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BSI Standards Publication

Thermal insulating products for building applications — Determination of compressive creep

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/540, Energy performance of materials components and buildings.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Thermal insulating products for building applications - Determination of compressive creep

Produits isolants thermiques destinés aux applications du bâtiment - Détermination du fluage en compression

Wärmestoffe für das Bauwesen - Bestimmung des Langzeit-Kriechverhaltens bei Druckbeanspruchung

This European Standard was approved by CEN on 15 December 2012.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

This document (EN 1606:2013) has been prepared by Technical Committee CEN/TC 88 “Thermal insulating materials and products”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2013 and conflicting national standards shall be withdrawn at the latest by September 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1606:1996.

The revision of this standard contains no major changes, only minor corrections and clarifications of an editorial nature.

This European Standard is one of a series of standards which specify test methods for determining dimensions and properties of thermal insulating materials and products. It supports a series of product standards for thermal insulating materials and products which derive from the Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (Directive 89/106/EEC) through the consideration of the essential requirements.

This European Standard has been drafted for applications in buildings, but it may also be used in other areas where it is relevant.

This European test standard is one of the following group of interrelated standards on test methods for determining dimensions and properties of thermal insulation materials and products, all of which fall within the scope of CEN/TC 88:

— EN 822, *Thermal insulating products for building applications — Determination of length and width*

— EN 823, *Thermal insulating products for building applications — Determination of thickness*

— EN 824, *Thermal insulating products for building applications — Determination of squareness*

— EN 825, *Thermal insulating products for building applications — Determination of flatness*

— EN 826, *Thermal insulating products for building applications — Determination of compression behaviour*

— EN 1602, *Thermal insulating products for building applications — Determination of the apparent density*

— EN 1603, *Thermal insulating products for building applications — Determination of dimensional stability under constant normal laboratory conditions (23 °C/50 % relative humidity)*

— EN 1604, *Thermal insulating products for building applications — Determination of dimensional stability under specified temperature and humidity conditions*

— EN 1605, *Thermal insulating products for building applications — Determination of deformation under specified compressive load and temperature conditions*

— EN 1606, *Thermal insulating products for building applications — Determination of compressive creep*

- EN 1607, *Thermal insulating products for building applications — Determination of tensile strength perpendicular to faces*
- EN 1608, *Thermal insulating products for building applications — Determination of tensile strength parallel to faces*
- EN 1609, *Thermal insulating products for building applications — Determination of short-term water absorption by partial immersion*
- EN 12085, *Thermal insulating products for building applications — Determination of linear dimensions of test specimens*
- EN 12086, *Thermal insulating products for building applications — Determination of water vapour transmission properties*
- EN 12087, *Thermal insulating products for building applications — Determination of long-term water absorption by immersion*
- EN 12088, *Thermal insulating products for building applications — Determination of long-term water absorption by diffusion*
- EN 12089, *Thermal insulating products for building applications — Determination of bending behaviour*
- EN 12090, *Thermal insulating products for building applications — Determination of shear behaviour*
- EN 12091, *Thermal insulating products for building applications — Determination of freeze-thaw resistance*
- EN 12429, *Thermal insulating products for building applications — Conditioning to moisture equilibrium under specified temperature and humidity conditions*
- EN 12430, *Thermal insulating products for building applications — Determination of behaviour under point load*
- EN 12431, *Thermal insulating products for building applications — Determination of thickness for floating floor insulating products*
- EN 13793, *Thermal insulating products for building applications — Determination of behaviour under cyclic loading*
- EN 13820, *Thermal insulating materials for building applications — Determination of organic content*

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies the equipment and procedures for determining the compressive creep of specimens under various conditions of stress. It is applicable to thermal insulating products.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 826, *Thermal insulating products for building applications — Determination of compression behaviour*

EN 12085, *Thermal insulating products for building applications — Determination of linear dimensions of test specimens*

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
thickness
linear dimension measured perpendicular to the length and width plane, where

d is the original product thickness;

d_{S} is the thickness of the specimen;

d_{L} is the thickness of the specimen under the basic compressive stress of the loading device ('dead weight');

d_0 is the thickness of the specimen 60 s after the beginning of the loading process;

d_{t} is the thickness of the specimen at a given time, t

3.2
compressive stress
σ_{c}
ratio of the compressive force to the initial surface area of the cross section of the specimen

3.3
deformation
X
reduction in thickness of the specimen

3.4
relative deformation
ε
ratio of the deformation of the specimen, X, and its thickness d_{S}, measured in the direction of loading

3.5
compressive creep
X_{ct}
increase in deformation of the specimen under a constant stress with time under specified conditions of temperature and humidity

