BS EN 1156:2013

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# Wood-based panels — Determination of duration of load and creep factors

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**National foreword**

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The UK participation in its preparation was entrusted to Technical Committee B/541, Wood based panels.

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

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English Version

## Wood-based panels - Determination of duration of load and creep factors

Panneaux à base de bois - Détermination des facteurs de durée de charge et de fluage

Holzwerkstoffe - Bestimmung von Zeitstandfestigkeit und Kriechzahl

This European Standard was approved by CEN on 1 March 2013.

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# Foreword

This document (EN 1156:2013) has been prepared by Technical Committee CEN/TC 112 “Wood-based panels”, 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of an identical text or by endorsement, at the latest by October 2013, and conflicting national standards shall be withdrawn at the latest by October 2013.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 ENV 1156:1998.

Compared to ENV 1156:1998, the following significant technical modifications have been made:

a) status changed from ENV to EN;

b) accuracy of the deflection measurement changed from 0,001 mm to 0,01 mm.

According to the CEN-CENELEC Internal Regulations, the national standards organizations 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 a method of determining in a constant climate both a duration of load factor and a creep factor for wood-based panels stressed in flatwise bending with and without a shear component. Details of an alternative but provisional method employing medium sized test pieces are given in Annex A; this method can also be used for test pieces loaded under varying climates.

NOTE The duration of load factor is necessary to modify the characteristic strength values obtained in short-term structural tests in order to derive long-term values. The creep factor obtained in the test is used to predict a long-term deflection from the initial elastic deflection.

## 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 310, *Wood-based panels — Determination of modulus of elasticity in bending and of bending strength*

EN 325, *Wood-based panels — Determination of dimensions of test pieces*

EN 326-1, *Wood-based panels — Sampling, cutting and inspection — Part 1: Sampling and cutting of test pieces and expression of test results*

EN 1058*, Wood-based panels — Determination of characteristic 5-percentile values and characteristic mean values*

EN 1995-1-1, *Eurocode 5: Design of timber structures — Part 1-1: General — Common rules and rules for buildings*

## 3 Principle

Determination in a constant climate of the load duration factor (loss in strength with time under load) and the creep factor (ratio of increase in deflection with time to the initial elastic deflection) in bending by applying and sustaining a constant moment over the central region of a test piece; both the time to failure, and the increase in deflection with time are measured.

## 4 Apparatus

**4.1 Measuring instruments** as specified in EN 325.

**4.2 A number of test rigs** (see Figure 1), that have essentially the following components:

**4.2.1 Two parallel cylindrical supports** of a length exceeding the width of the test piece and of diameter $d$ = (15 ± 0,5) mm.

The distance between the supports shall be adjustable, and each support shall be capable of rotating in its frame.

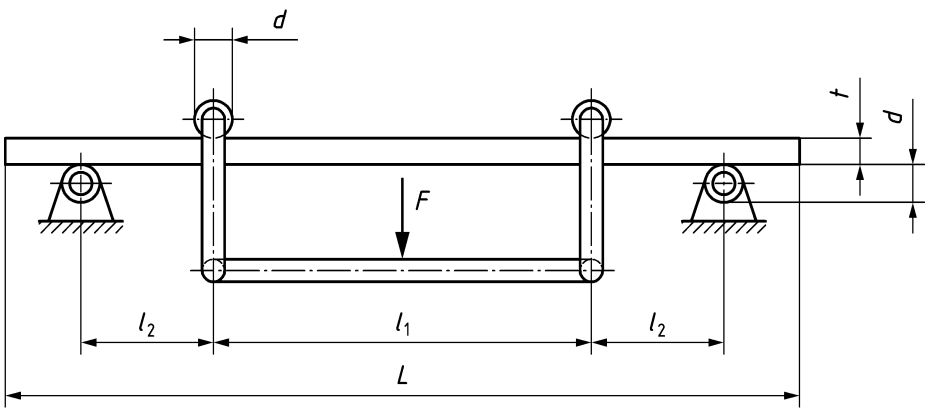
Two cylindrical loading rollers of the same length and diameter as the supports. These shall lie parallel to the supports, be capable of rotating, and be linked together with cross-arms of fixed length.

