INTERNATIONAL STANDARD

ISO 11093-7

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Paper and board — Testing of cores —

Part 7:
Determination of flexural modulus by the three-point method

Papier et carton — Essais des mandrins —
Partie 7: Détermination du module de flexion par la méthode à trois points

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11093-7 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 3, *Dimensions and grammages of paper, board and pulp products*.

ISO 11093 consists of the following parts, under the general title *Paper and board — Testing of cores*:

— *Part 1: Sampling*

— *Part 2: Conditioning of test samples*

— *Part 3: Determination of moisture content using the oven drying method*

— *Part 4: Measurement of dimensions*

— *Part 5: Determination of characteristics of concentric rotation*

— *Part 6: Determination of bending strength by the three-point method*

— *Part 7: Determination of flexural modulus by the three-point method*

— *Part 8: Determination of natural frequency and flexural modulus by experimental modal analysis*

— *Part 9: Determination of flat crush resistance*

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Paper and board — Testing of cores —

Part 7:
Determination of flexural modulus by the three-point method

1 Scope

This part of ISO 11093 specifies a method for the determination of the flexural modulus of cylindrical paper and board cores, which meet the following criteria:

— internal diameter: 50 mm to 350 mm;

— minimum wall thickness: 0,02 × internal diameter or not less than 2,0 mm;

— minimum length of core: 8 × internal diameter or not less than 1 000 mm.

NOTE — For the determination of the natural frequency and flexural modulus by experimental modal analysis, see ISO 11093-8.

2 Normative references

The following standards contains provisions which, through reference in this text, constitute provisions of this part of ISO 11093. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 11093 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 11093-1:1994, *Paper and board — Testing of cores — Part 1: Sampling.*

ISO 11093-2:1994, *Paper and board — Testing of cores — Part 2: Conditioning of test samples.*

ISO 11093-3:1994, *Paper and board — Testing of cores — Part 3: Determination of moisture content using the oven drying method.*

ISO 11093-8:1997, *Paper and board — Testing of cores — Part 8: Determination of natural frequency and flexural modulus by experimental modal analysis.*

3 Definition

For the purposes of this part of ISO 11093, the following definition applies.

3.1 flexural modulus, E**:** Material property which, together with core dimensions, describes the resistance of the core to bending deflection.

4 Principle

In the bending test, the test piece is considered a “beam” and Timoshenko's beam theory is applied in evaluating bending deflections. In this theory, the influence of shear deformations on deflections is also included. During the test, the test piece is supported at its ends and loaded transversally by a load applied by a hanging weight. Special measures are undertaken to avoid permanent deformation of the test piece and to ensure the validity of the calculation formulae. The flexural modulus is calculated as described in clause 8.

5 Apparatus

5.1 Test-piece support

The test piece is supported at each end by an arrangement of two-roller support prisms as shown in figure 1. The angle between the two rolls shall be (120 ± 2)°. The diameter (a) of the rolls shall be (30 ± 1) mm. The width (b) shall be large enough to allow the test piece to rest on the cylindrical surfaces of the rolls.

