TECHNICAL REPORT

ISO TR 1896

First edition
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Products in fibre-reinforced cement — Non-combustible fibre-reinforced boards of calcium silicate or cement for insulation and fire protection

Produits en ciment renforcé par des fibres — Plaques non combustibles, à base de ciment ou silico-calcaires, renforcées par des fibres, pour l'isolation et la protection contre le feu

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Contents

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Annexes

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future, but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 1896, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 77, *Products in fibre reinforced cement*.

It cancels and replaces ISO Recommendation R 1896:1971 of which it constitutes a technical revision.

Bearing in mind the nature of comments received and the fact that the products in question were still under technical development, the experts were unable to reach agreement on certain technical considerations.

Because there are no criteria for non-combustibility in ISO 1182, the term non-combustible, which is a key element in the Report, is defined only by regulations or national standards.

Even by establishing categories of thermal shrinkage, certain delegates considered that product interchangeability within each category was not possible, given that the concept of structure and performance of the board are closely connected to guarantee fire-resistance.

As a result of this lack of interchangeability, the Draft continually made reference to the need for the product to pass fire tests specified in other International Standards (e.g. ISO 834).

These facts are incompatible with the establishment of a complete International Standard. It was also noted that a large number of these products will be covered by a future International Standard.

As a consequence of these difficulties, it was decided to publish the Draft in the form of a Technical Report.

Annexes A, B and C form an integral part of this Technical Report. Annex D is for information only.

Introduction

ISO/R 1896, *Thermal insulating asbestos boards*, was published in May 1971. In 1974 ISO/TC 77 created a working group to revise this document. This Technical Report, which is the result of the deliberations of the working group, differs from the first edition in a number of important ways which reflect current trends in technology and market requirements. Some of the more important changes are as follows.

a) This Technical Report applies to any reinforcing fibres.

b) Greater emphasis has been given to the primary application of these boards in fibre protection and insulation. The boards are required to be non-combustible. Claims made for boards regarding their use in elements of construction required to provide fire resistance are based on the relevant national regulations, International Standard (e.g. ISO 834) or national standard.

   All claims should state the standard used.

   NOTE 1 In certain countries the term "non-combustible" is not permitted to apply to products. Refer to the appropriate national standards or regulations.

c) The minimum bending strength requirement has been related to both density and thickness. This is in accordance with practical experience regarding the requirements for board handling.

d) Many of the fire protection boards covered by this Technical Report retain their integrity in a fire by virtue of their low thermal shrinkage and consequently a test method for thermal shrinkage is included. Boards of higher thermal shrinkage and generally greater thickness can however provide fire protection by other mechanisms (e.g. the maintenance of a high thermal gradient through the thickness of the board so that, although the face exposed to the fire may shrink and micro-craze, the cool face maintains the integrity of the board).

The test methods given are, as far as possible, similar to those for fibre-cement flat sheets.

Products in fibre-reinforced cement — Non-combustible fibre-reinforced boards of calcium silicate or cement for insulation and fire protection

1 Scope

This Technical Report specifies the characteristics, test methods and checking of non-combustible fibre-reinforced boards of calcium silicate or cement intended primarily for insulation and for internal use in elements of construction required to provide fire resistance. Calcium silicate slabs for thermal insulation will be covered by a future International Standard.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 390:1977, *Asbestos-cement products — Sampling and inspection.*

ISO 834:1975, *Fire-resistance tests — Elements of building construction.*

ISO 1182:1990, *Fire tests — Building materials — Non-combustibility test.*

3 General composition

Non-combustible fibre-reinforced cement boards which are the subject of this Technical Report consist principally of an inorganic hydraulic binder[1] or a calcium silicate matrix formed by the chemical reaction of a siliceous material and a calcareous material reinforced with suitable fibres.

Process aids, fillers and pigments which are compatible with fibre-reinforced cement may be added.

4 Classification

The boards are classified in four categories according to their nominal density (see table 1). The general physical property requirements are given in table 1 and detailed in 5.4 and 5.5.

