International Standard 899

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Plastics — Determination of tensile creep

Plastiques — Détermination du fluage en traction

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Foreword

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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.

International Standard ISO 899 was developed by Technical Committee ISO/TC 61, *Plastics*.

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It was submitted directly to the ISO Council, in accordance with clause 5.10.1 of part 1 of the Directives for the technical work of ISO. It cancels and replaces ISO Recommendation R 899-1968, which had been approved by the member bodies of the following countries :

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The member body of the following country had expressed disapproval of the document on technical grounds :

United Kingdom

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Plastics — Determination of tensile creep

1 Scope and field of application

This International Standard specifies a method for the determination of tensile creep of rigid plastic materials in the form of test specimens such as are employed for the determination of tensile properties, moulded directly or cut from sheets.

Data from this method can be used

- to compare materials;
- in the design of fabricated parts;
- to characterize plastics for long-term performance under constant load;
- under certain conditions, for specification purposes.

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2 References

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

ISO 527, *Plastics — Determination of tensile properties.*[1)]

3 Definitions

For the purpose of this International Standard the following definitions apply.

3.1 creep : The time-dependent strain resulting from stress.

For the purpose of obtaining significant measurements by this method, tensile creep of plastics is determined at constant load, constant temperature and constant relative humidity (see ISO 291).

3.2 strain : The relative elongation. It is given by the equation

$$\varepsilon = \frac{\Delta l}{l_0}$$

where

$\Delta l = l - l_0$;

l is the gauge length at any given time during the test;

l_0 is the original gauge length of the unstressed specimen (prior to the application of load under the environmental conditions of the test).

The strain may be expressed as a percentage using the equation

$$\varepsilon = \frac{\Delta l}{l_0} \times 100$$

3.3 initial applied stress : The force divided by the area of the original specimen cross-section. It is given by the equation

$$\sigma = \frac{F}{A_0}$$

where

F is the load;

A_0 is the original cross-sectional area of the specimen.

The stress shall be expressed in megapascals[2)].

3.4 recovery : The decrease of strain at any given time after full unloading of the specimen, defined as a percentage decrease of the strain at the instant of removal of stress.

1) At present at the stage of draft. (Revision of ISO/R 527-1966.)

2) 1 MPa = 1 N/mm²

3.5 creep strain (ε_t) : The strain at any given time produced by the applied stress during a creep test.

3.6 creep modulus : The ratio of initial stress to creep strain. It is given by the equation

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

where

σ is the initial applied stress, in megapascals*;

ε_t is the creep strain at the time t.

The creep modulus shall be expressed in megapascals*.

3.7 isochronous stress-strain curve : From the series of creep curves measured at several stress levels, strain values are taken at the same time of loading. Corresponding values of the nominal stress (y-axis) and strain (x-axis) give the isochronous stress-strain curve. (See also figure 1.)

3.8 time to rupture : The time elapsing between the moment of full loading of the specimen and the moment of rupture.

3.9 creep strength limit : The initial applied stress that leads to rupture ($\sigma_{B,\,t}$) or to a specified strain ($\sigma_{\varepsilon,\,t}$) 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 creep recovery (instantaneous recovery + creep recovery = total recovery). It is recommended that the instantaneous strain be denoted by the symbol ε_0 as a value of strain occurring after a short measurable time interval of loading, for example, at 1 min.

4 Apparatus

4.1 Testing machine, consisting of the following devices :

4.1.1 Gripping device, designed and used so 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. Self-locking 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.

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

4.2 Strain-measuring device.

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 shall be ± 1 % of the total extension to be measured; the precision shall be indicated as (±) strain in percent. The ratio of the gauge length to the length of the working portion of the specimen shall 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 shall be marked on the specimen either by means of suitable (metallic) clamps with scratched-on gauge marks or by gauge marks ruled with an inert and thermally stable paint.

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

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4.3 Timer, the accuracy of which shall be ± 1 % of the elapsed time of creep measurement.