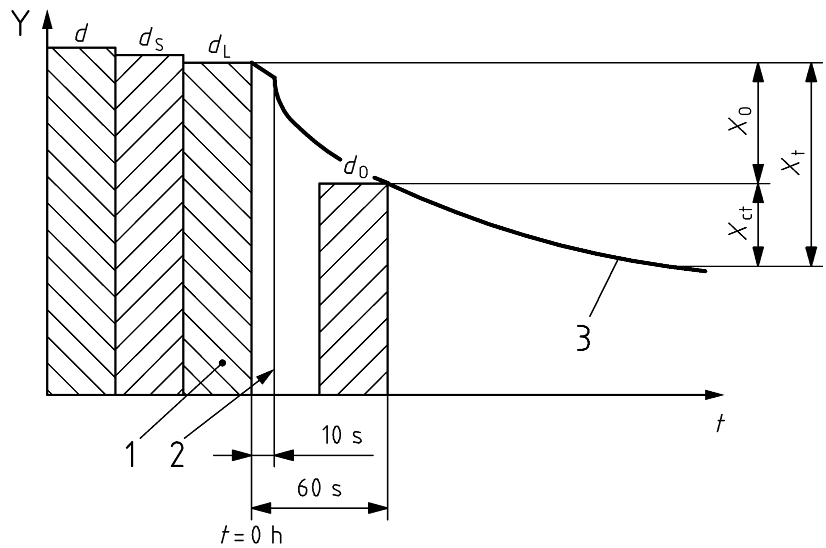
$$X_{ct} = X_t - X_0$$

where

X_t is the deformation at time t;

X_0 is the initial deformation (after 60 s from the beginning of loading)

Note 1 to entry: An illustration of the different thicknesses and deformations is given in Figure 1.



Key

d_L reference value for deformation measurements
t time
1 'dead weight' of the loading device (< 10 % of the smallest stress chosen for the creep test)
2 load applied in the compressive creep test
3 deformation curve

In this figure, d_L is used as a reference value for deformation measurements. If d_S is used as the reference value, the figure can be used, omitting the column for d_L (see 7.3).

Figure 1 — Illustration of the different thicknesses and deformations

4 Principle

The compressive creep is determined by measuring the increase in deformation of a specimen under constant compressive stress and specified conditions of temperature, humidity and time.

5 Apparatus

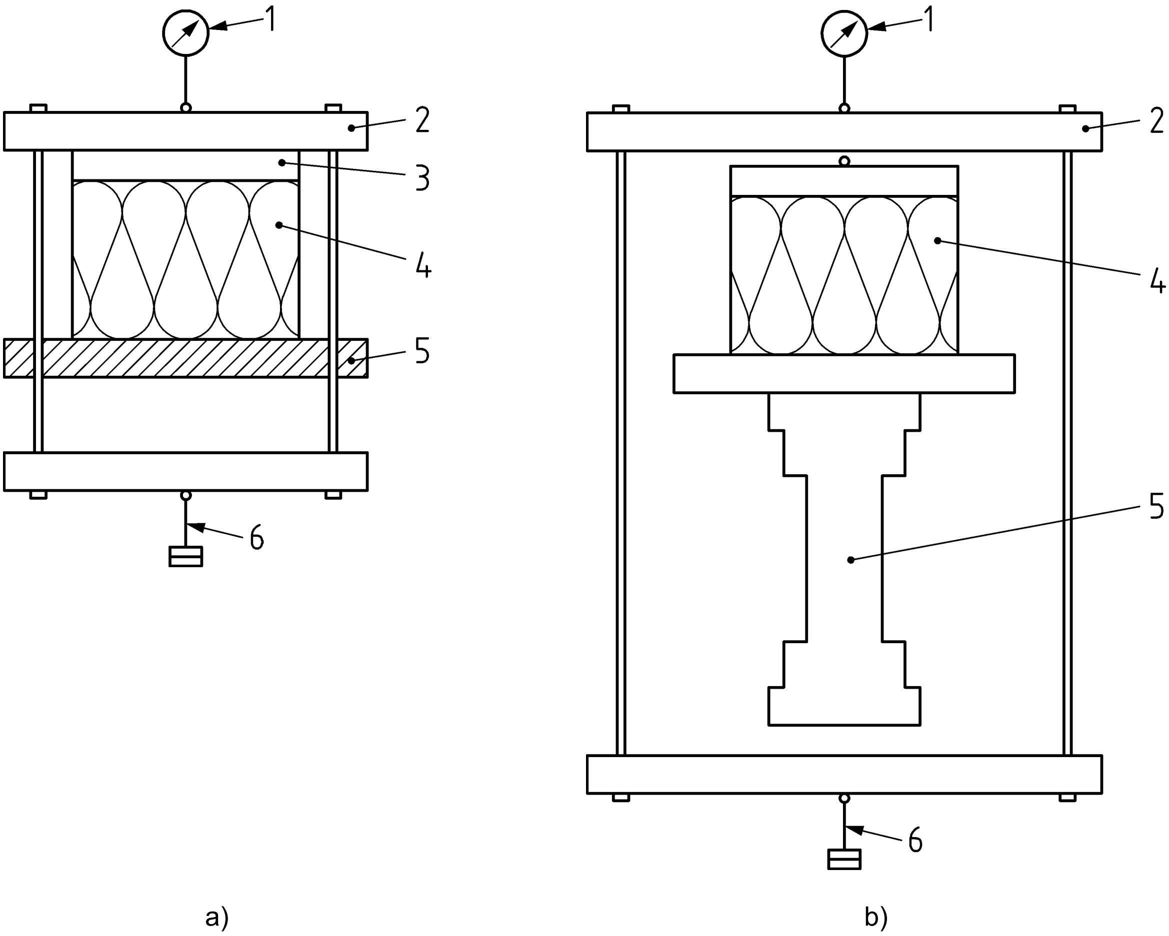
5.1 Loading device, consisting of two flat platens, one of which shall be movable, so arranged that they compress the specimen in a vertical direction.