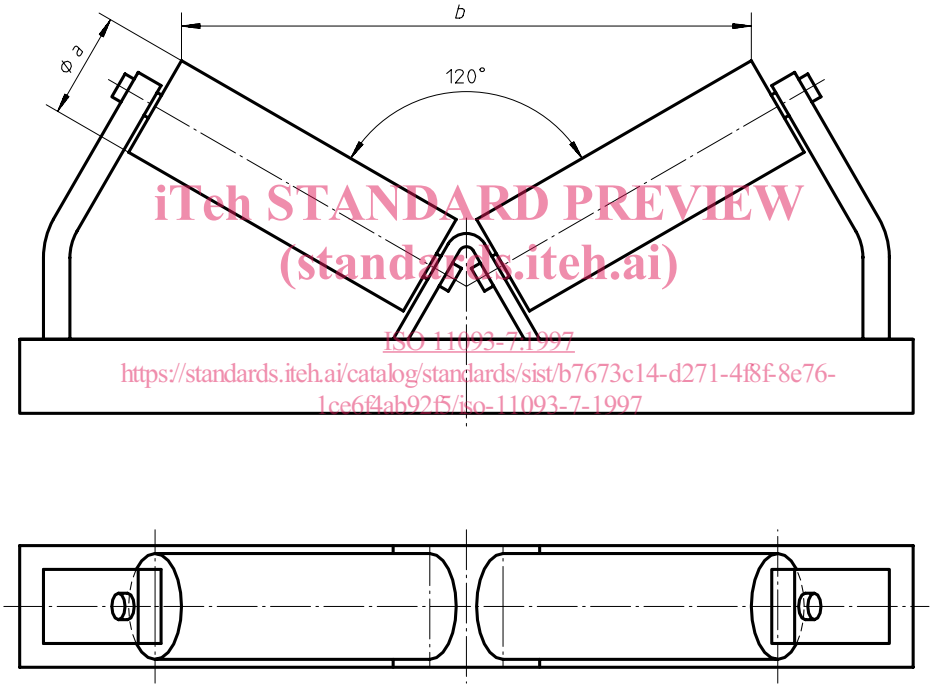
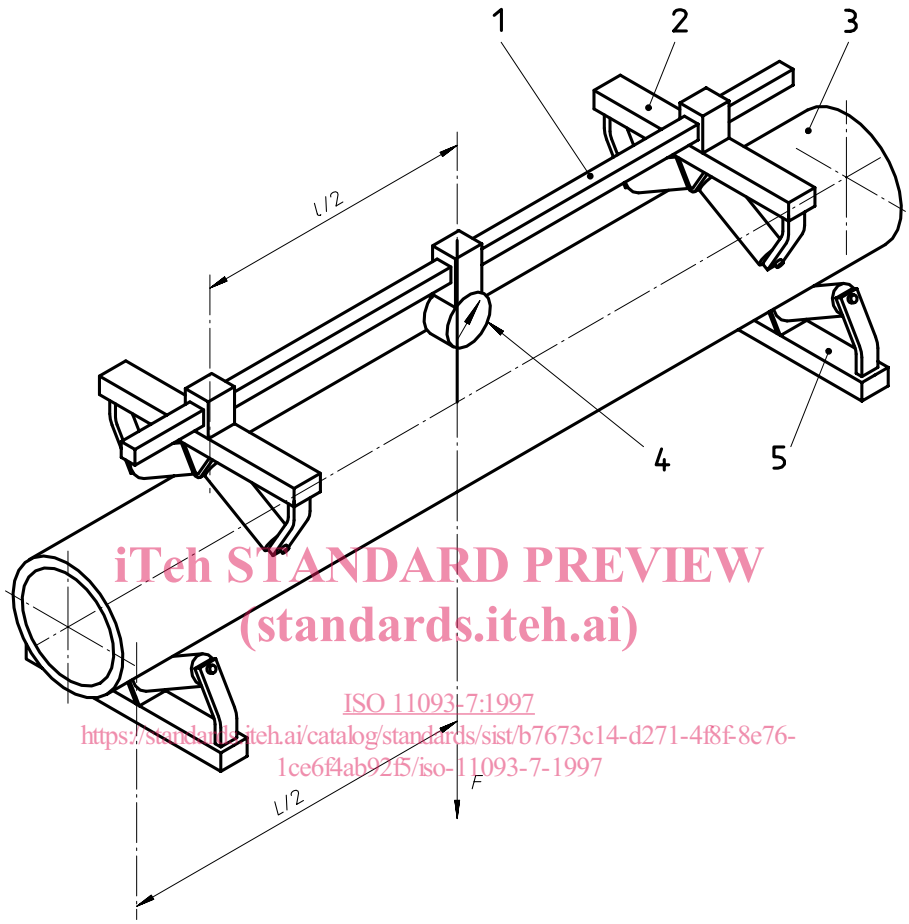


Figure 1 — Schematic drawing of the supports

5.2 Measuring device

The deflection change f of the test piece is measured in the direction of the applied force with a measuring feeler supported on the top of the test piece (see figure 2). The measuring feeler shall have a 0,01 mm resolution. The measuring device has two support prisms, a support bar and a measuring feeler. The prisms are the same shape as the test-piece support prisms. The distance between the prisms should be easily adjustable.



Key

1 Support bar
2 Support prism
3 Test piece
4 Measuring feeler
5 Two-roller support prism

L, l and F are defined in clause 8

Figure 2 — Schematic drawing of the measuring device

5.3 Load

The magnitude of the load to be used in the test depends on the measuring length l and is calculated using formula (5). The load is applied to the test piece loaded by hanging weights. The width of the belt shall be approximately 50 mm (see figure 3).