5 Requirements

5.1 General appearance and finish

The boards shall normally have at least one surface which appears smooth on visual inspection. If it is required, however, one or both surfaces may be specially finished for decorative or other purposes.

5.2 Geometrical characteristics

5.2.1 Nominal length and width

Fibre-cement boards are normally available in nominal lengths up to approximately 3 000 mm and nominal widths up to approximately 1 250 mm.

Preferred nominal dimensions for length and width may be specified in national standards taking into account that the dimensions of the sheet are determined largely by the purpose for which it is intended.

1) National standards may specify the binder to be used.

Table 1 — General physical characteristics

Board category	Nominal density, ϱ g/cm³	Minimum bending strength N/mm²			Maximum thermal conductivity W/(m·K)
		4,5 mm $< e \leqslant$ 7 mm	7 mm $< e \leqslant$ 12 mm	12 mm $< e \leqslant$ 70 mm	
A	$1{,}00 < \varrho \leqslant 1{,}25$	8	6	4	0,29
B	$0{,}75 < \varrho \leqslant 1{,}00$	6	5	4	0,25
C	$0{,}50 < \varrho \leqslant 0{,}75$	5	4	3	0,20
D	$\varrho \leqslant 0{,}50$	—	—	1,5	0,15

5.2.2 Thickness, e

The thickness selected depends on the application. The thickness range for the boards is from 4,5 mm to 70 mm.

5.2.3 Tolerances on dimensions

Tolerances on dimensions are as follows:

a) For each nominal width and length dimension

- above 2 m: ± 5 mm
- up to and including 2 m: ± 3 mm

The measurement method is given in 6.2.2.

b) For thickness: ± 10 % of nominal thickness up to a maximum of ± 2,5 mm. Within the same board, the difference between the maximum and minimum measurements shall not be greater than 10 % of nominal thickness up to a maximum of 2 mm.

The measurement method is given in 6.2.3.

5.2.4 Tolerances on shape

5.2.4.1 Straightness of edges

The tolerance on the straightness of edges is 0,2 % of the length of the edge, subject to a maximum tolerance of 3 mm. The measurement method is given in 6.2.4.

5.2.4.2 Squareness

The tolerance on squareness is 0,3 %. The measurement method is given in 6.2.5.

NOTES

2 Where boards are to be used in constructions employing the principles of modular co-ordination, the dimensions (work sizes) of the boards should follow the requirements for modular co-ordination. Information regarding these requirements is given in [1], [2], [3] and [4] (see annex D).

3 Other dimensions and tolerances may be supplied by special agreement between the manufacturer and purchaser.

4 The dimensions and tolerances given, except those for thickness, do not apply where oversized boards are supplied for applications where the board is required to be cut by the user.

5.3 Nominal density

When measured as described in 6.3, the density of a specimen shall not deviate from the nominal density declared by the manufacturer by more than 10 %.

5.4 Bending strength

5.4.1 Dry specimen

When tested as described in 6.4, the minimum bending strength shall be as given for the appropriate board category in table 1. The values given refer to the average of the bending strength in both directions.

5.4.2 Saturated specimen

In addition to the above requirement, the minimum saturated bending strength when tested as described in 6.4 shall be at least 50 % of the appropriate value shown in table 1.

5.5 Thermal conductivity

When measured as specified in 6.5, the maximum thermal conductivity of the dry specimen shall be as given in table 1.

NOTE 5 When calculating heat transfer through building structures, allowance for the effect of external factors, such as moisture, on the thermal conductivity may be necessary.

5.6 Non-combustibility

The board shall meet the criteria of non-combustibility as defined in national regulations.

5.7 Fire protection

Manufacturer's statements regarding the use of boards in elements of construction required to provide fire resistance shall be based on the relevant national regulations, International Standards (e.g. ISO 834) or national standards and be supported by certificates from an independent authority.

The manufacturer's literature shall state the standard used.

These requirements are compulsory for boards intended for fire protection.