The movable platen shall be guided in such a manner as to be self-aligning. The platens shall be capable of being loaded smoothly and without distortion so that, during the test, the static stress does not change by more than ± 5 %.

5.2 Measuring device (e.g. dial gauge), capable of determining the distance between the two platens, i.e. the deformation of the specimen, to an accuracy of 0,01 mm.

5.3 Suitable damping measures, to minimise the effects of external vibration (e.g. substantial foundation of the apparatus support).

Examples of the testing apparatus are given in Figure 2.



Key

1 displacement transducer or dial gauge
2 loading bridge
3 load distribution plate (movable, self-aligning)
4 test specimen
5 support beam
6 loading by weights

Figure 2 — Examples of test apparatus

6 Test specimens

6.1 Selection of test specimens

The specimens for determining the compressive creep shall be taken from the same sample, with the same preparation as the specimens used for the compression test as specified in EN 826.

The method of selecting the specimens shall be as specified in the relevant product standard.

In the absence of a product standard or any other European Technical Specification, the method of selection of the test specimens may be agreed between parties.

6.2 Dimensions of test specimens

The thickness of specimens shall be equal to the original product thickness. The width of the specimens shall not be less than its thickness. Products with facings or integrally moulded skins which are retained in use shall be tested with these faces or skins intact.

Test specimens shall not be layered to produce a greater thickness for testing.

The specimens shall be squarely cut and have sides with the following recommended dimensions:

50 mm × 50 mm or

100 mm × 100 mm or

150 mm × 150 mm or

200 mm × 200 mm or

300 mm × 300 mm.

The dimensions of specimens shall be the same as used in the compression test as described in EN 826. These are specified in the relevant product standard or agreed between parties.

The linear dimensions shall be determined in accordance with EN 12085, to an accuracy of 0,5 %.

The tolerance on parallelism and flatness between the upper and lower face of the specimen shall not be greater than 0,5 % of its side length, with a maximum of 0,5 mm. If the specimen is not flat, it shall be ground flat or an adequate coating shall be applied to prepare the surface for the test. Where it is coated, no significant creep should occur in the coating or it shall be taken into account by deducting the creep of the coating.

6.3 Number of test specimens

The number of specimens shall be as specified in the relevant product standard. If the number is not specified, then at least three specimens shall be used for each compressive stress selected from 7.2.

In the absence of a product standard or any other European Technical Specification, the number of specimens may be agreed between parties.

6.4 Preparation of test specimens

The specimens shall be cut so that the direction of loading applied to the product will correspond to the direction in which the compressive forces are applied to the product in use.

The specimens shall be cut by methods that do not change the original structure of the product.

For products with non-parallel faces, the parallelism of the upper and lower face of the specimen shall be in accordance with 6.2.

Special methods of preparation, when needed, may be given in the relevant product standard.

6.5 Conditioning of test specimens

The specimens shall be conditioned for at least 24 h under the test conditions. In case of dispute, the time for conditioning (equilibrium of moisture content) shall be as specified in the relevant product standard.

7 Procedure

7.1 Test conditions

The test shall be carried out at (23 ± 2) °C and (50 ± 5) % relative humidity.

