

International Standard



4586/2

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Plastics — Decorative laminated sheets based on thermosetting resins — Part 2 : Determination of properties

Plastiques — Plaques de stratifié décoratif à base de résines thermodurcissables — Partie 2 : Détermination des caractéristiques

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Foreword

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4586/2 was developed by Technical Committee ISO/TC 61, *Plastics*, and was circulated to the member bodies in August 1978.

It has been approved by the member bodies of the following countries:

Australia	Hungary	Romania
Austria	India	South Africa, Rep. of
Belgium	Iran	Spain
Brazil	Ireland	Sweden
Bulgaria	Israel	Switzerland
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Egypt, Arab Rep. of	Korea, Rep. of	USA
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Germany, F. R.	New Zealand	
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The member bodies of the following countries expressed disapproval of the document on technical grounds:

France
Netherlands

Plastics — Decorative laminated sheets based on thermosetting resins —

Part 2 : Determination of properties

1 Scope and field of application

This part of ISO 4586 specifies methods of test for determination of the properties of decorative laminated sheets as defined in clause 3. These methods are primarily intended for testing sheets for conformity with the requirements of ISO 4586/1.

2 References

ISO 48, *Vulcanized rubbers — Determination of hardness (Hardness between 30 and 85 IRHD)*.

ISO 62, *Plastics — Determination of water absorption*.

ISO/R 878, *Plastics — Determination of resistance of plastics to colour change upon exposure to light of the enclosed carbon arc*.

ISO/R 879, *Plastics — Determination of resistance of plastics to colour change upon exposure to light of a xenon lamp*.

ISO 4586/1, *Plastics — Decorative laminated sheets based on thermosetting resins — Part 1 : Specification*.

ISO 6506, *Metallic materials — Hardness test — Brinell test*.¹⁾

3 Definition

For the purpose of this International Standard, the following definition applies.

decorative laminated sheet : A sheet consisting of layers of fibrous sheet material (for example paper) impregnated with thermosetting resins and bonded together by means of heat and a pressure of not less than 5 MPa²⁾, the outer layer or layers on one or both sides having decorative colours or designs.

NOTE — Decorative laminated sheet as defined in this International Standard is made from core layers impregnated with phenolic resins and a surface layer or layers impregnated with aminoplastic resins (mainly melamine resins).

4 Thickness

4.1 Principle

Measurement of the thickness using a micrometer or a dial indicator.

4.2 Apparatus

Thickness gauge (ratchet-type micrometer or dial indicator), having two flat parallel measuring surfaces of diameter at least 6 mm and capable of being read to 0,01 mm. When the thickness of a decorative laminated sheet is being measured, the two surfaces shall exert a pressure of 10 to 20 kPa upon each other.

4.3 Test specimen

The specimen shall be the sheet under test, as received.

4.4 Procedure

Check the gauge for accuracy and then determine the thickness of the sheet to the nearest 0,02 mm. It is recommended that the thickness should be measured at a minimum of four points and at a distance of at least 20 mm from the edge of the sheet.

4.5 Test report

The test report shall state

- all values measured;
- the location of the points at which measurements were made.

5 Appearance

5.1 Principle

Inspection of sheets for surface appearance under standardized conditions of lighting and viewing.

1) At present at the stage of draft. (Revision of ISO/R 79-1968, ISO/R 191-1971, and ISO/R 403-1964.)

2) 1 MPa = 1 MN/m²

5.2 Apparatus

5.2.1 Horizontal inspection table, of height approximately 700 mm and large enough to accommodate the largest sheets to be inspected.

5.2.2 Overhead white fluorescent lights, of colour temperature approximately 5 000 K and giving an intensity of 800 to 1 000 lx over the whole area of the largest sheets to be inspected. A convenient distance of the lights from the inspection table is approximately 1,5 m.

5.3 Test specimen

The test specimen shall be the sheet under test, as received.

5.4 Procedure

Place the sheet, decorative face uppermost, on the inspection table. Wipe it free of any loose contamination, if necessary, with a soft cloth. Inspect it from the distance required by ISO 4586/1 for defects such as smudges, smears, finger-prints, scratches, foreign particles, damage or any other form of blemish evident within the decorative surface.

The inspector shall have normal vision, corrected if necessary. No magnifying glass shall be used in viewing the sheet.

5.5 Test report

The test report shall state the viewing distance and any defects observed.

6 Resistance to surface wear

6.1 Principle

Determination of the ability of the decorative surface of the sheet under test to resist abrasive wear through to the sub-layer.

Abrasion is achieved by rotating a specimen in contact with a pair of loaded cylindrical wheels covered with abrasive paper. The wheels are positioned so that their cylindrical faces are equidistant from the specimen's axis of rotation but not tangential to it. As they are turned by the rotating specimen, they abrade an annular track on the specimen's surface. The number of revolutions of the specimen required to cause a defined degree of abrasion is used as a measure of resistance to surface wear.

6.2 Materials

6.2.1 Calibration plates, of rolled zinc sheet, having a thickness of $0,8 \pm 0,1$ mm and a Brinell hardness of 48 ± 2 when tested in accordance with ISO 6506 using a ball of diameter 5 mm and a load of 306 N.

6.2.2 Abrasive paper strips, of width 12 mm and length about 160 mm, having the following composition :

- paper of grammage 70 to 100 g/m²;
- powdered aluminium oxide having a particle size such that it will pass through a sieve of aperture size 100 μ m and remain on a sieve having an aperture size of 63 μ m;
- adhesive backing (optional).

6.2.3 Double-sided adhesive tape, only required if the abrasive paper used has no adhesive backing.

6.3 Apparatus

6.3.1 Testing machine, consisting of the following items :

6.3.1.1 Specimen holder, in the form of a disc which rotates in a horizontal plane at a frequency of 58 to 62 min⁻¹ and to which the test specimen can be clamped flat.

6.3.1.2 Abrasive wheels : two cylindrical rubber-covered wheels of width 12 mm and diameter 50 mm, which rotate freely about a common horizontal axis. The curved surface of the wheels, to a depth of 6 mm, shall be of rubber of hardness 50 to 55 IRHD when tested in accordance with ISO 48. The inside faces of the wheels shall be 50 to 55 mm apart, and their common axis shall be 20 mm from the vertical axis of the specimen holder. The wheels shall be positioned symmetrically in a plane containing the axis of the specimen holder.

6.3.1.3 Holding and lifting device, for the abrasive wheels, so constructed that each wheel exerts a force of $5,4 \pm 0,2$ N on the test specimen.

6.3.1.4 Revolution counter.

6.3.1.5 Suction device, so fitted that two nozzles are over the abraded section of the specimen under test. One nozzle shall be situated between the wheels, the other diametrically opposite. The centres of the nozzles shall be 77 mm apart and 1 to 2 mm from the surface of the test specimen. When the nozzles are closed, there shall be a vacuum of 1,5 to 1,6 kPa.

6.3.2 Conditioning chamber, with a standard atmosphere of 23 ± 2 °C, relative humidity 50 ± 5 %.

6.4 Test specimens

The test specimen shall be a piece of the sheet under test, shaped to fit the type of clamping device used. It will usually be a disc of diameter about 130 mm, or a square of about 120 mm with its corners rounded to give a diagonal of about 130 mm, and it will usually have a hole of diameter 6 mm in its centre. Three specimens shall be prepared.

6.5 Preparation of test specimens and abrasive paper

Clean the surface of the test specimens with an organic solvent which is immiscible with water, for example 1,1,1-trichloroethane. Precondition the test specimens and the abrasive strips for at least 72 h in the conditioning atmosphere (see 6.3.2) before testing.

6.6 Procedure

6.6.1 Preparation of abrasive wheels

Bond a strip of preconditioned abrasive paper (6.2.2) to each of the rubber-covered wheels using either the adhesive backing, if present, or the double-sided adhesive tape (6.2.3), in such a way that the cylindrical surface is completely covered, but without any overlapping of the abrasive paper.

6.6.2 Calibration of abrasive paper

Prepare two abrasive wheels with previously unused strips of abrasive paper from the batch to be used for testing (see 6.6.1).

Weigh a zinc plate (6.2.1) to the nearest 1 mg and clamp it in the specimen holder (6.3.1.1). Lower the abrasive wheels on to the zinc plate and operate the suction device (6.3.1.5). Allow the zinc plate to rotate for 500 revolutions and then reweigh it to the nearest 1 mg. Its loss in mass shall be 130 ± 20 mg.

Any batch of abrasive paper which causes a loss in mass of the zinc plate outside this permitted range shall not be used for testing.

6.6.3 Abrasion of test specimen

Perform the test immediately after removal of the test specimen and calibrated abrasive paper from the preconditioning atmosphere (see 6.5).

Prepare sufficient abrasive wheels for the test using previously unused abrasive paper. Fit two wheels to the machine and set the revolution counter (6.3.1.4) to zero.

Clamp the specimen in the holder, ensuring that its surface is flat. Lower the abrasive wheels on to the specimen, operate the suction device and allow the specimen to rotate. Examine the specimen for wear after each 25 revolutions and examine the abrasive paper for clogging with abraded particles. Replace the abrasive paper if it becomes clogged, worn, or after 500 revolutions, whichever occurs first.

Continue the test in this way until the initial wear point (IP) is reached. Record the number of revolutions and resume the test until the final wear point (FP) is reached. Record the number of revolutions again.

The initial wear point (IP) is that point at which the first clearly recognizable wear-through of the print, pattern, plain colour coating or solid colour paper appears and the sub-layer becomes exposed. The sub-layer for printed patterns is the background on which the pattern is printed; for plain colours it is the first sub-layer of different colour.

The final wear point (FP) occurs in the case of a patterned laminate when about 95 % of the pattern is removed in the abraded area, and in the case of a plain colour laminate when an underlayer of a different colour is exposed over about 95 % of the abraded area.

Carry out the test on each of the three test specimens.

6.7 Expression of results

The wear resistance, expressed in revolutions, for each specimen, is given by the formula

$$\frac{IP + FP}{2}$$

Report the wear resistance of the sample under test as the average of the values obtained from the three test specimens, rounded to the nearest 50 revolutions.

6.8 Test report

The test report shall state the wear resistance of the sample under test, in revolutions.

7 Resistance to immersion in boiling water

7.1 Principle

Immersion of a test specimen in boiling water for 2 h and determination of the increase in mass and thickness of a test specimen and examination for blistering or delamination.

The test is generally in accordance with ISO 62, except for a longer period of immersion in the boiling water and the requirements for thickness measurements.

7.2 Apparatus

7.2.1 Balance, accurate to 1 mg.

7.2.2 Oven, capable of being controlled at 50 ± 2 °C.

7.2.3 Vessel, containing boiling distilled water.

7.2.4 Vessel, containing distilled water at 23 ± 2 °C.

7.2.5 Desiccator.

7.2.6 Micrometer thickness gauge.

7.2.7 Suitable heating apparatus (for example an electric hot plate).

7.2.8 Specimen holder, to hold specimens vertically during immersion and to prevent contact with other specimens and the vessel.