4.4 Micrometer, reading to at least ± 0,01 mm, for measuring the dimensions of the test specimen.

5 Test specimens

5.1 Unless otherwise required, test specimens as specified for the determination of tensile properties (see ISO 527) shall 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 For calculation of strain, the area of the cross-section of the test specimen shall be the mean of the cross-sectional areas measured at three points; for calculation of creep strength limit, the least cross-sectional area of the three measured shall be used. Variations of cross-section within the gauge length shall not exceed ± 2 %.

5.3 Specimens prepared from sheet shall be cut in a single direction unless the material is suspected to be anisotropic, in which case a set of specimens shall be cut for test from each of the two principal directions of the sheet. The direction in which the test specimen is taken shall be stated in the test report.

* 1 MPa = 1 N/mm²

5.4 The minimum number of test specimens at each stress shall be two.

6 Procedure

6.1 Conditioning and measurement of the dimensions of test specimens

Condition the test specimens in atmosphere 23 (or atmosphere 27) as specified in ISO 291. Measure their width to the nearest 0,05 mm and their thickness to the nearest 0,01 mm (or, in the case of test bars having circular cross-sections, their diameter to the nearest 0,05 mm) at least at three points along the gauge length, using the micrometer (4.4).

6.2 General remarks

To obtain design data or to characterize a material, stress levels shall be selected as follows :

6.2.1 For materials that show a large linear viscoelastic region, a minimum of three stress levels shall be selected at each temperature of interest.

6.2.2 For materials that show a small linear viscoelastic region, at least five stress levels and preferably more shall be selected.

6.2.3 In the case of determinations of creep strength limit ($\sigma_{B,\,t}$ and/or $\sigma_{\varepsilon,\,t}$), the loads shall be chosen so as to fall within the range from 10 to 90 % of the short-time tensile strength of the material and, having regard to this condition, shall be selected from the following number series :

1; 2; 3; 5; 7,5; 10 and their decimal multiples.

6.2.4 Stress levels that produce failure in less than 1 000 h shall not be used in creep testing.

6.2.5 For simple material comparisons, such as for data sheets, the stress to produce 1 % strain in 1 000 h shall be determined. This shall be done by selecting several loads to produce strains in the approximate range of 1 % (both somewhat greater and less than 1 % in 1 000 h) and plotting a 1 000 h isochronous stress-strain curve from which the stress to produce 1 % strain may be determined by interpolation.

6.3 Creep measurement

6.3.1 Mounting

Mount a conditioned and measured specimen in the grips (4.1.1).

6.3.2 Preloading

Where it is necessary to preload the test specimen prior to loading, for example in order to eliminate the backlash of the testing gear, take care to ensure that the preloading does not cause a measurable effect. The preloading shall not be applied before the test specimen (finally gripped in the testing machine) has reached equilibrium with the temperature and relative humidity of the selected test conditions. Measure the gauge length after application of the preload.

6.3.3 Loading

The loading of the test specimen (the temperature and moisture content of which correspond to the selected test conditions, and for which l_0 is already known) shall be done continuously. The rate of loading in a series of tests of one material shall be the same for each test run and shall be recorded. Determine the moment of full loading of the test specimen which shall preferably be 1 to 5 s, and in any case not more than 10 s, after beginning the application of the load.

In the case of a test concerned exclusively with strain, the additional load applied after preloading shall be taken as the test load.

In the case of a test of creep rupture (creep strength limit), the total load including preloading force may be taken as the test load.

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6.3.4 Programme of strain measurements

If the recording of changes in the measurement of length with time is not carried out continuously, it is recommended to measure them at the following time intervals : 1 — 6 — 12 and 30 min; 1 — 2 — 3 — 5 — 7 and 10 h. In the case of longer time measurements, use the decimal multiples of the series indicated for the measurement in hours.

NOTE — If discontinuities in the creep strain versus time plot are suspected or encountered, readings should be taken more frequently than recommended above.