Other conditions may be given in the relevant product standard or may be agreed between parties.

7.2 Stress selection

The test shall be carried out at three or more different stresses.

To verify one defined level of stress, only this level shall be used.

The alternative stresses for the creep test, σ_c, shall be based an either the compressive strength, σ_m, or the compressive stress, σ_{10}, at 10 % strain measured in accordance with EN 826, and shall be calculated as follows:

$\sigma_c = 0{,}15 \times \sigma_m$ or $\sigma_c = 0{,}15 \times \sigma_{10}$

$\sigma_c = 0{,}20 \times \sigma_m$ or $\sigma_c = 0{,}20 \times \sigma_{10}$

$\sigma_c = 0{,}25 \times \sigma_m$ or $\sigma_c = 0{,}25 \times \sigma_{10}$

$\sigma_c = 0{,}30 \times \sigma_m$ or $\sigma_c = 0{,}30 \times \sigma_{10}$

$\sigma_c = 0{,}35 \times \sigma_m$ or $\sigma_c = 0{,}35 \times \sigma_{10}$

If appropriate, other values of σ_c may be chosen.

7.3 Test procedure

If the thickness of a specimen, d_S, is to be determined without using the loading device, it shall be measured to an accuracy of 0,1 mm, in accordance with EN 12085.

Place the specimen carefully in the loading device, under the "dead weight" of the loading device. The thickness under this load, d_L, is to be considered the reference value for the deformation measurements. Determine d_L to the nearest 0,01 mm.

The stress imposed by the "dead weight" shall be less than 10 % of the minimum stress selected for the test.

If the thickness of the specimen, d_S, is determined using the loading device, the specimen shall be preloaded by applying a pressure of (250 ± 10) Pa and the thickness measured to an accuracy of 0,01 mm. This value shall then be used as the reference value for the deformation measurements.

If a significant deformation occurs under the pressure of 250 Pa, then a load corresponding to 50 Pa may be used, assuming that such a load is specified in the relevant product standard. In this case, the thickness, d_S, should be determined under the same load.

Apply the selected stress uniformly to the specimen within (10 ± 5) s.

Determine the initial deformation, X_0, to the nearest 0,01 mm (60 ± 5) s after loading has started.

Determine the deformation, X_t, to the nearest 0,01 mm at the following times after loading:

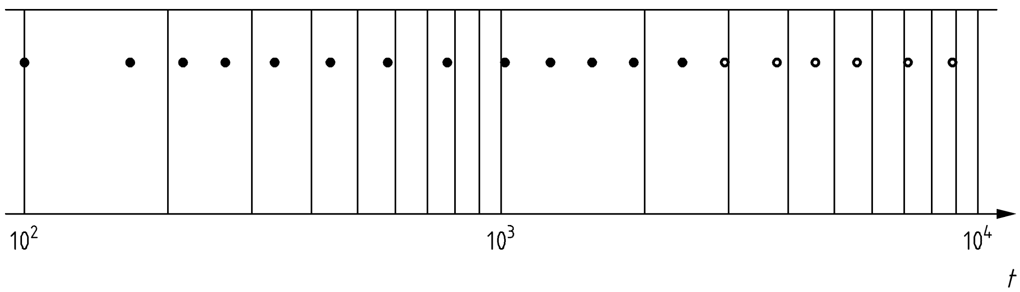
0,1 h, 1 h, 5 h, and then at the following days after loading has started: 1 day, 2 days, 4 days, 7 days, 9 days, 11 days, 14 days, 18 days, 24 days, 32 days, 42 days, 53 days, 65 days, and 80 days, and once between 90 days and 100 days.

NOTE These times, expressed in hours, are equidistant time increments in a logarithmic time scale.

If the test is continued after 90 days (see 7.4), readings shall be made at equidistant time increments (logarithmic scale). An example for appropriate reading time increments is given in Figure 3 and Table 1.

When the product to be tested incorporates a facing which is difficult to remove or if a coating is added for testing purposes, the compressive creep may be measured by the relative movement of the flat platens of the loading device. Alternatively, it may be measured from the relative movement of reference points placed on the edges of the material, if the intention is to access the material itself.

Equidistant time increments (logarithmic scale) up to 10 000 h:



Key

t time, in h

Readings for the required test duration of 90 days (see 7.3).

Readings for a test duration longer than 90 days (see 7.4).