5.8 Thermal shrinkage

Boards intended for fire protection, when tested in accordance with 6.7, shall have a linear thermal shrinkage according to their category as specified in table 2.

These requirements are obligatory for boards intended for fire protection.

Table 2 — Thermal shrinkage

Category	Thermal shrinkage, δ %
1	$\delta < 2$
2	$2 \leqslant \delta < 4$
3	$4 \leqslant \delta$

5.9 Moisture movement

When tested in accordance with 6.8, moisture movement shall not exceed 0,35 %.

5.10 Sag under humidity

Where there is a requirement for resistance to sag (e.g. ceiling panels), the test method described in 6.9 shall be used and the sag under humidity shall not exceed 3 mm.

5.11 Screw retention

Where there is a requirement for screw retention, the test method described in 6.10 shall be used.

6 Test methods

6.1 General

The acceptance tests shall be carried out on boards and specimens cut from boards which are representative of the material to be supplied using the inspection and acceptance procedures described in annex A.

6.2 Geometrical characteristics (obligatory acceptance test)

Geometrical characteristics shall be determined at normal ambient temperature and humidity.

6.2.1 Equipment

6.2.1.1 The smooth, flat inspection surface shall be large enough to take the sheet.

Two metal rules may be fixed at right angles along the edge of the inspection surface. The straightness of each metal rule shall be at least 0,3 mm/m and the right angle shall be accurate to at least 0,1 % (less than 1 mm deviation from normal per metre of length) or 0,001 rad.

Alternatively, a portable square may be used. The same requirements for straightness and angularity apply.

6.2.1.2 Suitable metal rulers, capable of being read to 0,5 mm, are used.

6.2.1.3 A micrometer accurate to 0,05 mm, with flat parallel metal jaws, between 10 mm and 15 mm in diameter is needed.

6.2.2 Length and width

For each dimension, carry out three measurements, taking care to avoid measuring over any local deformation large enough to constitute a visible defect.

Each reading shall be taken to the nearest 0,5 mm. Before taking a reading, ensure that the edges are clean. Each of the three measurements shall conform to the tolerance requirements of 5.2.3.

6.2.3 Thickness

Take three measurements at one end, with the micrometer, as indicated in figure 1.

Each of the three measurements and the difference between the extreme values of the measurement shall conform to the tolerance requirements of 5.2.3.

Dimensions in millimetres

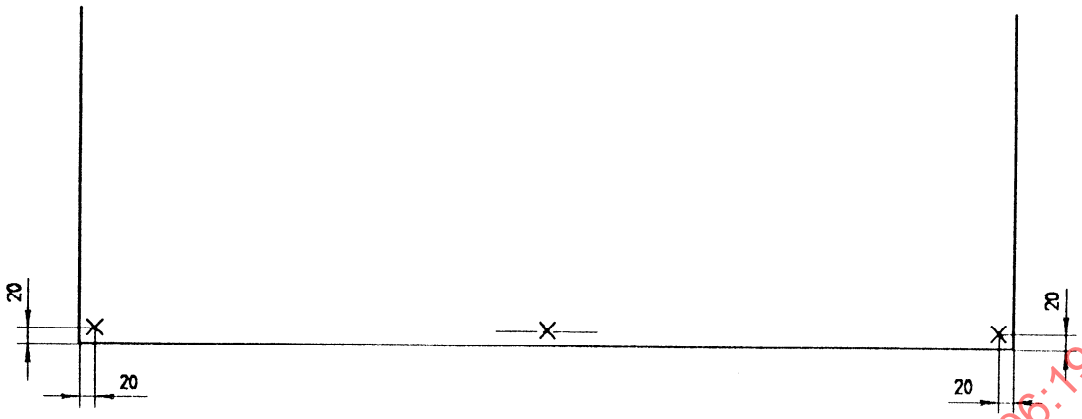


Figure 1 — Location of thickness measurements

6.2.4 Straightness of edges

Apply each edge of the board to the straight edge which shall be longer than the edge being tested. Measure to the nearest 0,05 mm the greatest distance between the edge of the board and the reference edge. The result expressed as a percentage of the length of the edge of the board shall conform to the tolerance requirements of 5.2.4.1.