7.3 Test specimens

The test specimen shall be 50 ± 1 mm square, the thickness of the sheet and cut in such a way that no appreciable heat is generated and the edges are free from cracks. Cut edges shall be smooth. Three specimens shall be used.

7.4 Procedure

Dry the three test specimens for 24 ± 1 h in the oven (7.2.2), controlled at 50 ± 2 °C, allow to cool in the desiccator (7.2.5) to 23 ± 2 °C and weigh each specimen to the nearest 1 mg (mass m_1).

Measure the thickness of each specimen as specified in clause 4, but at the centres of its four edges (d_1, d_2, d_3, d_4) and with the external edge of the micrometer anvil approximately 5 mm from each edge. Mark the measuring points so that subsequent measurements can be made in the same places.

Place the specimens in the vessel (7.2.3) containing boiling distilled water. Take care to prevent the specimens from making contact over any substantial area with one another or with the vessel.

After $2 \text{ h} \pm 5 \text{ min}$, remove the specimens from the boiling water and allow to cool for $15 \pm 5 \text{ min}$ in the vessel (7.2.4) containing distilled water maintained at 23 ± 2 °C. Take the specimens out of the water and remove all surface water with a clean dry cloth or with filter paper. Weigh the specimens again to the nearest 1 mg (mass m_2) within 1 min of taking them out of the water.

Determine the thickness of each test specimen to the nearest 0,01 mm at the same points as before (d_5, d_6, d_7, d_8).

Examine each test specimen visually for blisters or delamination.

7.5 Expression of results

The boiling water absorbed by each test specimen, expressed as a percentage by mass, is given by the formula

$$\frac{m_2 - m_1}{m_1} \times 100$$

where

m_1 is the mass of the specimen before immersion;

m_2 is the mass of the specimen after immersion.

The percentage increase in thickness at the measuring points of each test specimen is given by the formulae

$$\frac{d_5 - d_1}{d_1} \times 100$$

$$\frac{d_6 - d_2}{d_2} \times 100, \text{ etc.}$$

where

d_1, d_2, d_3, d_4 are the thicknesses measured before immersion;

d_5, d_6, d_7, d_8 are the thicknesses measured after immersion.

Report the percentage by mass of boiling water absorbed by the sample under test as the average of the values obtained from the three test specimens.

Report the percentage increase in thickness of the sample under test as the average of the twelve values obtained at the four measuring points on all three specimens.

7.6 Test report

The test report shall state

- the average percentage increase in mass of the three specimens;
- the average percentage increase in thickness of the three specimens;
- whether any test specimens have blistered or delaminated.

8 Resistance to dry heat

8.1 Principle

Subjection of a specimen taken from the sheet under test, bonded to wood chipboard to simulate service conditions, to dry heat by contact with a vessel of defined heat capacity, initially at 180 °C but cooling during the 20 min of contact. Assessment of resistance to the test conditions by visual examination.

The test is intended to determine the suitability of decorative laminated sheets for use in kitchens where contact with moderately hot cooking utensils is to be expected.

8.2 Materials

8.2.1 Glycerol tristearate.

NOTE — The same glycerol tristearate may normally be used for at least twenty tests, but if it has been heated to a temperature above 200 °C, or in case of dispute, fresh glycerol tristearate shall be used.

8.2.2 Fine-faced wood chipboard, 230 ± 5 mm square, $19 \pm 1,5$ mm thick, of density 600 to 680 kg/m³ and having a moisture content of 9 ± 2 % (m/m).

8.2.3 Urea-formaldehyde adhesive, containing approximately 15 % (m/m) of filler, or an adhesive with equivalent characteristics.

8.3 Apparatus

8.3.1 Cast cylindrical aluminium or aluminium alloy vessel, without a lid, the bottom of which has been machined flat. It shall have an external diameter of $100 \pm 1,5$ mm and an overall height of $70 \pm 1,5$ mm. The wall thickness shall be $2,5 \pm 0,5$ mm and the base thickness $2,5 + 0,5$ mm.

8.3.2 Heat source, for heating the vessel (8.3.1) uniformly.

8.3.3 Asbestos or suitable inorganic heat-insulating board, of thickness about 25 mm and 150 mm square. Asbestos cement shall not be used.

WARNING — In view of the health hazard, care must be taken when cutting or machining asbestos to avoid inhaling any dust.

8.3.4 Thermometer, range -5 °C to $+250$ °C.

8.3.5 Fixing frame, to hold the test specimen flat.

8.3.6 Stirrer.

8.4 Test specimen

The test specimen shall be prepared by uniformly bonding a piece of the sheet under test to the wood chipboard (8.2.2) using the specified adhesive (8.2.3). One specimen 230 ± 5 mm square shall be used. The bonded specimen shall be preconditioned for at least 7 days at 23 ± 2 °C and 50 ± 5 % relative humidity before being used for the test.

NOTE — For materials of thickness greater than 2 mm, the effect of bonding the specimen is insignificant and the test may be conducted with the specimen resting in close contact with the chipboard. This technique is also acceptable for routine quality control testing of laminates less than 2 mm thick; however, in cases of dispute, laminates less than 2 mm should be bonded to chipboard.

8.5 Procedure

Place 400 ± 10 g of the glycerol tristearate (8.2.1) in the vessel (8.3.1). Fix the thermometer (8.3.4) centrally in the vessel with its bulb about 6 mm from the bottom. Raise the temperature of the glycerol tristearate to approximately 185 °C, stirring from time to time. Transfer the vessel to the heat-insulating board (8.3.3) and allow the temperature to fall to 180 ± 1 °C, stirring continuously.

Immediately place the vessel of hot glycerol tristearate on the surface of the test specimen and allow to stand for 20 min without further stirring.

At the end of this period, remove the vessel and allow the specimen to cool for a period of 45 min. Examine the specimen for surface disturbance, for example blistering, crazing, discoloration or loss in gloss visible to the naked eye, allowing the light to fall on the specimen at various angles of incidence.

8.6 Test report

The test report shall state whether the specimen shows any change of appearance.

9 Dimensional change at elevated temperatures

9.1 Principle

Measurement of the lateral dimensional changes of specimens taken from the sheet under test over an extreme range of relative humidities at elevated temperatures.

9.2 Apparatus

9.2.1 Oven, capable of being controlled at 70 ± 2 °C.

9.2.2 Conditioning chamber, with an atmosphere of 40 ± 2 °C and relative humidity within the range 90 to 95 %.

NOTE — This relative humidity occurs at a temperature of 40 °C in equilibrium above a saturated solution of sodium tartrate [(CHOH-COONa)₂·2H₂O].

9.2.3 Conditioning chamber, with a standard atmosphere of 23 ± 2 °C and a relative humidity of 50 ± 5 %.

9.2.4 Bedplate and mounted dial gauge, or other apparatus capable of measuring to an accuracy of 0,02 mm.

9.2.5 Rigid jig, for holding the specimen straight during measurement. A typical jig is shown in figure 1.

9.2.6 Desiccator, of suitable size.

9.3 Test specimens

The test specimen shall be $140 \pm 0,8$ mm long, $12,7 \pm 0,4$ mm wide and of the thickness of the sheet under test. The edges shall be free from cracks and shall be made smooth with fine abrasive paper or cloth. Machining and abrading operations shall be slow enough to avoid appreciably heating the material.

Twelve test specimens shall be tested, six of them with their major axes parallel to the machine direction of the paper from which the sheet has been made, and six with their major axes at right angles to the machine direction. Three specimens from each direction shall be used for the low humidity test and three for the high humidity test.

NOTE — If the machine direction is not known, carry out flexural strength tests at various angles. The highest value will usually be given by the test specimen cut parallel to the machine direction.

Before making the first measurements, all specimens shall be kept for 4 days in a standard atmosphere of 23 ± 2 °C and 50 ± 5 % relative humidity.

9.4 Procedure

Make all measurements of length to the nearest 0,02 mm with the test specimen vertical in the jig (9.2.5), the lower end in contact with the bedplate and the upper end in contact with the foot of the dial-gauge (see 9.2.4). When any test specimen is

measured for the second time, take care to ensure that it is located in the jig in the same relative position as when it was first measured. Make all measurements within 1 min after removal from the conditioning atmosphere.

9.4.1 Low humidity test

Measure the length of each of the six specimens and then place them in the oven (9.2.1), controlled at $70 \pm 2\text{ }^{\circ}\text{C}$. After 24 h, remove them and allow them to cool to ambient temperature in the desiccator (9.2.6) for 1 h. Again measure the length of each specimen.

9.4.2 High humidity test

Measure the length of each of the six specimens and then place them in the conditioning chamber (9.2.2) at $40 \pm 2\text{ }^{\circ}\text{C}$ and relative humidity 90 to 95 %. After $96 \pm 4\text{ h}$, remove each specimen, wipe it free of surface water with a cloth, and again measure its length. Note whether any specimen shows any change of appearance.

9.5 Expression of results

Calculate the change as a percentage of the initial length for each specimen.

Calculate the mean percentage change for each of the four sets of three test specimens, to the nearest 0,05 %.

Calculate the combined dimensional change for each direction of the sheet. It is the sum of the average absolute dimensional changes in each of the low and high humidity tests if the movements are in opposite directions. If they are in the same direction, the larger of the two average changes shall be taken as the combined dimensional change. The absolute figure shall be reported.

Example (using test specimens in one direction only) :

Low humidity test

Test specimen	1	2	3	Mean to nearest 0,05 %
Initial length (mm)	139,77	139,85	139,83	
Final length (mm)	139,26	139,22	139,24	
Change in length (mm)	-0,51	-0,63	-0,59	
Change (%)	-0,36	-0,45	-0,42	-0,4

High humidity test

Test specimen	4	5	6	Mean
Initial length (mm)	139,88	139,80	139,83	
Final length (mm)	140,33	140,21	140,31	
Change in length (mm)	+ 0,45	+ 0,41	+ 0,48	
Change (%)	+ 0,32	+ 0,29	+ 0,34	+ 0,3

The movements in the two tests are in opposite directions, therefore : combined dimensional change = $(0,3 + 0,4)\text{ \%} = 0,7\text{ \%}$.

9.6 Test report

The test report shall state :

- a) the combined dimensional change for the machine direction;
- b) the combined dimensional change for the cross-machine direction;
- c) whether the test specimens show any change of appearance.

10 Dimensional change at 20 °C

10.1 Principle

Measurement of the lateral dimensional changes of specimens taken from the sheet under test due to changes of humidity at 20 °C.

10.2 Apparatus

10.2.1 Conditioning chambers, maintaining the following three atmospheres :

- $20 \pm 2\text{ }^{\circ}\text{C}$, relative humidity $32 \pm 3\text{ \%}$
- $20 \pm 2\text{ }^{\circ}\text{C}$, relative humidity $90 \pm 3\text{ \%}$
- $23 \pm 2\text{ }^{\circ}\text{C}$, relative humidity $50 \pm 5\text{ \%}$

10.2.2 Means for measuring lengths of 200 mm to the nearest 0,05 mm.

10.3 Test specimens

Four test specimens, approximately 250 mm × 50 mm, shall be cut from the sheet under test in both the machine and cross-machine directions of the papers from which the sheet was manufactured. If these directions are not known, they may be determined as specified in 9.3. Measuring marks shall be made on the decorative face of the specimens approximately 200 mm apart and 25 mm from each end.

