---

*Rules for rounding off numerical values (revised).
1. SCOPE

1.1 This standard prescribes the methods for carrying out physical tests for all types of leathers.

1.2 Should any inconsistency exist between the methods of test in this standard with those of the methods prescribed in the material specifications, the latter shall prevail.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 1640-1960* shall apply.

NOTE — Additional terms not covered in IS : 1640-1960* relating to methods of test have been covered in individual test methods.

3. SAMPLING LOCATION

3.1 Unless otherwise specified, the test piece shall be taken from the designated location in accordance with 3.2.1 of IS : 5868-1969†.

3.2 For all physical tests half of the test pieces are to be taken along the backbone and the other half along the direction parallel to the backbone. In cases where the exact directions are not known half of the test pieces shall be taken in one direction and the other half at right angles to the initial directions.

4. PRESS KNIVES

4.1 To obtain cleanly cut test pieces for physical tests, the press knives used should be sharp. It is advantageous to place a thick sheet of paper between the sample and the cutting board. Unless otherwise stated, the internal surface of all press knives shall be normal to the plane which contains the cutting edge. The angle formed at the cutting edge between the internal and external surfaces of the press knives shall be approximately 20° and the wedge of this angle shall be of a depth exceeding the thickness of the leather. In cutting the samples, the knives shall be applied to the grain surface.

*Glossary of terms relating to hide, skin and leather.
†Methods of sampling for leather.
5. CONDITIONING

5.1 During 48 hours immediately preceding its use in a test, keep each test piece for physical testing at a standard atmospheric temperature of 27 ± 2°C and relative humidity 65 ± 2 percent (see IS : 196-1966*). Support the test piece so that air has free access to its surface and keep the air in continuous rapid motion by a fan suitably placed. Perform all physical tests in the same standard atmosphere unless otherwise specified.

NOTE 1 — Results not very different from those obtained by testing in the standard atmosphere may be usually obtained by conditioning the test pieces in the standard atmosphere and removing them one at a time for test. This procedure, however, is known to be unsatisfactory for abrasion test and may be unsuitable for some other tests as well.

NOTE 2 — The required relative humidity of 65 ± 2 percent at 27 ± 2°C may be maintained in a closed space either by the use of saturated solutions of certain salts and water (in which the solid phase is also present in excess) or by the use of a solution of given concentration of sulphuric acid and water. The selected solution should be placed in a large shallow dish inside the enclosure. Saturated solutions of either pure ammonium nitrate or pure sodium nitrate are satisfactory. Creeping of the solid phase is made negligible by the use of dishes thinly coated on their inside walls with paraffin wax. If sulphuric acid is used, it is necessary to check up its relative density from time to time and to restore it to the value required by appropriate conditions of either water or more concentrated sulphuric acid. Continuous circulation of air is essential.

6. TESTS

6.1 Unless otherwise agreed to between the purchaser and the supplier, normally, tests should be carried out within two months from the date of receipt of the material by the purchaser.

NOTE 1 — It may be necessary in certain cases to carry out tests immediately after receipt of the material.

NOTE 2 — Care should be taken to store the material in a dark cool place before testing.

*Atmospheric conditions for testing (revised).
METHOD FOR MEASUREMENT OF THICKNESS OF TEST PIECES

(LP : 1)

(This method supersedes the method given in 20 of IS : 582-1954* and is based on the method given in IUP/4†.)

1. SCOPE

1.1 This method prescribes the procedure for the measurement of thickness of leather test pieces in which the dimensions of the test pieces are used directly in determining the results of test or analysis.

2. TERMINOLOGY

2.0 For the purpose of this method, the following definition shall apply.

2.1 Thickness — Thickness of leather measured with the help of a presser foot, exerting a pressure of 500 ± 5 g/cm².

3. PRINCIPLE OF METHOD

3.1 Thickness of leather is measured with the help of a dial micrometer type of gauge whose presser foot is flat and exerts a pressure of 500 ± 2 g/cm² on the leather placed on a firm base: This method is used where precise dimensions are necessary for calculation of properties expressed in physical units. It is not intended to replace practical thickness measurements based on commercial portable tools, nor it is implied that thickness measurements made by the two procedures will agree exactly. In routine testing, spring load type of measuring devices are frequently used. Their readings, however, are liable to change with time due to constant use and it may, therefore, be necessary to calibrate them periodically by comparing their readings with those of a standard gauge prescribed in this method.

4. APPARATUS

4.1 Dial Micrometer Gauge — The instrument shall be a dial micrometer standing on a firm base. It shall be dead weight loaded and the load applied shall be 393 ± 10 g (equivalent of 500 g/cm²). The presser foot shall be flat, circular of a diameter 10.00 mm and its direction of movement shall be normal to the face of the anvil. The anvil shall be flat, horizontal surface of a cylinder of 10.00 mm, which shall be projected 3 mm from the surface of a flat circular platform of diameter 5 cm. The axes of the presser foot, the platform and the projecting anvil shall coincide and shall be the same as the direction of the movement of the foot.

*Methods of sampling and test for vegetable and chrome tanned leather.
The faces of the foot and anvil shall be parallel for all positions of the foot, the error not exceeding 0.005 mm.

The dial gauge shall be graduated to read 0.01 mm directly. It shall have a dial of sufficiently large size so as to give an open scale and shall have a suitable pointer close to the scale to keep errors due to parallax to the minimum. The readings of the gauge shall be accurate to 0.01 mm all along the scale.

5. PROCEDURE

5.1 Place the test piece in the gauge with the grain side up, if this is known. Apply the load gently and take the readings after full load is reached. When the greatest possible accuracy is required, pre-condition the leather in accordance with 5 of LP : 0.

NOTE 1 — This method may be followed for accurate measurement of leather and leather articles like diaphragm leathers, gaskets, oil seals and cut components of footwear.

NOTE 2 — For all normal changes in humidity, the changes of thickness of most leathers are less than 3 percent. For many purposes, therefore, conditioning prior to testing is not necessary.

NOTE 3 — The circular platform of 50 mm diameter helps to support medium weight leathers which otherwise present a convex surface to the presser foot. The anvil is raised 3 mm above the platform so that serious errors are avoided in measurement of heavy leather which are not flat.

6. REPORT

6.1 Report the average of three readings in millimetres to an accuracy of 0.01 mm, unless otherwise specified in the particular method of test.

7. ACCURACY

7.1 The coefficient of variation of measurements of thickness of test pieces by this method is less than five percent.
1. SCOPE

1.1 This method prescribes the procedure for the measurement of thickness of all types of leather. It is not suitable for measuring the thickness of test pieces.

2. TERMINOLOGY

2.0 For the purpose of this method, the following definition shall apply.

2.1 Unit — A piece of leather in the form in which it is purchased, such as a single hide, side, skin or part thereof; or a single fabricated leather article in the form in which it is purchased, such as a counter, a pair of shoes or bucket washer.

3. PRINCIPLE OF METHOD

3.1 This method is intended for the routine measurement of the thickness of leather units as a means of production control and determining conformance of specifications. It utilizes a secondary type of gauge that is capable of rapid measurement. Their readings, however, are liable to change with time due to constant use and it is, therefore, necessary to calibrate them periodically.

4. APPARATUS

4.1 The apparatus shall be either spring-type gauge or standard wedge-type gauge.

4.1.1 Spring-Type Gauge — graduated in 0.1 mm, having a flat presser foot 10.2 ± 0.6 mm in diameter and a flat anvil 10.2 ± 0.6 mm in diameter. The spring shall exert a force of 450 g on the foot when the gauge reads 0.8 mm and 900 g when the gauge reads 4.8 mm.

4.1.2 Standard Wedge-Type Gauge — having one leg graduated in 0.1 mm, preferably constructed of stainless steel, in which the legs enclose an angle of about 4°.

5. TEST PIECE

5.1 The test piece for measurement shall be the full unit.
6. PROCEDURE

6.1 Light Leathers — Place the portion of the test piece to be measured between the anvil and presser foot of the spring-type gauge (4.1.1) in such a manner that the test piece is in contact with the whole area of the anvil. With the test piece held in this position, compress the thumb lever of the gauge so that the gauge reads approximately 6 mm. Allow the thumb to slide off the lever so that the gauge presser foot snaps upon the leather. Read the thickness to the nearest 0.1 mm. Measure the thickness at not less than five approximately equally spaced places along and approximately 150 mm from the backbone. Space the measurements from an initial point of measurement approximately 125 mm from the root of the tail and the final place of measurement, which shall extend no farther than 125 mm into the neck area.

NOTE — If the dimensions of the test pieces are such that the gauge will not reach from the edge to the point at which the thickness is desired, the test pieces may be folded upon itself with the flesh inside. Measure the thickness of the folded test pieces and take one half of this value as the thickness.

6.2 Sole and Heavy Leathers — Insert the cut edge of the test piece between the legs of a standard wedge-type gauge (4.1.2) so that the plane of the leather is perpendicular to the plane of the gauge and bisects the angle formed by the legs. Push the gauge over the edge of the leather to make firm contact with the leather so that the gauge stays in position when inverted but not cause any visible deformation of the test piece contacts the legs of the gauge. Measure the thickness as follows for different units.

6.2.1 Bellies — Measure the thickness of the test piece at 2 locations approximately 150 mm on either side of the backbone opposite to the centre of the main width of the belly.

6.2.2 Double Shoulders — Measure the thickness of the test piece at two places at the cut edge opposite the neck and 150 mm on each side of the backbone.

6.2.3 Single Shoulders — Measure the thickness of the test piece at one place on the cut edge opposite the neck and 150 mm remote from the backbone line.

6.2.4 Butts — Measure the thickness of the test piece on the cut edge at the shoulder end and 150 mm on each side of the backbone.

6.2.5 Bends — Measure the thickness of the test piece at 3 places along the backbone starting 300 mm from the root of the tail and at 150 mm interval from that point towards the shoulder end.
6.2.6 *Backs and Crops*—Measure the thickness of the test piece at 5 places along the backbone starting 350 mm from the root of the tail and 150 mm interval from that point.

NOTE—For all normal changes in humidity, the changes of thickness of most leathers are less than 3 percent. For routine purposes, therefore, conditioning prior to testing is not necessary.

7. REPORT

7.1 The report shall include the following:

a) Thickness of each unit, reported as the average value of the measurements taken;

b) Thickness of the sample unit from a lot (*see IS : 5868-1969*); and

c) Range of thickness measured.

8. ACCURACY

8.1 If the spring-type gauge has been adjusted to read the correct value and is of suitable construction, then the results will have only small errors (± 0.05 mm) when used to measure leather up to 5-mm thickness.

NOTE—Test the gauge periodically measuring with it the thickness of a rigid material that has also to be measured with a standard micrometer or with the instrument described in 3.1 of LP : 1. If the spring gauge gives a reading that is higher or lower than that of the micrometer-type instruments, adjust it to give the same reading. Readjustment may be necessary if leather to be measured is much thicker than 5 mm.

8.2 The wedge-type gauge gives readings reproducible to 0.25 mm when proper precautions are taken during positioning for uniform pressure and avoidance of edge effect. The thicker gauge (6.35 mm) gives more reproducible results than the tinner gauge (2.4 mm).

NOTE—The gauge should be frequently checked against deformation by using a stainless steel block graduated in thickness from 0.3 to 7.5 mm.

---

*Methods of sampling for leather.*
METHOD FOR MEASUREMENT OF WIDTH
(LP : 3)

(Adopted from ASTM Designation : D 1516-60)

1. SCOPE

1.1 This method is intended for use in measuring the width of physical test pieces and of regularly shaped units and pieces of all types of leather.

2. APPARATUS

2.1 Steel Scale — graduated in 0.5 mm.
2.2 Steel Tape— graduated in 1 mm.
2.3 Vernier Calipers

3. CONDITIONING OF TEST PIECE

3.1 Condition the test piece in accordance with 5 of LP : 0.

4. PROCEDURE

4.1 Measure the width according to either 4.1.1 or 4.1.2.

4.1.1 For Test Piece — Place the test piece on a flat surface and flatten it out without pulling or stretching. Measure the width by vernier calipers or with the steel scale to the nearest 0.5 mm at the locations designated in the method for making the particular test for which the test piece has been prepared.

4.1.2 For Regularly-Shaped Units and Pieces — Lay the piece on a flat surface and flatten as well as possible without pulling or stretching. Measure the width in at least three places equally spaced along the piece or unit with the scale specified in 2.1. Take the measurements to the nearest millimetres.

NOTE — The method may be suitably adopted for other linear measurements of test pieces and regularly shaped units and pieces.

5. REPORT

5.1 Report the width of the test piece used as prescribed in the method for making the particular physical test for which the test piece has been prepared.

5.2 Report the average of the width measurements taken on any regularly-shaped unit or piece to the same accuracy as observed on the original measurements as the width of the piece or unit.
METHOD FOR MEASUREMENT OF AREA

( LP : 4 )

( Adopted from ASTM Designation: D 1515-60 )

1. SCOPE

1.1 This method is intended for use in measuring the area of units of all types of leather.

1.1.1 It is unsuitable for measuring the area of pieces taken for physical testing.

2. APPARATUS

2.1 Graduated Sheet — sheet of transparent, flexible material, ruled in square centimetres. The sheet shall be large enough to cover the test piece ( see 3.1 ) completely.

3. TEST PIECE

3.1 The test piece shall be the full unit of leather conditioned in accordance with 5 of LP : 0. This may be in the form in which it is purchased, such as a single hide, side, skin or part thereof; or a single fabricated leather article in the form in which it is purchased, such as a counter or a gasket.

4. PROCEDURE

4.1 Spread the test piece out on a flat surface. Spread the graduated sheet smoothly over and in contact with it. Determine the area by counting the number of square centimetres required to cover the test piece. Estimate the area represented by parts of squares not completely over the test piece.

NOTE — Calibrated planimeter may also be used.

5. CALCULATION

5.1 Calculate the measured area of each unit to the nearest 0.25 dm$^2$.

6. REPORT

6.1 Report the total area of the leather in a lot as the sum of the areas of the individual units of leather.
METHOD FOR DETERMINATION OF APPARENT DENSITY

(LP : 5)

(This method given in LP : 5 supersedes that given in 19 of IS : 582-1954* and is adopted from IUP/5†.)

1. SCOPE

1.1 This method is intended for the determination of apparent density of leather of any type, for which it is possible to make an accurate measurement of thickness.

2. OUTLINE OF METHOD

2.1 A circular piece is cut from the leather; weighed and volume determined. Apparent density is calculated by dividing the mass of the test piece by its volume.

3. APPARATUS

3.1 Steel Press Knife—Steel press knife, inner wall of which shall be a right circular cylinder of diameter 70 mm.

4. TEST PIECES

4.1 Punch out test pieces (right circular) with the steel press knife from the sample location for physical tests in accordance with 3 of LP : 0 and condition them in accordance with 5.1 of LP : 0.

5. PROCEDURE

5.1 Measure the thickness of each test place in accordance with the method given in LP : 1, at three points forming the corners of an equilateral triangle and each situated approximately 2 cm from the centre of the grain surface of the test piece. Take the arithmetic mean of the three results as the thickness of the test piece. Measure the diameter of the test piece in two directions at right angles to one another on the flesh surface in accordance with the method given in 4.1.1 of LP : 3. Take the arithmetic mean of the four results so obtained as a diameter of the test piece. Weigh the test piece.

NOTE 1 — With compressible leather, the application of any load by the gauge used in measuring thickness may result in appreciable changes of thickness, and hence in apparent density.

*Methods of sampling and test for vegetable and chrome tanned leathers.
NOTE 2 — For certain purposes, it may be desirable to use a smaller load than that laid down in LP : 1. If this is done, the fact should be noted and the load used should be reported.

NOTE 3 — For test pieces cut from leathers of uneven thickness, it may be desirable to make more than three measurements of thickness.