6.2.5 Out-of-squareness

Place each of the four corners of the board in succession between the arms of the square, keeping the longer edge of the board firmly in contact with the longer arm of the square. Measure to the nearest 0,5 mm the greatest distance, d, between the board and the other arm of the square, as shown in figure 2. The out-of-squareness angle, given by d/L and expressed as a percentage shall conform to the tolerance requirements of 5.2.4.2.

L is given by the short arm of the square or the edge of the board as indicated in figure 2.

A similar procedure applies to the use of either the control surface or the portable square.

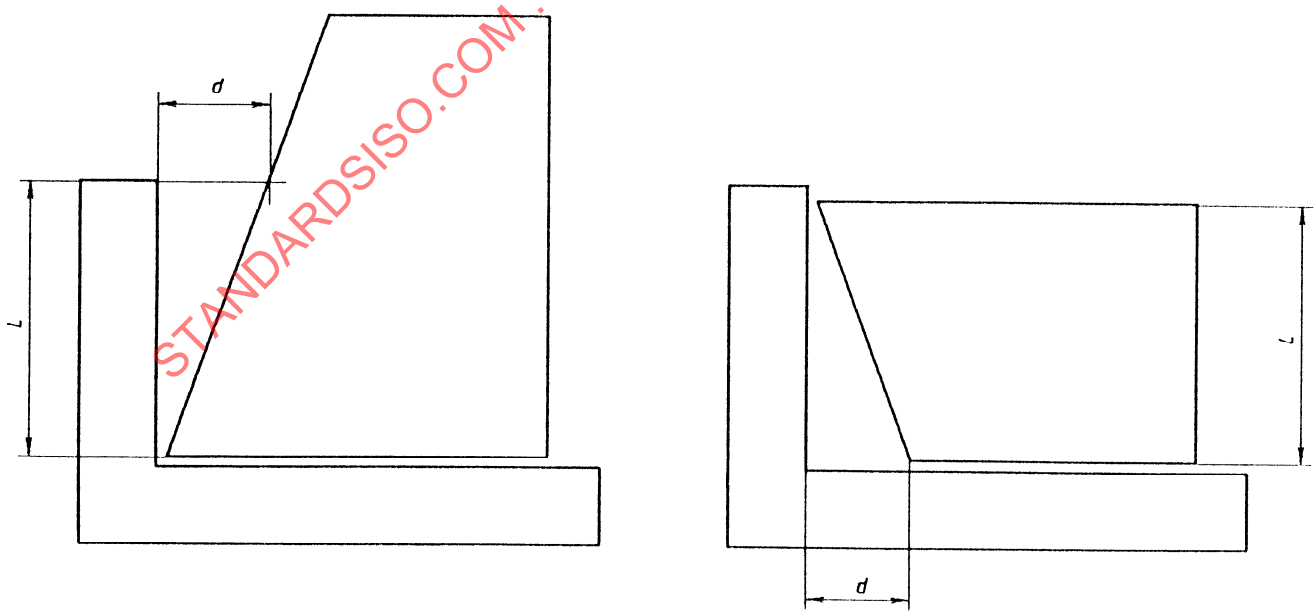


Figure 2 — Out-of-squareness measurements

6.3 Density (obligatory acceptance test)

6.3.1 Specimen preparation

Take a specimen of approximately 40 mm × 60 mm (see note in 6.3.2) from the material to be tested.

6.3.2 Procedure

Determine the dry mass of the test specimen by drying it out in an oven at 100 °C to 105 °C until the difference between two consecutive weighings made in an interval of not less than 2 h is less than 1 % by mass.