10.4 Procedure

Precondition the specimens for 7 days in a standard atmosphere of $23 \pm 2\text{ }^{\circ}\text{C}$ and $50 \pm 5\text{ \%}$ relative humidity.

Measure the distance between the marks on all eight specimens to the nearest 0,05 mm with the specimens laid out flat.

Keep four specimens, two in the lengthwise and two in the crosswise direction, for 7 days at $20 \pm 2\text{ }^{\circ}\text{C}$ and $32 \pm 3\text{ \%}$ relative humidity.

Keep the remaining four specimens for 7 days at $20 \pm 2^\circ\text{C}$ and $90 \pm 3\%$ relative humidity.

Remeasure the distance between the marks as before within 1 min after removal from the conditioning atmosphere.

Note whether any specimen shows crazing, delamination or change in surface appearance.

10.5 Expression of results

Calculate the change in measured length of each specimen as a percentage of the initial measured length.

Calculate the mean percentage change in measured length for each of the four pairs of specimens, to the nearest 0,05 %.

Calculate the combined dimensional change for each direction of the sheet. It is the sum of the mean absolute percentage changes in each of the low and high humidity tests. The absolute figure shall be reported.

10.6 Test report

The test report shall state

- a) the combined dimensional change for the machine direction;
- b) the combined dimensional change for the cross-machine direction;
- c) whether any specimens show any change of appearance.

11 Resistance to impact by spring-loaded bolt

11.1 Principle

Subjection of the decorative surface of a test specimen, taken from the sheet under test and bonded to wood chipboard to simulate service conditions, to the impact of a 5 mm steel ball mounted at one end of a spring-loaded bolt. Measurement of the minimum spring force needed to cause visible damage which is taken as a measure of resistance to impact.

11.2 Materials

11.2.1 Fine-faced wood chipboard, $19 \pm 1,5$ mm thick, of density 600 to 680 kg/m³ and moisture content $9 \pm 2\%$ (m/m).

11.2.2 Urea-formaldehyde adhesive, containing approximately 15 % (m/m) filler, or an adhesive with equivalent characteristics.

11.2.3 Solution of dye in alcohol, graphite or talcum, to contrast with the colour of the sheet under test (optional).

11.3 Apparatus

11.3.1 Impact tester (see figure 2), consisting of an impact bolt with a 5 mm steel ball mounted at one end, which is projected once against the surface under test by the release of a compression spring. The spring compression force before release can be adjusted continuously from 0 to 90 N by means of a force-setting barrel (housing).

(The N·m scale also provided on the tester is only to be used for orientation, as the introduction of a non-linear scale involves relatively great inaccuracies.)

The compression spring is 100 mm long when released and has a constant of $1\,962 \pm 50$ N/m. It is compressed by drawing back the impact bolt and is held in the loaded position by a retainer which engages in the bolt. It is released to deliver the impact blow by a release unit which withdraws the retainer.

11.3.2 Arrangement (for example a scale pan and weights), capable of being suspended from the impact bolt to exert a compressive force on the spring.

11.3.3 Support fixture (see figure 3), which clamps to the shaft of the impact tester and provides a convenient mounting of sufficient mass for the tester to be held at right angles to the surface of the test specimen and to avoid recoil following the release of the impact bolt.

11.3.4 Steel plate, approximately 300 mm × 300 mm × 50 mm.

11.3.5 Hand lens, with approximately X 6 magnification (optional).

11.4 Test specimens

The specimens shall be prepared by uniformly bonding a piece of the sheet under test to the wood chipboard (11.2.1) using the specified adhesive (11.2.2). About ten specimens, each 200 ± 5 mm square, shall be prepared. The bonded specimens shall be preconditioned for at least 7 days at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity before being used for the test.

NOTE — For materials of thickness greater than 2 mm, the effect of bonding the specimen is insignificant and the test may be conducted with the specimen resting in close contact with the chipboard.

11.5 Calibration of the impact tester

Suspend the tester with the impact bolt pointing upwards so that its longitudinal axis is free to hang vertically under gravity.

Set the force-setting barrel, which serves to vary the impact force, to zero on the scale. Compress the spring by a force P_e (calibration force) using a suitable arrangement (for example weights in a scale-pan) suspended from the knob used to draw back the impact bolt, ensuring that the bolt is clear of the retainer of the release unit.

Turn the force-setting barrel until the retainer of the release unit is just in contact with the impact bolt. This position can be determined by increasing or decreasing the compressing force very slightly to observe whether the retainer is just in contact. Record the indicated force P_x on the scale of the instrument corresponding to the calibration force P_e .

Repeat this calibration procedure for various values of P_e in the range required, and draw a graph relating values of the scale reading P_x to values of the calibration force P_e (see figure 4 for example).

The graph will be an approximately straight line which will not pass through the origin, because a constant but undetermined force is exerted during the calibration procedure by the mass of the impact bolt and any suspension arrangement (for example scale-pan). Draw a second line passing through the origin and parallel to the first line. This second line is the calibration graph for the instrument and shall be used to correct every indicated force P_x employed in testing.

Prepare a new calibration graph after every 500 tests.

11.6 Procedure

The test shall be carried out in the laboratory atmosphere, and in cases of dispute it shall be carried out at $23 \pm 2^\circ\text{C}$.

Place the steel plate on a convenient rigid horizontal surface and locate the test specimen on it with its decorative surface uppermost. Fix the impact tester in its support fixture, load the tester, place the assembly on the test specimen and release the impact bolt. Start preliminary tests with a spring force of 10 N and increase by 5 N on each occasion to determine the minimum spring force at which the surface of the specimen shows damage due to impact stress.

Test at least five additional specimens for the final determination of the maximum force at which no damage occurs. For this purpose, start with the spring force determined in the preliminary test and reduce it in suitable stages, for example 1 N, after every five tests.

To make the damage more easily visible, the surface of the specimen may be rubbed after the test with a solution of dye in alcohol or graphite or talcum (depending on the colour of the decorative surface). A magnifier with X 6 magnification may also be used.

The distance between points of impact shall be at least 20 mm and between points of impact and the edge of the test specimen at least 30 mm.

Examine the specimen for damage at the points of impact. For the purpose of this test, damage is defined by the presence of fine hairline cracks (which are frequently concentric), continuous cracks or flaking of the decorative surface. Indentations without cracks do not count as damage.

If the test is only conducted to determine whether the impact strength of a material exceeds a limiting value, the test specimen shall sustain no damage after ten successive individual impact blows with the prescribed spring force.

11.7 Expression of results

Enter the results of the series of tests onto an evaluation diagram (see figure 5 for example), in which they are subdivided into "test specimens not damaged" and "test specimens damaged", for each value of spring force used. This results in a transition range in which some specimens are damaged and some undamaged. The impact strength of the material is the maximum value of the spring force, in newtons, for which no damage occurs in a series of five tests.

11.8 Test report

The test report shall state the impact strength of the material, in newtons.

12 Resistance to impact by falling ball

12.1 Principle

Subjection of the decorative surface of an unbonded test specimen taken from the sheet under test, resting on the end of a hollow cylindrical support, to the impact of a 12,7 mm steel ball mounted on the end of a weighted striker which is allowed to fall from a known height. The energy of the minimum impact needed to cause breakage of the specimen is used as a measure of its resistance to impact.

12.2 Apparatus

Falling weight machine, consisting essentially of the following :

- a) **Heavy rigid base**, fitted with levelling screws.
- b) **Specimen support**, in the shape of a hollow steel cylinder of internal diameter $50,80 \pm 0,05$ mm, external diameter not less than 57,2 mm and height not less than 25,4 mm. The support shall be so fixed to the base that its axis coincides with the line of fall of the striker. A soft shock-absorbing disc of thickness approximately 6 mm shall be placed inside the cylinder and shall rest on the base.
- c) **Rigid superstructure**, for carrying the release mechanism and, if used, guides for the striker.
- d) **Weighted striker**, with a hardened hemispherical striking surface of diameter $12,7 \pm 0,05$ mm. The striking surface shall be free from flats or any other imperfections.
- e) **Plumb line** or other devices, for ensuring that the striker is directly above the centre of the specimen support.
- f) **Appropriate set of weights**, that can be firmly attached to the striker and which will give the increments of energy specified in tables 1 and 2. The combined mass of the weights and striker shall be known to within 3 g or 5 %, whichever is the smaller.

- g) **Release mechanism**, such that the striker can fall 305 ± 1 mm for test specimens of thickness greater than 1,0 mm and 100 ± 1 mm for test specimens of 1,0 mm thickness or less.

The striker may fall between guides or without guides, but in either case the point of impact of the striker with the specimen shall be not more than 2,5 mm from the axis of the specimen support. If guides are used the fall shall be substantially without friction. If guides are not used and the striker is supported electromagnetically, the magnetic flux should be reduced to the minimum necessary to support the loaded striker.

The machine shall stand on a rigid foundation.

A machine of suitable form and incorporating guides is shown in figure 6.

12.3 Test specimens

The test specimen shall be a piece 60 ± 3 mm square and the thickness of the sheet under test. Twenty specimens shall be used, or more if required. No specimen shall be struck more than once.

12.4 Procedure

The test shall be carried out in the laboratory atmosphere, and in cases of dispute it shall be carried out at 23 ± 2 °C.

Measure the thickness of the test specimen as described in clause 4. Set the release mechanism to allow the height of fall appropriate to the specimen thickness [see 12.2 g)]. Place the specimen at the centre of its support.

12.4.1 Trial run

Load the striker with weights so that the product of the height of fall and the combined mass of weights and striker is equal to the expected impact strength of the material under test. The striker shall be held in position by the release mechanism.

Operate the release mechanism so that the striker falls on to the specimen.

If the specimen is unbroken or cracked on one surface only, record it as "unbroken". If the specimen is broken or shows a crack or tear extending from one surface to the other, record it as "broken".

Proceed as follows:

a) If the first specimen breaks, test a second specimen but with an impact energy less by an amount $\Delta_1 E$ than that of the blow applied to the first specimen, where $\Delta_1 E$ is as shown in table 1. If the second specimen also breaks, test a further specimen in the same manner but with an energy less by an amount $\Delta_1 E$ ¹⁾ than that of the blow applied to the second specimen. Continue this sequence of operations until a specimen does not break.

b) If the first specimen does not break, test a second specimen with an impact energy greater by an amount $\Delta_1 E$ than that of the blow applied to the first specimen. If the second specimen also does not break, test a further

specimen in the same manner but with an energy greater by an amount $\Delta_1 E$ ¹⁾ than that of the blow applied to the second specimen. Continue this sequence of operations until a specimen breaks.

Table 1 — Relationship between increments of energy for trial run and energy of blow immediately preceding increment

Energy of blow immediately preceding increment		Increment $\Delta_1 E$ of energy for trial run
Greater than	Up to and including	
J	J	J
5,4	—	2,7
2,7	5,4	$1,4 \pm 0,14$
1,4	2,7	$0,54 \pm 0,14$
0,7	1,4	$0,27 \pm 0,07$
0,35	0,7	$0,14 \pm 0,07$
	0,35	$\leq 0,05$

The trial run comprises the first blow and subsequent blows preceded by an energy change of $\Delta_1 E$. The minimum number of blows in the trial run is 2.

