INTERNATIONAL STANDARD

ISO 8515

First edition
1991-07-01

Textile-glass-reinforced plastics — Determination of compressive properties in the direction parallel to the plane of lamination

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Plastiques renforcés de fibres de verre textile — Détermination des caractéristiques en compression parallèlement au plan de stratification

ISO 8515:1991
https://standards.iteh.ai/catalog/standards/sist/6b999938-1abe-4c92-9d9e-0f817e8b11f7/iso-8515-1991

Reference number
ISO 8515:1991(E)

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 8515 was prepared by Technical Committee ISO/TC 61, *Plastics*.

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International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Textile-glass-reinforced plastics — Determination of compressive properties in the direction parallel to the plane of lamination

1 Scope

This International Standard specifies two methods for determining compressive properties, in the direction parallel to the plane of lamination of flat textile-glass-reinforced laminates.

Method A is applicable to laminates of 2 mm to 4 mm thickness.

Method B is applicable to laminates of 3 mm to 10 mm thickness.

The compressive properties are of interest for specifications and quality control.

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2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard 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 291:1977, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 468:1982, *Surface roughness — Parameters, their values and general rules for specifying requirements.*

ISO 1268:1974, *Plastics — Preparation of glass fibre reinforced, resin bonded, low-pressure laminated plates or panels for test purposes.*

ISO 2602:1980, *Statistical interpretation of test results — Estimation of the mean — Confidence interval.*

ISO 9353:1991, *Glass-reinforced plastics — Preparation of plates with unidirectional reinforcements by bag moulding.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 modulus of elasticity in compression: Ratio of stress to corresponding strain within the range of proportionality between stress and strain. It is expressed in megapascals.

3.2 compressive stress in the direction parallel to the plane of lamination: Compressive force, carried by the test specimen at any particular moment, divided by the initial cross-sectional area of the parallel portion of the specimen. It is expressed in megapascals.

3.3 compressive strain: Ratio of the decrease in the distance between gauge marks on the parallel portion of the test specimen (due to a compressive force) to the initial distance between the gauge marks.

4 Principle

An axial force is applied to the two ends of a vertically held parallelepipedic bar by means of a ram moving at constant speed.

5 Apparatus

5.1 Method A

5.1.1 Test machine.

A properly constructed and calibrated test machine shall be used which can be operated at an approximately constant rate of relative movement of the members and in which the error for the indicated loads does not exceed ± 1 % and the error for the indicated strains does not exceed ± 2 %.

Two flat steel platens at least 20 mm thick are attached to the test machine in such a way that one is on top and the other on the bottom of the assembled test fixture.

5.1.2 Compression fixture.

A line drawing and a schematic of the compresssion fixture are given in figure 1 and figure 2, respectively. Referring to figure 2, the fixture has split collet-type grips, A, B and A′, B′, at both ends. The grip cavities have file face linings, alignment pins for proper closure, and a closed width and thickness of 7 mm and 3,6 mm, respectively. The grips have an outer 10° conical taper and fit into sleeves (C) with a matching inner taper. It is allowed to use other types of grip and sleeve (trapezoid, for example).

