International Standard

ISO **458/1**

Plastics — Determination of stiffness in torsion of flexible materials —
Part 1 : General method

Plastiques — Détermination de la rigidité en torsion des plastiques souples — Partie 1 : Méthode générale

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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.

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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 458/1 was prepared by Technical Committee ISO/TC 61, *Plastics*.

International Standards ISO 458/1 and ISO 458/2 cancel and replace ISO Recommendation R 458-1965, of which they constitute a technical revision.

Plastics — Determination of stiffness in torsion of flexible materials —
Part 1 : General method

1 Scope and field of application

This part of ISO 458 specifies a general method for determining the stiffness in torsion of flexible plastics at various temperatures, particularly at temperatures below 0° C.[1)]

2 References

ISO 291, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 458/2, *Plastics — Determination of stiffness in torsion of flexible materials — Part 2 : Application to plasticized compounds of homopolymers and copolymers of vinyl chloride.*

3 Principle

An observation of torque and angle of deflection is made after an arbitrarily fixed time of load application. This procedure is employed at single temperatures or at selected temperature intervals over a range specified for the material to be tested.

NOTES

1 It is necessary that the duration of load application be arbitrarily fixed and the values of angles of deflection be limited because of the known non-linear characteristics of plastics and their tendency to creep.

2 Comparison between values of stiffness in torsion may be made only when the values have been obtained using test specimens of the same thickness and at the same span and approximately at the same angle of deflection.

4 Apparatus

4.1 Testing machine, capable of exerting a torque sufficient to deflect a test specimen with a span between 35 and 55 mm. A schematic diagram of a machine suitable for this test is shown in the figure.

4.2 Different weights, to vary the amount of torque depending on the stiffness of the specimen and its span. It is recommended that the actual amount of torque being applied by any given combination of weights, torque pulley and shaft bearings be determined by periodic calibration.

NOTE — For operation at low temperatures, it is recommended that the shaft of the machine be provided with a heated collar next to the lower bearing to prevent the formation of ice.

4.3 Dewar flask or **thermal chamber** of suitable dimensions.

4.4 Thermometer, accurate to 1 °C and having the necessary range. The bulb should be placed in close proximity to the test specimen.

4.5 Timer, accurate to 0,1 s.

4.6 Heat-transfer medium. For normal laboratory purposes, a substance which is liquid over the desired temperature range is used for the heat-transfer medium, provided it has been shown that the liquid does not soften or otherwise affect the test specimen. With special precautions, a gaseous medium may be used (see note 1). Good stirring shall be ensured by appropriate means, during cooling and heating.