Determine the volume of the specimen by any method capable of giving a result accurate to within 2 %, e.g. immersion in potable water. If water is used, the specimen shall be saturated before determining the volume. The density, ϱ, is given by the formula:

$$\varrho = \frac{m}{V}$$

where

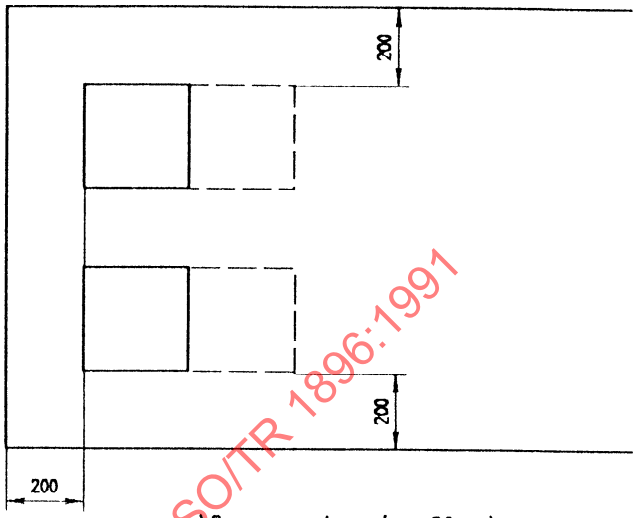
m is the dry mass of the specimen, in grams;

V is the volume of the specimen, in cubic centimetres.

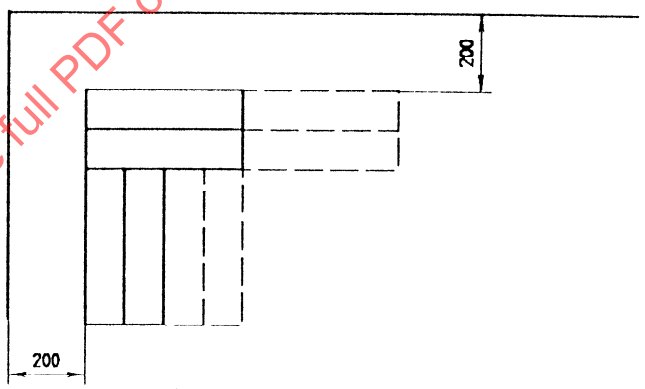
Check that the measurement conforms to the tolerance requirements of 5.3.

NOTE 6 It is convenient to use a fragment from a specimen which has been subjected to a bending test. In the case of the specimen having an added coating, the coating shall be removed before testing.

Dimensions in millimetres



a) Square specimens ($e \leqslant 20$ mm)



b) Rectangular specimens ($e > 20$ mm)

Figure 3 — Cutting of specimens

6.4 Bending strength (obligatory type test)

6.4.1 Specimen preparation

6.4.1.1 Dry strength

Cut two specimens per board from boards with a thickness, $e \leqslant 20$ mm, and four specimens per board from boards with a thickness, $e > 20$ mm, observing the conditions in table 3.

The specimens are cut from the board as shown by the solid lines in figure 3 (the dimension of 200 mm is indicative) and conditioned by drying them in an oven following the procedure given in 6.3.2.

Cool the specimens in a rack at ambient temperature and humidity and test within 1 h to 2 h of removal from the oven.

6.4.1.2 Saturated strength

Cut two specimens per board from boards with a thickness, $e \leqslant 20$ mm, and four specimens per board from boards with a thickness, $e > 20$ mm, observing the conditions in table 3.

The specimens are cut from the same board as specimens for determining the dry strength as shown by the dashed lines in figure 3 (the dimension of 200 mm is indicative).

Immerse the specimens in water at a minimum temperature of 5 °C for at least 24 h before testing.

Table 3 — Test dimensions

Dimensions in millimetres

Thickness, e mm	Specimen dimensions		Distance between supports
	length	width	
$e \leqslant 20$	250	250	215
$e > 20$	Test span + 40	$3e$ (with a minimum of 100)	$10e$

6.4.2 Equipment

The equipment consists of

a) A bending machine, comprising:

— Two parallel supports situated in the same horizontal plane, the upper face of each being rounded to a radius between 3 mm and 25 mm: the distance between the centres of the supports shall be adjusted according to the specimen thickness as given in table 3;

— A loading bar, identical to the two supports, situated parallel to the supports and equidistant from the supports.

b) A micrometer, accurate to 0,05 mm, equipped with flat measuring surfaces of approximately 10 mm to 15 mm.

