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ISO RECOMMENDATION

R 899

DETERMINATION OF TENSILE CREEP OF PLASTICS

1st EDITION
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BRIEF HISTORY

The ISO Recommendation R 899, *Determination of tensile creep of plastics,* was drawn up by Technical Committee ISO/TC 61, *Plastics,* the Secretariat of which is held by the United States of America Standards Institute (USASI).

Work on this question by the Technical Committee began in 1961 and led, in 1963, to the adoption of a Draft ISO Recommendation.

A first Draft ISO Recommendation (No. 748) was circulated in 1964 to all the ISO Member Bodies for enquiry. The voting summary having been reviewed, it was decided to prepare a second Draft ISO Recommendation which was circulated to all the ISO Member Bodies in February 1967. This second Draft was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia
Austria
Belgium
Canada
Chile
Czechoslovakia
Finland
France
Germany
Hungary
India
Iran
Israel
Italy
Japan
Netherlands
New Zealand
Poland
Portugal
Romania
South Africa, Rep. of
Spain
Sweden
Switzerland
Thailand
U.A.R.
U.S.A.
U.S.S.R.
Yugoslavia

One Member Body opposed the approval of the Draft :

United Kingdom

The second Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in December 1968, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 899 December 1968

DETERMINATION OF TENSILE CREEP OF PLASTICS

1. SCOPE

1.1 This ISO Recommendation describes the testing of plastics specimens in tension for long periods of time under conditions of constant temperature and humidity.

1.2 The test consists in applying a tensile load to the test specimen under exactly defined conditions :

(*a*) measuring the elongation of the specimen in the course of time during which these conditions are acting on it, and/or

(*b*) determining the time elapsed during the action of these conditions from the start of the test to the rupture of the specimen and/or to attaining the specified value of strain.

1.3 Since the creep test is a time-consuming test whose results are sensitive to variations in material composition and in the effects of the environment, it is at present recommended for use where the variations in the environment can be kept under close control.

1.4 The mechanical behaviour of plastics in tensile creep tests is of importance in determining the resistance and stability of these materials under conditions of loads applied for long periods of time. The tensile creep test results are useful in predicting the probable dimensional changes (or occurrence of fracture) of plastics parts under these service conditions.

2. DEFINITIONS

2.1 *Creep*. The time-dependent strain resulting from force.

For the purposes of obtaining significant measurements by this method, tensile creep of plastics is determined at constant load, constant temperature and constant humidity, under the conditions defined in section 3.

2.2 *Strain.* For the purpose of this ISO Recommendation, the relative elongation

$$e = \frac{\Delta \ell}{\ell_o}$$

where

$\Delta \ell = \ell - \ell_o$

ℓ is the gauge length at the respective moment of the test,

ℓ_o is the initial gauge length of the unstressed specimen (prior to the application of load under environmental conditions).

The strain may be reported as a percentage:

$$e\,(\%) = \frac{\Delta \ell}{\ell_o} \times 100$$

2.3 *Recovery.* The decrease of strain at any given moment after full unloading of the specimen, defined as a percentage decrease of the strain at the instant of removal of stress.

2.4 *Stress (nominal).* The force acting per unit area of original specimen cross-section. It is denoted by the following formula :

$$\sigma = \frac{F}{S}\,(\text{kgf/cm}^2)$$

where

F is the load (kgf),

S is the original cross-sectional area of the specimen (cm^2).

2.5 *Rate of creep* (k_c). Increase in strain per unit of time. The usual practice is to report the average rate of creep in a time interval defined by the relation

$$k_{c\,(t_2, t_1)} = \frac{e_2 - e_1}{t_2 - t_1}$$

where e_1 and e_2 are total strains observed at the moments t_1 and t_2 respectively.

NOTES

1. The instantaneous rate of creep at a time instant t_x is defined as the slope of the creep curve at the point corresponding to the time t_x.
2. When reporting the rate of creep, the conditions (temperature, humidity, initial stress), under which it has been determined, should be stated in each case.

2.6 *Index of creep* (k_c'). Increase of strain $e_2 - e_1$ in a specified interval of time from t_1 to t_2 expressed as a percentage of the strain e_1. It is defined conventionally by the following formula :

$$k'_{c\,(t_2, t_1)} = \frac{k_c\,(t_2 - t_1)}{e_1} \times 100 = \frac{e_2 - e_1}{e_1} \times 100$$

2.7 *Apparent modulus.* The ratio stress/strain at a specified moment of the creep experiment. It is denoted by the symbol E_c calculated by the following formula :

$$E_{c,t} = \frac{\sigma}{e_t}$$

where σ is the nominal stress and e_t is the relative elongation at the time t.

NOTES

1. Owing to the viscoelastic nonlinearity the apparent modulus depends on the applied stress. In reporting the apparent modulus, the nominal stress of the particular creep experiment should be stated.
2. Instead of the creep curve (depending on the purpose of testing) the curve E_c versus t may be used for the interpretation of the results of creep experiments.