6. CALCULATION

6.1 Calculate the apparent density of leather as follows:

\[
\text{Apparent density, g/cc} = \frac{W}{V}
\]

where

\[ W = \text{weight in g of the test piece, and} \]
\[ V = \text{volume of the test piece in cubic centimetres.} \]

6.1.1 The volume of the test piece shall be calculated from the following expression:

\[
V = \frac{\pi d^2}{4} \times t
\]

where

\[ d = \text{diameter of the (right circular cylinder) test piece in cm, and} \]
\[ t = \text{thickness of the test piece in cm.} \]

NOTE — The calculation is based on the assumption that the test piece is a right circular cylinder having a diameter and height.
METHODS FOR DETERMINATION OF TENSILE STRENGTH, MODULUS ELONGATION AT SPECIFIED LOAD AND ELONGATION AT BREAK

(LP: 6)

(These methods supersede those given in 23 of IS : 582-1954* and are partly based on IUP/6†.)

1. SCOPE

1.1 The methods are intended for the determination of tensile strength, temporary and permanent elongation at specified load, modulus and elongation at break of leathers of all types.

2. TERMINOLOGY

2.0 For the purpose of the methods of test given in LP : 6, the following shall apply.

2.0.1 Tensile Strength — The force per unit of the original cross-sectional area of the unstretched test piece which is applied at the time of rupture of the test piece. It is calculated by dividing the breaking force in kilograms-force by the cross-section of the unstretched test piece in square centimetres.

2.0.2 Elongation — The extension between bench marks produced by a tension force applied to a test piece. It is expressed by a percentage of the original distance between the marks on the unstretched test piece.

2.0.3 Elongation at Specified Load — The extension between bench marks produced by a specified tension force applied to a test piece. It is calculated by taking the difference between the original length and the length at the specified load, expressed as a percentage of the original length.

2.0.4 Elongation at Break — The extension between bench marks produced by a tension force applied to a test piece, at the time of its rupture. It is calculated by taking the difference between the original length and the length at the time of rupture under the tension force, expressed as a percentage of the original length.

2.0.5 Modulus — The tensile stress required to stretch the test piece from the unstained condition to a fixed elongation.

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*Methods of sampling and test for vegetable and chrome tanned leathers.
3. APPARATUS

3.1 Tensile Tester — A tensile strength testing machine having a uniform speed for separation of the jaws of 100 ± 20 mm/min. The faces of the jaws shall measure at least 40 mm in the direction of the applied load. Readings of load should fall in that part of the scale which has been shown by calibration to be correct within one percent. The machine shall be equipped with a scale graduated to one millimetre for measuring the elongation shown by the distance between the gauge marks on the dumb-bell test pieces.

3.1.1 For measurement of elongation automatically recorded load-extension graphs may be used if calibration shows that they do not lead to errors greater than 2 percent of the length of the test piece that is the distance between the lines AB and CD (see Fig. 1).

3.2 Press Knives — The shape and dimensions of the internal surfaces of three press knives for cutting large, medium and small test pieces shall be as given in Fig. 2. The internal walls of the press knife are shown in the plan, and these walls shall be normal to the plane that contains the cutting edge. The angle formed at the cutting edge between the internal and external walls of the knife shall be approximately 20°C, and the wedge of this angle shall be a depth exceeding the thickness of the leather.
FIG. 2 SHAPE AND DIMENSIONS OF INTERNAL SURFACES OF PRESS KNIVES

4. TEST PIECES

4.1 Cut test pieces of required shape and dimensions from the sampling location for physical test of leather in accordance with 3 of LP : 0 with either of the three press knives specified in 3.2. For small test pieces, condition the sample of leather and measure the thickness before cutting the test piece. Condition the test pieces in accordance with 5.1 of LP : 0.

5. PROCEDURE

5.1 Measurement of Tensile Strength

5.1.1 Measure the width of each test piece to the nearest 0.1 mm at three positions on the grain, and at three positions on the flesh side according to 4.1.1 of LP : 3. In each group of three, make one measurement at the mid-point $E$ of the waist of the test piece (Fig. 1) and the other two positions approximately midway between $E$ and the lines $AB$, $CD$. Take the arithmetic mean of the six measurements as the width of the test piece.

5.1.2 Measure the thickness of each test piece in accordance with the method given in LP : 1. On large and medium size test pieces make the
measurement at three positions; namely, at the point \( E \) and midway between \( E \) and the lines \( AB, CD \) (see Fig. 1). Take the mean of the three thickness measurements as the thickness of the test piece. If small test pieces are to be used, condition the leather and make one measurement of thickness for each test piece at the point \( E \) before the test piece is cut out.

5.1.3 Calculate the area of cross-section of each specimen by multiplying its width by its thickness.

5.1.4 Set the jaws of the tensile strength machine 100, 50 or 20 mm apart, for large, medium and small test pieces respectively. Clamp the test piece in the jaws so that the edges of the jaws lie along the lines \( AB, CD \) (see Fig. 1). When it is clamped, the grain surface of the test piece shall lie in one plane.

5.1.5 Run the machine until the test piece breaks and take the highest load reached as the breaking load.

5.2 Temporary Elongation at a Specified Load

5.2.1 Clamp the test piece between the jaws of the machine as described in 5.1.4. Measure the distance between the jaws to the nearest 0.5 millimetre and take this distance as the initial length of the test piece for the purpose of the test. Start the machine. Unless the machine automatically draws a load-extension graph with the necessary accuracy (see 3.1.1), follow the distance between the pairs of jaws as the load increases with the aid of a pair of dividers.

5.2.2 Note the distance between the pair of jaws at the instant when the load first reaches the specified value. Take this as the length of the test piece at this load.

NOTE — If tensile strength and elongation at break is also to be measured, do not stop the machine until the test piece breaks.

5.3 Permanent Elongation at a Specified Load — Follow the procedure given in 5.2.1. Release the load and allow the test piece to rest for one or more specified periods. Measure the residual length immediately after the rest period (s).

5.4 Modulus — Determine the modulus at one or more tensile strains during the uninterrupted stretching of the test piece following the procedure given in 5.1.4. Calculate the distance between the reference lines corresponding to the required elongation by adding one to the elongation factor or multiple and multiplying by the original distance, for example, for 300 percent elongation, the distance is \( 4 \times \) initial distance.

5.5 Measurement of Elongation at Break

5.5.1 Carry out the test following 5.2.1.
5.5.2 Note the distance between the pairs of jaws at the instant when rupture of the test piece occurs. Take this as the length of the test piece at break.

NOTE 1 — The medium size test piece is convenient for most tests on light leathers, but is less satisfactory than the large size for thick leathers because of the difficulty of obtaining sufficiently accurate measurements of width. The small size test piece should be only used if the amount of leather available for test precludes the use of the other test piece sizes.

NOTE 2 — The forces applied to many leathers during their use are such as to cause stretch in several directions, and not in one direction only. Also, the forces are frequently only a small fraction of those required to cause rupture of the leathers. In such cases, measurements of tensile strength are of little value as guides to the performance of the leathers. Even if the load is applied in one direction only (as in belting leathers, for example) tensile strength measurements may be less informative than measurements of elongation at specified loads. For control work in a tannery or factory, measurements of tear strength are usually to be preferred to measurements of tensile strength.

NOTE 3 — The results of all the tests depend not only on such factors as the type of hide or skin and the methods of tanning and finishing the leather, but also to a marked extent upon the location in the hide or skin from which the specimens are cut, and upon the direction of cutting at any location. It is, therefore, essential, when comparing two or more leathers, to cut the test piece from the same location in each, and also in the same direction relative to the backbone or other structural features.

NOTE 4 — If, during the application of load, a test piece slips at the jaws of the machine, or if rupture of the test piece occurs within the non-parallel parts of the test piece between the jaws, reject the reading and take a further test piece for test.

6. CALCULATION

6.1 Calculate the tensile strength by dividing the breaking load by the area of cross-section of the test piece and express the result in kilograms-force per square centimetre (kgf/cm²).

6.2 Calculate temporary elongation at the specified load by taking the difference between the original length and the length at the specified load and express this difference as a percentage of the original length.

6.3 Calculate the permanent elongation from the residual length, expressed as a percentage on the original length.

6.4 Modulus — Note the load at the specified elongation and express the result in kilograms-force per square centimetre (kgf/cm²) by dividing the load by the area of cross-section of test piece.

6.5 Calculate the elongation at break by taking the difference between the original length and the length at break and express this difference as a percentage of the original length.
7. REPORT

7.1 The following shall be reported:

a) Type of dumb-bell test piece (large, medium and small);

b) Individual test results;

c) Average of all the test results, in case a number of test pieces are tested;

d) Maximum and minimum results, in case a number of test pieces are tested;

e) Load if specified (6.2);

f) Specified elongation (6.4); and

g) Period of recovery (6.3).
METHOD FOR MEASUREMENT OF TEAR STRENGTH

( LP : 7 )

(This method supersedes the method given in 24 of IS: 582-1954* and is based on the method given in IUP8i.)

1. SCOPE
1.1 This method is intended for the measurement of tear strength of any type of leather.

2. TERMINOLOGY
2.0 For the purpose of this method, the following definition shall apply.
2.1 Tear Strength — The load in kilograms required to tear a leather having a thickness of one centimetre.

3. APPARATUS
3.1 Press Knife — a press knife which cuts out the test piece shown in Fig. 1 and slot in one operation.

NOTE — The press knife may be made up from two parts which are subsequently bolted or welded together, or two press knives may be used separately and in succession to cut out the test piece and the slit. The part used to cut the slit may be worked from a block of tool steel of length 25 mm and breadth 10 mm; it has vertical internal walls, and the sloping edge of the knife on its exterior surface. This sloping edge tapers so that the corners at A and B consist of sharp edges normal to the plane of the figure. When the two knives are assembled to make a single one, all the cutting edges should be in one plane; the heights of the inner and outer parts of the knife should be the same, so that pressure is applied to both simultaneously.

![Figure 1: Dimensions of Test Piece](image)

All dimensions in millimetres.

FIG. 1  DIMENSIONS OF TEST PIECE

*Methods of sampling and test for vegetable and chrome tanned leathers.
3.2 **Tensile Testing Machine** — Same as in 3.1 of LP : 5 with arrangement to make the test-piece holders possible to be clamped by the jaws of the machine, the moving jaw having a rate of traverse of 100 ± 20 mm.

3.3 **Test-Piece Holders** — A pair of test-piece holders of the type shown in Fig. 2 shall be provided. Each consists of a strip of steel 10 mm wide and 2 mm thick, bent through a right angle at one end, and welded to a bar which makes the strip and which fits one pair of jaws of the tensile tester of replace them.

![FIG. 2 TEST-PIECE HOLDER](image)

4. **TEST PIECES**

4.1 Cut out 50 × 25 mm pieces of leather with a slot, having the shape and dimension shown in the figure, from the sampling location specified in 3 of LP : 0 with the longer sides of rectangles parallel to the backbone, preferably with a press knife specified in 3.1 which passes through from the grain to the flesh side of the sample and cuts the test piece and slot in one operation. The test piece shall be conditioned according to 5.1 of LP : 0.

NOTE — In tests of light leathers, simpler test pieces of the form shown in Fig. 3, with a 20-mm long straight cut instead of a slot, give results nearly the same as those given by the above method.

![FIG. 3 SIMPLIFIED TEST PIECE](image)
5. PROCEDURE

5.1 Measure the thickness of conditioned test pieces according to LP: 1. Slip the test piece over the turned-up ends of the holders of the tensile testing machine, so that they protrude through the slot with the widths of the turned up ends parallel to the straight edges of the slot. Press the test piece down firmly on to the holder. Run the machine until the test piece is torn apart. Record the highest load reached during tearing as the tear strength.

6. REPORT

6.1 Report the tear strength of the leather in kilograms per centimetre thickness of the test piece. Report also the tearing load in kilograms and the thickness of the test piece in millimetres separately.
DETERMINATION OF DOUBLE HOLE STITCH TEAR STRENGTH

(LP : 8)

(Adopted from E ??? of ALCA methods of analysis)

1. SCOPE
1.1 This method is intended for determining the double hole stitch tear strength of leather of any type.

2. TERMINOLOGY
2.0 For the purpose of this method, the following definition shall apply.

2.1 Double Hole Stitch Tear Strength — The load required to tear the leather between two holes, a given distance apart.

3. APPARATUS
3.1 Metal Wire — A piece of soft steel wire 1.000 ± 0.025 0 mm in diameter and not less than 100 mm in length.

3.2 Means to Make Holes — A punch or other instrument for making holes 2 mm in diameter in the test pieces.

3.3 Testing Machine — The testing machine is similar to the machine used for testing tensile strength as prescribed in LP : 5 except that the jaws of the grips of the machine shall be covered with a material suitable for protecting the gripping surface from possible damage by the metal wire.

4. TEST PIECES
4.1 The test pieces shall be 50 × 25 mm rectangular pieces, cut from leather samples from the sampling location for physical testing of leather in accordance with 3 of LP : 0. The test pieces shall be free from mechanical damage and defects. Punch two holes as in Fig. 1 on these pieces. Condition the test pieces in accordance with 5.1 of LP : 0.

5. PROCEDURE
5.1 Test three test pieces cut from the sampling position for physical tests from three different samples of leather.

5.2 Measure the thickness of the test piece according to the method given in LP : 1. Make the metal-wire into a U-shape loop and pass through the two holes so that both ends project from the flesh side of the test piece. Clamp the ends of the wire in the wrapped grips of the testing machine.

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All dimensions in millimetres.

FIG. 1 DIMENSIONS OF TEST PIECES

Grip the free end of the test piece in the other grip of the machine. Apply force to the test piece at such a rate that the actuated grip travels at a uniform speed of 25 ± 5 cm per minute. Note the load required to tear the test piece at the moment of the initial tear of the test piece.

6. RESULTS

6.1 Average the test results obtained from the three pieces tested for the double hole tear strength and calculate the strength in kg/cm thickness of the sample.

6.2 Record the nearest 0.5 kg, the double hole tear strength for cm thickness of the test pieces.
MEASUREMENT OF TONGUE TEAR TEST

(LP: 9)

(Adopted from Method PM 30 of Shoe and Allied Trades Research Association, U.K.)

1. SCOPE
1.1 This method is intended for use on all upper and lining materials.

2. TERMINOLOGY
2.0 For the purpose of this method, the following definition shall apply.

2.1 Tongue Tear Strength — The load required to tear the leather between two tongues formed by splitting the leather perpendicular to its surface.

3. OUTLINE OF METHOD
3.1 Two tongues, formed by cutting through a strip of material along much of its centre line, are pulled apart so as to tear through the remainder of the strip. With some materials the force needed to start a tear is not the same as that needed to continue it. This point is checked by having the centre line cut end in a small circular hole, so that the tear must start at some point round the edge of the hole during the test, and the corresponding load be measured. This shape of test piece and manner of tear initiation correspond to the conditions most commonly met in shoes.

4. APPARATUS
4.1 A low inertia recording tensile strength machine, with a load range of 0 to 50 kg and one or more lower load ranges, and a speed of traverse of 75 mm.

5. TEST PIECE
5.1 Six strips 75 × 25 mm, three in the 'along' direction and three in the 'across' direction from the sample location specified in 3.1 of LP: 0. Punch a hole 5 mm in diameter, 25 mm from one end of each test piece and on the centre line. Cut through the test piece from the hole to the further end along the centre line to produce the test piece shown in Fig. 1.

6. PROCEDURE
6.1 Set the tensile strength machine to a suitable load range. Insert one tongue of the test piece in each jaw of the machine as shown in Fig. 2, so that there is an inch length of each tongue clamped, with the inner cut edge along the centre line of the jaws. Separate the jaws at a constant-rate-of-traverse of the lower jaw of 75 mm/min. Watch the start of the tear closely and obtain a load extension record for the tearing which takes place.
FIG. 1 TONGUE TEAR TEST PIECE

FIG. 2 METHOD OF CLAMPING THE TEST PIECE
6.2 Read from the load/extension graph the following:
   a) The load at which the first signs of a tear starting are evident.
   b) The maximum load (if there is one) close to the start of the tear. (This maximum seems to correspond to the establishment of a tear through the full thickness of the material. Once this stage is reached a somewhat lower load is often sufficient to continue the tear).
   c) The average load to continue the tear.