6.4.3 Procedure

Arrange the specimen with one face resting on the supports and load the specimen at mid-span by means of the loading bar.

Adjust the rate of loading so that breakage occurs after 15 s to 30 s.

6.4.3.1 For square specimens ($e \leqslant 20$ mm), proceed as follows.

After the first rupture, measure the thickness of the specimen at two points along the line of fracture as shown in figure 4 a).

Re-assemble the broken sections and submit the reconstituted specimen to a second bending test along an axis perpendicular to that used in the first test. Re-measure the thickness of the specimen after rupture at two points as shown in figure 4 b).

Repeat the above procedure using the second specimen.

6.4.3.2 For rectangular specimens ($e > 20$ mm), proceed as follows.

The strengths in the two directions are obtained by testing the appropriate rectangular specimens and measuring their thickness at two points along the line of fracture as shown in figure 4 a).

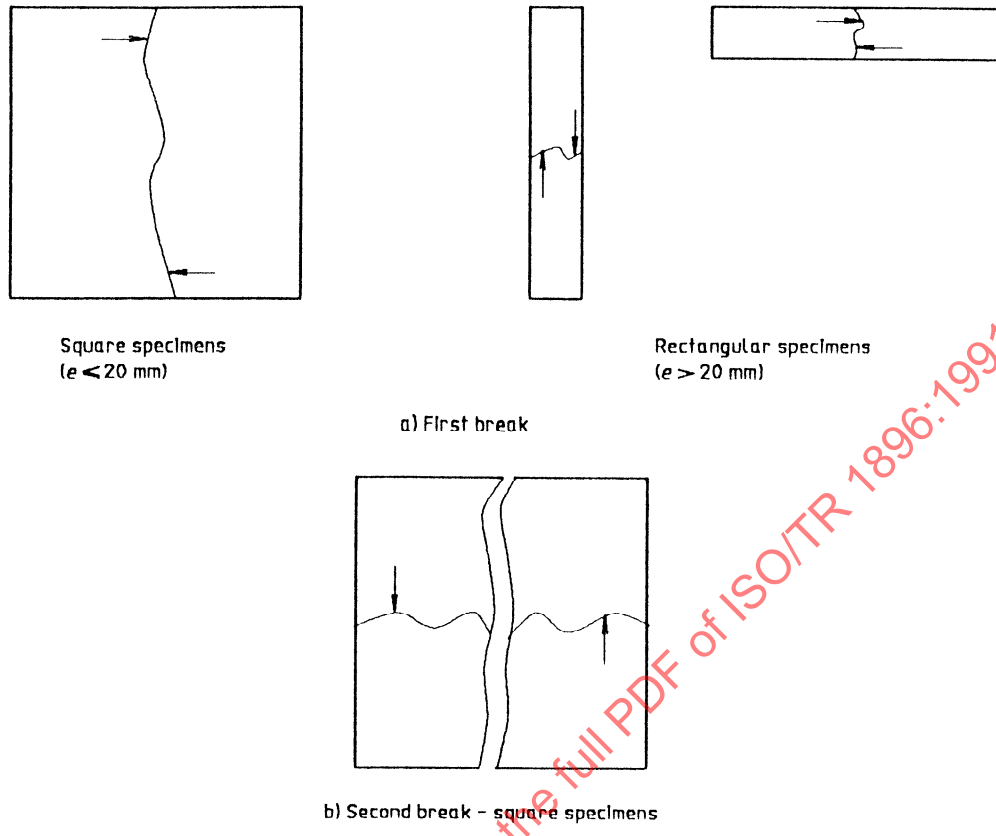


Figure 4 — Strength testing

The flexural strength, R_f, of the specimen, in newtons per square millimetre, is given by the formula:

$$R_f = \frac{3PL}{2be^2}$$

where

P is the breaking load, in newtons;

L is the distance between the supports, in millimetres;

b is the width of the specimen, in millimetres;

e is the average of two thickness measurements on the specimen along the line of fracture, in millimetres.