Figure 3 — Reading times: example for time intervals for deformation measurements

Table 1 — Reading times: example for time intervals for deformation measurements

Day	Time	Duration in hours	Weekday
0	10:00	0 (loading)	Monday
0	10:01	0,017	Monday
0	11:00	1,0	Monday
0	15:00	5,0	Monday
1	10:00	24	Tuesday
2	10:00	48	Wednesday
4	14:00	100	Friday
7	10:10	168	Monday
9	10:00	216	Wednesday
11	10:00	264	Friday
14	10:00	336	Monday
18	10:00	432	Friday
24	10:00	576	Thursday
32	10:00	768	Friday
42	10:00	1 008	Monday
53	10:00	1 272	Friday
65	10:00	1 560	Wednesday
80	10:00	1 920	Thursday
100	10:00	2 400	Wednesday
123	10:00	2 952	Friday
156	10:00	3 744	Wednesday
190	10:00	4 560	Tuesday
231	10:00	5 544	Monday
295	10:00	7 080	Tuesday
365	10:00	8 760	Tuesday

7.4 Duration of test

The compressive creep shall be measured at time intervals given in 7.3 over a period of at least 90 days. The duration of the test shall be as specified in the relevant product standard or shall be agreed between the parties. The total duration of testing depends on the required extrapolation time, which shall be determined in accordance with Annex A.

8 Calculation and expression of results

The deformation value, X_t, shall be tabled for each specimen.

Calculate the relative deformation, ε_t, as a percentage, for each specimen, using Formula (1):

$$\varepsilon_t = \frac{X_t}{d_S} \times 100 \quad (1)$$

where

X_t is the deformation at time *t*, in millimetres;

d_S is the thickness of the specimen, in millimetres.

The relative deformation for each specimen and the mean value of the three relative deformations for each stress level shall be plotted in a semi-log (time) or a log/log diagram.

The calculation of creep deformation and the formula for its extrapolation is given in Annex A.

9 Precision of the method

Following the experience of a “round robin test” where comparable test equipment and test specimen preparation were used, the accuracy for compressive creep, ε_{ct} and total deformation ε_t when measured under a static load, can be estimated as given below:

Repeatability limit *r* with a probability of 95 %: Approximately 0,5 %

Reproducibility limit *R* with a probability of 95 %: Approximately 1,2 %

The above mentioned terms are applied as described in ISO 5725-2.

10 Test report

The test report shall include the following information:

a) reference to this European Standard;

b) product identification:

   1) product name, factory, manufacturer, or supplier;

   2) production code number;

   3) type of product;

   4) packaging;

   5) the form in which the product arrived at the laboratory;

   6) other information as appropriate (e.g. nominal thickness, nominal density);

c) test procedure:

   1) pre-test history and sampling (e.g. person taking the sample, place of sampling);

   2) conditioning;

3) deviations from Clauses 6 and 7, if any;

4) date of testing;

5) dimensions and number of specimens;

6) kind of surface treatment (grinding or type of coating);

7) general information relating to the test (strength, σ_m, or stress, σ_{10}, measured in accordance with EN 826 and the chosen stresses, σ_c);

8) events which may have affected the results;

d) results:

1) the tabled deformation values and the diagrams X_t versus t in semi-log or log/tog form for each specimen, and the mean values for the chosen stresses;

2) results according to Annex A for each stress level, if any:

i) the statistical parameters a, b, and r^2;

ii) factors m and b of the Findley formula;

iii) the creep deformation, X_{ct}, together with the linear regression analysis in a log/log diagram;

iv) the relative deformation, ε, and the extrapolation curve in a semi-log diagram.

Information about the apparatus and identity of the person responsible for the test should be available in the laboratory, but it need not be recorded in the report.

Annex A
(normative)

Calculation method

A.1 General

This annex specifies a calculation method for the determination of a long-term deformation value of thermal insulating products due to compressive creep. In case of positive validation of another mathematical model, that model shall be incorporated by amendment or revision of this annex.

This method may be used to define a permissible load in practical applications and/or to define the compressive behaviour of a certain product.

NOTE In order to make a reliable extrapolation of the behaviour of thermal insulating products with time, when tested in accordance with this standard, the results of many tests and experience are required. This experience is not yet available for all products. It has been well established and confirmed for different plastic foam products. For other products, tests are still running and no mathematical model has yet been validated.

A validation shall be based on measurements over a period of at least five years for different products within the same product family. Based on these measurements, different mathematical models shall be evaluated by using measured values from periods of up to two years and comparing the extrapolation with the data obtained over a period of five years.

This annex gives a permissible extrapolation, with a maximum extrapolation up to 30 times the testing time.

To validate the characteristic form of a curve based on the mathematical model, it should be similar to that obtained by the measured values.

Even with an extrapolation up to 30 times the testing time, it is recommended that a safety factor be applied for the determination of long-term allowable stress and the corresponding deformation.