6.2.1 These three loads are illustrated in Fig. 3. Record if the test piece tears to the strip.

![Diagram of load/extension curve](image)

FIG. 3 AN EXAMPLE OF A LOAD/EXTENSION CURVE FOR A TEAR TEST SHOWING THE THREE LOADS MEASURED

7. EXPRESSION OF RESULTS

7.1 Calculate the mean (initial first signs, initial maximum, and average) of the tearing loads for the three test pieces in each direction, to the nearest 0.1 kg. Record with the results either the thickness or the weight/unit area of the material.

7.2 Record if the test piece tears to the side of the strip.
1. SCOPE

1.1 This method is intended for determination of shrinkage temperature of all types of leather whose shrinkage temperature lies below 100°C.

2. PRINCIPLE OF METHOD

2.1 If a strip of leather is slowly heated in water, a sudden shrinkage occurs at a temperature which is characteristic of the tannage. This temperature is called the Shrinkage Temperature. Nearly all leathers have a shrinkage temperature above 60°C but there are a few (chiefly chamois leather) which shrink at low temperatures.

3. APPARATUS

3.1 Apparatus for Wetting Test Piece—The apparatus consists of a desiccator or other glass vessel which may be evacuated, a vacuum pump capable of reducing the pressure in the vessel to less than 30 mm of mercury within two minutes, and a test-tube in which the test piece can be immersed in 5 ml of water; the test-tube should be supported approximately upright in the vessel during its evacuation.

NOTE 1 — If the leather fibres have hydrophobic surfaces, water uptake and wetting of the leather may be slow if it is merely immersed in water. Reduction of pressure removes air from the leather and restoration of pressure forces water into it; this results in rapid wetting.

NOTE 2 — A test-tube of internal diameter between 8 and 11 mm is suitable.

3.2 Apparatus for Shrinkage Temperature Measurement—The apparatus is shown in Fig. 1 and has the following parts:

a) A glass beaker \( (A) \) of volume 500 ml and internal diameter 70 ± 2 mm. The beaker stands on the platform of a magnetic stirrer.

b) A brass tube \( (B) \) of internal diameter 4 mm closed at the bottom. It carries a rod \( C \) (which keeps it in position in \( A \)) and another rod \( D \) of 1.5 mm diameter which is passed through the lower hole in the test piece \( E \). The rod \( D \) is 30 ± 5 mm above the bottom of the beaker.

c) A circular scale \( F \) of diameter 45 mm marked at the rim with divisions of 1 mm.

d) A light pointer \( G \), balanced in all positions and rigidly attached to the pulley \( H \), whose diameter is 10 mm.

e) A hook $J$ made of copper wire. One end of $J$ passes through the hole at the top of the test piece. The other is attached to the thread $K$, which passes over $H$, and supports a brass weight $L$ in the tube $B$. The pulley and circular scale are attached rigidly to $B$, so changes of length of the test piece cause rotation of the

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**FIG. 1 SHRINKAGE TESTER**

$A$ — Glass beaker  
$B$ — Brass tube  
$C$ — Rod  
$D$ — Rod  
$E$ — Test piece  
$F$ — Circular scale  
$G$ — Pointer  
$H$ — Pulley  
$J$ — Hook  
$K$ — Thread  
$L$ — Weight  
$M$ — Thermometer

All dimensions in millimetres.
pointer over the scale. The pulley moves in its bearing with little
friction, and the weight of \( L \) is 3 g more than that of \( J \), so the
tension in the test piece is somewhat more than 3 g.

f) A thermometer \( M \) graduated in degrees, supported by a disc \( N \),
which also supports \( B \) and the parts attached to \( B \). The bulb of
\( M \) is close to the middle of the test piece. The hook \( J \) moves
freely through a hole in the disc without touching it. The ther­
mometer \( M \) used for temperature measurements, is one that has
been shown, by calibration against a standard thermometer, to
have no error exceeding 0.5°C at any point in the temperature
range 50 to 105°C.

g) An 80 to 100 watt electric heater, perferably of the type having a
glass or silica envelope (not shown in Fig. 1). The heater is
supported in the beaker so that its lower end is not more than
30 mm from the bottom and may be regulated to give a rate of
heating of approximately 2°C per minute when the beaker
contains 350 ml of water.

4. TEST PIECE

4.1 Cut a strip of leather from the sample location specified in 3.1 of
LP : 0 as a 50 × 3 mm rectangle (see LP : 1); if the thickness exceeds 3 mm
(see LP : 1), cut it as a rectangle 50 × 2 mm. To allow the test piece to
be supported from hooks, punch two small holes at positions 5 mm from
the ends and on a line parallel to and equidistant from the sides of the
rectangle.

5. PROCEDURE

5.1 Before using the apparatus, ensure that the stirring is adequate by
testing as follows:

Put into the apparatus a piece of leather to act as a dummy test
piece and support two thermometers, \( M_1 \) and \( M_2 \), which have been
calibrated against one another so that the mid-points of their bulbs are
adjacent to, and at the same level as, the top and bottom of the test
piece. Put in 350 ± 10 ml of water and switch on the stirrer and
heater, raising the temperature at approximately 2°C per minute. Read both thermometers every three minutes and calculate each time
the temperature difference between the top and the bottom of the test
piece making allowance for the difference between the thermometers as
shown by their calibration. The stirring is adequate if none of the
calculated temperature differences exceeds 1.0°C.

5.2 Put 5 ml of distilled water at 27 ± 2°C into the test-tube, and immerse
the test piece in it, with a glass bead or piece of glass rod on top of the
test piece if this is necessary to keep it immersed. Stand the test-tube in
the vessel which is to be evacuated. Evacuate the vessel, and maintain
the pressure in it below 30 mm of mercury for one to two minutes. Allow the air to enter the vessel. Stop the pump, and keep the test piece immersed for at least one hour before using it for measurements of shrinkage temperature. Attach the test piece to the hooks D and J. Put into the beaker A 350 ± 10 ml of warmed distilled water. Unless the test piece is known or suspected to have a shrinkage temperature below 60°C put in this water at 50 ± 5°C. Heat the water and maintain the rate of rise of temperature as nearly as possible at 2°C per minute. At half minute intervals, note the temperature and the corresponding reading of the pointer G. Continue these readings until the test piece shrinks considerably or the water boils vigorously. By inspection of the tabulated results, or by use of a graph of pointer readings versus temperature, find the temperature at which the test piece has shrunk to such an extent as to move the pointer half a division from the position corresponding to the maximum length of the test piece. Take this temperature as the shrinkage temperature, and record its value to the nearest degree (see Note 1). If the shrinkage temperature is not reached before the water boils, record the shrinkage temperature as above the boiling point (see Note 2).

5.3 If the shrinkage temperature measured as above is not at least 5°C higher than the temperature at which water was put into the beaker, discard the result and wet another test piece as in 5.2. For measurements on the test piece and on test pieces known or suspected to have shrinkage temperature below 60°C put the water at least 10°C below the expected shrinkage temperature and discard the results if the measured shrinkage temperature is not at least 5°C higher than the temperature at which the water is put in. Proceed otherwise as in 5.2 (see Note 3).

NOTE 1 — Even the slight tension of 3 g is sufficient to cause some test pieces to extend, and apparent slight changes of length of the test piece may be caused by changes of the dimensions of the apparatus, by flexing of the test piece due to currents in the water, and so on. It is necessary to tabulate or plot pointer readings against temperature in order to differentiate between movements of the pointer caused in these ways and the beginning of the larger and progressively increasing movement due to shrinkage of the test piece. The shrinkage temperature is taken as that temperature where a small, but finite, shrinkage has occurred, because there is often difficulty in deciding when shrinkage begins. The pointer movement of half a division corresponds to a contraction of the test piece by about 0.3 percent of its length.

NOTE 2 — The method described above is not applicable to test pieces whose shrinkage temperatures exceed 100°C. If it is necessary to measure the shrinkage temperature of such leathers, it is recommended that the apparatus used should contain water under pressure and not a mixture (for example, of water and glycerol).

NOTE 3 — Nearly all leathers have shrinkage temperatures above 60°C but there are a few (chiefly chamois leathers) which shrink at lower temperatures.
IS : 5914 - 1970

MEASUREMENT OF ABSORPTION OF WATER:
GRAVIMETRIC METHOD

( LP:11 )

(This method supersedes the method given in 21.2 of IS : 582-1954*.)

1. SCOPE

1.1 The method is intended for use with all types of leather, to measure apparent water absorption after 15 minutes, corrected water absorption in 24 hours and the percentage loss on soaking.

2. APPARATUS

2.1 Glass Vessel—A glass vessel having a flat circular bottom whose diameter exceeds 80 mm and is less than 115 mm in length.

2.2 Press Knife—A press knife, the inner wall of which is a right circular cylinder of diameter 70 mm.

3. TEST PIECE

3.1 Cut a right circular cylinder of diameter 70 mm from the sample location specified in 3.1 of LP : 0. Before carrying out the test, keep the test piece in an atmosphere at a temperature of 27 ± 2°C and relative humidity less than 10 percent for a period of at least 72 hours alternatively in a vacuum desiccator at a pressure not exceeding 10 mm of mercury for 24 hours. Next, condition each test piece in accordance with 5.1 of LP : 0 during the 48 hours preceding the test.

4. PROCEDURE

4.1 Weigh the test piece to the nearest 0.01 g without removing it from the standard atmosphere. Call this weight $W_0$. Place water of a weight approximately 10 times that of the test piece in the glass jar and adjust its temperature to 27 ± 2°C. Maintain the water at this temperature throughout the test. At a known time place the test piece, flesh side downwards, in the water and, if necessary, place a small weight of some non-corrosive material on the grain surface to keep the whole of the test piece immersed. Rest the test piece on small pieces of glass.

4.2 Fifteen minutes after the test piece was first immersed take it from the water, blot it lightly with dry blotting paper, weigh the test piece as before, return it to the water, and call this weight $W_1$. Perform the procedure of removing, blotting, weighing and re-immersing the test piece as rapidly as is practicable.

*Methods of sampling and test for vegetable and chrome tanned leathers.
4.3 Twenty-four hours after the test piece was first immersed remove it again from the water and blot and weigh as before. Call its weight so measured \( W_2 \).

4.4 Allow the test piece to dry at room temperature for at least 48 hours. Then for at least 72 hours keep it in an atmosphere of \( 27 \pm 2^\circ \text{C} \) and relative humidity less than 10 percent or alternatively 24 hours in a vacuum desiccator at a pressure not exceeding 10 mm of mercury. Then place it for 48 hours in the standard atmosphere for conditioning, and weigh again. Call this weight \( W_3 \).

NOTE — During the periods of conditioning at relative humidity less than 10 percent the test piece may be stored in a desiccator. For this conditioning (but not for that at 65 percent relative humidity) no device for circulating the air need be used, but free access of the air to the faces of the test piece should be allowed.

5. CALCULATION

5.1 Calculate the apparent percentage of water absorbed during immersion for 15 minutes as follows:

\[
\text{Water absorption in 15 min (} Q_{15}\text{), percent by weight} = \frac{100 (W_1 - W_0)}{W_0}
\]

NOTE — The method of measuring \( Q_{15} \) takes no account of any soluble material that may be removed from the leather while it is immersed.

5.2 Calculate the corrected percentage of water absorbed during immersion for 24 hours (free water) as follows:

\[
\text{Free water (} F\text{), percent by weight} = \frac{100 (W_2 - W_3)}{W_0}
\]

5.3 Calculate the percentage loss on soaking as follows:

\[
\text{Loss on soaking, percent by weight} = \frac{100 (W_0 - W_3)}{W_0}
\]

NOTE — For interpretation of symbols \( W_0, W_1, W_2 \) and \( W_3 \), see 4.
MEASUREMENT OF ABSORPTION OF WATER: KUBELKA METHOD

(LP:12)

(This method supersedes the method given in 21.1 of IS : 562-1954* and is adopted from IUP/7†.)

1. SCOPE

1.1 This method is intended for use with all types of leather by employing Kubelka's apparatus.

2. PRINCIPLE OF METHOD

2.1 The method measures the water absorption in millilitres of water per 100 g of leather. It may be used to measure the water absorption $P$ in millilitres of water per 100 ml of leather. When $P$ is required the volume of the test piece has to be determined as described in the method for measuring apparent density in LP : 5.

3. APPARATUS

3.1 Kubelka Apparatus — A glass apparatus which has the dimensions shown in Fig. 1. To the rubber stopper $C$ a glass rod or a nickel or stainless steel wire of diameter about one millimetre is fastened, to keep the test piece at the end of $B$ distant from $C$.

FIG. 1 KUBELKA APPARATUS

All dimensions in millimetres.

*Method of sampling and test for vegetable and chrome tanned leathers.
4. TEST PIECE

4.1 Cut the test piece with a steel press knife, the inner wall of which is a right circular of diameter 70 mm (from the sampling location specified in 3.1, LP : 0). Condition it in accordance with 5.1 (see P 8).

NOTE — Test piece, which has been used for the measurement of apparent density in LP : 5 may be used if desired for the measurement of the absorption of water.

5. PROCEDURE

5.1 Thoroughly clean the Kubelka's apparatus before use and use in a room at a controlled temperature of 27 ± 2°C. Then follow the procedure as given below:

a) Wet the interior surfaces of the apparatus with distilled water, and pour the water out again.

b) Place the apparatus with the bulb A directly below the cylinder B. Fill the apparatus approximately to the zero mark with distilled water by running into it 75 ml at 27 ± 2°C.

c) Weigh the test piece in the cylinder B, and run the water into this part of the apparatus to immerse it. Close the cylinder with a rubber stopper C, to prevent evaporation losses.

d) After the test piece has been immersed for the required time, turn the apparatus so that the liquid drains into bulb A. One minute after drainage has begun, measure the volume of liquid absorbed.

e) If the water absorptions after other durations are required, turn the apparatus immediately so that the liquid flows back into the cylinder B, and again covers the test piece.

f) Report (d) and (e) at the required times.

NOTE 1 — The periods of one minute during which the water is being drained back into A are not to be considered as part of periods of immersion which precede them, but are to be considered as parts of subsequent periods of immersion. For example, if the water absorption during periods of immersion of 15 and 60 minutes are to be measured on the same test piece, and the instant of first immersion is at time zero, subsequent actions will be as follows:

a) At 15 minutes, begin draining.

b) At 16 minutes, read off the residual volume and immediately reimmerse the test piece.

c) At 60 minutes, begin draining.

d) At 61 minutes, read off the residual volume.

NOTE 2 — For most purposes, measurements after two durations of immersion are sufficient and, if possible, the periods specified should be chosen from the following:

\( \frac{1}{4} \text{h}, \frac{1}{2} \text{h}, 1 \text{h}, 2 \text{h}, 24 \text{h}. \)
6. CALCULATION

6.1 Calculate the percentage absorption $Q$ and $P$ from the formulae:

\[ Q = 100 \frac{v}{m} \]
\[ P = 100 \frac{v}{V} \]

where

- $Q$ = quantity of water, in ml, per 100 g of leather:
- $v$ = volume, in ml, of water absorbed:
- $m$ = weight, in g, of the test piece;
- $P$ = quantity of water, in ml, per 100 ml of leather: and
- $V$ = volume, in ml, of the test piece.
RESISTANCE TO CRACKING OF GRAIN AND CRACK INDEX  
(LP : 13)  
(This method supersedes the method given in 22 of IS : 582-1954* and is adopted from IUP/12†.)

1. SCOPE

1.1 This method prescribes the procedure for assessing the resistance to cracking of grain of the leather and determination of crack index.