6.3.5 Completion of the test

Upon completion of the test interval without rupture, remove the load rapidly and smoothly. If desired, measurements of the recovery can be made on the same schedule as used during the load application.

7 Calculations

7.1 Calculate creep modulus ($E_{c,\,t}$) by dividing the initial applied stress (σ) by the strain (ε_t) at the times specified in 6.3.4.

7.2 To calculate the stress to produce 1 % creep strain at 1 000 h, plot the 1 000 h isochronous stress-strain curve (see figure 1) and interpolate to obtain the stress at 1 % strain. The isochronous stress-strain curve at 1 000 h is obtained from several (at least three and preferably more) creep curves at different stresses by plotting stress versus creep strain calculated from deformation measurements at 1 000 h.

7.3 Isochronous stress-strain curves may be plotted at times other than 1 000 h for purposes of analysis or for specialized design situations involving relatively short-time loads and materials that show pronounced creep at such times. For long-term loading and in general, however, creep modulus curves are more useful.

8 Test report

The test report shall include the following particulars :

a) reference to this International Standard;

b) description of the material tested, including all pertinent information on composition, preparation, manufacturer, trade name, code number, date of manufacture, type of molding, annealing, direction in which the test specimens had been taken, etc.;

c) nominal dimensions of the test specimen;

d) preconditioning used and description of test conditions, including the relative humidity, temperatures, as well as concentration and composition of environment, type of loading, etc.;

e) for each test temperature a curve showing the common logarithm of creep strain (in percent) versus the common logarithm of time (in hours) under load with stress as a parameter (see figure 2);

f) for each test temperature a curve showing the common logarithm of creep modulus [in megapascals (or in newtons per square millimetre*)] versus the common logarithm of time (in hours) under load with stress as a parameter (see figure 3);

g) for each test temperature the isochronous stress-strain curve in accordance with 3.7, if desired;

h) for each test temperature, a creep rupture curve if rupture occurred during the test, plotting nominal initial applied stresses ($\sigma_{B,\,t}$) [in megapascals (or in newtons per square millimetre*)] versus corresponding times to rupture (in hours) under load.

NOTE — According to the purpose of the test, $\sigma_{\varepsilon,\,t}$ instead of $\sigma_{B,\,t}$ may be used.

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* Instead of reporting the stress values and creep modulus values in newtons per square millimetre, the unit meganewton per square metre can be used, both units leading to the same numerical value.