The distance $l_1$ between the loading rollers shall be 150 mm, the distance between one support and the nearer loading roller shall be five times the nominal thickness *t* of the test piece. The horizontal and vertical components of the loading cradle shall be rigidly connected.

NOTE 1 For boards with a low bending stiffness large deflections can occur. In general, the test configuration described here is suitable for a test piece with a stiffness ($E_m I$) greater than 9 000 kNmm$^2$; test pieces with a lower stiffness can be tested by proportionately reducing the distances between the rollers ($l_1$+2 $l_2$) as well as the distance between the deflection measuring points.

NOTE 2 The load can be applied to the cross-arms through some form of mechanical advantage.

Dimensions in millimetres




**Key**

*F* dead-load

*t* thickness

$l_1$ = 150

$l_2$ = 5 $t$

$L$ = $l_1$+10 $t$+60

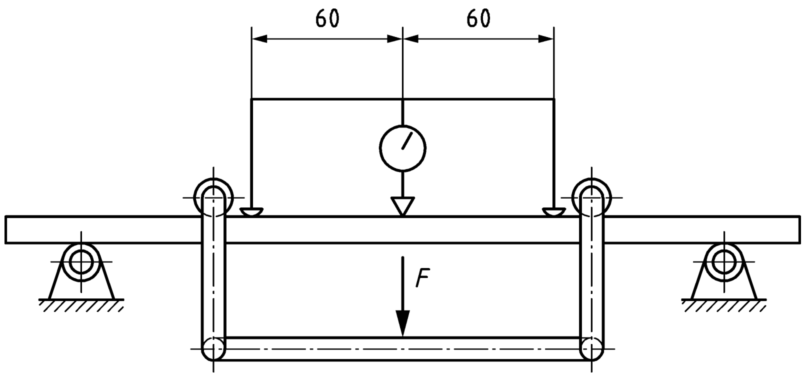
*d* = 15 ± 0,5

**Figure 1 — Test arrangement for applying load for static bending and creep tests with test piece in position**

**4.2.2 A suitable instrument for measuring the deflection of the test piece** in the middle of the span which is graduated to allow a reading to 0,01 mm or better and which enables readings of the displacement at the centre of the upper surface of the test piece to be taken in relation to two points on the upper surface of the test piece each 60 mm from the transverse centre line (see Figure 2).

This general method will measure creep in bending free of any influence of shear (method 1).

Dimensions in millimetres



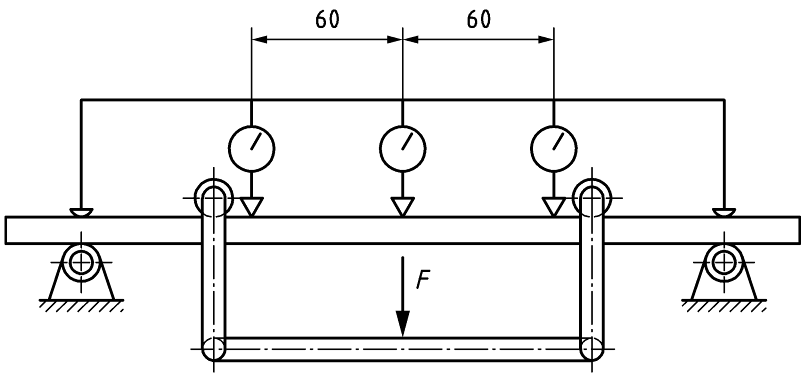

**Key**

*F* dead-load

**Figure 2 — Method 1 (general method) for the measurement of deflection**

Where it is desired to measure creep in bending both with and without a shear component a measuring system as illustrated in Figure 3 shall be used (method 2).