2. TERMINOLOGY

2.0 For the purpose of this method, the following definitions shall apply.

2.1 Crack Index — Crack index is the product of \( nt \), where \( n \) is the number of the largest mandrel, mandrel number being defined in terms of its diameter, bending round which causes cracks to appear in the grain and \( t \) is the thickness of the sample in millimetres.

2.2 Mandrel Number — Mandrel number is defined by the diameter as follows:

<table>
<thead>
<tr>
<th>Mandrel Number</th>
<th>Nominal Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61.7</td>
</tr>
<tr>
<td>2</td>
<td>35.0</td>
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<tr>
<td>3</td>
<td>23.6</td>
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<tr>
<td>4</td>
<td>17.2</td>
</tr>
<tr>
<td>5</td>
<td>13.2</td>
</tr>
<tr>
<td>6</td>
<td>10.4</td>
</tr>
<tr>
<td>7</td>
<td>8.3</td>
</tr>
<tr>
<td>8</td>
<td>6.8</td>
</tr>
</tbody>
</table>

3. PRINCIPLE OF METHOD

3.1 The principle of the test is to observe whether the leather cracks when bent, grain outwards, around a mandrel of known diameter, the forces applied to the leather in bending it being the smallest that are required to maintain the leather and mandrel in contact. For some purposes it is merely necessary to decide whether a leather does or does not crack when

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*Method of sampling and test for vegetable and chrome tanned leathers.
†Office ??? of International Union of Leather Chemists' Societies, 1961.
bent round a mandrel of specified diameter, no account being taken of the thickness. For other purposes it is desirable to take into account the thickness of the leather.

3.2 The diameters of the set of mandrels are so chosen that bending a leather 5 mm thick round them causes extensions of the grain of \( (5n \pm 2.5\%) \), if the neutral axis of the leather is assumed to be midway between the grain and the flesh surfaces in the bent sample. If such a leather does not crack on mandrel number \((n - 1)\), but cracks on mandrel number \(n\), it cracks when its percentage extension lies between \([5(n - 1) + 2.5]\) and \((5n + 2.5)\) [that is, when the percentage extension lies between \((5n - 2.5)\) and \((5n + 2.5)\)], so \(5n\) is an acceptable estimate of the percentage extension of the grain at crack. For a leather 5 mm thick, however, \(5n\) is the crack index, so for this leather the crack index is equal to the estimated percentage extension of the grain when cracking occurs.

3.3 For leathers of thickness other than 5 mm, the crack index \(nt\) is not accurately equal to the percentage extension of the grain at crack, but is a sufficiently close estimate of the grain at crack, but is sufficient close estimate of it for those mandrel sizes on which cracking is likely to occur in practice. The following table shows, for different leather thicknesses and mandrels on which the leather first cracks:

- **a)** The crack index, and
- **b)** The percentage extension of the grain at grain crack, if this occurs midway between the extensions given by those mandrels where cracking just occurs and just fails to occur.

<table>
<thead>
<tr>
<th>Mandrel No.</th>
<th>Nominal Mandrel Diameter (mm)</th>
<th>Thickness of Leather in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>61.7</td>
<td>3</td>
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<tr>
<td>2</td>
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<td>3</td>
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<td>10.4</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>8.3</td>
<td>21</td>
</tr>
<tr>
<td>8</td>
<td>6.8</td>
<td>24</td>
</tr>
</tbody>
</table>

4. APPARATUS

4.1 The apparatus consists of a clamp device which rigidly holds one end of the test piece. A mandrel of the desired diameter and a roller of diameter 25 mm make contact with the flesh and the grain surface
respectively of the middle portion of the test piece, across its full width. The axes of both the mandrel and the roller are perpendicular to the length of the test piece; the axis of the mandrel is fixed relative to the clamp: the axle of the roller is attached to a handle pivoted at the axis of the mandrel. The relative positions of the clamp, the mandrel and the roller in plain view are shown in Fig. 1.

![Diagram](image)

**FIG. 1 POSITIONS OF CLAMP MANDREL AND ROLLER**

### 4.1.1 Mandrels — The mandrels shall have the following diameter:

<table>
<thead>
<tr>
<th>Mandrel Number</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61.67 ± 0.03</td>
</tr>
<tr>
<td>2</td>
<td>35.00 ± 0.03</td>
</tr>
<tr>
<td>3</td>
<td>23.57 ± 0.03</td>
</tr>
<tr>
<td>4</td>
<td>17.22 ± 0.03</td>
</tr>
<tr>
<td>5</td>
<td>13.18 ± 0.03</td>
</tr>
<tr>
<td>6</td>
<td>10.38 ± 0.03</td>
</tr>
<tr>
<td>7</td>
<td>8.33 ± 0.03</td>
</tr>
<tr>
<td>3</td>
<td>6.76 ± 0.04</td>
</tr>
</tbody>
</table>

### 4.1.2 A suitable form of apparatus that has been found convenient for the test is shown in Fig. 2. It consists of a horizontal base plate to which
is rigidly attached a shouldered spigot $BC$ whose narrow part $B$ has the diameter of the smallest mandrel. The circular hole $D$ in the handle $H$ fits over $C$, which thus acts as a pivot. A mandrel $E$ of the desired diameter fits over $B$. A roller $F$ of diameter 25 mm is carried on a vertical axle fixed to the handle $H$ in such a way that its distance from $L$ may be set at any value desired. The test piece clamp $A$ is attached to a slotted strip which allows its position relative to the base plate to be varied.

5. TEST PIECE

5.1 Cut out rectangular test piece 25 mm in width of the full thickness of the leather and at least 150 mm in length from the sampling location specified in 3.1 (of LP: 0). Condition the test piece in accordance with 5.1 of LP: 0.

6. PROCEDURE

6.1 Thickness — Measure the thickness to the nearest hundredth of a millimetre in accordance with LP: 1.

6.2 Resistance to Cracking — Turn the handle through 180° in five seconds, thus bending the test piece grain outwards around the mandrel. During the bending watch the grain to see whether cracking occurs. If the leather is to be tested on more than one mandrel the largest is to be used first, followed in order of decreasing size by the others.

6.3 Crack Index — Measure the thickness of the leather in accordance with LP: 1 and then bend the leather in turn around the mandrel specified in 4.1.1.

NOTE 1 — For some purposes it may be desirable to condition the leather and test it at temperatures or humidities other than those of the standard atmosphere. When this is done, the fact should be recorded.

NOTE 2 — When the apparatus specified in 4.1.2 is used, follow the procedure given below:

The test piece is clamped in $A$ which is moved along until the flesh surface of the leather touches the mandrel, and the wing-nuts $G$ are then tightened. The roller $F$ is moved along the handle (which is at right angles to test piece) until it touches the grain surface of the leather and its axle is locked at this distance from $B$. The rotation of the handle should take as nearly as possible five seconds. During the bending the grain is watched to see whether cracking occurs.

7. REPORT

7.1 Resistance to Cracking — The report shall state the diameters of the mandrels used in testing and whether each test piece cracked when bent round them.

7.2 Crack Index — The report shall state the crack index of each of the test pieces tested. If the grain cracks when the leather is being bent round the largest mandrel of all, the crack index shall be recorded as 'less than 1.5 $t$' (not $T$). If it fails to crack when bent round the smallest mandrel the crack index shall be recorded as 'greater than 8.5 $t$' (not 8 $t$).
FIG. 2 DETAILS OF CONSTRUCTION OF APPARATUS FOR GRAIN CRACK TEST

All dimensions in millimetres.
MEASUREMENT OF TWO-DIMENSIONAL EXTENSION
( LP:14 )
( Adopted from IUP/13* )

1. SCOPE

1.1 This method describes procedures for measuring the percentage area extension and the percentage radial extension, at first crack of finish, at first crack of grain and at burst of the leather.

1.2 This method is applicable to any type of light leather. The method may be used with suede leathers whose flesh surface has been buffed, but for these leathers the sueded flesh surface shall be regarded as the grain surface.

2. TERMINOLOGY

2.0 For the purpose of this method, the following definition shall apply.

2.1 Grain—Full grain of the leather or that surface of the leather which has been dressed or otherwise finished in such a way as to simulate a grain, or is intended to be used in place of the grain in an ordinary leather.

3. PRINCIPLE OF THE METHOD

3.1 The test piece, which consists of a circular disk, is clamped at its edges and pressure is applied hydrostatically to its flesh surface. This causes the disk to distend and assume a form which is approximately that of a spherical tap. The changes which occur in the grain surface and finish are observed, and the heights of the cap are noted at various pressures; from these heights the percentage area extension and radial extension of the test piece are calculated.

3.2 In calculating percentage area of distended leather, the area of distended leather is to be taken as that of the spherical cap to which it corresponds approximately in form; namely, a cap of the same height \( h \) millimetres and bounded by a plane which intersects in a circle of 50 mm diameter.

3.3 For calculating the radial extension \( R \), the linear extension is taken to be the same along the radii and at all distances from the centre.

3.4 The linear tension \( T \) per unit length is similar to that of a spherical soap bubble, and if \( p \) is in killograms-force per square centimetre and \( r \) is in cm, \( T \) is given in killograms-force per square centimetre by the

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The equation $T = \rho \cdot r / 2$. This equation shows that $\rho$ is not itself a measure of the tension in the leather; for example, a completely inextensible material would have $r$ infinite for all values of $\rho$, and hence would have to exert an infinitely large linear tension to withstand any pressure.

4. APPARATUS

4.1 The apparatus consists of the following parts:

a) A metal head in which the test piece is clamped for testing with an oil resistant rubber diaphragm beneath it. The dimensions and functions of the various parts of the head are indicated in the sectional elevation (Fig. 1).

b) A constant output rotary oil pump and valves which may be set to raise the pressure applied to the leather to $10 \text{ kgf/cm}^2$ in 30 seconds as shown in Fig. 2.

c) A manometer to indicate the pressure reading from 0 to $25 \text{ kgf/cm}^2$ and having no errors greater than $0.1 \text{ kgf/cm}^2$ at any part of its range.
FIG. 2  CONSTANT OUTPUT ROTARY OIL PUMP (SCHEMATIC)
d) Means for recording automatically in graphical form the pressure applied to the leather and the corresponding height of the spherical cap, the pressures being plotted as ordinates and the heights as abscissae (a suitable arrangement is indicated in Fig. 2). The pressures recorded automatically should have no errors exceeding 0.1 kgf/cm² and the heights of the cap should not have errors exceeding 0.5 mm.

5. TEST PIECE

5.1 It is informative to make tests on test piece conditioned at a low and a high relative humidity as well as at the standard relative humidity of 65 percent. Cut as circular disks of diameter 68 mm two test pieces for use at 65 percent relative humidity, and one test piece for conditioning at each of the other humidities which are specified. One of the two test pieces for the standard humidity is used merely for adjustment of the apparatus and not for measurement. Condition both these test pieces in accordance with 5.1 of LP:0 and measure the thickness of that which is to be used for measurement in accordance with LP:1. If tests at other humidities are specified, condition one test piece at each humidity and measure its thickness in the same way.

6. PROCEDURE

6.1 Securely clamp in the head the test piece which is merely to be used for adjusting the apparatus. Set the valves of the pumping system so as to cause the pressure to rise from 0 to 10 kgf/cm² in (as nearly as possible) 30 seconds. Release the pressure, and remove the test piece. Securely clamp another test piece in the head, with the grain upwards and exposed to view. Switch on the pump, and observe the leather for the first signs of cracks in the finish and for the first signs of cracks in the grain of the leather itself. If either occurs, record the relevant pressure on the pressure-height curve by a momentary interruption in the increase of another pressure with the aid of valve (Fig. 2), or by other suitable means. Unless pressure other than 15 kgf/cm² is specified or the test piece bursts at a pressure below 15 kgf/cm², allow the pressure to rise to 15 kgf/cm². As soon as the pressure reaches 15 kgf/cm² (or other specified maximum pressure), allow the pressure to fall again at approximately the same rate as it was increased. While the pressure is at or near its maximum, note whether there is good adhesion of the leather finish to the grain of the test piece. From the graph of pressure versus height of cap \( h \), measure \( h \) in millimetres at pressure of 5, 10 and 15 kgf/cm² on the ascending pressure branch, and at 10 and 5 kgf/cm² on the descending branch. Examine the test piece when it is removed from the head. If there is any sign that slip has occurred, the results shall be rejected and the test repeated, with extra precautions against slip if necessary. For this, a pair of grip rings as
shown in Fig. 3 may be used. If test pieces have been conditioned at other humidities, test them with the minimum of delay as described above.

NOTE 1 — A suitable method of conditioning test piece at low humidity is to suspend them for 48 hours in an enclosed space at 27 ± 1°C over a saturated solution of magnesium chloride (relative humidity 34 percent), with some arrangement for keeping the air in the closed space in movement. A suitable method for conditioning test pieces at a high humidity is to suspend them similarly, but over water instead of over magnesium chloride solution. Test pieces so conditioned shall be removed one at a time for test in the standard atmosphere at 65 percent relative humidity, and tested immediately to minimize reconditioning in that atmosphere.

NOTE 2 — If several test pieces of the same leather or several test pieces of similar leathers are to be used, it is not necessary to adjust the apparatus repeatedly as described in 6.1; it is sufficient to make the adjustment once, when the testing of the group of test pieces is begun.

NOTE 3 — Poor adhesion of the finish at maximum extension may be shown by rubbing the cap lightly with a white cotton fabric as the extension approaches the maximum, or by pressing an adhesive tape against the cap and peeling it off again.

All dimensions in millimetres.

FIG. 3 A PAIR OF GRIP RINGS

7. CALCULATION

7.1 Calculate the percentage area extension by the formula:

\[ A = 0.16 \times h^2 \]

where

\[ A = \text{percent area of extension of the leather, and} \]
\[ h = \text{height in mm (see 3.2).} \]
7.2 Calculate the percentage radial extension by the formula:

\[ R = 100 \left[ \frac{\alpha}{\sin \alpha} - 1 \right] \]

where
\[ \alpha = \cos^{-1} \left[ 1 - \left( \frac{h}{r} \right) \right] \]
and the radius of curvature \( r \) of the cap is given in mm by the equation:

\[ r = \frac{h^2 + 625}{2h} \]

7.2.1 The values of \( R \) corresponding to various values of \( h \) are shown in Appendix A.

7.3 Calculate the linear tension by the following formula:

\[ T = P \cdot Z \]

where
\[ T = \text{linear tension in kg/cm}; \]
\[ P = \text{force in kgf/cm}^2; \]
\[ Z = \frac{h^2 + 625}{40h}; \text{ and} \]
\[ h = \text{height in mm}. \]

7.3.1 To facilitate calculation corresponding values of \( h \) and \( Z \) are given in Appendix A.

8. Report

8.1 For each test piece report such of the following quantities as the maximum pressure allows to be measured:

a) Thickness of the test piece before its use on the apparatus;

b) The percentage area extension and the percentage radial extension, at the first crack of the finish, at the first crack of the grain, and at burst of the leather;

c) The percentage area extension and the percentage radial extension at 5, 10 and 15 kgf/cm\(^2\) with pressure increasing, and at 10 and 5 kgf/cm\(^2\) with pressure decreasing;

d) The pressure and the linear tension, at first crack of the finish, at first crack of the grain, and at burst of the leather; and

e) The adhesion of the finish at maximum pressure.
APPENDIX A

(Clause 7.2.1)

DIMENSIONAL EXTENSION VALUES

A-1. PERCENTAGE RADIAL EXTENSION

A-1.1 Values of the percentage radial extension $R$ for various values of the cap height $h$ are given in Table 1.