12.4.2 Testing run

After completing the procedure in 12.4.1 a) or 12.4.1 b) as appropriate, test the remaining specimens, the energy of the blow applied to any specimen being less by an amount $\Delta_2 E$ than that for the previous specimen if that specimen was broken, or greater by an amount $\Delta_2 E$ if the previous specimen was unbroken, where $\Delta_2 E$ is as shown in table 2.

The testing run comprises the blows which are preceded by an energy change of $\Delta_2 E$. The maximum number of blows in the testing run is 18, and the minimum number is 12. If less than twelve specimens remain following the trial run, more shall be prepared.

Table 2 — Relationship between increments of energy for testing run and energy of last blow of trial run

Energy of last blow of trial run		Increment $\Delta_2 E$ of energy for testing run
Greater than	Up to and including	
J	J	J
5,4	—	$\geq 1,4$
2,7	5,4	$0,8 \pm 0,14$
1,4	2,7	$0,3 \pm 0,1$
0,7	1,4	$0,14 \pm 0,04$
0,35	0,7	$0,06 \pm 0,03$
—	0,35	$\leq 0,03$

1) During the trial run, the value of $\Delta_1 E$ should be varied as specified in table 1.

12.5 Expression of results

Report the impact strength of the material as the average energy of the blows struck during the testing run. It shall be expressed in joules.

12.6 Test report

The test report shall state

- the impact strength of the material, in joules;
- the thickness of the sheet under test.

13 Resistance to cracking

13.1 Principle

Rigidly clamping a test specimen taken from the sheet under test in a steel fixture under slight curvature with the decorative face in tension. Imposition of additional stress by heating the clamped specimen at 80 °C for 20 h, and assessment of the resistance to cracking by visual examination.

13.2 Apparatus

13.2.1 Clamping device, as shown in figure 7.

13.2.2 Conditioning chamber, with a standard atmosphere of 23 ± 2 °C, relative humidity 50 ± 5 %.

13.2.3 Electrically heated oven, provided with air circulation and capable of being controlled at 80 ± 2 °C.

13.2.4 Hand lens, with approximately X 6 magnification.

13.2.5 Lighting, of intensity 800 to 1 000 lx.

13.3 Test specimens

The test specimen shall be 120 ± 2 mm $\times$ 50 ± 2 mm and of the thickness of the sheet under test. The lengthwise direction of the specimen shall coincide with the direction of greatest change in dimensions as determined according to clauses 9 or 10. Two specimens shall be used.

13.4 Procedure

Precondition the test specimen for 48 h at 23 ± 2 °C and 50 ± 5 % relative humidity before testing.

Clamp the specimen at 23 ± 2 °C with the decorative side up-permost (i.e. in tension) in the clamping device (13.2.1). It is essential that the specimen does not slip in the clamp during the test.

Transfer the clamped specimen to the oven (13.2.3), controlled at 80 ± 2 °C, and leave for 20 ± 1 h.

After removal from the oven and cooling to ambient temperature with the test specimen still clamped in position, examine the surface with the naked eye and under X 6 magnification (13.2.4) for the presence and extent of any cracking. The light intensity during the examination shall be 800 to 1 000 lx.

Carry out the test on both specimens.

13.5 Expression of results

Express the result of the examination according to the grades of susceptibility given in table 3.

Table 3 — Grades of susceptibility to cracking

Grade of susceptibility to cracking	Result of testing according to 13.4
0	Decorative surface unchanged from as received condition; no hairline cracks.
1	Hairline cracks only visible under X 6 magnification, irregularly distributed across the surface.
2	In addition to grade 1 faults, cracks visible to the naked eye (normally parallel to the short edge of the specimen).
3	A gaping crack which may extend right across the specimen.
4	Specimen broken into separate parts.

13.6 Test report

The test report shall state the lower result (i.e. the higher numbered grade) of the tests on the two specimens.

14 Resistance to scratching

Test under consideration.

15 Resistance to domestic staining

15.1 Principle

Leaving test specimens taken from the sheet under test for 16 to 24 h in contact with a series of liquid stains and solvents which are likely to be encountered in everyday use. Assessment of resistance to the liquids by the presence and difficulty of removal of any marks produced.

15.2 Materials

15.2.1 Staining materials and solvents for the test :

15.2.1.1 Tea, prepared by pouring boiling water on to Indian or Ceylon tea in a hot vessel, stirring occasionally, and decanting from the leaves after infusion for 5 min. Use 9 g of tea per litre of water.

15.2.1.2 Coffee, prepared by pouring boiling water on to ground coffee in a hot vessel, stirring occasionally, and decanting from the grounds after infusion for 5 min. Use 120 g of coffee per litre of water.

15.2.1.3 Milk.

15.2.1.4 Commercial malt vinegar.

15.2.1.5 Citric acid, 10 % (*m/m*) solution.

15.2.1.6 Ethanol, 95 % (*V/V*).

15.2.1.7 Acetone.

15.2.1.8 1,1,1-trichloroethane.

15.2.2 Wetting agent, for example domestic detergent.

15.2.3 Mild abrasive, for example toothpaste.

15.2.4 Soft clean cloth.

15.3 Apparatus

15.3.1 Glass covers, for example watch glasses, one for each test material, to restrict evaporation.

15.3.2 Horizontal inspection surface, illuminated by white fluorescent light of intensity 800 to 1 000 lx, other light being excluded.

15.4 Test specimens

Sixteen test specimens of any suitable size shall be used, cut from the sheet under test. Alternatively, a single piece of laminate, large enough to allow the staining materials to be applied side by side, shall be used.

15.5 Procedure

The specimens shall be initially at ambient temperature.

Apply a small quantity of each test material (15.2.1) to two specimens. The tea, coffee and milk shall be at approximately 80 °C; the remaining materials shall be at ambient temperature. Cover the materials on one of the two specimens in each case with a glass cover.

After 16 to 24 h at ambient temperature, wash each test specimen with water containing a suitable wetting agent (15.2.2) and then with ethanol. One hour after washing, carry out the following examination on each specimen.

Place the specimen on the inspection surface (15.3.2) and view it from various angles. If there is any discoloration or marking at this stage, attempt to remove it by light rubbing with the mild abrasive (15.2.3). Examine the specimen again under the same conditions.

15.6 Expression of results and test report

The effect on the surface of the specimen shall be expressed and reported as follows for each test material in each condition :

- a) No effect : no change visible at the first examination.
- b) Superficial effect : stains or surface attack observed, but removed by mild abrasive cleaning and not visible at the final examination.
- c) Considerable effect : stain or surface attack not removed by mild abrasive cleaning.

16 Resistance to colour change in xenon arc light

16.1 Principle

Partial exposure of a test specimen taken from the sheet under test, together with standard blue wool specimens, to the light of a xenon arc lamp. Determination of the light dosage by the effect on the wool specimens, and assessment of the effect on the test specimen at a specified light dosage by the contrast between exposed and unexposed portions of the specimen.

The test is fully described in ISO/R 879.

NOTE — ISO/R 879 is being revised and detailed requirements in this method may need stating in a different manner following the revision.

16.2 Apparatus

As specified in ISO/R 879, without control of humidity.

16.3 Test specimen

As specified in ISO/R 879.

16.4 Procedure

Carry out the test using the single exposure method described in ISO/R 879, sub-clause 5.7 a), and discontinue the exposure when wool standard No. 6 shows a contrast between exposed and unexposed portions equal to Grade 4 of the grey scale.

16.5 Evaluation and expression of results

Examine the contrast between exposed and unexposed portions of the test specimen and record it in terms of grades on the grey scale.

Express the result in relation to the resistance to colour change of Blue Wool Standard No. 6 as one of the following :

Specimen contrast (Grey Scale Grade No.)	Resistance to colour change (Blue Wool Standard No.)
> 4	> 6
4	6
< 4	< 6

16.6 Test report

The test report shall state whether the specimen has a resistance to colour change greater than, equal to, or less than that of Blue Wool Standard No. 6.

17 Resistance to colour change in enclosed carbon arc light

17.1 Principle

Partial exposure of a test specimen taken from the sheet under test, together with standard blue wool specimens, to the light of an enclosed carbon arc lamp. Determination of the light dosage by the effect on the wool specimens, and assessment of the effect on the test specimen at a specified light dosage by the contrast between exposed and unexposed portions of the specimen.

The test is fully described in ISO/R 878.

NOTE — ISO/R 878 is being revised and detailed requirements in this method may need stating in a different manner following the revision.

17.2 Apparatus

As specified in ISO/R 878, without control of humidity.

17.3 Test specimen

As specified in ISO/R 878.

17.4 Procedure

Carry out the test using the single exposure method described in ISO/R 878, sub-clause 5.7 a), and discontinue the exposure when wool standard No. 5 shows a contrast between exposed and unexposed portions equal to Grade 4 of the grey scale.

17.5 Evaluation and expression of results

Examine the contrast between exposed and unexposed portions of the test specimen and record it in terms of grades on the grey scale.

Express the result in relation to the resistance to colour change of Blue Wool Standard No. 5 as one of the following :

Specimen contrast (Grey Scale Grade No.)	Resistance to colour change (Blue Wool Standard No.)
> 4	> 5
4	5
< 4	< 5

17.6 Test report

The test report shall state whether the specimen has a resistance to colour change greater than, equal to, or less than that of Blue Wool Standard No. 5.

18 Resistance to cigarette burns

18.1 Principle

Subjection of test specimens taken from the sheet under test, and bonded to wood chipboard to simulate service conditions, to the heat from burning cigarettes placed on their surfaces. Expression of the result in terms of any resultant damage.

18.2 Materials

18.2.1 Fine-faced wood chipboard, 100 ± 5 mm square, $19 \pm 1,5$ mm thick, of density 600 to 680 kg/m³ and having a moisture content of 9 ± 2 % (m/m).

18.2.2 Urea-formaldehyde adhesive, containing approximately 15 % (m/m) filler, or an adhesive with equivalent characteristics.

18.2.3 Pale tobacco cigarettes without filters, from each of three well-known brands, each with a mass of 0,1 to 1,1 g for a length of 70 mm and with the tobacco evenly distributed over its length. They shall be kept in the conditioning chamber (18.3) for at least 48 h before being used for the test.

18.2.4 Ethanol, 95 % (V/V).

18.2.5 Soft cloth.

18.3 Apparatus

Conditioning chamber, with a standard atmosphere of 23 ± 2 °C, relative humidity 50 ± 5 %.

18.4 Test specimens

The test specimen shall be prepared by uniformly bonding a piece of the sheet under test to the wood chipboard (18.2.1) using the specified adhesive (18.2.2). The bonded specimen shall be kept in the conditioning chamber (18.3) for at least 7 days before being used for the test. Three specimens, 100 ± 5 mm square, shall be prepared.

18.5 Procedure

Ignite one cigarette from each of the brands and smoke it to consume a length of approximately 10 mm.