A.2 Principle

The calculation method is based on a mathematical function, called the Findley Formula[1)] (A.1), which allows the description of the creep behaviour of thermal insulating products, provided that the linear regression analysis according to Formula (A.2) fits with a coefficient of determination $r^2 \geq 0,9$.

$$X_\mathrm{t} = X_0 + m \times t^\mathrm{b} \qquad \text{(A.1)}$$

where

m and b are material constants.

Formula (A.1) can be written in a logarithmic form, as follows:

$$\log \left(X_\mathrm{t} - X_0\right) = \log m + b \times \log t \qquad \text{(A.2)}$$

1) Findley, W. N., *Creep characteristics of Plastics*. Symposium on Plastics, Am. Soc. Testing Mats., 1944.

Hence it follows that log m is the intercept of the ordinate and b is the slope of the straight line defined by this formula. These constants shall be calculated by a regression analysis based on the measured deformation as a function of time.

A.3 Procedure

A.3.1 Using the values for the thickness of the test specimens, d_S and d_L, and deformation values, X_0 and X_t, at a time, t, measured in accordance with this standard, the terms log t, X_{ct}, log X_{ct} shall be calculated starting with the value read after 7 days (= 168 h).

This period of 7 days may be reduced, if the measured data show a linear behaviour in a log-log diagram corresponding to Formula (A.2).

A.3.2 For the linear regression analysis, the following statistical terms shall be determined.

General formula for the linear regression line:

$$y = a + b \times x \quad \text{(A.3)}$$

$$x_m = \sum x_t / n \quad \text{(A.4)}$$

$$y_m = \sum y_t / n \quad \text{(A.5)}$$

$$Q_x = \sum x_t^2 - \left(\left(\sum x_t \right)^2 / n \right) \quad \text{(A.6)}$$

$$Q_y = \sum y_t^2 - \left(\left(\sum y_t \right)^2 / n \right) \quad \text{(A.7)}$$

$$Q_{xy} = \sum x_t \ y_t - \left(\left(\sum x_t \right) \times \left(\sum y_t \right) / n \right) \quad \text{(A.8)}$$

$$s_R^2 = \left(Q_y - \left(Q_{xy}^2 / Q_x \right) \right) / \left(n - 2 \right) \quad \text{(A.9)}$$

$$s_R = \sqrt{s_R^2} \quad \text{(A.10)}$$

$$r^2 = Q_{xy}^2 \ / \left(Q_x \times Q_y \right) \quad \text{(A.11)}$$

$$r = \sqrt{r^2} \quad \text{(A.12)}$$

$$b = Q_{xy} \ / \ Q_x \quad \text{(A.13)}$$

$$a = y_m - b \times x_m \quad \text{(A.14)}$$

where

n is the number of values;

x_t is the time, log t;

y_t is the creep deformation, log X_{ct};

x_m is the mean value of x_t;

y_m is the mean value of y_t;

Q_x is the sum of squares of deviations, referring to x values;

Q_y is the sum of squares of deviations, referring to y values;

Q_{xy} is the sum of the deviations;

s_R^2 is the variance;

s_R is the standard deviation;

r^2 is the coefficient of determination;

r is the correlation coefficient;

a is the intercept of the ordinate;

b is the slope of the line.

A.4 Calculation of long-term deformation

By using Formula (A.1), with b from Formula (A.13), and by putting $m = 10^a$, a long-term deformation at any time, t, can be calculated. Extrapolation is permissible up to 30 times of the testing time, provided that $r^2 \geq 0{,}9$ (see example in Annex B).

Annex B
(informative)

Example of a linear regression analysis

Table B.1 gives the measured values for the deformation of three single specimens for one compressive stress. These are recorded after various time periods. In this example, the results are analysed using a linear regression technique, as described in Annex A, for the mean values of the specimens.

The calculated statistical values are:

X_m = 3,238 72

Y_m = –0,868 83

Q_x = 7,770 76

Q_y = 0,277 14

Q_{xy} = 1,444 65

s_R^2 = 0,000 41

s_R = 0,020 20

r^2 = 0,969 08 ($r^2 > 0{,}9$)

r = 0,984 42

b = 0,185 91

a = –1,470 94

Figure B.1 shows straight line regression analysis of the values of log X_{ct}, versus log t, with m = 0,033 81 and b = 0,185 91.