### Table 1: Values of Percentage Radial Extension ($R$) for Various Values of Cap Height ($h$)

<table>
<thead>
<tr>
<th>$h$ (mm)</th>
<th>$R$ (percent)</th>
<th>$h$ (mm)</th>
<th>$R$ (percent)</th>
<th>$h$ (mm)</th>
<th>$R$ (percent)</th>
<th>$h$ (mm)</th>
<th>$R$ (percent)</th>
<th>$h$ (mm)</th>
<th>$R$ (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.01</td>
<td>0.50</td>
<td>0.04</td>
<td>0.75</td>
<td>0.07</td>
<td>1.00</td>
<td>0.11</td>
<td>1.25</td>
<td>0.17</td>
</tr>
<tr>
<td>0.25</td>
<td>2.9</td>
<td>0.50</td>
<td>3.2</td>
<td>0.75</td>
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<td>1.00</td>
<td>3.8</td>
<td>1.25</td>
<td>4.1</td>
</tr>
<tr>
<td>0.25</td>
<td>9.0</td>
<td>0.50</td>
<td>11.4</td>
<td>0.75</td>
<td>11.9</td>
<td>1.00</td>
<td>12.5</td>
<td>1.25</td>
<td>13.0</td>
</tr>
<tr>
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<td>15.2</td>
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<td>15.7</td>
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<tr>
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A-2. VALUES OF 'Z' FOR VARIOUS VALUES OF HEIGHT

A-2.1 The values of the cap height and the corresponding values of 'Z' given in the equation in 7.3 of LP: 14 are given in Table 2.
**TABLE 2** VALUES OF THE CAP HEIGHT AND THE CORRESPONDING VALUES OF 'Z'  
*(Clause A-2.1)*

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**NOTE** — The values of $h$ are in millimetres.
RESISTANCE TO COMPRESSION
(LP: 15)
(Adopted from SLP 12*)

1. SCOPE
1.1 This method prescribes a procedure for measurement of resistance to compression of light leathers.

2. PRINCIPLE OF METHOD
2.1 Resistance to compression $R$ is defined by the equation:

$$R = \frac{\text{Increase of load per unit area}}{\text{Decrease in thickness per unit thickness}}$$

2.2 Thicknesses at two different loads of a test piece of leather are determined by means of a thickness gauge. From the known area of the leather which is subjected to these different loads and the difference in thicknesses, resistance to compression is calculated.

3. APPARATUS
3.1 Standard Measuring Gauge — The instrument used is a dial micrometer gauge standing on a firm base. It is dead weight loaded and the load applied is 393 ± 10 g weight (equivalent to 500 g/cm$^2$). The presser foot is flat, circular, and of diameter 1.00 cm, and its direction of movement is normal to the face of the anvil. The anvil is the flat, horizontal surface of a cylinder of diameter 1.00 mm, which projects 0.3 cm from the surface of a flat circular platform of diameter 5 cm. The axes of the presser foot, the platform and the projecting anvil coincide and are the same as the direction of movement of the foot. The faces of the foot and anvil are parallel for all positions of the foot, the error not exceeding 0.005 mm. The dial gauge is graduated to read to 0.01 mm directly. It has a dial of sufficiently large size to give an open scale, and a suitable pointer close to the scale to keep errors due to parallax small. The readings of the gauge are to be accurate to 0.01 mm all along the scale.

4. TEST PIECE
4.1 Use test piece of any dimensions which permit measurements to be made as laid down in 5. Condition and test them in the standard atmosphere in accordance with 5.1 of LP: 0.

NOTE — The test for resistance to compression is not a destructive one, so that it will not usually be necessary to prepare test pieces for this test alone. Test pieces which are subsequently to be used for another measurements may first be used for the compression test.

5. PROCEDURE

5.1 Lay the test piece out flat on the anvil of the thickness gauge, with the grain side uppermost, if this is known. So place the test piece that when the presser foot is lowered on to it, none of the edges of the test piece is less than 1.5 cm from the centre of the foot. With such load added to the gauge that its presser foot is capable of exerting a force of 25 ± 5 g weight, lower the foot gently on to the test piece. Measure the thickness $d_0$ under this load 5 ± 1 seconds after the load has reached its full value; tap gently the base of the gauge during this time. Add gently such a load as will increase the load exerted by the presser foot to 225 ± 5 g weight and measure the thickness $d_1$ under this load 5 ± 1 seconds after the load has reached its full value, the base of the gauge being tapped gently during this time.

NOTE — When a number of test pieces are tested, report the result of each test, and not merely the arithmetic mean.

6. CALCULATION

6.1 Calculate the resistance to compression as follows:

$$R = \frac{200 \times 4/\pi}{1000 \ (d_0 - d_1)/d_0} = 0.2546 \frac{d_0}{d_0 - d_1} \text{kgf/cm}^2$$

where

$d_0$ = thickness in mm under a load of 25 ± 3 g, and
$d_1$ = thickness in mm under a load of 225 ± 5 g.

7. REPORT

7.1 When a number of test pieces are tested, report the result of each test as well as the arithmetic mean.
1. SCOPE

1.1 This method describes a procedure for the determination of the compressibility of sole leather.

2. TERMINOLOGY

2.1 Compressibility — Percentage change in thickness of a test piece on being subjected to a specified pressure for a period of time.

3. PRINCIPLE OF METHOD

3.1 Compressibility is considered an important factor which influences wear resistance to sole leather.

3.2 A load of 5 450 kg or 210 kgf/cm$^2$ is applied to a leather test piece of 50 × 50 mm. The percentage change in initial thickness, determined by measuring thickness before and after compression, represents the compressibility of the sample.

4. APPARATUS

4.1 Press — either hand- or power-driven, having a capacity of at least 5 450 kg permitting a pressure of 210 ± 5 kgf/cm$^2$. The rate of increase shall not exceed 14 kgf/cm$^2$. The press shall contain two flat steel plates and an indicator for reading the applied force. A suitable testing machine may also be used.

4.2 Stop Watch

5. TEST PIECE

5.1 The test piece shall be square of leather 50.0 × 50.0 mm with a tolerance of ± 0.5 mm on each side, cut by a die. Condition the test pieces in accordance with 5.1 of LP : 0.

6. PROCEDURE

6.1 Measure the initial thickness of the test piece at the middle of each side approximately 12.5 mm from the edge in accordance with LP : 1, average and record as $T_1$. Place the test piece between the flat steel plates and apply pressure at a rate not greater than 14 kgf/cm$^2$ until the required 210 ± 5 kgf/cm$^2$ is reached. Maintain the load for 3 min,
continuously correcting for relaxation or loss in force, and then release. Remove the test piece from the apparatus and immediately remeasure the thickness. Record the final thickness as \( T_2 \).

NOTE — The operator shall take care to apply the force uniformly and perpendicular to the leather surfaces.

7. **CALCULATION**

7.1 Calculate the percentage compressibility on the basis of original thickness as follows:

\[
\text{Compressibility, percent} = \frac{T_1 - T_2}{T_1} \times 100
\]

where

\( T_1 = \) initial thickness in mm of the uncompressed test piece, and
\( T_2 = \) thickness in mm of the test piece after compression.

8. **REPORT**

8.1 Report the following:

a) Compressibility of each test piece from each test location; and
b) Compressibility based on the average of all test pieces tested, recorded to the nearest 0.1 percent.

9. **ACCURACY**

9.1 The mean difference between two laboratories using seven pairs of matched samples is 1.40 and confidence limits at 95 percent are 0.23 to 2.67.
1. SCOPE

1.1 This method is intended for all types of leather. It may be used for measurement of the indentation index of leather at the grain surface, at the flesh surface, or at any intermediate surface prepared by cutting or otherwise removing part of the leather from a thicker piece.

2. APPARATUS

2.1 Use a standard type thickness gauge (see LP: 1), modified by removing the flat presser foot and replacing it with a steel ball of diameter 3 mm. The ball is to be carried on a rod whose diameter for a distance of 3 mm above the ball is not greater than 0.75 mm. The gauge shall be so adjusted that, when no load is put on its platform and the ball is applied to the test piece, the total load on the ball is 15 ± 5 g.

3. TEST PIECE

3.1 The test pieces may be of any size, provided that each contains an area such that there is a point in it, distant not less than 25 mm from all cut edges. They shall be conditioned and tested in the standard atmosphere in accordance with 5.1 of LP: 0.

4. PROCEDURE

4.1 Place the test piece on the anvil of the gauge and lower the ball gently on to its upper surface at a point not less than 12.5 mm from its nearest cut edge. Tap the gauge gently to overcome friction, and read it 5 ± 1 seconds after applying the ball to the leather. Add a kilogram weight gently to the platform of the gauge, tap the gauge, and read it again after 5 ± 1 seconds. Make five tests at points not less than 12.5 mm from any cut edge and from one another.

NOTE – The value obtained in a test of this kind is determined mainly by the properties of a small element of the material directly below the ball, and close to the surface on which the ball rests. Indentation indices may be different on flesh and grain surfaces of a leather.

5. REPORT

5.1 Report the indentation index as 'the mean of the live determinations of the difference between the first and second gauge readings when they are taken as described in 4.1, and expressed in units of 1/100 g of a millimetre'.

5.2 When a number of test pieces are tested, the result obtained with each test piece shall be reported and not merely the arithmetic mean.

NOTE — High indentation index is obtained if the material is soft.

1. SCOPE

1.1 The method describes a procedure for determining dynamic waterproofness of boot and shoe sole leather.

2. TERMINOLOGY

2.0 For the purpose of this method, the following definitions shall apply.

2.1 Penetration Time — Duration of flexing in minutes which is just sufficient to cause water to penetrate from the wetted (grain) surface to the other face of the material.

2.2 Water Absorption \((R)\) — The gain of weight of the test piece as a percentage of its conditioned weight prior to test for each hour of test or for such periods as may be specified.

3. PRINCIPLE OF METHOD

3.1 The leather test piece is wetted on one surface, and is flexed and compressed in the same manner as the sole of a shoe during walking. Measurements are made of the following quantities:

   a) The duration of flexing which is just sufficient to cause water to penetrate through the test piece from one face to the other,

   b) The percentage gain of weight \(\rho\) of the test piece due to water absorption during one or more specified time intervals, and

   c) The mass \(m\) of water transmitted through the test piece from the face in contact with the water to the other face during one or more specified time intervals.

4. APPARATUS

4.1 The apparatus consists of:

   a) A brass roller \(A\), of diameter 120 mm and width 50 mm which rests on a rectangular leather test piece 100 × 40 mm. The leather test piece \(B\) is supported by a horizontal platform \(C\), and is pressed against the roller with a force of 8 kg by the spring \(D\). The axis

*Official methods of International Union of Leather Chemists' Societies.
of the roller is constrained to move with crank motion along a horizontal line $XY$ with amplitude 50 mm and frequency 20 per minute about a point on $XY$ situated directly above the middle of the test piece. The movement of its axis causes the roller to roll backwards and forwards along the test piece.

b) A clamp which holds one of the 40-mm sides of the test piece fixed in a horizontal position on the platform, and a second clamp which attaches the other 40-mm side to the rim of the roller, both the 40-mm sides being maintained parallel to the axis of the roller. The clamp which attaches the test piece to the roller is held by a weak spring which maintains the test piece under slight tension and prevents it from puckering. As shown in Fig. 1, the movement of the roller raises one end of the test piece, and bends it to conform to the shape of the roller.

![Diagram of testing apparatus](image-url)

FIG. 1 APPARATUS FOR TESTING DYNAMIC WATERPROOFNESS
c) The upper surface of the platform $C$ is roughened and covered by a strip of cotton gauze, which is kept moist by a slow flow of distilled water through the tube $E$.

d) Pieces of absorbent cellulosic board in the shape of rectangles $100 \times 60$ mm, and cut from a sheet 1.5 to 1.7 mm thick with a weight of about 1 200 g/m$^2$. A suitable board is of strong bleached or semi-bleached kraft pulp. For measurements of water penetration, a weighed piece of this is placed between the roller and the leather test piece so as to cover the whole of its upper surface.

e) Apparatus for measuring time, and an automatic, or semi-automatic balance for rapid weighings of the leather and pieces of board.

5. TEST PIECE

5.1 The test pieces are rectangles $100 \times 40$ mm. Unless otherwise specified, cut the test piece from the sampling location specified in 3.1 of LP:0 with their longer sides parallel to the backbone. On a piece of grade 120 emery paper, place that surface of the leather test piece which in wear would be in contact with the ground (normally the grain surface). Press the test piece against the emery with a load of 1 kg. Roughen the leather surface slightly by moving the test piece 10 times backwards and forwards over the emery for about 100 mm each time.

Smear the cut edges of the test piece with petroleum jelly to prevent them from absorbing water. Condition the test piece in accordance with 5.1 of LP:0 and weigh it.

NOTE — A thin waterproof finish applied to the grain of sole leather may greatly reduce penetration of water into it during the test, but be quite ineffective on a sole because it is rapidly removed in wear. For this reason, the test pieces should be roughened before test, as described in the method.

6. PROCEDURE

6.1 Condition the test piece in accordance with 5.1 of LP:0 and weigh it. Measure its thickness. From the absorbent board cut rectangles $100 \times 60$ mm. Condition them, and weigh each. Maintain the cotton gauze moist with a slow flow of distilled water, lay the test piece on the gauze with the roughened (grain) surface downwards, and attach its end to the platform and roller. Set the roller in motion and note the time.

NOTE 1 — An optical or a coustic signal may be used to show when water has penetrated through the test pieces. If penetration is assessed by repeated visual inspection, water should be taken to have penetrated a water absorbent test piece when one area of about 5 mm diameter or two areas of about 2 mm diameter have become wetted on the upper surface. For test-pieces which are highly water repellent, the appearance of one or more droplets on the upper surface indicates that penetration has occurred.

NOTE 2 — The period when the machine is stopped for weighing the test piece of for insertion or removal of the absorbent board should be made as short as possible and the fact that the machine was stopped during these periods should then be ignored in the measurement of the longer time intervals. In measurement of $R$, however, the intervals of 10 minutes shall be accurate.
6.3 Water Absorption — At the end of the first hour of test, or at such other times as may be specified remove the test piece, blot it lightly with filter paper to remove water adhering to its surfaces, weigh it, and immediately return it to the machine to continue the test. Repeat this procedure at the end of each hour until the test is completed.

NOTE — It is generally convenient to measure water absorption and water penetration rates at intervals of one hour (For example, after 1, 2, 3, …… hours flexing), but for some leathers shorter intervals may be more appropriate.

6.4 Water Penetration — Beginning at the end of the hour during which first penetration occurs, measure the water penetration as follows. Stop the machine. Wipe the roller to remove any water adhering to it. Place a weighed piece to the absorbent board between the test piece and roller to absorb water which penetrates through the leather, and switch on the machine again. At the end of a further 10 minutes, remove the board and weigh it. Repeat this procedure at the end of each further hour until the test is completed.

NOTE — At the time when the absorbent board used for measurement of water penetration rate is removed from the machine for weighing, parts of it should still be dry, (that is, similar in feel and appearance to the same board after conditioning). If it has no dry parts, all the results of the first test (including penetration time and water absorption) shall be rejected, and the test repeated with another test piece and piece of absorbent board. In the second test of water penetration, the interval should be reduced from 10 minutes to such a value as leaves parts of the absorbent board dry; in calculating $R$, the fact that a reduced interval was used shall be taken into account.

7. RESULTS

7.1 Report the following:

a) Penetration time.

b) Water absorption $\rho$. Indicate clearly the time interval to which it corresponds (for example, water absorption for the period three to four hours).

c) Water penetration rate:

$$\text{Water penetration rate } (R), \frac{g}{dm^2/h} = 15 \ m$$

where

$m = \text{the gain in weight of the absorbed board in g for a ten-minute period.}$

State clearly the time interval to which $R$ refers by reference to the time at the beginning of the interval, for example, 'R = 12 g/dm²/h at time three hours' should be understood to mean the mean rate of the period from 3 h to 3 h 10 min from the beginning of flexing (not from the time of first penetration).

d) The thickness of each test piece as well its penetration time, water absorption and water penetration rates.
FLEXING ENDURANCE  
(LP: 19)  
(Adopted from IUP/20*)

1. SCOPE

1.1 This method is intended for use on light leathers for assessing their flexing endurance as well as their surface finishes.

2. OUTLINE OF METHOD

2.1 The test piece is folded and clamped at each end to maintain it in a folded position in a machine designed to flex it. One clamp is fixed and the other moves backwards and forwards causing the fold in the test piece to run along it. The test piece is examined periodically to assess what damage has been produced.