Place one of the burning cigarettes in full-length contact with the horizontal surface of a test specimen in a draught-free area so that the glued seam of the cigarette is not in contact with the specimen. Allow the cigarette to continue burning until a further 20 mm length is consumed. If the cigarette goes out before this occurs, repeat the test.

Follow this same procedure with the other two cigarettes.

Examine the surface of each specimen to determine whether the combustion residue can be removed with a cloth moistened with alcohol and whether the cleaned surface reveals any changes such as discoloration, cracks or blisters.

18.6 Test report

The test report shall state

- a) the brands of cigarette used;
- b) whether the surfaces show any changes such as discoloration, cracks or blisters.

19 Resistance to cigarette burns (simulated test using electric heater)

19.1 Principle

Subjection of test specimens taken from the sheet under test, and bonded to wood chipboard to simulate service conditions, to local radiant heat from an electric heater. Assessment of the resistance of the material in terms of the duration of exposure needed to cause visible damage.

19.2 Materials

19.2.1 Fine-faced wood chipboard, $19 \pm 1,5$ mm thick, density 600 to 680 kg/m³ and moisture content 9 ± 2 % (m/m).

19.2.2 Urea-formaldehyde adhesive, containing approximately 15 % (m/m) filler, or an adhesive with equivalent characteristics.

19.3 Apparatus

19.3.1 Heating element support (C) (see figure 8), consisting of electrically non-conducting laminated sheet.

19.3.2 Heating element (D) (see figure 8), of iron-aluminium alloy, having the following characteristics :

- cross-section of flat wire : $1,6 \text{ mm} \times 0,25 \text{ mm}$
- wire length : 480 mm
- electrical resistance : $1,8 \pm 0,1 \Omega$

This heating element shall be in the form of a spiral (outside diameter approximately 15 mm, external ring not included).

19.3.3 Adjustable mounting, for the heating element (see figure 8), consisting of an externally threaded brass sleeve located vertically by two knurled brass nuts.

19.3.4 Calibrator block (E) (see figure 9), of electrically insulating laminate on which are mounted.

- a) **disc support (F)**, made from homogeneous heat insulating diatomaceous earth/asbestos sheet material of bulk density 512 to 576 kg/m³, and thermal conductivity 0,10 to 0,12 W/(m·K) in the temperature range 0 to 300 °C;

- b) **stainless steel disc (G)**, to the bottom of which is silver-soldered an iron-constantan thermocouple. The surface of the disc shall be highly polished and flat, and shall be in the same plane as the surface of the disc support. The disc shall be clamped firmly on its support.

19.3.5 Glass windowed cover (H), (see figure 10).

19.3.6 Stop-watch.

19.3.7 Power source, producing a constant current for the heating element. This source may be either

- a) a series of well-charged accumulators with elements in good condition, able to provide the heating element with a power greater than 20 W, or
- b) an electrical unit powered from the mains supply.

19.3.8 Control circuit (J), to adjust and maintain the power consumption of the heating element with a precision of $\pm 0,1$ %. Measurements are made by means of a voltmeter and an ammeter. The circuit for use with the mains supply is shown in figure 11.

19.3.9 Potentiometer, for measuring the temperature of the stainless steel disc.

19.3.10 Cotton wick, saturated with liquid paraffin.

19.3.11 Conditioning chamber, with a standard atmosphere of 23 ± 2 °C, relative humidity 50 ± 5 %.

19.4 Test specimens

The test specimen shall be prepared by uniformly bonding a piece of the sheet under test to the wood chipboard (19.2.1) using the specified adhesive (19.2.2). The bonded specimen shall be kept in the conditioning chamber (19.3.11) for at least 7 days before being used for the test. Three specimens, $230 \pm 2 \text{ mm} \times 80 \pm 1 \text{ mm}$, shall be prepared.

19.5 Procedure

19.5.1 Calibration

The bottom of the heating element shall be flat.

Adjust the heating element so that the distance between its lower side and the disc is $8 \pm 0,1$ mm (without including the edging ring).

Stand the heating block on its end and adjust the power input to approximately 20 W.

Allow to heat for 30 min.

Blacken the stainless steel disc with the flame from the burning paraffin-saturated wick to produce a uniform coating of carbon. The insulating support shall be kept clean.

Place the heating element on the calibration block so that the heating spiral covers the disc.

Cover the assembly to exclude draughts.

Allow the heating element to warm the disc for 10 min so as to produce a final temperature of approximately 285 °C.

It is not necessary to record the intermediate temperatures. If the final temperature is not 285 °C, adjust the power input. Lift up the heating element without disconnecting the power supply and replace it in a vertical position.

Keep the calibration block under the cover until the disc cools to $40 \pm 0,5$ °C, then replace the heating element on the calibration block and cover immediately.

Start the stop watch when the heating element support and the calibration block touch. Measure and record the temperature at 1 min intervals, for a period of 10 min.

The calibration curve shall be within the following limits :

Time (min)	Temperature (°C)
0	$40 \pm 0,5$
1	215 ± 3
2	251 ± 3
3	265 ± 3
4	274 ± 3
5	279 ± 3
6	282 ± 3
7	284 ± 3
8	285 ± 3
9	286 ± 3
10	287 ± 3

During the calibration, the current shall not fluctuate. If necessary, adjustments shall be made and further calibration carried out until the desired curve is obtained (each time letting the calibration block cool to $40 \pm 0,5$ °C).

When the calibration curve is obtained, proceed with the test.

19.5.2 Test

Position the heater on the specimen so that the resistance coil is at least 40 mm from the nearest edge, start the timer at the same time, and cover the assembly with the enclosure within 2 s.

Continue the test until the specimen fails or for 10 min. Failure is defined for this purpose as blistering, charring, permanent discoloration or crazing. If failure occurs in less than 10 min, record the time of failure.

The test shall be invalid if

- the heating element is moved during the test or is not positioned $8 \pm 0,1$ mm above the surface of the specimen;
- the power input to the heating element does not remain constant at the level of last calibration;
- the cover is removed at any time during the test.

Repeat the test on further specimens to obtain three valid results.

The calibration of the heating element shall be checked at least once per hour, and at any time that irregular results or unsteady power input are observed.

19.6 Expression of results

Report the result as the average of the three times to failure, in seconds.

If one or two tests are discontinued without failure, their results shall be taken as 600 s for the purpose of calculating the average. If all three tests are discontinued without failure, the result shall be recorded as "no failure in 600 s".

19.7 Test report

The test report shall state

- the average time to failure, or that failure did not occur in 600 s;
- the cause of failure.

20 Formability (radiant-heat) test

20.1 Principle

Subjection of a test specimen taken from the sheet under test to radiant heat on its decorative face until the reverse side reaches a predetermined temperature. Forming in a jig to a specified radius, cooling and examination for signs of failure. Repetition of the test with specimens in each direction of the sheet and with the decorative face on both the outside and inside of the bend. Assessment of the ability to form in terms of success or failure at the specified radius.

NOTE — This method may be used by agreement between supplier and purchaser, but the preferred method for determining formability is that described in clause 21.

20.2 Apparatus

20.2.1 Radiant heater, consisting of two electrically heated sheathed elements, mounted parallel and in a horizontal plane in a metal-lined trough, approximately 115 mm wide and 125 mm deep, and with a support for the test specimens at a distance of approximately 75 mm above the heating elements.

20.2.2 Variable output transformer, to control the potential difference across the heater. Use a suitable voltmeter to check the applied voltage.

20.2.3 Set of thermal crayons, or the equivalent, ranging from 135 to 190 °C.

NOTE — Thermal crayons consist of waxes of known melting points, and they are used by marking the surface whose temperatures are to be determined.

20.2.4 Stop-watch, or other suitable timer.

20.2.5 Forming apparatus (see figure 12).

It is recommended that a fitting be placed on top of the male forming blocks which will securely grip the ram or sprindle of the press used in conjunction with these blocks.

20.2.6 Conditioning chamber, with a standard atmosphere of $23 \pm 2^\circ\text{C}$, relative humidity $50 \pm 5\%$.

20.3 Test specimens

The test specimens shall measure approximately $200\text{ mm} \times 50\text{ mm}$, shall be of the thickness of the sheet under test and shall be sanded smooth on the edges to remove minute cracks.

Eight specimens shall be tested, four with their major axes in the machine direction of the papers from which the laminate was made, and four at right angles to this direction.

The specimens shall be conditioned for 24 h at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity before testing.

20.4 Procedure

Measure the thickness of the sheet as specified in clause 4.

Use a thermal crayon with a melting point of the temperature recommended by the laminate manufacturer, to make several marks about 100 mm long, on the centre of the sanded surface of the test specimen in the area to be formed.

Adjust the potential across the heater so that the required temperature for forming, as described in the following paragraph, is reached 30 to 60 s after placing the test specimen on the heating jig or trough. Maintain this potential throughout the test.

Place the test specimen on the heating jig or trough so that the heat is applied to the decorative face. Remove the specimen when the thermal crayon is completely melted in the area to be formed, place it within 5 s in the bending jig and carry out the forming test. The closing time of the die after initial contact with the specimen shall be 0,5 to 1 s. Remove and inspect the specimen after allowing it to cool for 1 min in the jig. Failure to form satisfactorily shall be defined by the presence of cracks, blisters or delamination.

Carry out the test to assess the formability in both the machine and cross-machine directions, and with the decorative face on both the inside and outside of the bend, testing two specimens in each case.

20.5 Test report

The test report shall state

- a) radius of the male forming block;
- b) whether the decorative face is inside or outside the bend;

- c) direction of the test specimen (machine direction or at right angles to machine direction);

- d) thickness of the test specimen;

- e) temperature used for forming;

- f) heating time, in seconds;

- g) results of forming; if failure occurs, the type of defect shall be described, for example, edge cracks, cracks all the way across or blisters.

21 Formability (hot-mandrel) test

21.1 Principle

Forming a test specimen taken from the sheet under test around a mandrel of radius as specified for the material and having a temperature maintained at a predetermined level. Repetition of the test with specimens in each direction of the sheet and with the decorative face on both the outside and inside of the bend. Assessment of the ability to form in terms of success or failure at the specified radius.

The method allows for adjustment of all the test variables in order to establish the optimum conditions for the forming of individual materials, and it is to be expected that different types, thicknesses and colour/patterns, even from the same manufacturer, will require different conditions for satisfactory forming. The requirements are satisfied if any conditions for successful forming can be found, and the information obtained is of value in the forming of the material under production conditions.

21.2 Apparatus

21.2.1 Forming jig (see figure 13), comprising a support fixture for the test specimen and the hot mandrel (see figure 14) and a forming bar mounted on a plywood base (see figure 15) to which the support fixture is clamped.

The mandrel may be heated either electrically or by hot oil. Its temperature may be measured by any convenient means and it shall be maintained within $\pm 3^\circ\text{C}$ of any temperature chosen for the test up to a maximum of 200°C . The radius of the mandrel shall be as required in the material specification.

