UDC 678.5/8 Ref. No.: ISO / R 458 - 1965 (E)

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 458

PLASTICS

DETERMINATION OF STIFFNESS IN TORSION AS A FUNCTION OF TEMPERATURE

1st EDITION

November 1965

For each individual country the only valid standard is the national standard of that country.

Printed in Switzerland

Also issued in French and Russian. Copies to be obtained through the national standards organizations.

BRIEF HISTORY

The ISO Recommendation R 458, *Determination of Stiffness in Torsion as a Function of Temperature*, was drawn up by Technical Committee ISO/TC 61, *Plastics*, the Secretariat of which is held by the American Standards Association, Inc. (ASA).

Work on this question by the Technical Committee began in 1959 and led, in 1960, to the adoption of a Draft ISO Recommendation.

In April 1962, this Draft ISO Recommendation (No. 469) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies:

Australia	India	Spain
Austria	Italy	Sweden
Brazil	Japan	Switzerland
Chile	Mexico	United Kingdom
Czechoslovakia	New Zealand	U.S.A.
Finland	Poland	Yugoslavia
France	Republic of South Africa	
Germany	Romania	

Two Member Bodies opposed the approval of the Draft:
Belgium, U.S.S.R.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in November 1965, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 458 November 1965

PLASTICS

DETERMINATION OF STIFFNESS IN TORSION AS A FUNCTION OF TEMPERATURE

1. SCOPE

1.1 This ISO Recommendation describes a procedure for determining the stiffness in torsion properties of plastics over a wide temperature range.

1.2 It is particularly used for determining the stiffness properties of non-rigid plastics at temperatures below 0 °C.

2. PRINCIPLE OF TEST

An observation of torque and deflection is made after an arbitrarily fixed time of load application. This procedure is employed at selected temperature intervals over a wide range. It is necessary that the dimension of time for load application be arbitrarily fixed because of the known " creep " characteristics of this type of material.

The property actually measured by this method is the apparent modulus of rigidity G, sometimes called the apparent shear modulus of elasticity. It is important to note that this property is not the same as the modulus of elasticity E, measured in tension, flexure or compression. (See note 1.)

NOTES

1. By means of certain simplifying assumptions, an apparent modulus of elasticity may be calculated from the apparent modulus of rigidity. This is described in the Annex A to this ISO Recommendation.
2. The variation of the apparent shear modulus of elasticity of the material with temperature is an important consideration in the application of various plastics.