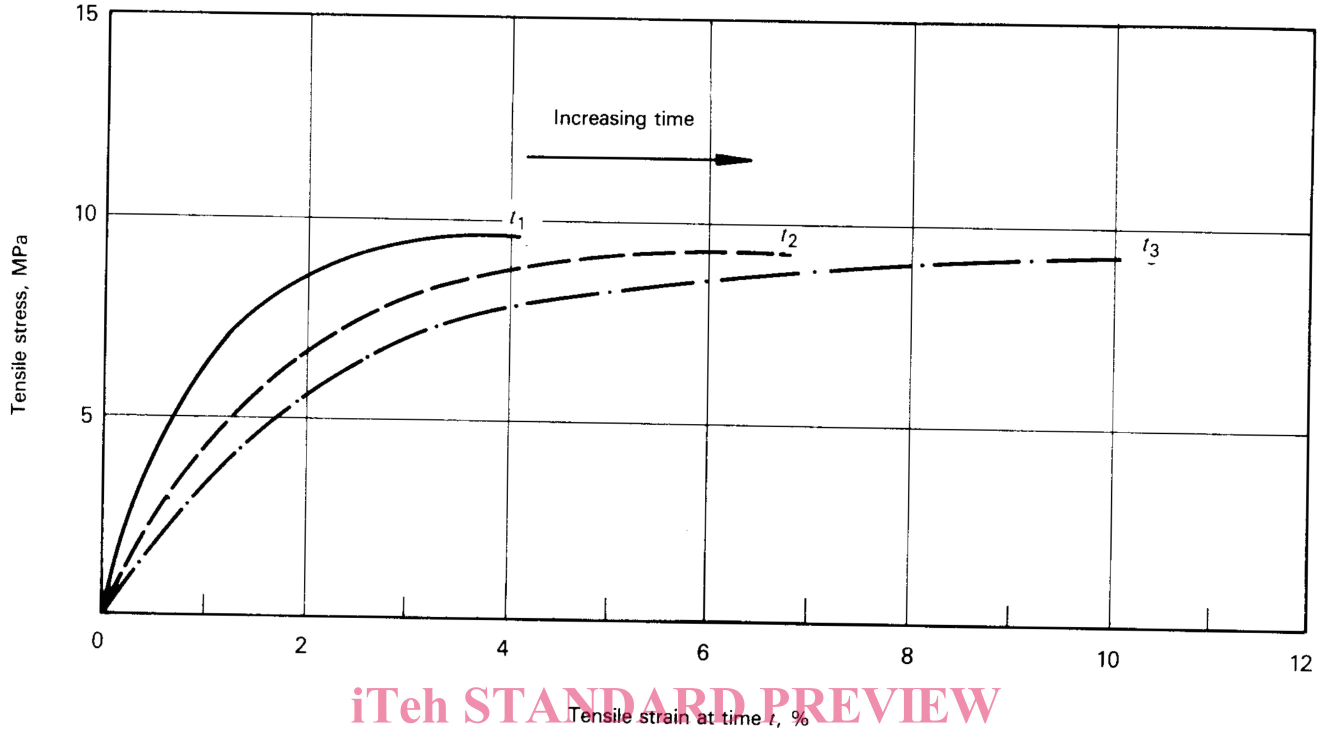

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Figure 1 — Typical isochronous stress-strain curves

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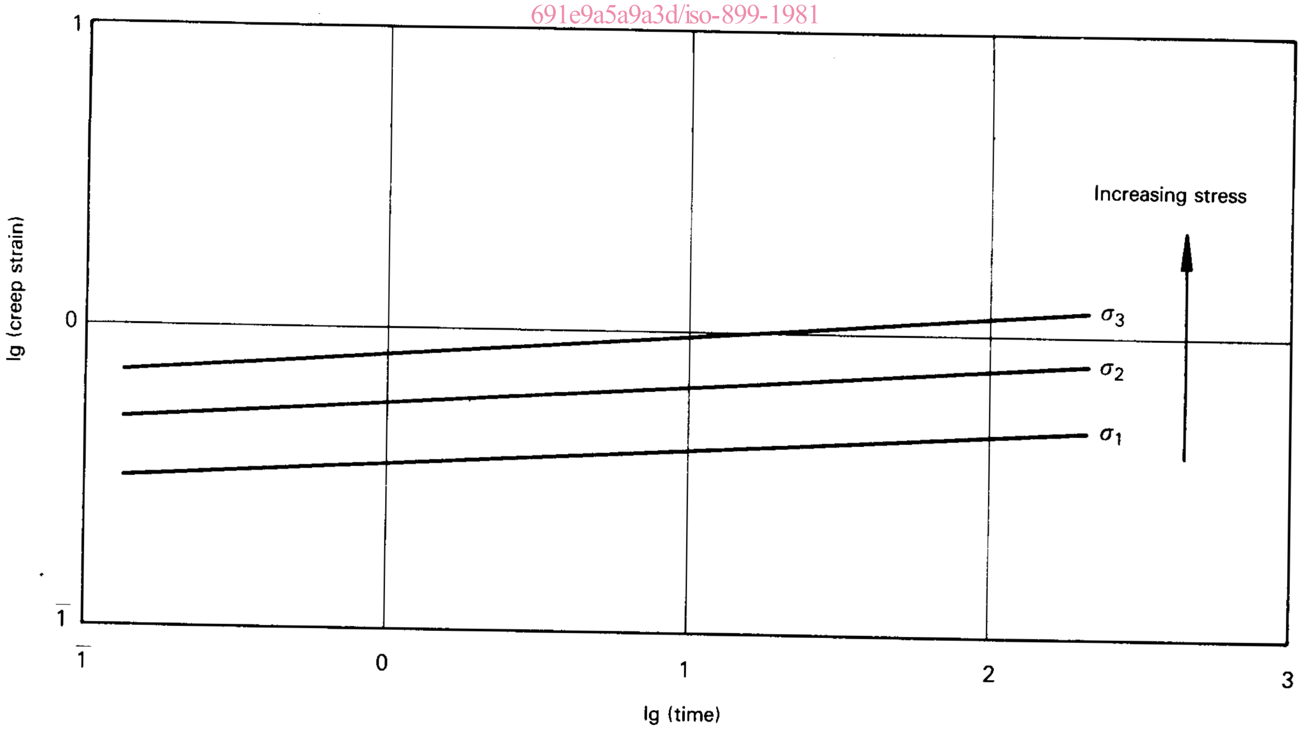