The forming bar is free to rotate about its own axis and is mounted between two pulley wheels which are held in a fixed relationship to each other by an additional rigid connecting bar parallel to the forming bar. The pulley wheels are counter-balanced so that the forming assembly exerts no bending force in the absence of suspended weights. The axis of the pulley wheels coincides with that of the hot mandrel when the support fixture is in position. A bending force is applied to the test specimen by suspending weights from the pulley wheels or by a motor driving the wheels. Additional weights may also be added near the circumference of the wheels in order to reduce the bending force as forming proceeds and compensate for the effect of increasing specimen temperature. For example, additional weights attached to the circumference of each pulley wheel so that they reach the lowest point after the test specimen has been formed through 60° have been found to provide satisfactory compensation.

Alternatively the bending force may be applied at a constant speed which completes the required rotation through 120° in a time between 30 s and 2 min.

21.2.2 Vessel containing cold water, for cooling specimens after forming.

21.2.3 Stop-watch, or other suitable timer.

21.2.4 Conditioning chamber, with a standard atmosphere of $23 \pm 2^\circ\text{C}$, relative humidity $50 \pm 5\%$.

21.3 Test specimens

The test specimens shall measure approximately 200 mm $\times$ 50 mm, shall be of the thickness of the sheet under test and shall be sanded smooth on the edges to remove any minute cracks.

At least eight specimens shall be prepared, four with their major axes in the machine direction of the paper from which the laminate was made, and four at right angles to this direction. Additional specimens may be required.

The specimens shall be conditioned for 24 h at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity before testing.

21.4 Procedure

Measure the thickness of the test specimen as specified in clause 4.

Position the mandrel support fixture so that whatever mandrel is being used, its axis is in line with the centre of the two pulley wheels. Adjust the mandrel temperature to that chosen for the test (normally as recommended by the manufacturer).

Suspend equal masses from each pulley wheel. A total mass (both weights) of 400 g is normally sufficient for materials of type HGP, or 200 g for type VGP but any mass may be used. Further weights may also be added near the circumference of the pulley wheels. Rotate the wheels raising the weights until the connecting bar is resting against the specimen clamp. Clamp the test specimen on the support fixture and allow the forming bar to exert a bending force on the specimen.

Measure the time required for the specimen to form round the mandrel to an angle of 120° . If the time is between 30 s and 2 min, remove the formed sample from the apparatus immediately and immerse it in cold water, maintaining the angle of 120° in a suitable template until cool.

Dry the cool specimen and inspect it for signs of failure, for example cracks, blisters or delamination. Measure the formed angle of the specimen to determine the spring-back, which is the difference between this angle and 120° .

If failure occurs, or if the forming is either complete in less than 30 s or incomplete after 2 min, adjust the test conditions and repeat the test on a new specimen. Continue this procedure until either the optimum conditions have been determined, or if the specimen still fails to form within 2 min under any conditions, report the final angle of bend achieved. Repeat the test under the optimum conditions to obtain two results.

Alternatively, the test may be carried out at a constant forming rate to complete forming through 120° in a time between 30 s and 2 min.

Carry out the test on specimens in both the machine and cross-machine directions, and with the decorative face on both the inside and outside of the bend, to obtain two results under optimum conditions in each case. If the dimensions of the equipment permit, several test specimens can be formed side by side simultaneously.

21.5 Test report

The test report shall state for each specimen tested

- whether the decorative face is on the inside or outside of the bend;
- direction of the specimen (machine or cross-machine);
- thickness;
- radius of mandrel used;
- temperature of mandrel;
- angle of spring back;
- total mass suspended from the wheels, and details of any additional weights used; alternatively that the wheels are motor driven;
- time to form;
- any failure : defects, for example cracks and their extent, blisters, delamination, or formed angle if forming is incomplete.

22 Reaction to fire

Test under consideration.

See ISO 4586/1, sub-clause 5.2 — Notes on requirements for reaction to fire — and sub-clause 6.4, table 3 — Property requirements : Reaction to fire.

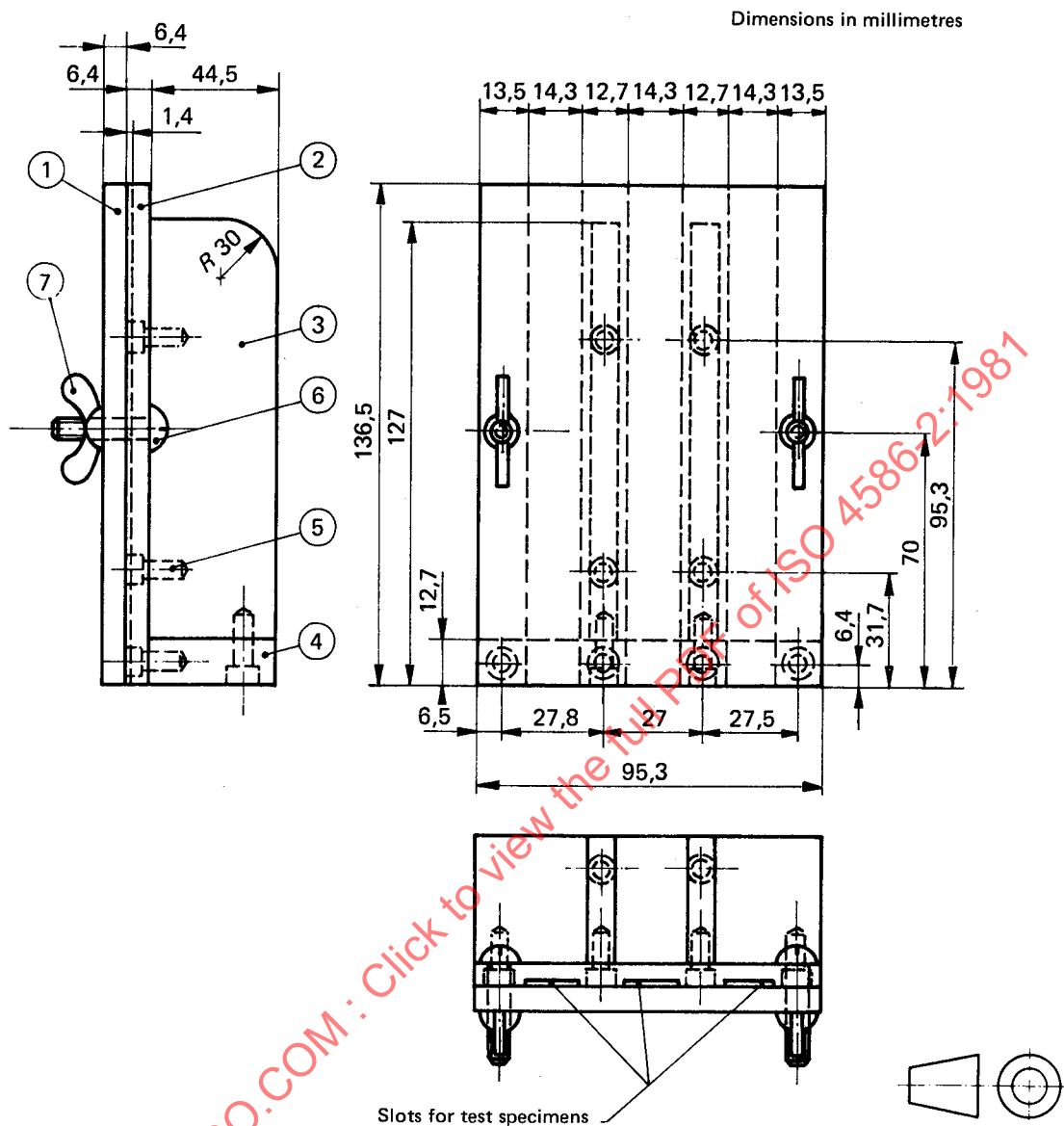


Figure 1 — Typical holding jig for determination of dimensional change (see 9.2.5)

List of items

Item	Material	Name	Size	Number required
1	Stainless steel	Face plate	6,4 × 95,3 × 136,5	1
2	Stainless steel	Back plate	6,4 × 95,3 × 136,5	1
3	Stainless steel	Brace	6,4 × 44,5 × 114,3	2
4	Stainless steel	Base	12,7 × 44,5 × 95,3	1
5	Brass	Cheese head screw		10
6	Brass	Round head screw		2
7	Brass	Wing nut		2

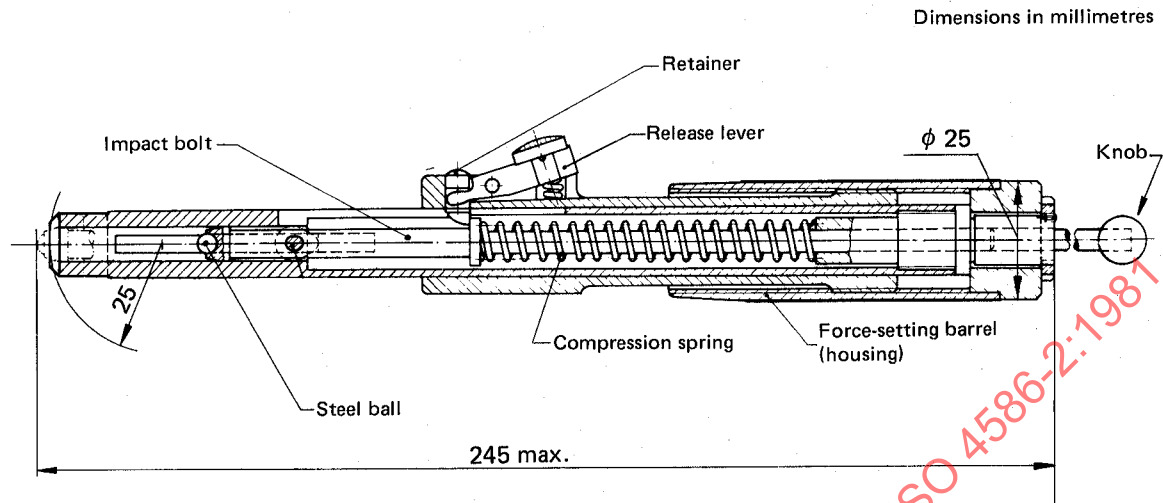


Figure 2 — Impact tester (shown with spring compressed) (see 11.3.1)