Calculate the average bending strength obtained from the four measurements of R_f and check that it is less than the minimum bending strength specified in 5.4.

NOTE 7 It is recommended that the broken pieces be preserved for re-use in density measurements (see 6.3).

6.5 Thermal conductivity (obligatory type test)

The thermal conductivity shall be measured at a mean temperature of 20 °C ± 5 °C on specimens which have been dried to constant mass, following the procedure given in 6.3.2. The test method shall conform to a national standard or to a method which has been agreed between the purchaser and the manufacturer. A test method is given in annex C for guidance.

Check that the thermal conductivity does not exceed the value specified in 5.5.

6.6 Non-combustibility (obligatory type test)

The test method shall correspond to that laid down in the relevant national regulations, International Standards (e.g. ISO 1182), or national standards.

The standard used shall be stated in the test report.

6.7 Linear thermal shrinkage (obligatory type test)

The method entails measurement of the shrinkage, in both directions, of a square specimen exposed at an elevated temperature for a period of time.

Measure the sides of two square specimens (35 mm × 35 mm), predried following the procedure given in 6.3.2 and cooled in a desiccator, with a gauge accurate to 0,01 mm. Then place the specimens in a furnace at 950 °C for 4 h. On removal from the furnace, cool the specimens in a desiccator and repeat the measurements at the same point. Calculate the shrinkage by dividing the difference between the initial and final measurements by the initial measurement.

Check that the average of the four values, expressed as a percentage, satisfies the requirements of 5.8.

NOTE 8 The results are invalidated if the specimens are cracked or delaminated after heat treatment.

6.8 Moisture movement (obligatory type test)

6.8.1 Specimen preparation

Cut two specimens, of approximately 300 mm × 300 mm, from each board as shown by the solid lines in figure 3 a). The specimens shall be taken at a time, t_1, which is 10 h at the earliest and 7 days at the latest after manufacture (10 h < t_1 < 7 days).

The specimens are conditioned at a temperature of 23 °C ± 5 °C and a relative humidity greater than 90 % for a time, t_2, where (t_1 + t_2) is between 21 days and 40 days (21 days < (t_1 + t_2) < 40 days).

For autoclaved products, conditioning is not required.

6.8.2 Procedure

Position the measurement points (screwed, stuck, traced, etc.) on each specimen as shown in figure 5 such that the points are approximately 250 mm apart.

The specimens are immersed in water at a minimum temperature of 5 °C for at least 24 h.

Measure the lengths between points 1-2, 2-3, 3-4 and 4-1, and dry the specimens following the procedure given in 6.3.2. Allow the specimens to cool and re-measure the lengths between points 1-2, 2-3, 3-4 and 4-1.

The moisture movement is calculated by dividing the difference between the saturated and dry lengths for each pair of points by the dry length.

Check that the average of the eight values, expressed as a percentage, satisfies the requirements of 5.9.

Dimensions in millimetres

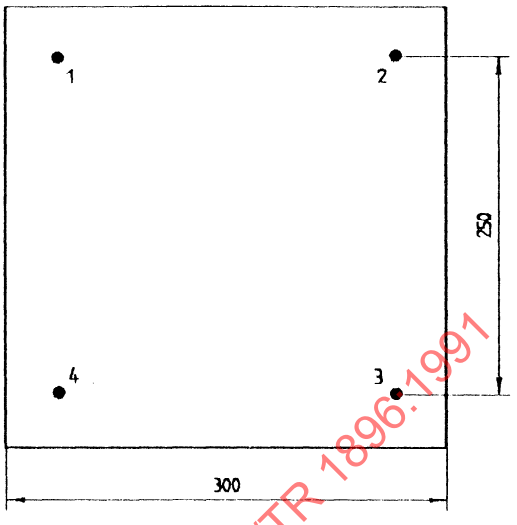


Figure 5 — Moisture movement specimens

6.9 Sag under humidity (optional type test)

The method entails measuring the maximum deflection perpendicular to the plane of a panel supported horizontally on all four edges when the panel is exposed to a humid environment and subjected to a representative loading.