The long-term deformation value of the specimens for ten years (about 87 600 h), for example, is to be calculated using Formula (A.1), with m and b as given above:

$X_{87\,600} = X_0 + 0{,}033\,81 \times 87\,600^{0{,}185\,91}$

$X_{87\,600}$ = 0,50 mm

The relative deformation follows from (see Clause 8):

$\varepsilon_t = (X_t/d_S) \times 100$

$\varepsilon_{87\,600} = (0{,}50/50{,}2) \times 100$

$\varepsilon_{87\,600}$ = 1,0°%

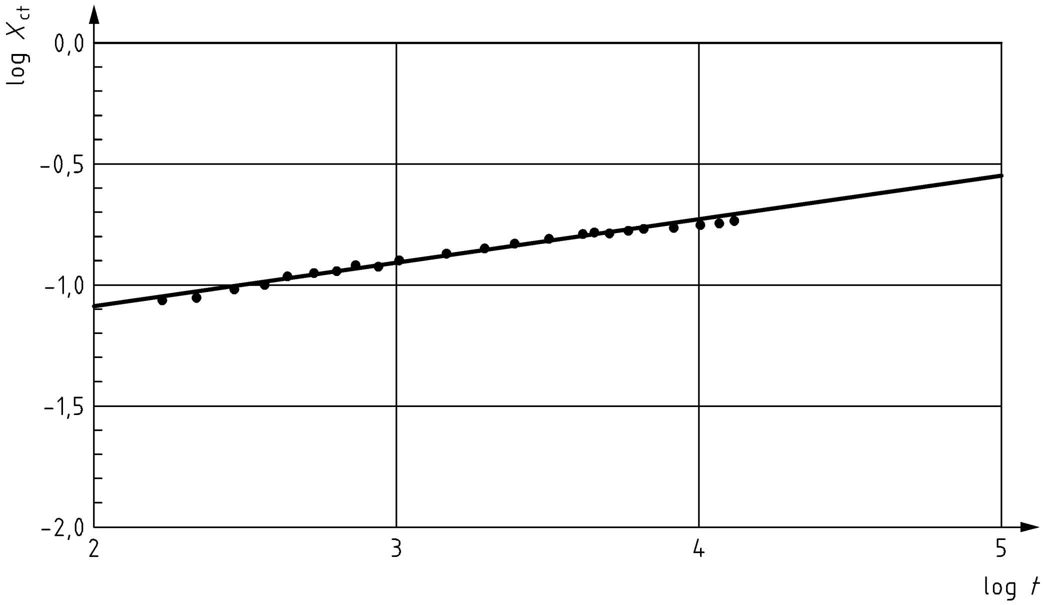
In Figure B.2, the relative deformation, ε_t, shall be plotted against time in a semi-log diagram. In this plot, the measured values are depicted as points (•) and the curve is based an the mathematical calculation showing the extrapolation up to 100 000 h (about 11,4 years).

Table B.1 — Measured values for the deformation of three single specimens for one compressive stress

Test specimen		No. 1	No. 2	No. 3
Thickness, d_S	mm	50,2	50,2	50,2
Thickness, d_L	mm	50,19	50,24	50,24
Deformation, X_0	mm	0,22	0,23	0,21