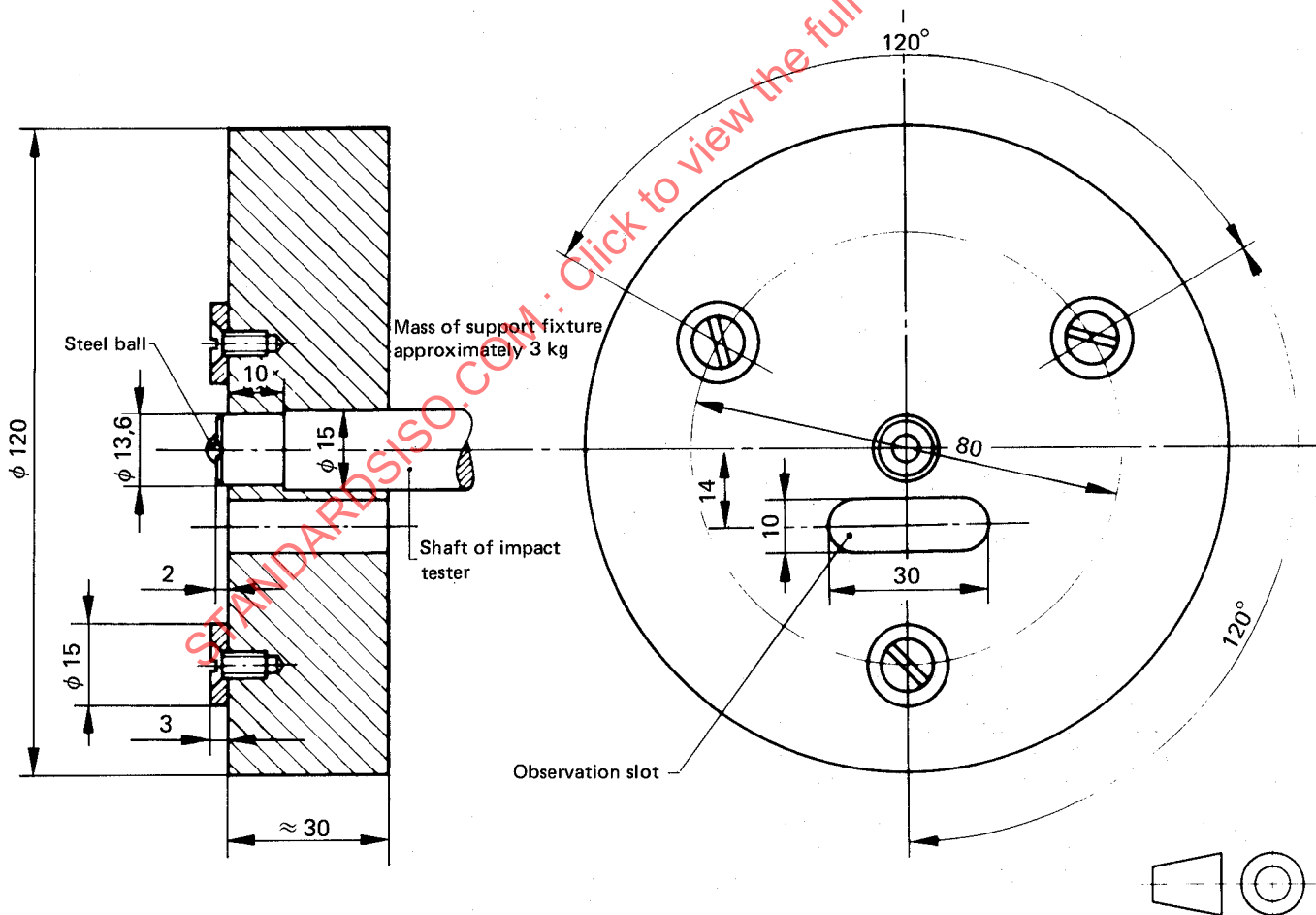


Figure 3 — Support fixture for impact tester (see 11.3.3)

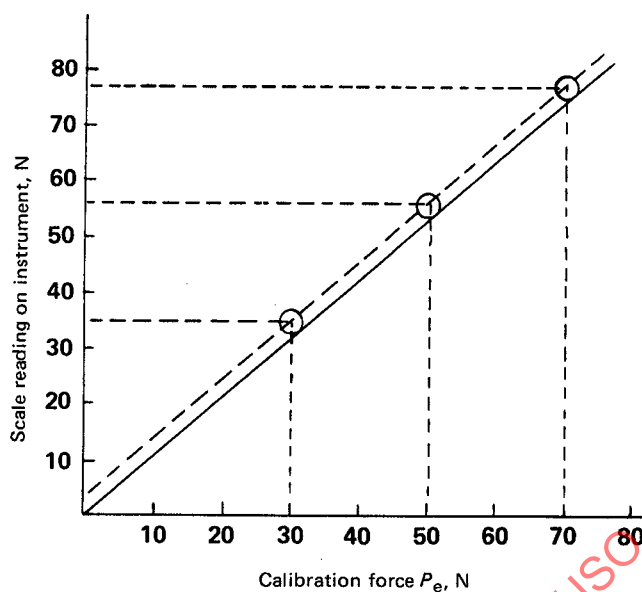
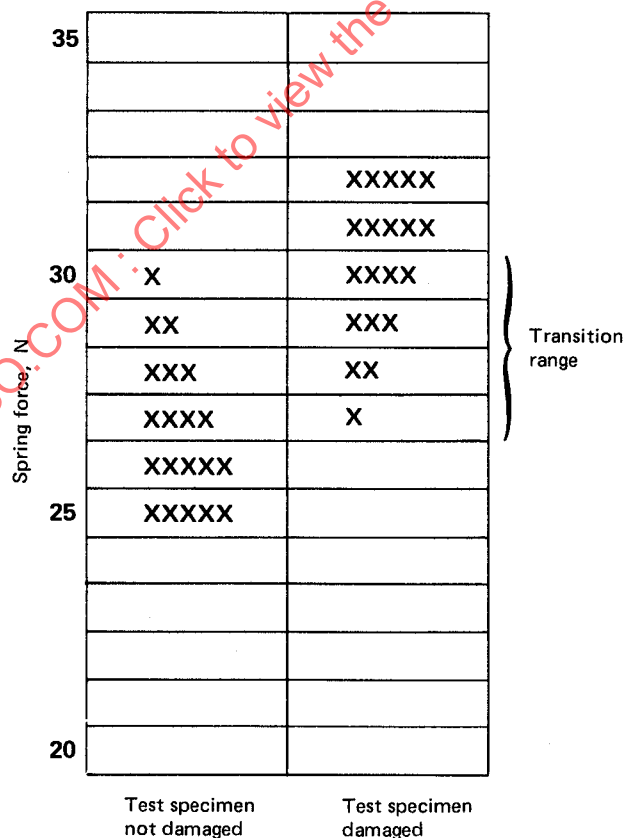


Figure 4 — Example of calibration graph relating actual force to scale value (see 11.5)



NOTE — In the example the impact strength of the material is 26 N.

Figure 5 — Example of evaluation diagram for assessing the effect of impact blows with an impact tester (see 11.7)

Dimensions in millimetres

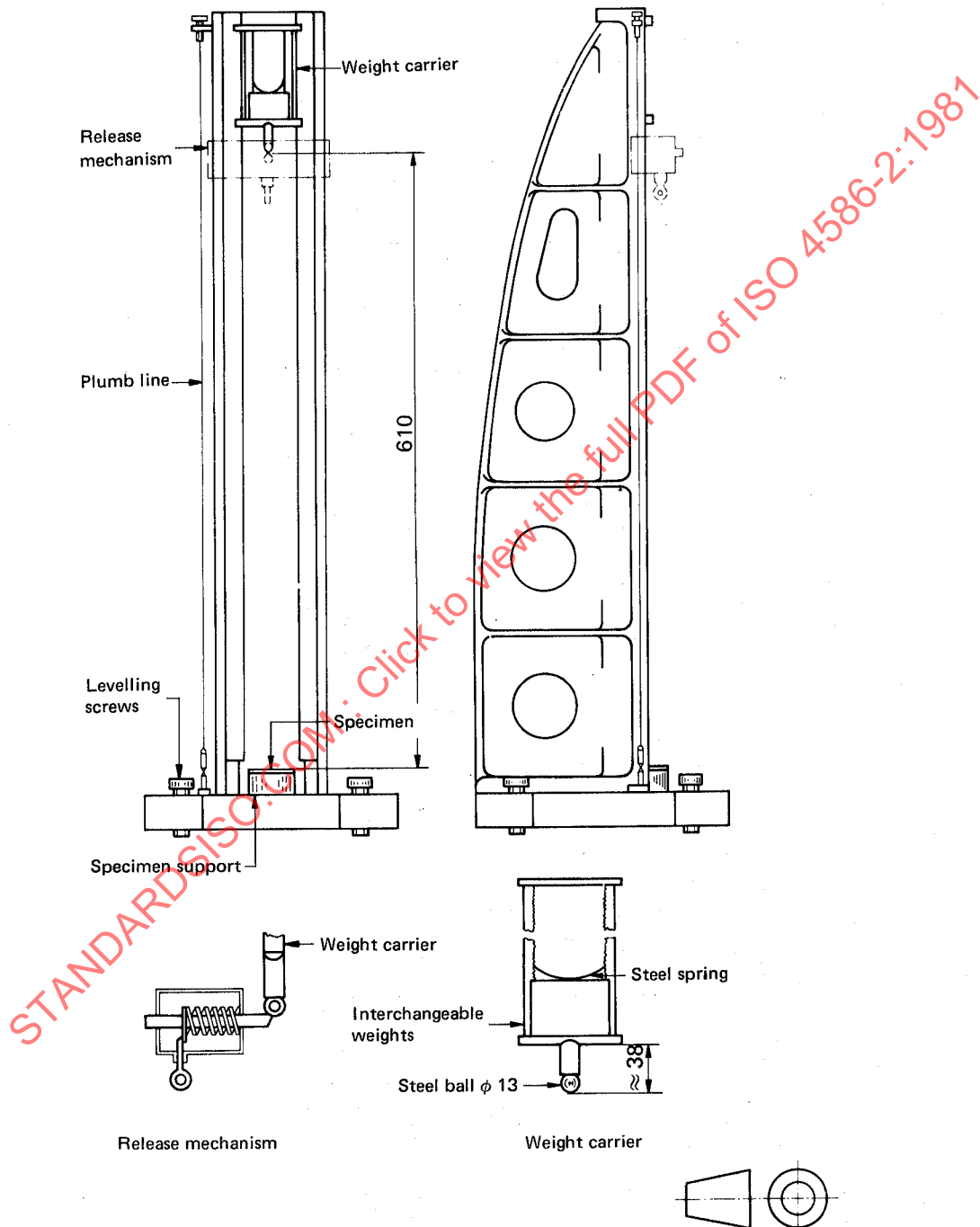


Figure 6 — Falling ball impact tester (see 12.2)