Dimensions in millimetres




**Key**

*F* dead-load

**Figure 3 — Method 2 for the measurement of deflection with and without a shear component**

**4.3 An arrangement for testing the short-term bending strength** with the same loading configuration to the creep test arrangement.

**4.4 Weights** (= dead load) for applying different constant loads (forces) on the test pieces.

**4.5 A controlled environment room** capable of maintaining a fixed temperature to ±1 °C and a fixed relative humidity to ± 3 %.

**4.6 Equipment for recording temperature and relative humidity.**

# 5 Sampling of panels and preparation of test pieces

## 5.1 Sampling and cutting

Panels shall be sampled from production sites in accordance with EN 1058.

Where previous static bending tests have indicated that the differences between the means of strength or modulus of elasticity in the two directions of the panel, i.e. longitudinal and transverse, is equal to, or less than 15 %, then a single set of test pieces may be used, provided that these are orientated in the direction of the lower values of strength and elasticity.

Where these tests have indicated differences greater than 15 % in strength or modulus in the two directions, then two sets of test pieces shall be used. However, if the end-use direction of span is known, then it is only necessary to carry out tests in that direction.

Where there is no available information on the relative strength and modulus in the longitudinal and transverse directions, then this shall be determined prior to the start of creep testing. Test pieces from the two directions shall be removed and tested according to EN 310.

For creep, and load-duration tests, each set of test pieces shall comprise 70 pairs of side-matched test pieces cut in a manner that ensures that all panels and test pieces are sampled as equally as possible. This number of samples is based on the assumption that at low stress levels the material is behaving in a linear viscoelastic mode. However, if there is doubt about this assumption, then creep tests should be carried out at more than one stress level as recommended in 6.4.3, and this will necessitate additional test pieces equivalent to an extra 10 for each additional stress level.

Test pieces shall be free of visible strength-reducing characteristics.

Test pieces containing visible strength-reducing characteristics and of a larger size may be tested according to the provisional test method given in Annex A.

## 5.2 Dimensions of test pieces

The test pieces shall be rectangular, and of the following dimensions:

The width shall be (50 ± 0,5) mm.

For test pieces having a stiffness ($E_m\, I$) greater than 9 000 kNmm$^2$ the length $L$ shall be 10 times the nominal thickness plus 210 mm, with a maximum length of 1 200 mm.

For test pieces having a stiffness ($E_m\, I$) of 9 000 kNmm$^2$ or less, the length of test piece may be reduced according to NOTE 1 of 4.2.1.

## 5.3 Conditioning

Before testing, the test pieces shall be conditioned to constant mass in an atmosphere corresponding to the most severe conditions in each of the service classes (SC) according to EN 1995-1-1 to which the appropriate characteristic values apply: these are 20 °C/65 % relative humidity for SC1, 20 °C/85 % relative humidity for SC2, and 20 °C/95 % relative humidity for SC3 (for tolerances see 4.5). Constant mass is considered to be reached when the results of two successive weighing operations, carried out at an interval of 24 h, do not differ by more than 0,1 % of the mass of the test piece.

# 6 Procedure

## 6.1 Measurement of dimensions

Measure the width and thickness of each test piece in accordance with EN 325 at the following points:

— the thickness at the intersection of the diagonals;

— the width at the mid length.

## 6.2 Setting up the test rigs with test pieces

Adjust the distance between the centre of the support rollers of both the static bending rig and the creep test arrangement to within 1 mm of 150 mm plus 10 times the nominal thickness of the panel (see Figure 1). Measure the distance between the centres of the support rollers with apparatus graduated to allow a reading of 0,5 mm or better. Reference points for the subsequent measurement of deflection shall be added to the top surface of each of the 10 creep test pieces; these will usually take the form of thumbtacks, or small glass or metal plates with the measuring contact point defined with a limit of error ± 0,01 mm or better.