Figure 2 — Typical creep strain-time curves

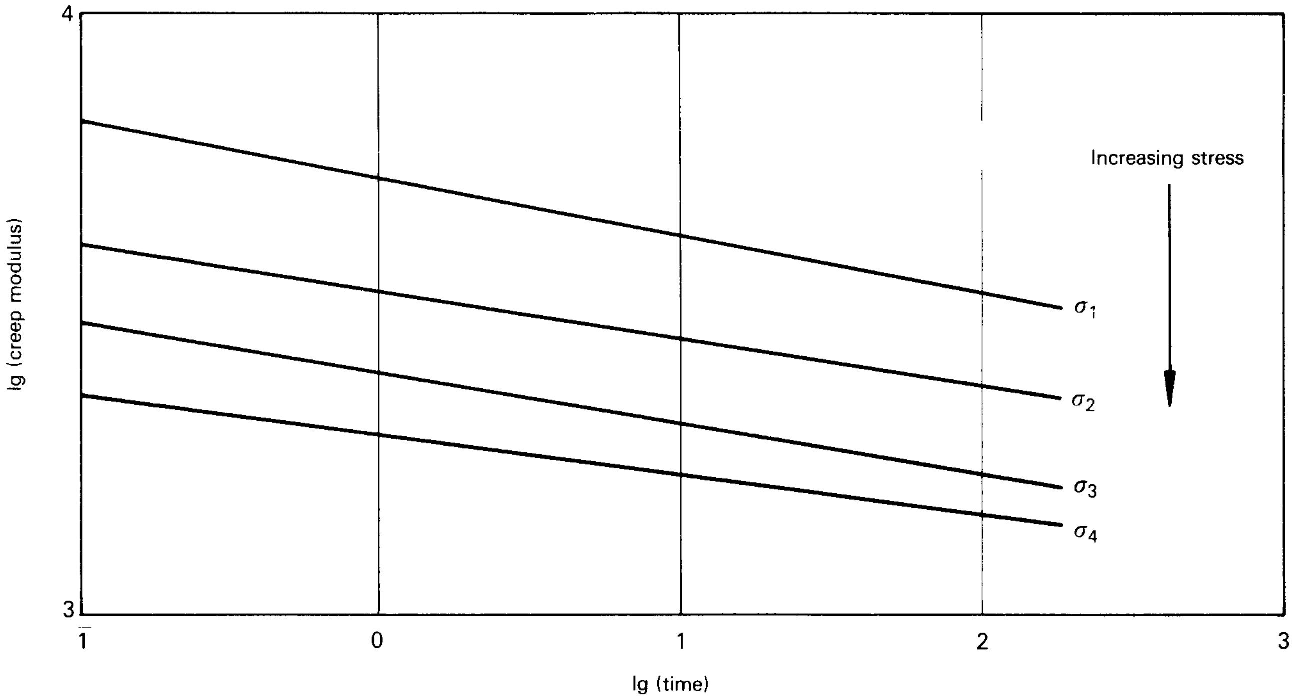

Figure 3 — Typical creep modulus-time curves

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