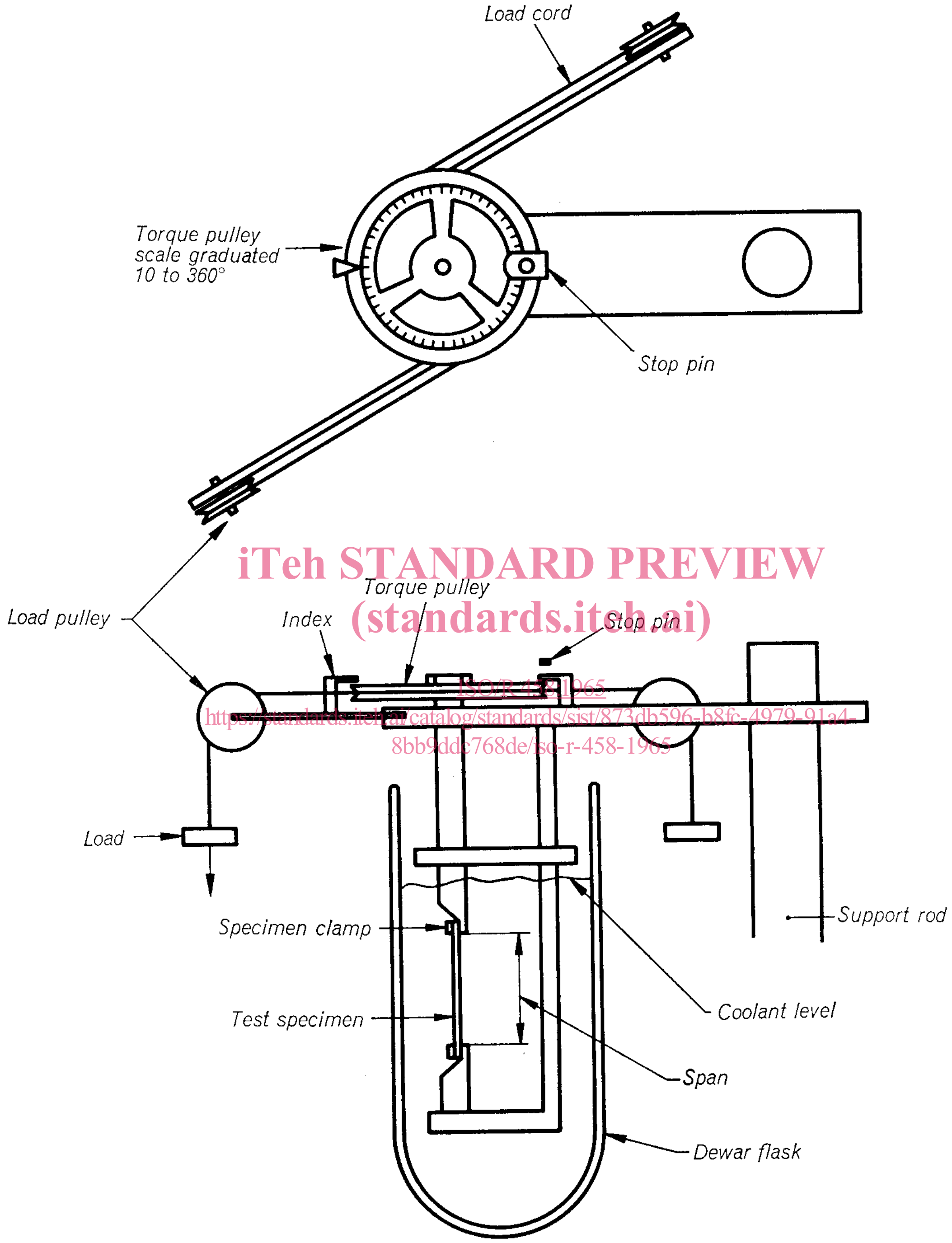

FIGURE — Torsion tester

3. APPARATUS

The apparatus consists of the following:

(*a*) *Testing machine* capable of exerting a torque of approximately 0.1 to 1.2 kgf·cm (0.1 to 1.0 lbf·in) on a test specimen with a span of 35 to 55 mm (1.4 to 2.2 in) measured to an accuracy of ± 0.5 mm (± 0.02 in) and immersed in an adequately circulated heat transfer medium. A schematic diagram of a machine suitable for this test is shown in the Figure (page 4).

(*b*) *Different weights* to vary the amount of torque and to suit the stiffness of the test specimen. The actual amount of torque being applied by any given combination of weights, torque pulley radii and shaft bearings should be determined by calibration, unless it can be demonstrated that friction is negligible. This is necessary in order that frictional effects may be eliminated.

NOTE 3.—For operation at low temperature, the shaft of the machine should be provided with a heated collar next to the lower bearing to prevent the formation of ice.

(*c*) *Dewar flask* of 500 ml capacity, or with suitable dimensions.

(*d*) *Thermometer* graduated in Celsius degrees and having the necessary range. The bulb should be located in close proximity to the test specimen.

(*e*) *Timer* accurate to 0.1 second.

(*f*) *Heat transfer medium.* For normal laboratory purposes, a substance which is liquid over the desired temperature range should be used for the heat transfer medium, provided it has been shown that the liquid does not soften or otherwise affect the test specimen.

NOTES

4. Among the liquids found useful are acetone, ethyl alcohol, butyl alcohol, normal hexane, silicone oil and a mixture of methyl phosphate and water in the ratio of 87 to 13 by volume. For temperatures to 70 °C a mixture of 50 parts ethyl alcohol, 30 parts ethylene glycol and 20 parts water may be found useful. If no suitable liquid can be found, a gaseous heat-transfer agent may be used. In this case, great care should be taken to ensure that sufficient time is allowed for the test specimen to reach temperature equilibrium.

5. Good stirring should be assured by appropriate means during cooling and heating.

6. For cooling, mechanical refrigeration or dry ice chest or both, according to the desired temperature, may be used. For heating, it is possible to use an electric immersion heater in the Dewar flask.

(*g*) *Micrometer.* A dead-weight dial-type micrometer graduated to 0.01 mm (0.001 in) should be used for thickness measurements. These measurements should be accurate to three significant figures.

4. TEST SPECIMENS

4.1 Test specimens should be right prisms with a length of 70 ± 10 mm (2.8 ± 0.4 in) and a width of 6.0 to 6.3 mm (0.23 to 0.25 in) measured to an accuracy of ± 0.02 mm (± 0.001 in). The fixation holes in the clamps of the machine should have elongated shape in the direction of the length of the test specimen and their axis-to-axis dimension should be 60 ± 10 mm (2.4 ± 0.4 in). In anisotropic sheet the test specimens should be cut along the two main directions.

4.2 The thickness of the test specimen lies generally between 1 and 5 mm (0.04 and 0.2 in). This range gives usually enough possibilities to test materials of various stiffness.