3. APPARATUS

3.1 A general view of the apparatus is shown in Fig. 1.

---

3.2 The apparatus consists of the following:

a) **Upper Clamp** — The upper clamp consists of a pair of flat plates. One has the shape of a trapezium $ABCD$ (Fig. 1) with the sharp corner at $D$ rounded to a radius of 2 mm. It has a ledge $EF$ on which the folded test piece rests. The other plate has the shape $ECHCF$. It is possible to screw the two plates together, so as to hold one end of the test piece between them as shown in Fig. 3 (A). The screw $K$ which draws the plates together acts also as a stop, which prevents the end of the test piece from being thrust too far towards the back of the clamp. Between the plates near the edge $AB$ is a stop which prevents them from coming together near $AB$, and so ensures that they clamp the leather firmly near $F$. The upper clamp may be reciprocated by a motor about a horizontal axle $J$ (Fig. 2). In the position shown in Fig. 2 the ledge $EF$ is horizontal, and the end $F$ is at its highest point. The clamp descends through an angle of $22\frac{1}{2}^\circ$ and returns $100 \pm 5$ times per minute. The number of cycles is recorded by a counter.

![Diagram of Upper Clamp for Holding the Test Piece](image)

All dimensions in millimetres.

**FIG. 2 UPPER CLAMP FOR HOLDING THE TEST PIECE**
b) **Lower Clamp**—The lower clamp is fixed and lies in the same vertical plane as the upper clamp. It consists of a pair of plates which are possible to be screwed together to hold the other end of the test piece between them. If the upper clamp has been turned to the position where the ledge $EF$ is horizontal (Fig. 2) the upper edges of the plates of the lower clamp are 25 mm below the ledge $FF$.

### 4. TEST PIECE

4.1 Cut out test pieces rectangular in shape $70 \times 45$ mm from the sampling location specified in 3.1 of LP:0 unless otherwise specified. Condition them in accordance with 5.1 of LP:0.

### 5. PROCEDURE

5.1 **Insertion of Test Piece in Clamps**—Turn the motor until the ledge $EF$ is horizontal. Fold the test piece so that the two longer sides are brought together, turning inwards that surface of the leather which is to be observed during the test. (Unless otherwise specified, fold the leather grain inwards.) Clamp the folded test piece in the upper clamp as shown in Fig. 3A, with one end of the test piece against the stop and the folded edge against the ledge. Draw the free corners of the test piece outwards and downwards as shown in Fig. 3B, so that the surface which is turned inwards in the clamp is turned outwards below it. Draw the test piece down, bringing together its two corners which have not been clamped; clamp it in the lower clamp as shown in Fig. 3C with the part of the fold between the clamps vertical, and using no more force than is needed to make the leather just taut (see Note).

**NOTE**—The force needed to pull the leather taut when first clamping the test pieces in the machine depends upon the thickness and stiffness of the leather. The force applied should not exceed what is needed to pull the leather taut.

5.2 **Flexing**—Clamp the test piece in the machine in the manner described in 5.1, and switch on the motor. After 100, 1000, and 10000 cycles, switch off the motor and examine the leather finish to see whether it has been damaged. Record any damage observed, its nature and the number of cycles at which it was observed. After 2, 4, 6, 8, 12, 16, 24, and 32 hours of flexing, examine the leather itself to see whether it has been damaged. Record any damage observed, its nature and the number of cycles at which it was observed.

5.2.1 To find whether it has been damaged, remove the test piece from the clamps for examination, if necessary, and subsequently return it for further flexing. When it is replaced, it should be clamped as nearly as possible in the same position as before. Use the clamps marks as a useful guide for replacing the test piece correctly. If the test pieces extend during flexing, do not pull them taut while removing and replacing.
5.2.2 If the machine is stopped for any considerable time (for example, overnight) while test pieces are clamped on it, the clamp should be rotated to a position such that the test pieces are not fully extended.

5.2.3 For examining the finish of a leather damage, illuminate surface and use a magnifying glass giving about six-fold magnification, if necessary.

6. REPORT

6.1 The report as to the damage of the finish shall include description of damages of the following kinds:

a) Change of shade (greying) of the finish film without other damage;

b) Crazing of the finish with smaller or greater surface cracks;

c) Loss of adhesion of finish to the leather with slight or considerable changes of colour in the folded area;

d) Loss of adhesion of one finish layer to another, with slight or considerable changes of colour; and

e) Powdering or flaking off of finish, with slight or considerable changes of colour.
6.2 The report as to the damage of the leather shall include description of damage of the following kinds:

a) Development of coarse grain folds (called 'pipey grain');

b) Loss of an embossed grain pattern;

c) Cracking of the grain layer;

d) Powdering of the fibres (usually on the flesh side or in the corium rather than in the grain layer); if much powdering has occurred, the leather may develop an empty feel, even if there is little sign of powder on its surfaces; and

e) Continuation of the breakdown of fibres to such an extent that a hole develops through the entire thickness of the leather.
DYNAMIC WATERPROOFNESS TEST FOR UPPER LEATHER  
(LP: 20)  
(Adopted from IUP/10*)

1. SCOPE

1.1 This method describes procedures for determining the degree of waterproofness of boot or shoe upper leather under dynamic conditions simulating the conditions of wear.

2. TERMINOLOGY

2.0 For the purpose of this method, the following definitions shall apply.

2.1 Penetration Time — The duration of flexing in minutes which just causes penetration of water to occur.

2.2 Water Absorption — Mass of water absorbed by the leather during a specified interval and expressed as a percentage of the initial mass of the leather.

2.3 Water Transmission — The mass of water which passes through the leather in a specified time interval and measured by the gain of mass.

3. PRINCIPLE OF METHOD

3.1 The leather test piece is flexed on a machine in a manner simulating conditions of wear. Measurements are made of the following quantities:

   a) The duration of flexing which is just sufficient to cause water to penetrate through the test piece from one face to the other;

   b) The percentage gain of water $\rho$ of the test piece due to water absorption during one or more specified time intervals from the beginning of flexing; and

   c) The mass of water which is transmitted through from one face to the other during one or more specified time intervals.

4. TEST PIECE

4.1 The test piece is a rectangle $75 \times 60$ mm. Unless otherwise specified, cut it from the sampling location specified in 3.1 of LP: 0 with the longer sides parallel to the backbone. Condition the test piece in accordance with 5.1 of LP: 0.

5. APPARATUS

5.1 The apparatus consists of the following parts (see Fig. 1):

a) Two cylinders, 30 mm in diameter, made of inert, rigid material which is an electrical insulator. They are mounted with their axes horizontal and co-axial. One cylinder is fixed, and the other is movable along the direction of its axis.

b) An electric motor which drives the movable cylinder backwards and forwards along its axis with crank motion at 50 cycles per minute, and with amplitude 1.0, 1.5, 2.0 or 3.0 mm about its mean position. When the movable cylinder is at its greatest distance from the fixed one, the adjacent flat faces of the two cylinders are 40 mm apart. The four amplitudes of the crank motion are such that the length of the trough is reduced by 5, 7.5, 10 or 15 percent when the cylinders approach one another.

c) Ring-shaped clamps (similar to jubilee clips) to clamp the longer edges of the test piece round the adjacent ends of the cylinders so that the leather forms a trough whose ends are closed by the cylinders.
d) A tank containing distilled water, in which the trough-shaped test piece may be partly immersed.

e) An electrically operated device which provides a signal to indicate when penetration of water through the test piece has occurred. This consists of a mass of fine, spiral, brass lathe turnings forming an easily compressible conducting cushion which occupies about two-thirds of the space in the leather trough; a metallic plate electrode which makes contact with the top of the turnings; and a suitable electric circuit which gives a signal when the electrical resistance between the plate electrode and the water in the tank decreases below a fixed value.

f) Absorbent cloth for absorbing water which is transmitted to the interior of the trough formed by the test piece. Each absorbent cloth consists of a rectangle 120 × 40 mm. A suitable cloth is terry towelling, weighing about 300 g/m².

g) Apparatus for measuring time, and an automatic or semi-automatic balance for rapid weighing of the test piece and pieces of absorbent cloth.

   NOTE 1 — The plate electrode is carried by a spring, and the load it applies when resting on the brass turnings or on the roll of absorbent cloth should lie in the range 100 to 200 g.

   NOTE 2 — Terry towelling is a wrap pile fabric with a pile in the form of loops, made principally in cotton, and used for towelling, beach robes, bath mats, etc. If the new fabric is not readily wettable, it should be washed and dried before use.

   NOTE 3 — The brass lathe turnings should be long, thin and springy and, therefore, be from a brass of low lead content.

6. PROCEDURE

6.1 Cut out a test piece as described in 4.1. Unless otherwise specified, buff its grain surface lightly by rubbing it with emery paper, grade 180. Condition the test piece in accordance with the conditioning method for physical tests.

   6.1.1 To buff the leather, place its grain surface on a piece of grade 180 emery paper. Press it against the emery with a load of 1 kg uniformly distributed over the leather and move the test piece 10 times backwards and forwards over the emery for about 100 mm each time.

   NOTE — Many leathers have on the grain a surface coat which greatly increases the waterproofness of the leather. If micro cracks develop rapidly in this coat as the result of flexing in wear, or by abrasion in wear, measurements of waterproofness made on the leather as received may be misleading. The test pieces should, therefore, generally be abraded lightly on the grain before test. The purpose of this is not to remove the surface coat, but merely to scratch it lightly. If this is done, the reduction of waterproofness is not highly dependent on either the load applied in buffing or the duration of buffing.
6.2 If the amplitude of crank motion has not been specified or determined on other grounds, choose the most suitable amplitude for test by the method described in the Appendix A. Set the waterproofness testing machine to give the required amplitude. Weigh the sample. Call its mass \( m_1 \). With the two cylinders at their maximum distance apart, wrap the test piece round their adjacent ends so that it forms a trough whose upper edges, formed by the shorter sides of the test piece, are horizontal and at the same level. The outer surface of the trough is to be that surface of the leather which forms the outer layer when it is made up into footwear (normally the grain layer). Keep the leather between the cylinders under slight tension to remove folds, and with approximately the same length (about 10 mm) overlapping on each cylinder, and clamp it with the aid of the ring clamps. The inner edges of the two ring clamps should lie as nearly as possible in the planes of the adjacent ends of the cylinders, so that the length of the trough is the same as the free length of the leather between clamps. Insert the brass turnings, and lower the plate electrode to make contact with them (see Fig. 2).

![Fig. 2 Clamping of Test Piece with Plate Electrode Above](image1)

Raise the level of the water in the tank until its surface lies 10 mm below the top of the cylinders. Start the motor, and measure the time interval until water first penetrates through the test piece. At the end of the interval during which the water absorption of the test piece is to be measured, stop the motor, remove the test piece, blot it lightly to remove adhering moisture, and weigh it to find its mass \( m_2 \). If other measurements are to be taken on the same test piece, replace it as quickly as possible, and re-start the motor. Weigh the absorbent cloth just before it is to be used. At the beginning of the interval during which water transmitted is to be measured, remove the plate electrode and brass turnings, roll the cloth
so that it forms a cylinder 40 mm long and lay it in the trough formed by the leather. Replace the plate electrode so that it rests on the roll. At the end of the interval, remove the cloth (if necessary, use it to mop up any surplus water within the leather trough) and re-weigh it; let the masses of the cloth at the beginning and end of the interval be \( m_3 \) and \( m_4 \) grams.

6.3 Unless otherwise specified, measure the water absorption at hourly intervals from the beginning of the test, and water transmitted at hourly intervals beginning with the first hour after that in which penetration occurred.

6.4 If prescribed in the material specification, tests may be carried out at 0°C. This may be done by adding crushed ice to the water in the tank. It is not necessary then to cool the rest of the machine.

6.5 The time intervals during which the percentage water absorption and mass of water transmitted are to be measured should be specified in material specification from considerations of what is required of the leather in practical wear, as well as from considerations of convenience in testing. Either time interval may be specified as that between two times related to the moment when the test is begun that is an interval may be specified with reference to the time of first penetration of water, for example, as the 60 minutes following first penetration.

7. **CALCULATION**

7.1 Calculate the water absorption from the formula:

\[
\text{Water absorption, percent (}\rho\text{) } = \frac{100 \left( m_2 - m_1 \right)}{m_1}
\]

where

- \( m_2 \) = final weight in g of the blotted test piece at the end of the interval during which water absorption is measured, and
- \( m_1 \) = weight in g of the test piece.

7.2 Calculate water transmission from the following formula:

\[
\text{Gain in weight (} m \text{) = (} m_4 - m_3 \text{)}
\]

where

- \( m_4 \) = weight in g at the end of the time interval during which water transmission is measured, and
- \( m_3 \) = weight in g at the beginning of the time interval during which water transmission is measured.
8. REPORT

8.1 The report shall state the following for each test piece:

a) Contraction of length of test piece used in its test of waterproofness (5, 7.5, 10 or 15 percent);

b) Penetration time in minutes;

c) The time interval or intervals during which water absorption is measured and the value of $\rho$ for that interval; and

d) The time interval (or intervals) during which water transmitted is measured and the mass $m$ transmitted in that interval.

NOTE — For many purposes the logarithm of the penetration time is a better guide to water resistance than the penetration time itself, because when leathers are to be compared, the ratio of their penetration times is more informative than the difference of penetration times.

APPENDIX A

(Clause 6.2)

CHOICE OF AMPLITUDE OF CRANK MOTION

A-1. PURPOSE

A-1.1 Penetration through most upper leathers would be very slow if they were merely put into contact with water without flexing, and the rate of penetration of most leathers may be greatly accelerated by increasing the severity of the flexing (for example, by increasing the amplitude of the crank motion on the test machine). Experience shows that if all types of upper leather are flexed to the same extent when tested on the machine, the waterproofness of thick leathers in actual wear will be under-estimated, and that of thin leathers over-estimated. For this reason, the machine is so constructed that any one of four amplitudes may be chosen for particular tests.

A-2. APPARATUS

A-2.0 A general view of the auxiliary apparatus for choosing the amplitude of crank motions is given in Fig. 3.
FIG. 3 AUXILIARY APPARATUS FOR CHOOSING THE AMPLITUDE OF THE CRANK MOTION

A-2.1 A suitable apparatus to use for deciding whether a particular leather or group of leathers should be flexed with 5, 7.5, 10 or 15 percent amplitude has the following parts:

a) Two cylinders like those of the main apparatus mounted coaxially, and equipped with ring clamps for holding the leather test piece. One clamp may be advanced towards the second (without rotation) by turning a handle attached to the instrument. The movement of this clamp towards the other is shown on a dial gauge.

b) A cylinder containing a spring which is compressed when the moving clamp is advanced to reduce the length of the leather trough; the compression of this spring indicates what load is being applied. The construction of the instrument is such that loads above 12 kg may be used. If any test leads to a loading of 12 kg, stop the test, and take 12 kg as the reading.

A-3. PROCEDURE

A-3.1 The following method of using this auxiliary apparatus is recommended:

a) Clamp the test piece in the auxiliary apparatus with the cylinders 40 mm apart. Condition it mechanically by moving one cylinder 2 mm closer to the other (equivalent to 5 percent reduction in
length of the free part of the sample), at a speed of approximately 2 mm in five seconds. Withdraw the cylinder at the same speed to its original position. Again advance it to give the 5 percent reduction of length and immediately read the load.

b) Proceed as under (a) except that the reductions of length are to be 10 percent (4 mm) instead of 5 percent (2 mm).

c) If the mean value of readings according to (a) and (b) exceeds 10 kg, use 5 percent amplitude for the penetration tests. If the mean value lies between 5 kg and 10 kg, use 7.5 percent amplitude for the penetration tests.

d) If the mean value is less than 5 kg, make further measurements as under (a) except that the reductions of length are to be 15 percent (6 mm) instead of 5 percent. If the mean value of results obtained as under (a), (b), and (c) exceeds 2 kg, use 10 percent for the penetration tests, and if it is below 2 kg use 15 percent.
1. SCOPE

1.1 This method describes a procedure for measurement of water vapour permeability of all types of leathers.

2. PRINCIPLE OF METHOD

2.1 The leather test piece is clamped across the mouth of a bottle which contains a solid desiccant, and is kept in a rapid current of air in a conditioned room. The air within the bottle is circulated by keeping the desiccant in motion. The bottle is weighed periodically to determine the mass of vapour transmitted through the leather and absorbed by the desiccant.