2.8 *Isochronous stress-strain curve.* From the series of creep curves measured at several stress levels, the strain values should be taken at the same time of loading. Corresponding values of the nominal stress (x axis) and strain (y axis) give the isochronous stress - strain curve.

2.9 *Time to rupture.* The time elapsing between the moment of full loading of the specimen and the moment of rupture.

2.10 *Creep strength limit.* The nominal stress that leads to rupture ($\sigma_{B/t}$) or to a specified strain ($\sigma_{e/t}$) for a specified time t at a given temperature and relative humidity.

NOTE. – It may be useful (depending on the purpose of testing) to differentiate between the so-called *instantaneous strain* and *creep strain* (instantaneous strain + creep strain = *total strain*) and/or *instantaneous recovery* and *total recovery.* It is recommended that the instantaneous strain be denoted by the symbol e_0 as a value of strain occurring after short measurable time interval of loading, for example, at 1 minute.

3. TEST CONDITIONS

3.1 A constant temperature should be maintained during the test over the whole length of the working portion of the specimen (or along the gauge length). Unless otherwise specified, the temperature should be constant to ± 1 degC or less.

3.2 The device for maintaining the constant temperature of the test specimen should operate on the airbath principle. It is recommended that no liquid be used. The device should be equipped with a reliable thermostat. Automatic recording of the temperature during the whole time of the test is recommended.

3.3 For creep tests of high moisture absorptivity plastics, it is recommended that a constant relative humidity be maintained in the space of the test specimen. Relative humidity should not fluctuate during the test more than ± 5 % relative humidity. Control may be obtained either by carrying out the test in a controlled atmosphere laboratory, or in a small controlled enclosure around the specimen.

3.4 Unless otherwise required, one of the recommended standard atmospheres in ISO Recommendation R 291, *Standard atmospheres for conditioning and testing,* should be used during the test.

4. APPARATUS

The testing apparatus should consist of a gripping device (grips) for the specimen, a loading system and a strain-measuring device.

4.1 *The gripping device* should be so designed and used as to ensure that the direction of the load applied to the test specimen coincides as closely as possible with the longitudinal axis of the specimen. This means that the test specimen is subjected to simple stress and that the stresses in the working portion of the specimen may be assumed to be uniformly distributed over cross-sections perpendicular to the direction of the applied load.

NOTE. – It is recommended that such grips be used as will allow the final centred fixing of the specimen to be effected prior to applying the load. Selflocking grips, permitting a displacement of the specimen under rising load, are not suited for this test. In the case of contactless (optical) measurement of strain, the longitudinal axis of the specimen should be perpendicular to the optical axis of the measuring device.

4.2 *The loading system* should be so designed that the load applied is within ± 1 % of the desired load. In creep-rupture tests, provision should be made to prevent shocks at the moment of rupture. The loading mechanism should allow rapid, smooth and reproducible loading.

4.3 *The extension of specimen gauge length* under load may be measured by means of any contactless or contact device that will not influence the specimen behaviour by mechanical effects (undesirable deformations, notches, etc.), other physical effects (heating of specimen, etc.) or chemical effects. The accuracy of the extension-measuring device should be ± 1 % of the total extension to be measured; otherwise the actual accuracy should be indicated as ± strain in per cent. The ratio of the gauge length to the length of the working portion of the specimen should not be more than 5/6. For creep-rupture tests, it is recommended that the strain be measured by means of a contactless optical system on the principle of a cathetometer. An automatic indication of time to rupture is highly desirable. The gauge length should be marked on the specimen either by means of suitable (metallic) clamps with scratched-in gauge marks or by gauge marks ruled with an inert and thermally stable paint.

Electrical resistance strain gauges are suitable only if the material tested is of such a nature as to permit perfect adhesive application of such strain gauges, and if the creep tests are of short duration.

5. TEST SPECIMEN

5.1 Unless otherwise required, test specimens as specified for the determination of tensile properties should be employed for creep testing.

NOTE. – For comparative tests, if specimens having the same dimensions cannot be used, it is recommended that geometric similarity of test specimens be maintained.

5.2 The test specimens should be measured prior to the test so as to determine their width and thickness (or, in the case of test bars having circular cross-sections, their diameter) at least at five points along the gauge length.

5.3 The equipment used for measuring the test specimen should work with an accuracy of at least ± 0.01 mm.

5.4 Variations of cross-section within the gauge length should not exceed ± 2 %.

6. TEST PROCEDURE

6.1 Conditioning of test specimens

Conditions of the creep test (temperature, humidity) can, in the course of the test, change the structure of the material tested to such a degree that the change will influence the mechanical behaviour of the material or the dimensions of the specimen. It is therefore recommended that

(*a*) such thermal conditioning of the test specimen be carried out as to ensure that the test temperature will not influence its dimensions;

(*b*) the test specimen be preconditioned to a water content corresponding to the relative humidity of the space surrounding the test spcimen;

(*c*) simultaneously with the test, the strain be measured of a test specimen carrying no load (under the test conditions) and having the same properties as the test specimen under load.