Table B.2 — Measured deformation and calculations for the specimens in Table B.1

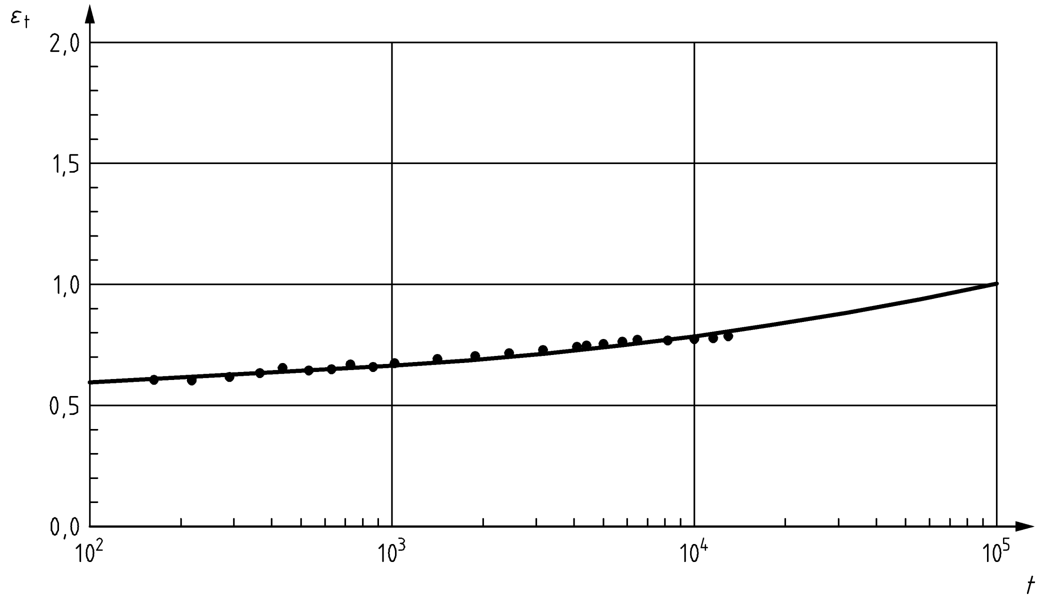
Time, t h	log t	Deformation, X_t Mm			Relative deformation, ε_t %			ε_t (mean) %	Compressive creep, X_{ct} mm			X_{ct} (mean) mm	log X_{ct}
		No. 1	No. 2	No. 3	No. 1	No. 2	No. 3		No. 1	No. 2	No. 3		
167	2,222 72	0,31	0,31	0,29	0,61	0,61	0,58	0,601	0,09	0,08	0,08	0,082	–1,086 19
215	2,332 44	0,31	0,31	0,30	0,61	0,63	0,59	0,608	0,09	0,08	0,09	0,085	–1,068 88
287	2,457 88	0,31	0,32	0,30	0,62	0,64	0,60	0,621	0,09	0,09	0,09	0,092	–1,036 21
357	2,552 67	0,32	0,33	0,31	0,64	0,65	0,62	0,637	0,10	0,10	0,10	0,100	–1,000 00
431	2,634 48	0,33	0,33	0,32	0,66	0,66	0,63	0,652	0,11	0,10	0,11	0,107	–0,969 27
527	2,721 81	0,33	0,34	0,32	0,66	0,67	0,64	0,657	0,11	0,11	0,11	0,110	–0,958 61
623	2,794 49	0,34	0,34	0,32	0,67	0,68	0,64	0,663	0,12	0,11	0,11	0,113	–0,946 92
719	2,856 73	0,34	0,35	0,33	0,68	0,69	0,66	0,677	0,12	0,12	0,12	0,120	–0,920 82
863	2,936 01	0,34	0,35	0,32	0,67	0,70	0,64	0,672	0,12	0,12	0,11	0,118	–0,929 35
1 007	3,003 03	0,35	0,36	0,34	0,70	0,71	0,67	0,692	0,13	0,13	0,13	0,127	–0,895 06
1 439	3,158 06	0,36	0,37	0,35	0,72	0,73	0,69	0,715	0,14	0,14	0,14	0,139	–0,855 94
1 943	3,288 47	0,36	0,38	0,35	0,73	0,75	0,70	0,725	0,14	0,15	0,14	0,144	–0,841 64
2 447	3,388 63	0,37	0,38	0,36	0,74	0,76	0,72	0,740	0,15	0,15	0,15	0,152	–0,819 11
3 215	3,507 18	0,38	0,39	0,37	0,75	0,78	0,73	0,752	0,16	0,16	0,16	0,158	–0,802 26
4 127	3,615 63	0,38	0,40	0,37	0,77	0,79	0,74	0,765	0,16	0,17	0,16	0,164	–0,784 27
4 487	3,651 96	0,39	0,40	0,37	0,77	0,80	0,74	0,771	0,17	0,17	0,16	0,167	–0,777 28
5 015	3,700 27	0,39	0,40	0,38	0,78	0,80	0,75	0,775	0,17	0,17	0,17	0,169	–0,772 11
5 855	3,767 53	0,39	0,40	0,38	0,78	0,80	0,76	0,780	0,17	0,17	0,17	0,172	–0,765 31
6 527	3,814 71	0,40	0,41	0,38	0,79	0,81	0,76	0,787	0,18	0,18	0,17	0,175	–0,756 14
8 159	3,911 64	0,40	0,40	0,38	0,79	0,80	0,76	0,783	0,18	0,17	0,17	0,173	–0,761 12
10 007	4,000 30	0,40	0,41	0,39	0,80	0,81	0,77	0,792	0,18	0,18	0,18	0,178	–0,749 58
11 519	4,061 41	0,40	0,41	0,39	0,80	0,81	0,77	0,794	0,18	0,18	0,18	0,179	–0,747 15
12 959	4,112 57	0,41	0,41	0,39	0,81	0,82	0,78	0,800	0,19	0,18	0,18	0,182	–0,739 93



Key

log X_{ct} X_{ct} in mm
log t t in h

Figure B.1 — Creep deformation — regression analysis



Key

$\varepsilon_{t,}$ deformation, as a percentage
t time, in h

Figure B.2 — Long-term compressive creep behaviour: measured values and calculated extrapolation

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