2.2 The water vapour permeability $P$ given by the equation in 6.1 is the permeability for a relative humidity difference of 65 percent between the faces of the leather and at 27°C. For changes of humidity at constant temperature the permeability of most leathers increases approximately in the same ratio as the difference of relative humidity. At constant relative humidity differences, the permeability usually increases with temperature approximately in the same ratio as the saturation vapour pressure of water.

3. APPARATUS

3.1 The apparatus consists of the following:

a) Bottles of the approximate shape shown in Fig. 1 with screw tops cut away to leave a circular opening. The neck of each bottle is ground to give a flat end surface which is perpendicular to the interior wall of the neck, and the circular opening in the cap has the same diameter as the interior wall (each approximately 30 mm).

b) A bottle holder in the shape of a wheel which is rotated at 75 ± 5 revolutions per minute by an electric motor. The bottles are mounted on the wheel with their axes parallel to the axle (Fig. 2) and at a distance 67 mm from it.

c) A fan mounted in front of the mouths of the bottles and consisting of three flat blades in planes that are inclined at 120° to one another. The planes of the blades pass through the prolongation

of the axle of the wheel. The blades are of dimensions approximately $90 \times 75$ mm, and the $90$ mm long side of each blade nearest the mouths of the bottles passes them at a distance of not more than $15$ mm. The fan is driven by the motor at $1400 \pm 100$ revolutions per minute. The apparatus is used in a conditioned room at a temperature of $27 \pm 2^\circ$C and relative humidity $65 \pm 2$ percent.
d) Silica gel which has been freshly dried for at least 16 h in a ventilated oven at 125 ± 5°C and cooled for at least 6 h in a closed bottle. The particle size of the gel is sufficiently large to prevent it passing a 2.00-mm IS sieve.

NOTE — The silica gel should be sieved before drying to remove small particles and dust. The drying temperature of 125°C should not be greatly exceeded without reducing the absorptive capacity of the gel. Ventilation of the oven by use of a fan is not necessary, but the oven shall not be sealed; it should permit continuous exchange of the air within the oven with that outside. The gel should not be used while it is much warmer than the leather test pieces, and since it cools slowly in a closed bottle, a long cooling time is needed.

e) A balance for weighing to the nearest milligram; means of measuring time; vernier calipers reading to 0.1 mm for measuring the internal diameters of the necks of the bottles.

4. TEST PIECE

4.1 From the leather to be tested cut out a square piece of side 50 mm. Unless otherwise specified, buff the grain surface lightly, as follows:

Place the piece grain upwards on table. Press a piece of grade 180 emery paper against the leather, and draw it across the leather 10 times in various directions under a load of about 200 g uniformly applied by hand pressure. From the piece of leather so buffed, cut circular test pieces whose diameters are equal to the exterior diameters of the necks of the bottles (approximately 34 mm).

4.1.1 Many leathers have on the grain a surface coat which reduces the water vapour permeability of the leather, but which has less effect after the coat has been flexed or exposed to slight abrasive action. Unless otherwise specified, test pieces should, therefore, be buffed lightly on the grain before test. The purpose of this is not to remove the surface coat, but merely to scratch it slightly. The load applied in doing this is not critical, and the value of 200 g is merely quoted as a rough guide. Since the leather may be distorted by the buffing, the circular test piece should not be cut until after the leather has been buffed.

5. PROCEDURE

5.1 Put into a bottle about half the amount of freshly dried silica gel that is required to fill it. Clamp the test piece, grain inwards, across the mouth of the bottle. Put the bottle into its holder on the machine, and start the motor. Using vernier calipers, measure the internal diameter of the neck of a second bottle to the nearest tenth of a millimetre in each of two directions at right angles. Calculate the mean diameter $d$ in millimetres. If it is necessary to seal the junction between the test piece and the neck of the bottle warm the second bottle and apply a thin layer of beeswax to the flat end surface of the neck. After the machine has been running for
more than 16 h and less than 24 h, stop the motor, and remove the first bottle. Put into the second bottle about half the amount of freshly dried silica gel that is needed to fill it, and at once remove the test piece from the first bottle and clamp it, grain inwards, across the mouth of the second bottle. With as little delay as possible, weigh the second bottle with the test piece and silica gel, and not the time at which the weighing is made. Put the bottle into its holder on the machine, and start the motor. After the machine has run for not less than 7 h and not more than 16 h, stop the motor, remove the bottle and weigh it. Note the time at which the weighing is made.

NOTE 1 — For most light leather test pieces there is no need to seal the junction between test piece and bottle with beeswax because the test piece is sufficiently well clamped if the lid is screwed down firmly, but leathers whose thicknesses exceed 3 mm are often stiff and should be sealed with beeswax as described. Furthermore, even test pieces of light leathers should be sealed with beeswax if their permeability is low or if they have an embossed grain, since it is not possible to assume that leaks are completely absent at the edges of test pieces which are merely clamped. For this reason, if a test piece tested without sealing gives a value of \( P \) of less than 5 mg cm\(^{-2}\) h\(^{-1}\), the determination should be repeated with the rim sealed with beeswax as described, and the value so obtained should be taken as the value for the test piece. Except with specially stiff or impermeable leathers, it is not necessary to seal the junction the test piece makes with the neck of the first bottle (see 5.1), because the preliminary running with this bottle serves merely to condition the test piece to equilibrium with the steady-state flow of vapour.

NOTE 2 — If the leather is such that beeswax has been applied to the neck of the second bottle, warm the bottle in an oven at 50°C before introducing the silica gel and clamping on the leather.

6. CALCULATION

6.1 Calculate the water vapour permeability \( (P) \) from the following equation:

\[
\text{Water vapour permeability, } mg/cm^2/h = \frac{7639 m}{d^2 t}
\]

where

\( m = \) gain in weight in g between first and second weighings of the bottle,

\( d = \) mean internal diameter in mm of the neck of the second bottle, and

\( t = \) time in minutes.
WATERPROOFNESS OF GLOVING LEATHERS

(LP : 22)

(Adopted from IUP/14*)

1. SCOPE

1.1 This method prescribes a procedure for measurement of waterproofness of gloving leathers.

2. PRINCIPLE OF METHOD

2.1 The test piece is placed on the wetted surface of a metal block. The upper surface of the test piece is pressed intermittently by a hammer which falls on it. The number of taps required to produce penetration of water through the test piece is noted, and the test piece is weighed to determine the mass of water it absorbs.

3. APPARATUS

3.1 The apparatus consists of the following (see Fig. 1):

a) A brass anvil $A$ on which the test piece is placed. The top of the anvil consists of a circular cup of diameter 38 mm with a raised flat and smooth circular base of diameter 32 mm surrounded by an annular channel of depth and width 3 mm. Water is supplied by a constant head device (not shown) in which the water level is 4 to 6 mm above the level of the raised flat base of the cup. It flows to the chamber $C$ through a tube $B$, and from $C$ is led up to the base of the cup through four holes $D$ of diameter 0.4 mm, each situated 3 mm from the centre of the base and on the two mutually perpendicular lines through the centre. Surplus water drains away through the tube $E$.

b) A hammer whose head consists of a stainless steel bearing ball of diameter 25 mm, mounted in a brass casing which is rigidly attached to, but is electrically insulated from, an arm $G$. The arm is pivoted in ball races at $H$, and when $F$ rests directly on the anvil the arm is horizontal. The distance from $H$ of a vertical line through the centre of $F$ is then 150 mm, and the distance of $H$ from the other end of the arm $G$ is 75 mm. The arc carries two sets of weights $J, K$ which are such that $F$ applies a steady force of $100 \pm 2$ grams-weight, and the moment of inertia about $H$ of the arm and its attachments is $80 \pm 5$ kg.cm$^2$.

c) A shaft whose axis passes through \( L \). The shaft is mounted in ball races and is driven by an electric motor at 30 ± 2 revolutions per minute. A circular plate \( M \) is fixed to the shaft and rotates with it. A steel cam is in the form of two semicircles of diameters 86 and 102 mm joined along their diameters so that their arcs meet smoothly at \( M \) and form a step at \( P \). The cam is attached to \( M \) and rotates with it in the direction shown; but its action on a phosphor-bronze plate \( O \) attached to the arm \( G \), it alternately raises the ball \( F \) and lets it fall. When the arm \( G \) is horizontal, the point \( L \) is situated 59.0 ± 0.5 mm above the top surface of \( Q \), and vertically above the end of \( Q \) and the arm \( G \). The attachment of the cam to the plate \( M \) is such that adjustments are possible to the machine by moment of the cam relative to \( M \) along the line \( NLP \). In the mid-position of the cam the point \( L \) is at the mid-point of the diameter of the smaller semicircle.

d) A counter which records the number of taps made by the hammer.

e) A suitable electrical circuit and auxiliary apparatus which provide an audible or visual signal when penetration of water through the test piece occurs. One lead from the circuit is attached to the anvil \( A \). The other lead consists of a flexible insulated wire which is supported near \( H \) on the frame which carries the arm \( G \); this lead makes electrical contact with the casing in which \( F \) is mounted. The apparatus is set to provide a signal when the resistance between \( A \) and \( F \) falls below about 50 000 ohms (see Note; and Note 2 under 5.1).

NOTE — When water penetrates a test piece its resistance falls very rapidly from a value of several megohms to a few thousand ohms or less. The resistance at which the circuit provides a signal is not, therefore, critical.

f) An automatic, or semi-automatic balance for weighing test pieces to the nearest milligram.

4. TEST PIECE

4.1 From the leather to be tested cut out a square piece of side 50 mm. Unless otherwise specified, buff the leather surface lightly, as follows. Place the piece on a table with that surface upwards which, in use will be on the outside of the glove (normally the grain layer). Press a piece of grade 180 emery paper against the leather, and draw it across the leather 10 times in various directions under a load of about 200 g uniformly applied by hand pressure. From the piece of leather so buffed cut a test piece in the form of a circle of diameter 37 mm and condition it in accordance with 5.1 of LP:0.
4.1.1 Some leathers have on the grain a surface coat which greatly increases the waterproofness of the leather. If microcracks develop in this coat during wear, measurements of waterproofness made on the leather as received may be misleading. The test piece should, therefore, generally be buffed lightly before test. The purpose of this is not to remove the surface coat, but merely to scratch it slightly. The load applied in doing this is not critical and the value of 200 g is merely quoted as a rough guide. Since the leather may be distorted by the buffing, the circular test piece should not be cut until after the leather has been buffed.

5. PROCEDURE

5.1 Adjustment of the Machine — Raise that end of G which carries the ball F. Place a metal block which is 25.0 mm thick on the raised circular base of the cup, and lower F until it rests on the block. Adjust the position of the cam on the plate M until the cam just fails to touch the plate O when the cam rotates. Clamp the cam in this position and remove the block from the cup.

NOTE 1 — Once the machine has been adjusted to give the correct height of fall of the hammer, it is not likely to need this adjustment again. Nevertheless, the adjustment should occasionally be checked in the manner indicated.
NOTE 2 — If the height of fall differs by a few millimetres from the standard height of 25 mm, the results obtained on any leather are only slightly modified. For this reason, the apparatus is adjusted without a test piece on the anvil, and no account is taken of the fact that the fall of the hammer is somewhat less for thick leather than for thin.

NOTE 3 — To prevent the anvil and the bearing ball, the letter should be dried with a cloth after use and a rubber disc of the same size as test piece should be put in the cup until the machine is needed again.

5.2 Maintain a flow of distilled water to the constant head apparatus, thus keeping the upper surface of the anvil wet. Weigh the buffed and conditioned test piece. (All weighings are to be made to the nearest milligram). Place the test piece in the cup with its roughened surface on the wet surface of the anvil, and at once start the motor. After 20 taps, stop the motor, remove the test piece, and blot it lightly with dry blotting paper. Reweigh the test piece, replace it in the cup, and restart the motor (see Notes 1 and 2). After a further 980 taps (that is, after 1000 taps in all), stop the motor, remove the test piece, blot it lightly, and reweigh it. Note the number of taps at which penetration of water through the test piece occurs.

NOTE 1 — The first 20 taps generally produce a relatively rapid water absorption by the leather, and the gain of weight for 20 taps is a measure of this. After 1000 taps, the gain of weight is generally slow, so the gain at 1000 taps is a measure of the final water uptake.

NOTE 2 — The test pieces shall not be compressed when they are blotted. It is sufficient to place them on the blotting paper and draw them gently along it for one to two seconds.

6. REPORT

6.1 Report the following:

a) The gain of weight of the test piece in milligrams for the first 20 taps,

b) The gain of weight for the first 1000 taps, and

c) The number of taps at which first penetration occurred.

NOTE — For many purposes the logarithm of the number of pats is a better guide to water resistance than is the number itself, because, when leathers are compared the ratio of the number is more informative than their difference.
1. SCOPE

1.1 This method describes a procedure for determining the bond strength of two or more pieces of leather cemented together.

2. PRINCIPLE OF METHOD

2.1 This test procedure measures the adhesive strength of the cement used to bond together the laps of single-ply and the piles of double-ply such as belting leather. The method of reporting the results assumes that the adhesive strength is directly proportional to the width of the test piece. This method is used to ensure that the bond strength is in excess of certain minimum levels established by practical experience. The actual value recorded is the minimum load required for separation of the test piece. It is not possible to specify exactly the nature of the frequency distribution of the data secured by this method, but experience has shown that the values, according to their use, may vary over a 3 to 1 range from the highest to the lowest for belting leathers.

3. APPARATUS

3.1 The testing machine shall consist of the following:

   a) Tension Testing Machine — a power-driven machine in which the test piece is held between two grips and strained by a uniform movement of the pulling grip.

   b) Grips — The design of each grip shall be such that one jaw shall be an integral part of the rigid frame of the grip and the other shall be on a part hinged or swivelled to the movable member of the grip. The face of each jaw of each grip shall be 80 × 40 mm or more with the 80 mm dimension perpendicular to the direction of application of the force. The surfaces of the jaws shall be flat and knurled to prevent slipping of the test piece during test. The rate of travel of the power-actuated grip shall be 250 ± 50 mm/min and shall be uniform at all times.

   c) Recorder — The scale or automatic recorder shall permit the indication of the applied tension to the nearest 0.25 kg. Since the minimum load to separate the plies is to be detected, any test instrument, such as an inclined-plane tester, which is equipped with pawls which permit only unidirectional motion of the load sensing system, shall be operated with these pawls at rest.
4. TEST PIECE
4.1 A test piece 300 × 75 mm (or the full width of the unit if it is less than 75 mm wide) which includes a lap shall be cut so that no portion of the lap is nearer to one end than 75 mm.

5. PROCEDURE

5.1 Conditioning — Unless otherwise specified, soak the test piece in water at room temperature (27 ± 2°C) for 24 h and test immediately while wet.

5.1.1 Single Ply — After the test piece has been soaked in water, pry open the lap on the flesh side for a distance of 25 mm. Insert the end of the opening lap in one jaw of the testing machine and the end of the piece of test piece from which the other lap is formed into the other jaw so that when a force is applied the lap will open. Record the minimum load required to separate the bond.

5.1.2 Double Ply — After the test piece has been soaked in water, separate the plies at the end nearest the flesh part of the lap for a distance of 75 mm. Insert the end of one ply in one jaw of the testing machine and the end of the other ply into the other jaw so that when a force is applied the plies will separate. Record the minimum load required to separate the bond. Test the bond strength of the lap of one ply as described in 5.1.1.