Dimensions in millimetres

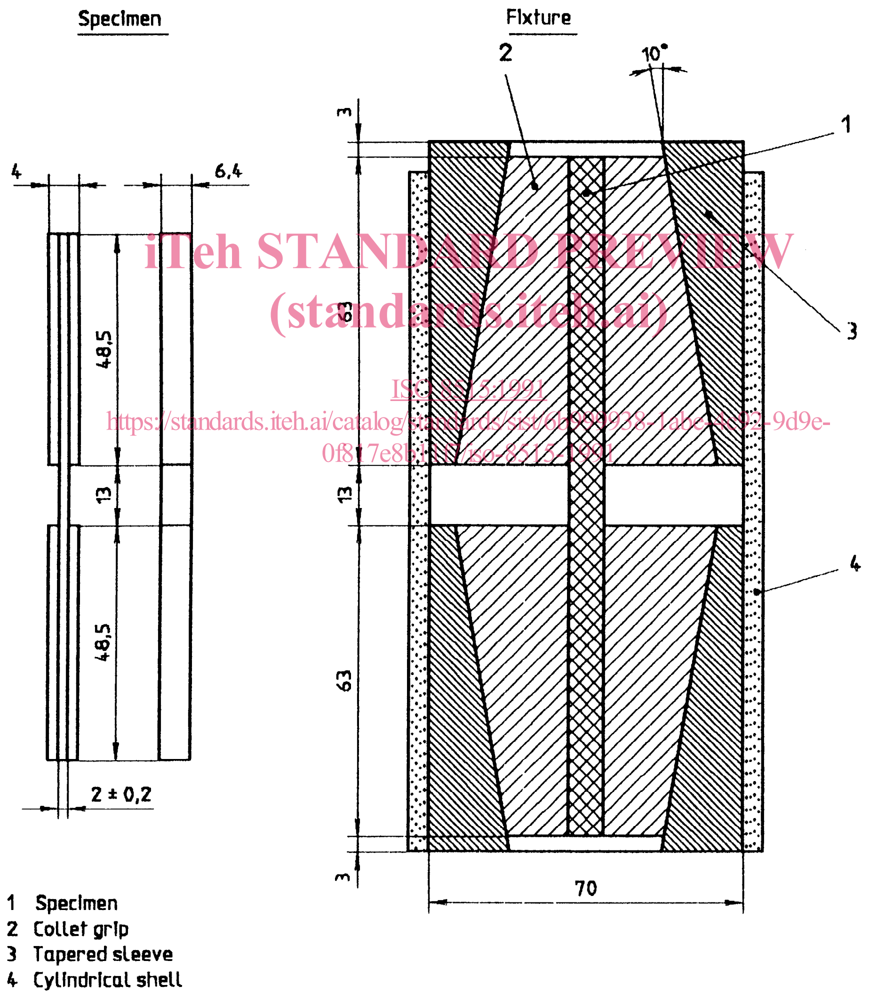

Figure 1 — Compression test specimen and fixture for method A

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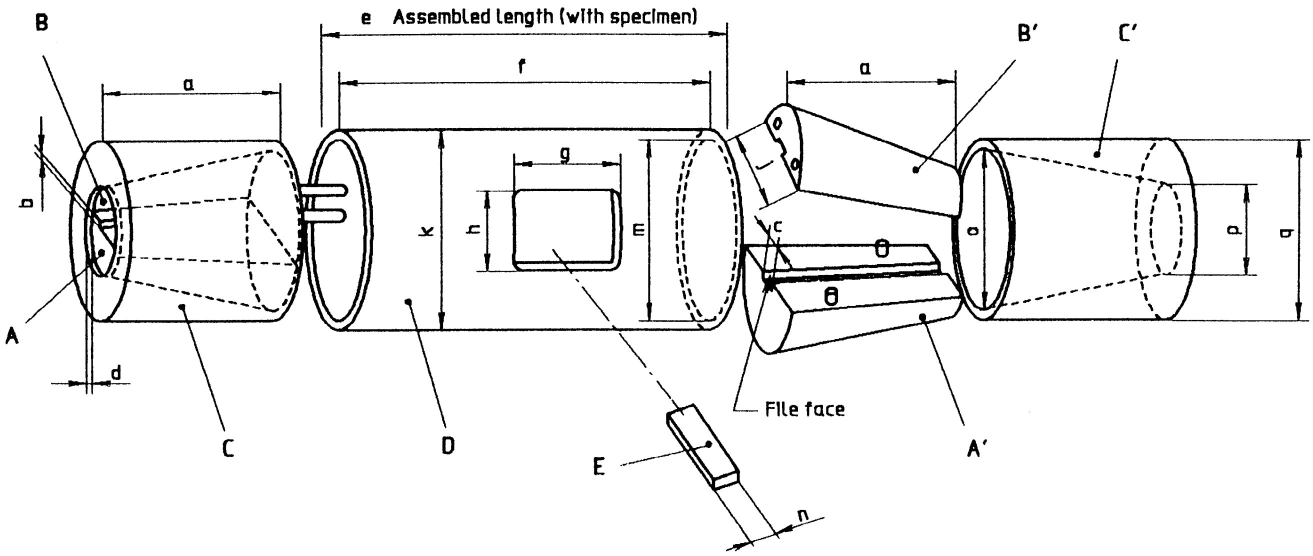

Figure 2 — Exploded view of compression fixture for method A (for dimensions see table 1)

These sleeves are inserted into a snugly fitting cylindrical shell (D) for ease of assembly and aligment, but the shell is not load-bearing during the test. A 13,0 mm wide preload spacer (E) is employed to separate the grips and to allow them to be closed with a preload of 270 N to 450 N without preloading the specimen. The assembled fixture with specimen is loaded between the flat steel platens.