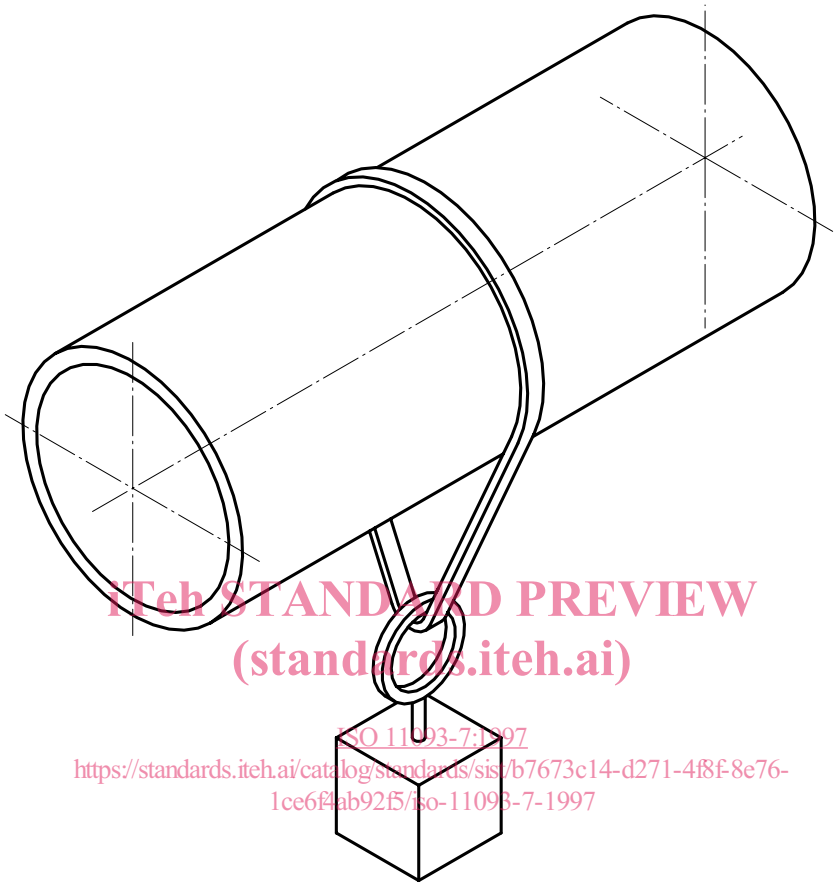


Figure 3 — Schematic drawing of the loading system

6 Test piece

6.1 Sampling

Samples shall be taken in accordance with ISO 11093-1.

6.2 Test-piece size

The minimum length of the test piece shall be 8 times the internal diameter of the core and not less than 1 000 mm.

6.3 Conditioning

The test piece shall be conditioned in accordance with ISO 11093-2. Measure the moisture content of the test piece in accordance with ISO 11093-3.

In practice, the test piece shall be conditioned and dried so that the moisture content shall be equal to that specified for the lot.

7 Procedure

7.1 General

Carry out the test under the same atmospheric conditions as those used to condition the test piece.

7.2 Positioning of supports and test piece

Position the two-roller support prisms symmetrically with respect to the applied load F, so that the distance between their midpoints is (300 ± 2) mm less than the total length of the test piece.

The distance between the supporting-roller midpoints is the supporting length L and shall be defined to an accuracy of ± 2 mm.

Place the test piece centrally on the supports to within ± 5 mm.

Position support prisms of the measuring device symmetrically with respect to the applied load F.

Position the inside faces of these support prisms so that the distance between them is (600 ± 2) mm less than the total length of the test piece.

The distance between the midpoints of the support prisms of the measuring device is the measuring length l and shall be defined to an accuracy of ± 2 mm.

7.3 Positioning of the measuring feeler

Mount the measuring feeler vertically on the support bar and place it at the midpoint of the measuring length l of the test piece, to within ± 2 mm, so that the transverse deflection is measured from the upper surface of the test piece.

7.4 Application of loading

Apply the load by hanging an appropriate weight on the belt which is placed at the midpoint of the measuring length l of the test piece (see figure 3).

7.5 Determination

Within 2 s after the load has been applied, read the deflection recorded by the measuring feeler. The value obtained for f and the applied load F are substituted in formula (1) to calculate the flexural modulus for each test piece.

8 Calculation of the flexural modulus

The flexural modulus E, or Young's modulus in bending, is calculated, in newtons per square millimetre, using the formula

$$E = \frac{Fl^3\left(1 + C_e + C_s\right)}{48If} \quad \ldots \quad (1)$$

where

F is the applied transversal load, in newtons;

l is the distance between the centres of the support prisms of the measuring device, in millimetres;

I is the second moment of area of the core cross-section, in millimetres to the power four;

f is the difference in deflection between the loaded and unloaded condition measured in the direction of the applied load, in millimetres;

C_e is a dimensionless coefficient which takes into account the difference in span length;

C_s is a dimensionless shear coefficient which takes into account the influence of shear deformation on bending deflection.

I is calculated according to the formula

$$I = \frac{\pi}{64}\left(D^4 - d^4\right) \quad \ldots(2)$$

where

D is the outer diameter of the core, in millimetres;

d is the internal diameter of the core, in millimetres.

The coefficient C_e is calculated using the formula

$$C_e = 1{,}5\left(\frac{L}{l} - 1\right) \quad \ldots(3)$$

where L is the distance between the centres of the two-roller support prisms, in millimetres.

The coefficient C_s is calculated using the formula

$$C_s = \frac{1{,}55\left(D^4 + d^4\right) + 7{,}25D^2d^2}{l^2\left(D^2 + d^2\right)} \quad \ldots(4)$$

9 Conditions of measurements

The required load F can be calculated approximately, in newtons, using the formula

$$F = \frac{24 \cdot E_{ass} \cdot I}{l^3\left(1 + C_e + C_s\right)} \quad \ldots(5)$$

where

E_{ass} is an assumed value for the flexural modulus, in newtons per square millimetre;

I, l, C_e and C_s are defined after formula (1).

NOTE — The deflection of the core should be 0,2 mm to 0,7 mm.

10 Test report

The test report shall include the following particulars:

a) reference to this part of ISO 11093;

b) type and designation of the cores tested;

c) place and date of sampling;

d) place and date of testing;

e) number of test pieces tested;

f) core dimensions;

g) measured moisture content;

h) l, L, f and F;

i) individual and mean values for E;

j) deviations, if any, from this part of ISO 11093;

k) date and signature.