## 6.3 Determination of short-term bending strength

Place one of the side-matched test pieces flat on the supports of the static bending test arrangement, with its length axis at right angles to those of the supports (see Figure 1).

Determine its short-term static bending strength, under the same climatic conditions in which it was conditioned, by applying a load at a constant rate of cross-head movement throughout the test. The rate of loading shall be adjusted so that the maximum load $F_{max}$ is reached within (60 ± 30) s. Record the ultimate load to an accuracy of 1 % and calculate the bending strength $f_m$ of the test piece from Formula (1):

$$f_m = F_{max} l_2 /(2 W) \qquad (1)$$

where

$l_2$ is 5 $t$ as shown in Figure 1

$W$ is the section modulus equal to $bt^2/6$, in cubic millimetres

($t$ is the measured thickness of test piece, in millimetres; and

$b$ is the measured width of test piece, in millimetres).

Repeat the test with the face of half of the test pieces (each test piece being half of a matched pair) lying upwards in the rig, and half with it lying downwards.

## 6.4 Determination of the duration of load and creep factors

### 6.4.1 General testing required

Place the second of the two side-matched test pieces on a creep test arrangement with the same surface lying upwards as in the static bending test in 6.3. Ensure that the climatic conditions are identical to those prevailing during the short-term bending test. The climatic conditions during test shall be monitored continuously.

Attach a mass to the centre of the cross-arm linkage, taking care to avoid too rapid loading, especially at high stress levels. Immediately after loading, record the time of starting to the nearest minute ($T_o$).

The mass applied shall be a percentage of the maximum load (stress level) of the other test piece of the matched pair.

NOTE Smooth application of load can be achieved by supporting the weights with a stand which can be smoothly lowered over 5 s to 10 s, until the mass is fully supported by the test piece.

### 6.4.2 Testing for duration of load

For determination of the duration of load factors, carry out a series of tests with recommended loads corresponding to 55 %, 60 %, 65 %, 70 %, 75 % and 80 % of $F_{max}$ for 20 °C/65 % relative humidity conditions. For conditions of 20 °C/85 % relative humidity and 20 °C/95 % relative humidity it is recommended that a lower set of stress levels be adopted e.g. 50 %, 55 %, 60 %, 65 %, 70 % and 75 %.

At each stress level, carry out 10 tests. From the seventy or more test pieces, select each set of ten test pieces such that as far as possible, each test piece within a set comes from a different production site or production period.

For all tests, record the time to failure in minutes expressed to the nearest 1 % of the elapsed time ($T_f$). Usually, the measurement of deflection is dispensed with when determining duration of load.

The tests shall continue until at least 7 test pieces at each stress level have failed.

### 6.4.3 Testing for creep

For the determination of creep factor, carry out a second series of tests at a single stress level. Where it is desired to carry out this determination of creep factor concurrently with the duration of load factor, a load corresponding to 25 % of $F_{max}$ shall be used. Alternatively, the load applied shall correspond to the stress level necessary to ensure a particular life span as set out in 6.4.2 and 7.1.

The use of a single level of stressing in order to calculate the creep factor rests on the assumption that the material is linearly viscoelastic up to levels of at least 40 % of $F_{max}$. If there is doubt about the validity of this assumption either in new board products, or in existing board types at high levels of relative humidity, then a series of creep tests should be carried out over a range of stress levels between 10 % and 40 % of $F_{max}$.

Carry out 10 tests at one or more stress levels (see the previous paragraph). From the seventy or more test pieces, select each set of ten test pieces such that as far as possible, each test piece within a set should come from a different production site or production period.

Prior to loading the test piece, place the deflection measuring instrument against the reference points described in 6.2. Record the reading as "zero" deflection, $a_o$, to the nearest 0,01 mm for whichever method of measurement is used.

Apply the test load, and measure and record the deflection at midspan 1 min after loading ($a_1$) to the nearest 0,01 mm for whichever method of measurement is used.