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Table 1 — Dimensions and tolerances for the test fixture parts shown in figure 2

Dimensions in millimetres

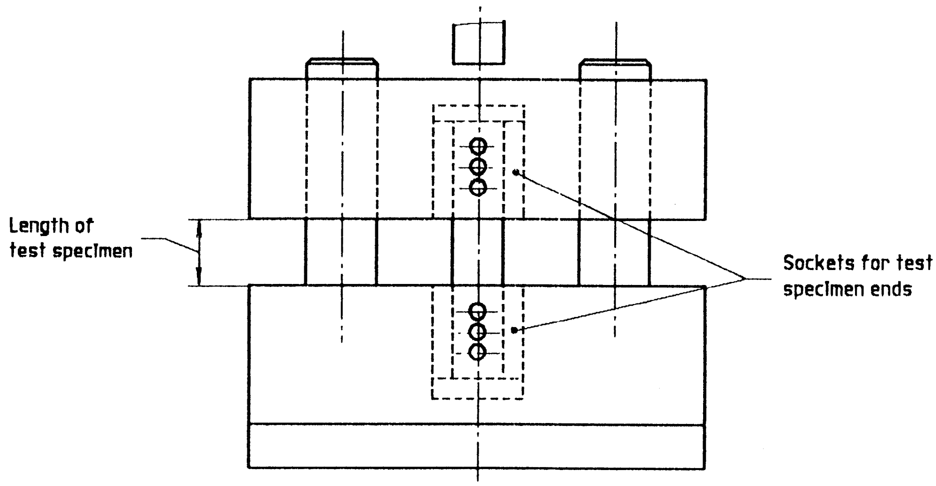
Symbol	Dimension	Tolerance
a	63	± 0,10
b	3,6	± 0,05
c	7	± 0,025
d	3	± 0,075
e	145	± 0,50
f	133	± 0,50
g	32	± 0,30
h	38	± 0,30
j	58	± 0,03
k	76	± 0,30
m	70	$^{+0,08}_{0}$
n	13	± 0,03
o	56	± 0,03
p	33	± 0,03
q	70	$^{0}_{-0,05}$

5.1.3 Strain gauge.

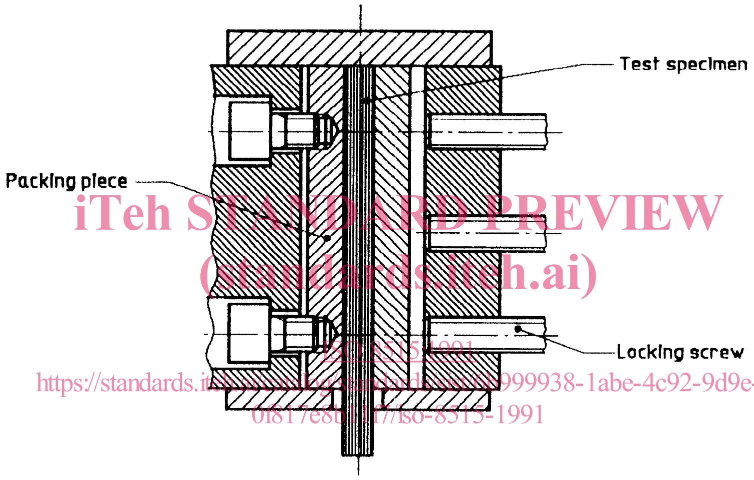
Strain shall be determined by means of either a strain gauge or a suitable extensometer. The strain gauge shall be not more than 3 mm in length. The gauges, surface preparation and bonding agents shall be chosen to give adequate performance on the subject materials, and suitable strain-recording equipment shall be employed.

5.1.4 Micrometer.

A screw-type micrometer capable of measuring to the nearest 0,02 mm shall be used to determine the width and thickness of the test specimen.



a) Schematic of setting device



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b) Schematic of device for fitting the test specimen in one of the sockets

Figure 3 — Compression fixture for method B

5.2 Method B

5.2.1 Test machine.

The test machine shall be in accordance with 5.1.1.

5.2.2 Compression fixture.

The compression fixture shall be in accordance with figure 3.

5.2.3 Strain gauge.

The strain shall be determined in accordance with 5.1.3.

5.2.4 Micrometer.

The micrometer shall be in accordance with 5.1.4.

6 Preparation of test specimens

If a comparison is to be made between different reinforced plastics, cut the test specimens out of flat sheets prepared in accordance with ISO 1268 or ISO 9353. If test specimens are to be cut from finished parts (for example, in quality control during manufacture or on delivery), they should be taken from flat areas. Furthermore, every effort shall be made to use test specimens without surface machining specifically intended to reduce their thickness. If the thickness of the specimens has been reduced by machining, the results obtained may not be comparable to those obtained on test specimens without machined surfaces.