[1)] See ISO 458/2 for application of the method to vinyl chloride polymers. Details necessary for testing other specific materials will form the subjects of subsequent parts of ISO 458.
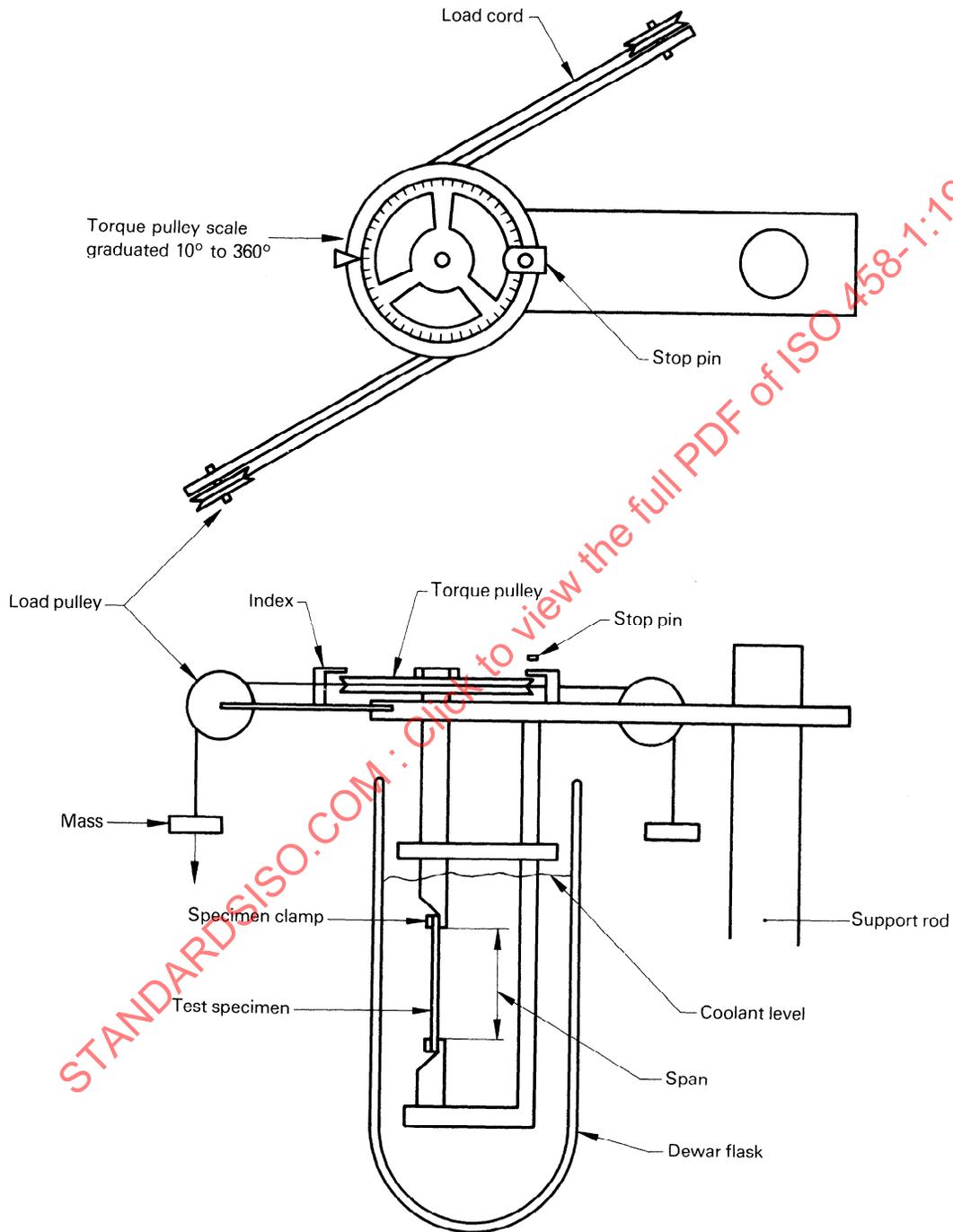
Load cord

Torque pulley scale
graduated 10° to 360°

Stop pin

Load pulley

Index

Torque pulley

Stop pin

Mass

Specimen clamp

Test specimen

Coolant level

Span

Support rod

Dewar flask

Figure — Torsion tester

NOTES

1 Among the liquids found useful are acetone, ethanol, butanol, *n*-hexane, silicone oil and a mixture of methyl phosphate and water in the ratio of 87 to 13 (V/V). For low temperatures to −70 °C a mixture by volume of 50 parts ethanol, 30 parts ethylene glycol and 20 parts water may be found useful. With a gaseous heat-transfer medium, care should be taken to ensure that sufficient time is allowed for the test specimen to reach thermal equilibrium.

2 For cooling, a refrigerator or a dry ice chest or both, according to the desired temperature, may be used. For heating, an electric heater may be used.

4.7 Micrometer. A dead-weight dial-type micrometer accurate to at least 0,01 mm shall be used for thickness and width measurements. The pressure exerted on the specimen shall be within the limits of 10 to 30 kPa.[1] An instrument accurate to at least 0,1 mm shall be used for measuring the span.

5 Test specimens

5.1 Dimensions

Test specimens shall be 70 ± 10 mm in length, 6,0 to 6,4 mm in width, and may have two holes for fixing in the clamps of the machine. Such holes shall have elongated shapes in the direction of the length of the test specimen. In anisotropic sheet the test specimens shall be cut along the two main directions.

The thickness of the test specimen shall be generally between 1 and 5 mm. This range is usually sufficient to test materials of various stiffnesses.

NOTE — In some cases it may be necessary to increase the width to 13 mm.

5.2 Number

Two test specimens of each material shall be tested.

5.3 Conditioning

Specimens to be tested shall be conditioned in accordance with ISO 291.

6 Procedure

6.1 Measure the span. Measure the thickness and the width of the test specimen at three points along the span. If the individual values differ by more than 0,1 mm, the specimen shall be discarded and another specimen taken. Calculate the mean values of the thickness and the width.