For all tests, record the deflection $a_T$ as a function of time $T$. It is recommended that this is done after 5, 10, 50, 100 and 500 min, and thereafter at 24 h intervals. Deflection shall be recorded to the nearest 0,01 mm for whichever method of measurement is used.

The duration of the creep factor test shall be at least 26 weeks, but preferably 52 weeks.

The duration of the loading period should be decided on prior to the start of testing.

# 7 Expression of results

## 7.1 Duration of load factor

**7.1.1** The duration of load factor at a given time is defined as the ratio of the stress level that results in failure at that time, to the short-term bending strength.

**7.1.2** The duration of load factor $k_d$ shall be determined by plotting the level of stress against $\log_{10}$ time to failure. Calculate the mean time to failure at each stress level for those test pieces which have failed. Calculate the linear regression line treating stress level as the independent variable, to provide Formula (2) of the form:

$$\log_{10} T = c - mSL \quad (2)$$

where

$c$ is the intercept on the vertical axis;

$m$ is the slope;

$SL$ is the stress level, in percent;

$T$ is the time to failure, in minutes ($T_f$-$T_0$).

Formula (2) is then rearranged algebraically to give the more traditional form:

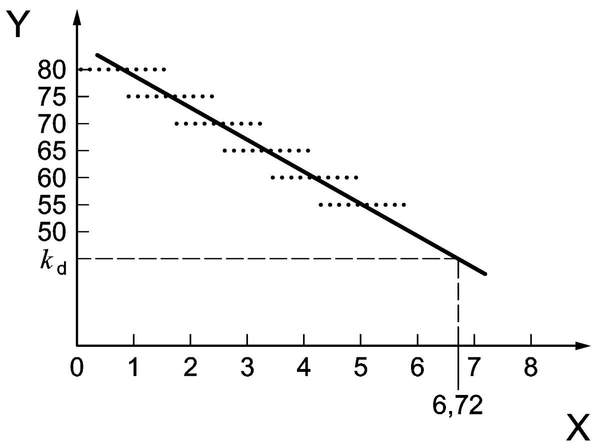
$$SL = e - f \log_{10} T = k_{d,T} \quad (3)$$

where

$$e = \frac{c}{m}$$

$$f = \frac{l}{m}$$

The extrapolated stress level for a particular life is then calculated using Formula (3) and expressed to three significant figures. An example for a 10-year life ($\log_{10}T$ = 6,72) is illustrated in Figure 4.




**Key**
X mean time to failure in $\log_{10}$ min
Y stress level in percent

**Figure 4 — Determination of duration of load factor $k_{d,\ T}$ from test results**

The symbol $k_d$ shall embrace the time of loading and service class to which it applies. An example of a predicted $k_d$ value at 10 years calculated from duration of load testing carried out under SC1 conditions is as follows:

$k_{d,10Y,SC1}$

**7.1.3** Where separate tests have been performed in the longitudinal and transverse directions, separate load duration factors shall be calculated.

## 7.2 Creep factor

**7.2.1** The creep factor is defined as the ratio of the increase in deflection with time under load to the initial elastic deflection: The value of the creep factor will therefore change with time under load, level of stressing, and climate. It is dimensionless.

Hence the creep factor, $k_c$ for a certain period of time $T$ is given by:

$$k_c = \frac{(a_T - a_0) - (a_1 - a_0)}{a_1 - a_0)} = \frac{a_T - a_1}{(a_1 - a_0)} \tag{4}$$

where

$a_T$ is the total deflection, in millimetres at time $T$ minutes;

$a_1$ is the deflection in, millimetres after 1 min;

$a_o$ is the deflection, in millimetres of unloaded test piece positioned in the creep test arrangement;