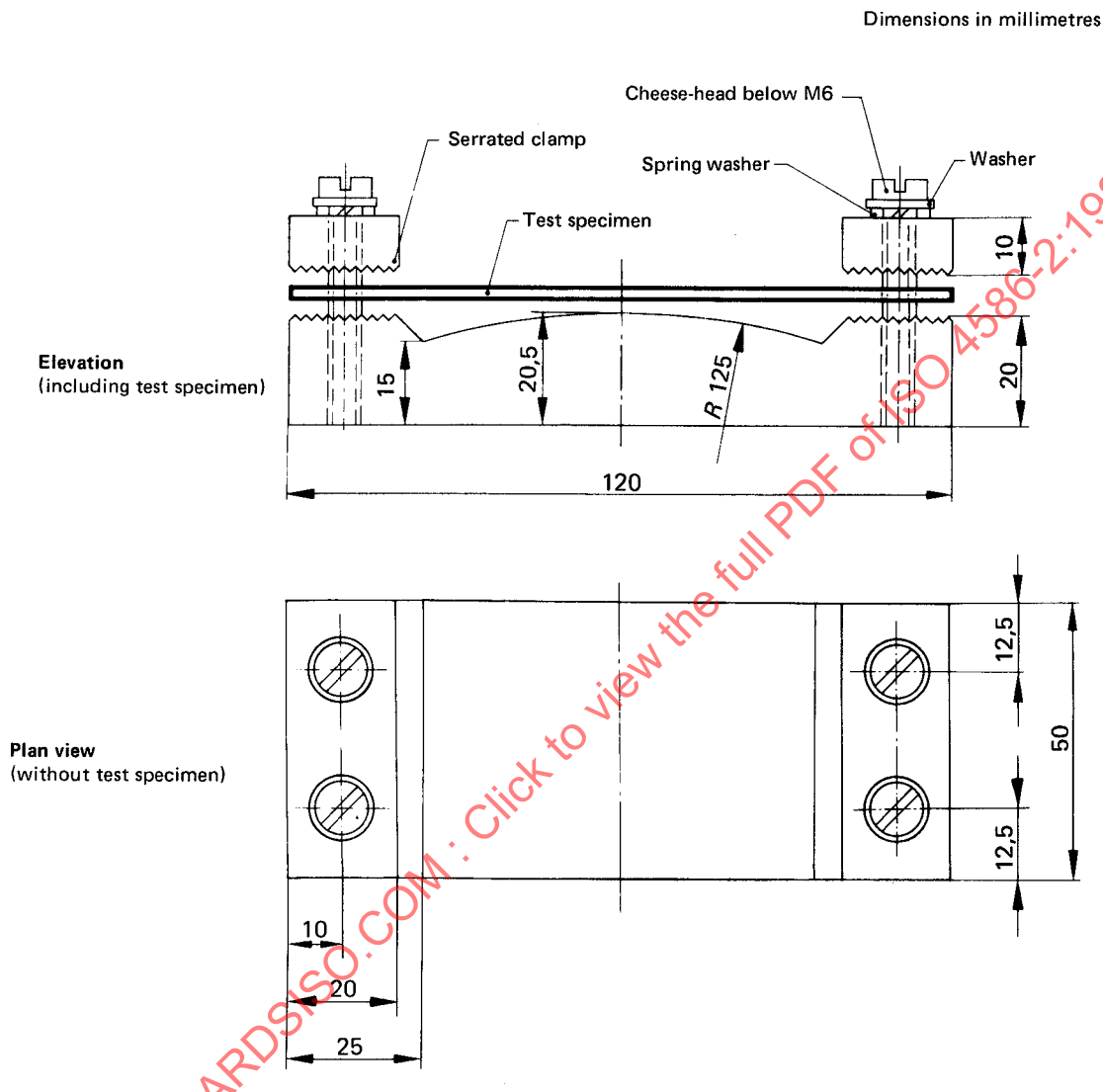
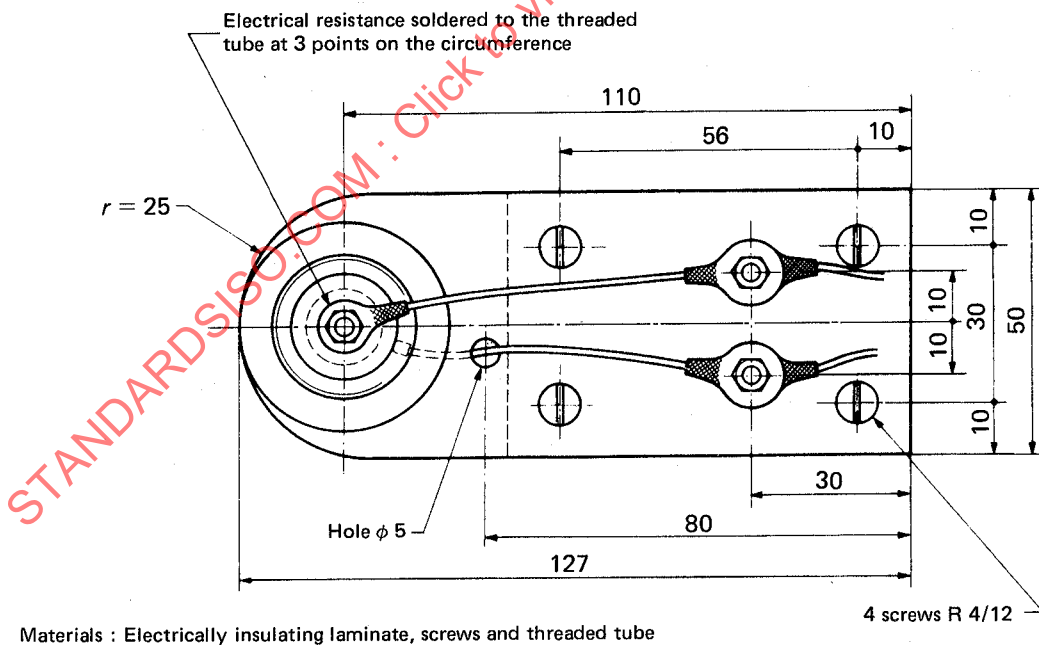
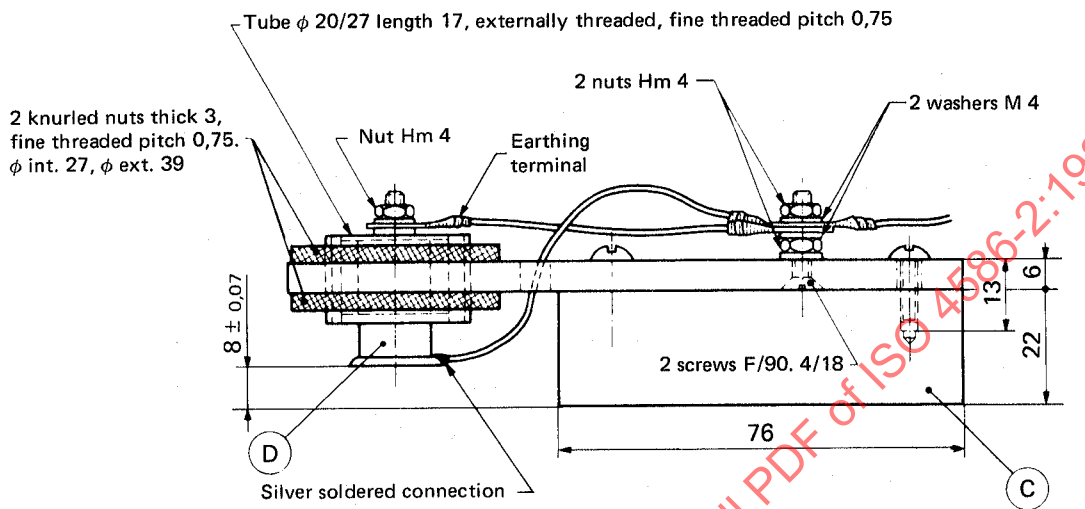


Figure 7 — Steel clamping device for testing resistance to cracking
(linear coefficient of thermal expansion = $11 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$) (see 13.2.1)

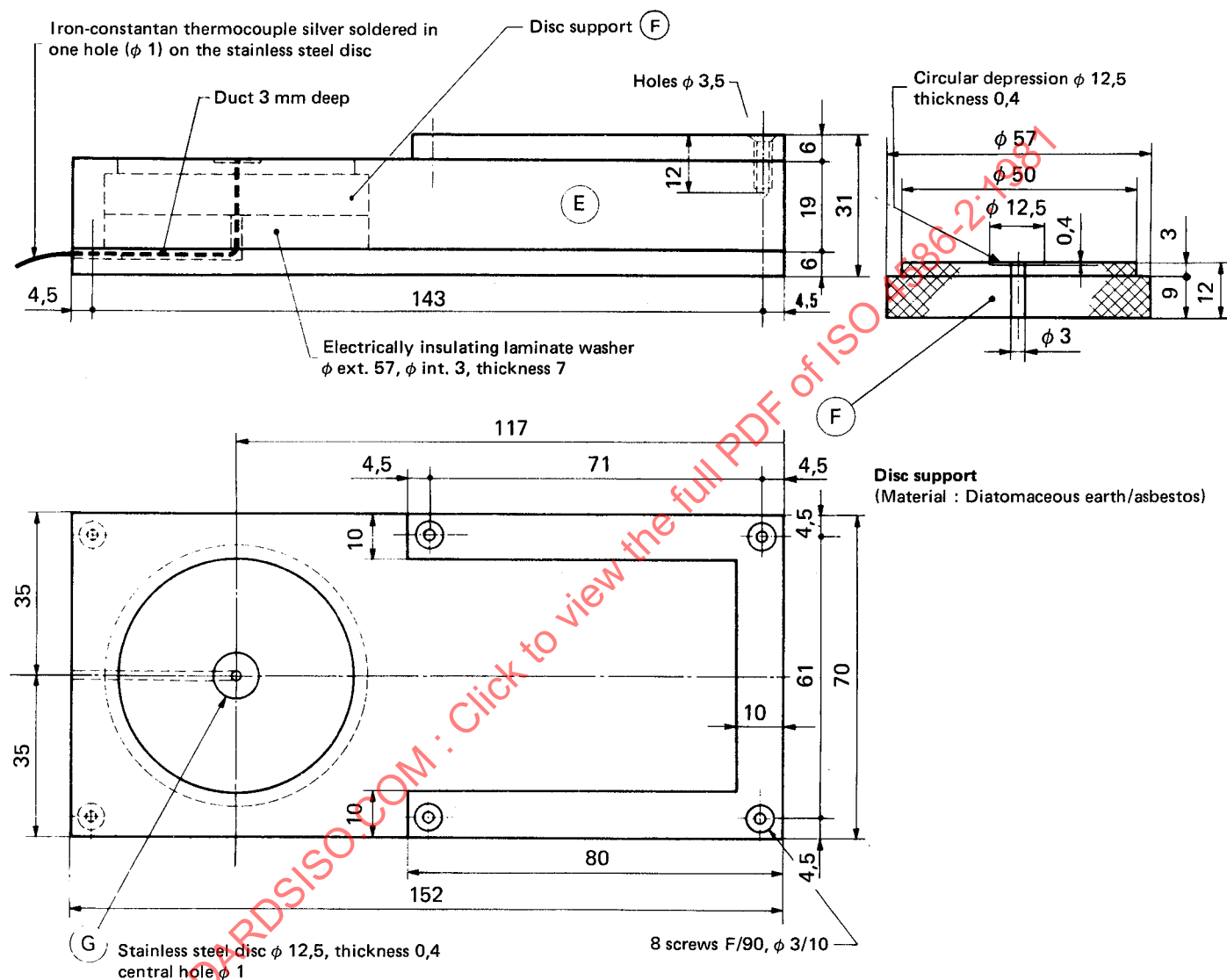
Dimensions in millimetres



Materials : Electrically insulating laminate, screws and threaded tube

Figure 8 — Heating element support (C) for cigarette test (see 19.3.1)

Dimensions in millimetres



Material : Electrically insulating laminate

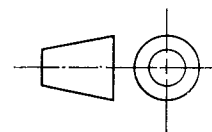


Figure 9 — Calibration block (E) for cigarette test (see 19.3.4)