6.1 Number of test specimens

Fibre-reinforced plastics are usually anisotropic. It is therefore often useful to cut test specimens as a function of at least the two main directions of anisotropy, or as a function of directions previously specified (for example lengthwise or crosswise to this sheet). For each direction and property considered (modulus of elasticity, compression strength, etc.), at least five results are necessary.

Discard and replace any test specimens that have undergone testing under faulty operating conditions, or have given manifestly inconsistent results for evident reasons. Increase the number of specimens if a greater precision of the mean value is required. It is possible to evaluate this precision by means of the confidence limits (95 % probability) (see ISO 2602).

6.2 Method A

6.2.1 Type of test specimen and specimen dimensions

See figure 1.

6.2.2 Preparation and application of end pieces

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The following method is recommended. Cut from the material under test a sheet having the length of the intended test specimens and of a width suitable for the number of test specimens required. To form the end pieces, cut parallelepipedic strips, preferably from a material having a modulus of elasticity equivalent to that of the material under test. The thickness of the end pieces shall be 1 mm ± 0,1 mm; the end pieces be taken from the material to be tested and machined down to the required thickness.

Attach the strips, as shown in figure 4, as follows:

a) Rub all surfaces to which adhesive will be applied with fine abrasive paper.

b) Carefully clean these surfaces with a suitable solvent.

c) For bonding, use a cold-hardening adhesive (for example, a two-part epoxide adhesive), strictly following the manufacturer's instructions. Heat-curing film adhesives can also be used provided that the cure temperature is at least 40 °C below the glass transition temperature of the resin in the laminate or the curing temperature, whichever is the lower.

d) Keep the assembled parts under pressure until the adhesive has set.

It is desirable that the adhesive used for bonding be of a flexible nature with an elongation at break greater than that of the material under test. The strips shall be perfectly superposed at each end, parallel with each other and normal to the longitudinal direction of the test specimens. The sheets, together with the strips constituting the end pieces, are the test blanks ready for cutting into test specimens.

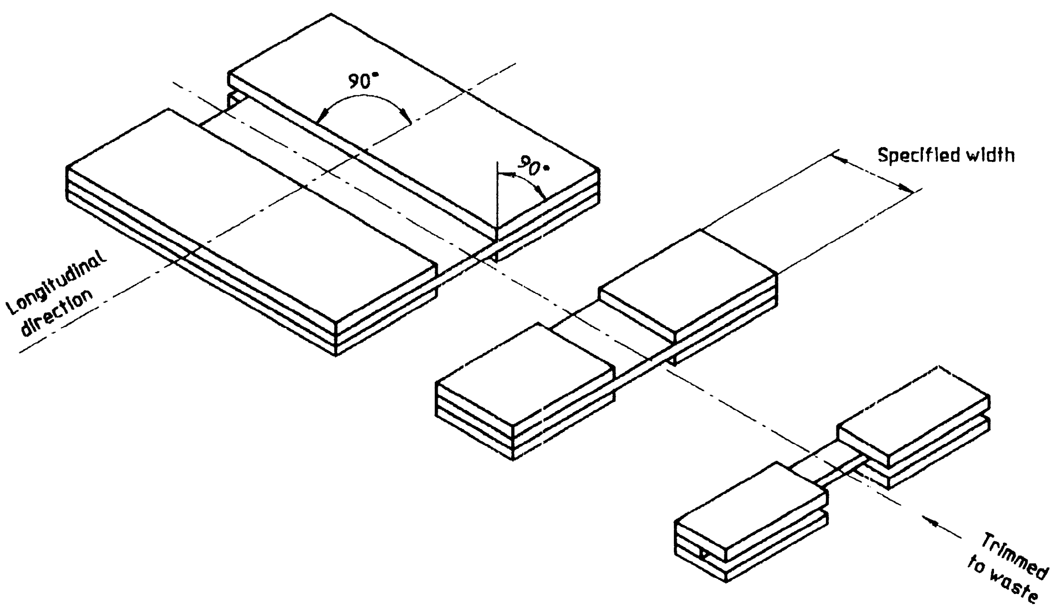

Figure 4 — Arrangement of specimen and end pieces for method A

6.3 Method B

6.3.1 Type of test specimen and specimen dimensions

The specimens shall be rectangular, having the following dimensions:

Length:	test length (20 mm ± 1 mm) plus twice the length between the grips (2 × 50 mm min.), i.e. 120 mm min. [see figure 3a)]
Width:	$(10\ ^{0}_{-0,05})$ mm
Thickness:	that of the material (between 3 mm and 10 mm)

6.4 Machining of the test specimens

Machine the loading ends of each specimen to be parallel to one another and perpendicular to the longitudinal axis of the specimen.