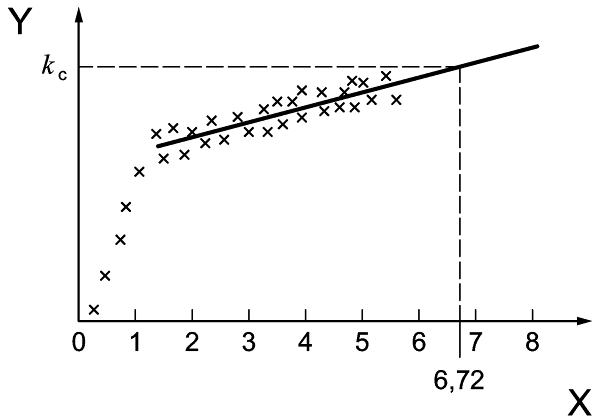
$a_1 - a_o$ is the initial elastic deflection, in millimetres as measured after 1 min of load application.

The symbol $k_c$ shall include the time of loading and service class to which it applies, as well as the level of stress used in its determination. An example of a predicted $k_c$ value at 10 years calculated from creep testing carried out under SC1 conditions and at a stress level of 25 % is as follows:

$k_{c,10Y,SC1,25\%}$

In order to determine for any one level of stressing the value of the creep factor at ten years, first calculate the mean value of $k_c$ for the ten test pieces at each period of time during the period of loading. Plot the $\log_{10}$ of the mean value of $k_c$ against $\log_{10}$ time in minutes under load for each time period as illustrated in Figure 5.

To determine an estimate of $k_c$, the regression line through these points, but excluding those up to 10 min of loading, shall be projected to a time period corresponding to the time span required. As an example, the derivation of $k_c$ at 10 years is illustrated in Figure 5. Where the regression coefficient is not above 0,9, alternative mathematical models should be used to predict long-term deflection as described below.




**Key**

X time under load in $\log_{10}$ min

Y $\log_{10}$ of creep factor

**Figure 5 — Determination of creep factor $k_c$ at 10 years from test results**

Where high accuracy in the prediction of the creep factor at long periods of time is required, the following alternative methods of calculation may be adopted.

Extreme caution shall be exercised in the fitting of exponential curves to experimental data; guidance is provided in the technical papers listed in the Bibliography.

1) Fit to the data a rheological model of the form:

$$k_c = \beta_1 + \beta_2[1 - \exp(-\beta_3 T)] + \beta_4 T^{\beta_5} \quad (5)$$

where

$k_c$ is the creep factor at time $T$; and

$\beta_1$ to $\beta_5$ are coefficients;

2) fit to the data a mathematical power function of the form:

$$k_c = a_1 T^{a2} \quad (6)$$

where

$k_c$ is the creep factor at time $T$; and

$\alpha_1$ and $\alpha_2$ are coefficients.

**7.2.2** Where separate tests have been performed in both longitudinal and transverse directions, separate values of the creep factor shall be determined.

## 8 Test report

The test report shall be prepared according to the procedure set out in EN 326-1, together with the following additional information:

a) estimates of $k_c$ and $k_d$;

b) time to failure, level of applied stress, in percent, and climatic condition for each test piece used in determining the duration of load factor;

c) mean deflection for each set of ten test pieces for each time period recorded, for each level of stress applied, in percent, and for each climate used in the determination of the creep factor;

d) method used to measure deflection (methods 1 or 2 in 4.2.2.);

e) model used in the calculation of $k_c$;

f) reference to this standard.

# Annex A
(informative)

# Provisional test method for medium-size test pieces

## A.1 General

This annex sets out a provisional test method of determining in either a constant or varying climate both a duration of load factor and a creep factor for medium-size test pieces stressed in flatwise bending without a shear component.

This method is suitable for test pieces containing visible strength reducing characteristics.

## A.2 Principle

Determination in a constant or variable climate of the load duration factor and creep factor in bending by applying and sustaining a constant bending moment over the central region of a test piece; both the time to failure and the increase in deflection with time are measured. The size of the test piece is identical to that specified in EN 789 for the determination of the short-term strength of structural panel products.