A 600 mm × 600 mm panel is conditioned at 23 °C ± 5 °C and 60 % ± 10 % relative humidity for two weeks before testing.

Support the panel simply without restraint on all four edges with an edge support of 10 mm ± 2 mm and a weight of 15 N uniformly distributed.

Measure the height of the centre of the panel and place the panel in an environment controlled at 23 °C ± 5 °C and a relative humidity greater than 90 %. After three weeks, re-measure the height of the centre of the panel.

Check that the difference between the initial and final heights, the sag, satisfies the requirements of 5.10.

6.10 Screw retention (optional type test)

The method entails measuring the force required to withdraw a specified screw from the material by a direct pull. Any tensile testing machine can be readily adapted for the purpose of the test by the addition of suitable screw-holding and gripping devices. The specimens shall be dried to constant mass following in the procedure given in 6.3.2.

Insert a self-tapping screw of suitable size (approximately 40 mm long by 5 mm to 7 mm in diameter) into an approximately sized pilot hole. The screw is

inserted vertical to the hole, the diameter of which shall be only slightly less than the root diameter of the screw in order to minimize the damage to the wall of the hole by crushing. Drive the screw home until it is held by the full thickness of the material, or approximately 20 mm for boards thicker than 20 mm.

The axis of the screw shall be at least 40 mm distant from the retaining grip's edges to prevent the latter from aiding the results in any way.

Apply the pull to the screw at a constant rate of approximately 50 N/s and note the yield value.

The statement of results shall include:

a) the specification, type and size of the screw;

b) the pilot hole size;

c) the penetration depth;

d) the yield load.

7 Marking

Marking shall ensure that a precise identification of the product can be made.

The identification and classification according to this Technical Report shall be described in the manufacturer's literature.

8 Conformity with standards

There are two main methods for establishing conformity with standards; they are described in annexes A and B.

Annex A
(normative)

Receiving inspection[2] for products which are not subject to third-party certification

A.1 When tenders and/or orders do not specify receiving inspection, the lot(s) delivered is (are) presumed to be in conformity with the relevant standard (valid in the manufacturer's country).

A.2 When tenders and/or orders so specify, the receiving inspection is carried out on (a) lot(s) of the consignment according to the test programme of the product standard, unless there is a special agreement. Therefore the test programme necessarily covers the compulsory acceptance tests and, if specified by one of the above documents, all or some of the optional acceptance tests.

Details related to the application of the sampling clauses shall be established in agreement between the manufacturer and purchaser.

A.3 After agreement on the sampling procedure, sampling shall be carried out, in the presence of both parties, from the lot(s) which are to be delivered to the purchaser. If the inspection lot(s) are not yet formed, the manufacturer should present to the purchaser the stock(s) from which the inspection lot(s) can be selected and marked. Failing such an agreement the maximum and minimum inspection lots shall be 300 boards and 4000 boards respectively for all dimensions.

A.4 The tests shall normally be carried out by an independent laboratory and the samples sent to the laboratory selected by mutual agreement between the manufacturer and the purchaser. The laboratory of the manufacturer can be used. In case of dispute, the tests shall be carried out in the presence of both parties.

A.5 When non-destructive tests are carried out and the results of the sampling inspection do not meet the acceptance requirements of the product standard, the tests can be required on each item of the consignment. The units of the consignment which do not meet the requirements when tested one by one can be refused and disposed of, unless otherwise agreed between manufacturer and purchaser.

A.6 The cost of tests shall be borne by the purchaser unless failures occur; in this case costs shall be borne by the manufacturer, unless other agreement has been reached between manufacturer and purchaser.

2) See ISO 390.