The allowed deviation in the parallelism of the supporting areas is 0,1 % of the initial height of the specimen, i.e. the distance between the grips. The tolerance on the parallelism (for specimens in the shape of a rectangular prism) shall be a maximum of 1 % of the initial height.

Avoid working under conditions that would create excessive heat build-up in the test specimen.

Check that the sides of the test specimen are free from defects.

7 Conditioning

7.1 Requirements on test atmosphere

One of the standard test atmospheres listed in ISO 291 shall be chosen.

7.2 Conditioning of the material

The specimens to be tested shall be conditioned in the chosen test atmosphere (see 7.1) for at least 16 h, unless otherwise specified.

8 Procedure

8.1 Method A

8.1.1 Measure the width b of each test specimen to the nearest 0,1 mm and the thickness h to the nearest 0,02 mm at several points between the tabs (end pieces). Record the minimum value of the cross-sectional area so determined.

8.1.2 Attach strain gauges and employ the necessary strain-recording equipment. The grid size of the gauge, which shall be centrally bonded on the specimen, shall be 3 mm or less. Double strain gauges (one on each face of the specimen) are recommended in order to ascertain that column bending is not occurring. Buckling may be detected if the strain on one face reverses (decreases) when the strain on the opposite face increases rapidly.

8.1.3 Mount a specimen in the compression fixture which has split collet-type grips, as shown in figure 2. Insert the tabbed parts of the specimen into the grip cavities with the grips (A and B) in the partly open position. After manually closing the grips, fit them into the sleeves (C) with an inside taper matching that of the grips. Place the spacer (E) between the top and bottom grips and insert the entire assembly into the cylindrical shell (D) which fits snugly around the sleeves. Place the fixture with the specimen between a pair of flat steel platens (at least one of them swivelling on the centreline of the test machine).

8.1.4 Set the speed of testing by adjusting the speed of the cross-head to 1 mm/min ± 0,5 mm/min. Load the assembly slightly with 230 N to 450 N before the spacer is removed. Remove the preloading spacer (E) and proceed with the test. As the axial compressive load is applied to the end faces of the tapered sleeves, the grip on the specimen tightens and the gauge section of the specimen is axially compressed by the shear force transmitted through the tabs. To ensure that the load is not being carried by the cylindrical shell (D), either assess the freeness of the shell by moving it up and down vertically during the test, or attach strain gauges to the shell and monitor any accompanying strain.

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8.1.5 Record load and strain (or deformation) continuously, if possible, or at least record load and deformation at even intervals of strain.

8.1.6 Record the maximum load carried by the specimen during the test.

8.1.7 Record the strain (deformation) at or as nearly as possible to the moment of failure of the specimen.

8.2 Method B

8.2.1 Measure the width and thickness in the middle of the test specimen to an accuracy of ± 0,1 mm and ± 0,02 mm, respectively.

8.2.2 Attach strain gauges or an extensometer as described in 8.1.2.

8.2.3 Adjust the grips to ensure that the test specimen is in the loading axis of the apparatus.

8.2.4 Position the test specimen, taking care that it is driven right to the bottom of its seat.

8.2.5 Tighten the grips with the torque spanner.

8.2.6 Adjust the speed of the moving clamp to 1 mm/min ± 0,5 mm/min.

8.2.7 Proceed as described in 8.1.5 to 8.1.7.

9 Expression of results

9.1 Calculate the compressive strength σ_c, expressed in megapascals, using the equation

$$\sigma_c = \frac{F_{max}}{b \cdot h}$$

where

- F_{max} is the maximum load, in newtons;
- b is the width, in millimetres, of the test specimen;
- h is the thickness, in millimetres, of the test specimen.

9.2 Calculate the compressive modulus E_c, expressed in megapascals, using the equation

$$E_c = \frac{\Delta F \cdot L}{b \cdot h \cdot \Delta L}$$

where

- ΔF is the load increment, in newtons;
- L is the gauge length, in millimetres;
- b is the width, in millimetres, of the test specimen;
- h is the thickness, in millimetres, of the test specimen;
- ΔL is the decrease in gauge length, in millimetres, corresponding to ΔF.

Calculate the arithmetic mean for the total number of tests carried out. For qualification purposes, also calculate the standard deviation and the coefficient of variation.

9.3 If required, calculate the standard deviation and coefficient of variation for the compressive strength, modulus and strain using the following equations:

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