6. REPORT

6.1 The report shall indicate the minimum load required to separate the bond, expressed in kilograms per centimetre of width for each test piece.
THERMAL CONDUCTIVITY CONSTANT OF LEATHER

( Adopted from ASTM Designation : D 2214-63 T )

0. GENERAL

0.1 This method is not limited to leather but may be used for any poorly conductive material, such as rubber, textiles and cork, associated with the construction of shoes. Test pieces up to 12 mm thick may be used.

1. SCOPE

1.1 This method describes a quantitative procedure for the determination of the thermal conductivity constant of leather. The measured parameters are the area, the thickness, and the temperature difference between the two sides of a leather test piece.

2. TERMINOLOGY

2.0 For the purpose of this method, the following definition shall apply.

2.1 Thermal Conductivity—The quantity of heat conducted per unit time through unit area of a slab of unit thickness having unit temperature difference between its faces.

3. PRINCIPLE OF METHOD

3.1 Part of the function of a shoe is to assist the foot in maintaining body temperature and to guard against large heat changes. The insulating property of a material used in shoe construction is dependent on porosity or the amount of air spaces present. A good insulating material has a low thermal conductivity value \(K\). The thermal conductivity value increases with an increase in moisture content since the \(K\) value for water is high, 14 by \(10^{-4}\) cal cm/sec cm\(^2\) deg C.

3.2 A conditioned test piece of leather is placed between two plates at different temperatures. The upper plate is at a constant temperature while the temperature of the lower plate is slowly changing. The temperature difference is measured by thermocouples. The rate of flow of heat through the test piece is proportional to the area and the temperature difference of the faces of the test piece, and inversely proportional to the thickness. Assuming no heat loss, the amount of heat flowing through the test piece per unit time is equal to the amount of heat received by the lower plate (copper block receiver) per unit time.
4. APPARATUS

4.1 Cenco Fitch Conductivity Apparatus — The apparatus shall consist of two parts, the source and the receiver. The source shall be a copper vessel, heat insulated on the sides. The base of the source shall be a heavy copper plate which shall be face-ground and nickel-plated. The receiver shall contain an insulated copper plug which shall also be face-ground. A copper-constantan junction shall be embedded in the base of the source and leads connected to a binding post in the side of the vessel. A second copper-constantan junction shall be embedded in the copper receiver and leads connected to a binding post on the side of the receiver. The mass of the copper plug shall be stamped on the receiver.

4.2 Galvanometer — A galvanometer with a linear scale shall be used to record the current or deflections. If the galvanometer is so sensitive that the readings are off scale; a shunt or fixed resistor may be connected between the galvanometer and receiver.

4.3 Immersion Heater — A knife-shaped heater shall be used to maintain a constant temperature of the liquid, — water at the boiling point.

4.4 Metal Plates — Two uniform metal plates, about 175 × 150 mm shall be used in measuring the thickness of the test piece. The test piece is sandwiched between the plates and the thickness measurement is made with the combination in place on the apparatus under testing conditions.

4.5 Micrometer — A micrometer shall be used to measure the diameter of the copper block and also to measure the thickness of the test piece.

4.6 Stop Watch — A stop watch may be used to measure the time intervals for taking galvanometer readings.

4.7 Weight, 5-kg — A weight of about 5 kg shall be placed around the collar of the vessel to ensure close contact between the surfaces of the apparatus and the test piece.

5. PROCEDURE

5.1 Assemble the apparatus as follows:

Connect one end of a constantan wire to the constantan terminal of the source and the other end to the constantan terminal of the receiver. Join one end of a copper wire to the copper binding post of the receiver and the other end to the positive binding post of the galvanometer. Connect a second copper wire to the copper binding post of the source and the other end to the negative binding post of the galvanometer. Fill the vessel with boiling water and place it upon the leather test piece. Keep the water boiling by means of the immersion heater. Continue heating until steady deflections are obtained.
on the galvanometer. Place the test piece and the vessel with a 5-kg weight around its collar on the receiver, which should be at room temperature. Measure galvanometer deflections, \( d \); at regular intervals of 1, 2, or 3 min, depending on the rate of heat conduction. Keep the water boiling with the aid of the immersion heater and replace the water evaporated by adding boiling water. Take about ten readings.

6. CALCULATION

6.1 Plot a graph of the data on semilogarithmic paper (2 cycles by 70 divisions). It may be shown mathematically that:

\[
t = -2.303 \times \frac{lMC}{KA} \times (\log d - \log d_0)
\]

where

- \( t \) = time, in minutes;
- \( l \) = thickness of test piece, in cm;
- \( M \) = mass of copper block, in g;
- \( C \) = specific heat of copper block = 0.093 cal/g deg C;
- \( K \) = thermal conductivity;
- \( A \) = area of copper block, in \( \text{cm}^2 \) = area of face of test piece; and
- \( d \) = deflections (\( d_0 \) = deflection at zero time).

Therefore, the graph of \( t \) as ordinate plotted against \( \log d \) as abscissa should be a straight line since all the other quantities including \( \log d_0 \) are constant.

The slope, \( m \), of \( t \) plotted against \( \log d \) is, therefore:

\[
m = -2.303 \times \frac{lMC}{KA}
\]

6.2 Inserting the value of the slope \( m \), obtained by calculation and multiplied by 60 sec as shown in the example in Appendix A, calculate the value of \( K \) in cal cm/sec \( \text{cm}^2 \) deg C, as follows:

\[
K = -2.303 \times \frac{lMC}{mA}
\]

7. PRECISION

7.1 The precision is in the order of a coefficient of variation of 8 to 10 percent. The precision depends on obtaining a series of points which lie on a straight line and drawing the best average line through these points to obtain a value for the slope. This may be done visually. However, the best average line and the slope are obtained more precisely and objectively by statistical calculations. An example of the method of calculation is given in Appendix A.
APPENDIX A  
(Clause 7.1)  
EXAMPLE OF METHOD OF CALCULATION OF THERMAL CONDUCTIVITY

A-1. Following is an example of a method to calculate the slope of a straight line and two points through which it is possible to draw the line:

a) Slope

<table>
<thead>
<tr>
<th>Time, Min</th>
<th>Deflections, d</th>
<th>log d</th>
<th>∑ t</th>
<th>∑ log d</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>0</td>
<td>24.0</td>
<td>1.380</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>23.0</td>
<td>1.362</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>22.0</td>
<td>1.342</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>21.5</td>
<td>1.332</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td>5.416</td>
</tr>
<tr>
<td>12</td>
<td>20.5</td>
<td>1.312</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>19.5</td>
<td>1.290</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>19.0</td>
<td>1.279</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>45</td>
<td>3.881</td>
</tr>
<tr>
<td>21</td>
<td>18.1</td>
<td>1.258</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>17.1</td>
<td>1.243</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>17.0</td>
<td>1.230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>16.5</td>
<td>1.218</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>102</td>
<td>4.949</td>
</tr>
<tr>
<td>Total</td>
<td>165</td>
<td></td>
<td></td>
<td>14.246</td>
</tr>
<tr>
<td>Average</td>
<td>15.00</td>
<td></td>
<td></td>
<td>1.2951</td>
</tr>
</tbody>
</table>

\[ \text{Slope, } m = \frac{- (102 - 18)}{5.416 - 4.949} = \frac{-84}{0.467} = -179.87 \]

\[ m' = m \times 60 \text{ sec} = -179.87 \times 60 = 10\,792.2 \]
b) Equation of line Passing Through $t$ and log $d$:

$$t = (t - m \log d) + m \log d$$

$$t = [ 15 - ( -179.87 ) ( 1.2951 ) - 179.87 ( \log d ) ]$$

$$t = 247.95 - 179.87 ( \log d )$$

Take two values of log $d$ at extremes as follows:

1) When log $d = 1.362; \ t = 2.97$
2) When log $d = 1.218; \ t = 28.87$

The line goes through the two points as follows:

<table>
<thead>
<tr>
<th>Point</th>
<th>$t$</th>
<th>log $d$</th>
<th>$d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.97</td>
<td>1.362</td>
<td>23.0</td>
</tr>
<tr>
<td>2</td>
<td>28.87</td>
<td>1.218</td>
<td>16.5</td>
</tr>
</tbody>
</table>
AREA STABILITY OF LEATHER ON IMMERSION IN WATER AND OIL
(LP: 25)

(Adopted from ALCA methods)

1. SCOPE

1.1 This method covers the determination of the area stability of leather in water and oil. The procedure is applicable to mechanical leathers. Suggested times and temperatures are given.

2. PRINCIPLE OF METHOD

2.1 This method is intended to detect practical differences in area changes of leathers when the leathers are immersed in water and oil at given temperatures and exposure times.

3. APPARATUS

3.1 Thermometer — Immersion thermometer having a range from –20 to 150°C.

4. REAGENTS

4.1 Distilled Water — conforming to IS : 1070-1960*

4.2 Immersion Oil — oil of following description:

- Aniline point, °C: 123.9 ± 1
- Kinematic viscosity measured at 99°C, m²/s: $19.5 \times 10^{-6} \pm 2 \times 10^{-6}$
- Flash point, °C, Min: 244

*Specification for water, distilled quality (revised).

NOTE — Any other oil or oil mixture may be specified depending on the service condition.

5. TEST PIECE

5.1 The leather test piece shall be a piece 5.08 ± 0.07 cm in area. A small hole, not in excess of 0.32 cm in diameter may be punched on the centre line of the test piece and 0.64 cm from the edge. Condition the test piece in accordance with 5.1 of LP : 0.

6. PROCEDURE

6.1 Measure the length of the test piece on the grainside along each of the four sides at a distance of 0.3 ± 0.1 cm from the edge and report the
average value. Compute the area by squaring the average value for the sides. Place the test piece to be measured, grainside up, on a smooth surface of contrasting colour, and place a ruler divided into 0.05-cm intervals on to the grainside, applying just enough pressure to flatten the test piece. Suspend the test pieces, not more than six per single test, on a copper wire in 800 ± 10 ml of distilled water or oil specified in 4.2 for a period of 16 to 24 h at room temperature. The test piece shall be not closer than 2.0 cm to the surface of the beaker from which the heat is applied. Space the test piece by brass nuts of 0.4 to 0.5 cm thickness. Also prevent the test pieces from touching the wall of the beaker by means of spacers. Heat the fluid at the rate of 3 to 5°C per minute until it reaches the test temperature and keep it at the test temperature for the length of time suggested below:

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Time</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>1 hour or as specified</td>
<td>Boiling temperature (tolerance ±2 percent)</td>
</tr>
<tr>
<td>Oil</td>
<td>&quot;</td>
<td>100 ± 2°C or as specified</td>
</tr>
</tbody>
</table>

Use a power stirrer for oil. If water is used, stir it by hand until the boiling temperature has been reached. After boiling has started replace the evaporated water by adding boiling water as soon as the water level has dropped 1.5 cm below the level reached when the boiling has started. At the end of the test time remove the test pieces from the fluid, wipe free of excess fluid, and allow to cool to room temperature. Compute the area as described above and record.

7. CALCULATION

7.1 Calculate the percentage area change as follows:

\[
\text{Area change, percent} = \frac{B - A}{A} \times 100
\]

where

- \( B \) = final area, and
- \( A \) = initial area.

8. PRECISION

8.1 Although the statistical analysis of area change data indicate poor quantitative precision, it is possible to rank leathers qualitatively in the order of their resistance to area change at given temperatures and exposure times.
1. SCOPE

1.1 This standard prescribes a method for estimating the water repellency (on the basis of the wetted area of the test piece) of clothing leathers.

1.1.1 This method is not intended for use in determining resistance to water penetration. A visual means is given to evaluate the relative effects of materials showing water repellence, but no comparison is possible with conditions found in actual use.

2. OUTLINE OF METHOD

2.1 The spray test consists essentially of allowing a spray of water to fall onto the test piece under test, under controlled conditions and comparing the effect with a standard chart. It measures the resistance of the clothing leathers to surface wetting, no account being taken of penetration. The spray test has the advantage that it can be carried out rapidly with the minimum of apparatus which can be readily assembled in a works laboratory and is very useful for routine checking of clothing leathers.

3. APPARATUS

3.1 For the purpose of this test, the following apparatus shall be used:

a) A Spray Device — consisting of a small brass perforated spray nozzle attached to the short stem of a funnel by means of a piece of rubber tubing (see Fig. 1). The face of the spray nozzle shall be 38 mm in diameter and shall have 19 holes, each 0.89 mm in diameter, the holes being arranged in two concentric circles around a central hole in the convex face of the spray nozzle. The outer circle shall be 25 mm in diameter and shall contain 12 holes and the inner circle shall be 12 mm in diameter and shall contain 6 holes. The spray nozzle shall be so fixed that its face is 75 mm below the neck of the funnel. The spray device shall be so constructed that 250 ml of water should take 25 to 30 seconds to spray on the test piece and the spray should cover an area approximately 150 mm in diameter in a horizontal place 150 mm below the perforated spray nozzle.
b) Stand — consisting of a ring and a stand for fixing the 'spray device' (see Fig. 1) so that the face of the spray nozzle is 150 mm above the centre of test piece under test. The stand shall also be provided with a support for the test piece so that the latter is held at an angle of 45° to the vertical central line of the funnel, the spray device also being vertical.

c) Test-Piece Holder — a thin circular frame of 150 mm inside diameter, closely fitting in an outer circular frame, similar in construction to hoops used for embroidery (see Fig. 1).

All dimensions in millimetres.

FIG. 1 APPARATUS FOR SPRAY TEST
4. TEST PIECE

4.1 The leather test piece shall be a circular piece 230 ± 1 mm in diameter from the sampling location specified in 3.1 of LP: 0. Condition the test piece in accordance with 5.1 of LP: 0. At least four test pieces cut out from sampling locations of different skins, selected in accordance with IS: 5868-1969* shall be subjected to this test.

5. PROCEDURE

5.1 Mount the test piece in the test-piece holder, face uppermost, taking care to keep the former taut. Place the test piece so that under the spray nozzle on the support provided in the stand for this purpose in such a way that the grainside is approximately parallel to the direction of flow of water running off the leather. Pour quickly into the funnel 250 ml of water at 27 ± 2°C and allow it to spray on the test piece. (In order to make the degree of wetting more visible, colouring matter may be added to water, only such colours being used as do not affect the surface tension of water.)

NOTE—Where it is not possible to distinguish between the grain and the flesh, the surface of the test piece mounted shall be the one that is likely to become wet while in use, that is the side with nap.

5.2 Remove the test-piece holder from the stand when the spraying has ceased. Hold the test-piece holder so that, firstly, the lowest point of the holder during spraying is in the lowest position, secondly, the holder is slightly inclined to the vertical, and thirdly, the face of the test piece leans slightly forward, and tap the lowest point of the holder three times in succession against a horizontal surface.

5.3 Repeat the test with remaining test pieces.

6. RESULTS

6.1 Immediately after the tappings, compare under reflected light, the wetting of the face of the test piece with the photographic standard spray test rating (see Fig. 2). Assign the test piece under the test and standard spray test rating to which its wetting most nearly approximates.

6.2 Average of the standard rating obtained on evaluating all the test pieces rounded off to the nearest standard rating number, shall be held to be the rating number of the sample representing the lot.

*Methods of sampling for leather.
6.3 **Standard Rating** — The standard spray test rating shall be as follows:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>No sticking or wetting of the exposed face.</td>
</tr>
<tr>
<td>90</td>
<td>Slight random sticking or wetting of the exposed face.</td>
</tr>
<tr>
<td>80</td>
<td>Wetting of the exposed face at spray points.</td>
</tr>
<tr>
<td>70</td>
<td>Partial wetting of the whole of the exposed face.</td>
</tr>
<tr>
<td>50</td>
<td>Practically complete wetting of the whole of the exposed face.</td>
</tr>
<tr>
<td>0</td>
<td>Complete wetting of the whole of the face.</td>
</tr>
</tbody>
</table>