6.2 Mount the test specimen in the machine (4.1). The test specimen shall be placed between the clamps in such a way that its vertical axis coincides with the axis of rotation of the machine. Wedges may be used for this purpose.

NOTE — To prevent effects of tension during cooling, it is recommended that the test specimen be fixed only when the temperature has fallen at least as low as the lowest point it is intended to study.

6.3 Place the thermometer (4.4) in position.

6.4 Fill the Dewar flask or the thermal chamber (4.3) with the heat transfer medium (4.6), the temperature of which should be somewhat below the lowest temperature of the range to be studied. Place the flask in position on the machine.

6.5 Start the agitator. When the desired temperature and thermal equilibrium have been reached, take the first reading as described in 6.7.

6.6 By intermittent use of the heater bring the test temperature above the initial test temperature, if applicable.

6.7 Take readings after the test specimen has been conditioned at each test temperature for $180 \, {}^{+15}_{-0}$ s. Weights shall be attached to give the required torque (M), calculated as

$$M = R \, \Sigma \, W$$

where

$$R = \frac{D_1 + D_2}{2}$$

D_1 being the diameter, in millimetres, of the torque pulley,

D_2 being the diameter, in millimetres, of the load cord;

$\Sigma \, W$ is the sum of the two weights, in newtons, used to apply the torque.

A reading shall be taken by releasing the torque pulley and noting the angle of deflection, θ, after an interval of 5 s. The pulley shall then be returned to the zero position and, if applicable, the procedure shall be repeated at successively higher temperatures. The value of θ and the temperature shall be recorded for each reading.

The testing shall be done in such a way that the angular deflection value falls within the range

from 10° to 100° (method A), or

from 50° to 60° (method B).

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1) 1kPa = 1 kN/m²

If the value of the angle of deflection does not fall within the range given above, the applied torque shall be varied in such a way as to produce a suitable reading. If this is found to be insufficient, a specimen of another thickness shall be taken for testing.

NOTE — Results obtained for a given material by methods A and B may differ from each other.

7 Expression of results

7.1 The stiffness in torsion, expressed as the apparent torsional modulus of elasticity T, for each temperature is given, in megapascals, by the equation

$$T = \frac{917 \, L \, M}{bd^3 \, \mu \, \theta}$$

or, in a modified form

$$T = k \, \frac{M}{\theta} \qquad k = \frac{917 \, L}{bd^3 \, \mu}$$

where

L is the span, in millimetres;

M is the applied torque, in newton millimetres;

b is the average width of the specimen (the larger cross-sectional dimension), in millimetres;

d is the average thickness of the specimen (the smaller cross-sectional dimension), in millimetres;

μ is a value depending on the ratio b/d; the table gives the values for μ for various ratios of b/d (intermediate values may be found by interpolation);

θ is the angle of deflection, in degrees;

917 is a dimensional constant, in angular degrees;

k is a factor depending on specimen dimensions, in angular degrees per cubic millimetre.

The modified equation is recommended for use when repeated tests of the same specimen are being made.

7.2 If testing has been done over a wide range of temperatures, plot for each specimen tested the logarithm of stiffness in torsion versus temperature.

Table — Values for μ as a function of b/d

Ratio b/d	μ	Ratio b/d	μ
1,20	2,64	2,50	3,99
1,30	2,82	2,75	4,11
1,40	2,98	3,00	4,21
1,50	3,13	3,50	4,37
1,60	3,26	4,00	4,49
1,70	3,37	4,50	4,58
1,80	3,48	5,00	4,66
1,90	3,57	5,50	4,72
2,00	3,66	6,00	4,77
2,25	3,84	6,50	4,81

NOTE — The μ values in the table are given by the equation

$$\mu = 5,33 - 3,36 \frac{d}{b}\left(1 - \frac{d^4}{12 \, b^4}\right)$$

8 Test report

The test report shall include the following information :

a) a reference to this part of ISO 458 and to the method selected (A or B);

b) full details necessary for identification of the material, including name, stock or code number, date made, form, etc.;

c) nominal dimensions of test specimen (span, width, thickness);

d) details of conditioning of test specimen prior to test;

e) heat-transfer medium used;

f) table of data and results (temperature, angular deflection, stiffness in torsion);

g) plot of the logarithm of the mean value of stiffness in torsion for both test specimens versus temperature (if a wide range of temperatures is used).