4.3 Duplicate test specimens of each material should be tested.

5. CONDITIONING

Specimens to be tested should be conditioned in accordance with ISO Recommendation R 291, *Plastics. Standard Atmospheres for Conditioning and Testing.*

6. PROCEDURE

6.1 Measure the thickness of the test specimen in accordance with the accuracy indicated in clause 3 (*g*).

6.2 Mount the test specimen in the machine. The test specimen should 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 7.—To prevent effects of tension during the 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 in position.

6.4 Fill the Dewar flask with the heat transfer medium, 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 has been reached, take the first reading as described under clause 6.7.

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

6.7 Take readings after the test specimen has been conditioned at each test temperature for 3 min $^{+15}_{\ 0}$ seconds. A reading should be taken by releasing the torque pulley and noting the angle of deflection, θ, after an interval of 5 seconds. The pulley should be then returned to the zero position and the procedure repeated at successively higher temperatures. The value of θ and the temperature should be recorded for each reading. Torque and test specimen thickness should be so chosen that no reading for θ should be below 20° of angle at the low temperature nor above 200° of angle at the high temperature.

NOTE 8.—In the case of particularly interesting values of the apparent modulus of rigidity, it is recommended, if it is possible, to determine the torque and the dimensions of the test specimen which will give an angle of deflection corresponding to this modulus of about 60°.

7. CALCULATION

7.1 Calculate the apparent modulus of rigidity G for each temperature as follows:

$$G = \frac{917\,T\,l}{\mathrm{bd}^3\,\mu\,\theta}$$

G = apparent modulus of rigidity, in kilogrammes-force per square centimetre (kgf/cm²);

T = applied torque, in kilogrammes-force-centimetre (kgf·cm);

l = specimen length (span), in centimetres;

b = specimen width (larger cross-sectional dimension), in centimetres;

d = specimen thickness (smaller cross-sectional dimension), in centimetres;

μ = value depending on ratio $\frac{b}{d}$. The Table below gives the values of μ for various ratios of $\frac{b}{d}$. The intermediate values should be found by interpolation;

θ = angle of rotation of the pulley, in degrees.

TABLE. — Values for μ

Ratio $\frac{b}{d}$	μ	Ratio $\frac{b}{d}$	μ
1.20	2.68	2.75	4.11
1.30	2.83	3.00	4.21
1.40	2.99	3.50	4.37
1.50	3.13	4.00	4.49
1.60	3.26	4.50	4.59
1.70	3.37	5.00	4.66
1.80	3.48	6.00	4.77
1.90	3.57	7.00	4.85
2.00	3.66	8.00	4.91
2.25	3.84	9.00	4.96
2.50	3.99	10.00	5.00

NOTE 9.—This expression and the Table are taken from Trayer and March, National Advisory Committee for Aeronautics, *Report 334 (1929)*.

7.2 Plot the apparent modulus of rigidity values calculated in accordance with clause 7.1 on a logarithmic scale versus temperature on a linear scale.

8. REPORT

The report should include the following:

(*a*) Complete identification of the material including name, stock or code number, date made, form, etc.;

(*b*) Dimensions of test specimen;

(*c*) Details of conditioning of test specimen prior to test;

(*d*) Table of data and results;

(*e*) Plot of logarithm of mean value for both test specimens of apparent modulus of rigidity versus temperature:

(*f*) Date of test.

ANNEX A

CALCULATION OF APPARENT MODULUS OF ELASTICITY

The calculation of the apparent modulus of elasticity from the apparent modulus of rigidity requires some simplification. The equation is

$$E = 2\,G\,(1 + \lambda) \qquad (1)$$

where

E = apparent modulus of elasticity,

G = apparent modulus of rigidity,

λ = Poissons's ratio.

If Poisson's ratio is close to 0.5, equation (1) becomes

$$E = 3\,G \qquad (2)$$

It then follows that

$$E = \frac{2750\,T\,l}{bd^3\,\mu\,\theta} \qquad (3)$$

where

E = apparent modulus of elasticity, in kilogrammes-force per square centimetre (kgf/cm^2);

T = applied torque, in kilogrammes-force centimetre ($kgf \cdot cm$);

l = specimen length (span), in centimetres;

b = specimen width (larger cross-sectional dimension), in centimetres;

d = specimen thickness (smaller cross-sectional dimension), in centimetres;

μ = value depending on ratio $\frac{b}{d}$ (see Table, page 7);

θ = angle of rotation of the pulley, in degrees.

Equation (3) may be used to calculate apparent modulus of elasticity from the experimental data.

NOTE 10.—The validity of formulae (2) and (3) is based on the fact that the value for Poisson's ratio is close to 0.5. If this condition is not satisfied, these formulae are not applicable.

Date of the first printing:
March 1966

Price: Sw. fr. 9.—