## A.3 Apparatus

**A.3.1 All the measuring instruments** which should be as specified in 4.1.

**A.3.2 A number of creep test rigs** corresponding to the bending test rig specified in EN 789.

An example of the configuration is illustrated in Figure A.1.

**A.3.3 A suitable instrument for measuring the deflection of the test piece** in the middle of the span graduated to allow a reading to 0,01 mm or better, by taking readings of displacement at the centre of the upper surface of the test piece in relation to two points on the upper surface of the test piece each 125 mm from the transverse centre line (see Figure A.1).

**A.3.4 An arrangement for testing the short-term bending strength** with the same loading configuration to the creep test arrangement.

**A.3.5 Weights (= dead load)** for applying different constant loads (forces) on the test pieces.

**A.3.6 One of the following environmental facilities** which will be required, depending on the application of the test results.

Temperature and relative humidity throughout the test shall be continuously monitored.

1) constant climate provided by a controlled environment room capable of maintaining a fixed temperature to ± 1 °C and a fixed relative humidity to ± 3 %;

2) cyclic climate provided by a similar chamber to the above but with the ability to change fairly rapidly from one fixed condition (with the same tolerances as in 1)) to another;

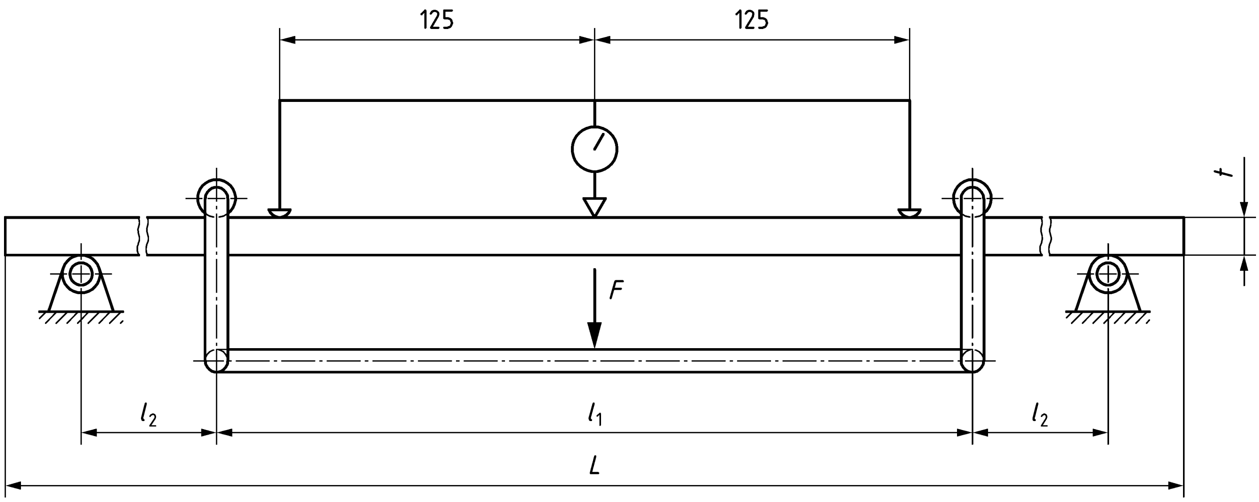
3) variable climate provided under protected exterior conditions which ensure the absence of precipitation on the test pieces while under load.

## A.4 Sampling of panels and the preparation of test pieces

According to Clause 5 except that the width of the test piece is (300 ± 5) mm in accordance with EN 789.

NOTE For thicknesses of test piece ≤ 9 mm, the distance of 250 mm between the measuring points on the upper surface (see Figure A.1) can be proportionately reduced in accordance with EN 789.

Dimensions in millimetres




**Key**

| | | |
|---|---|---|
| $F$ | dead load | $l_1 = 300$ |
| $t$ | thickness | $l_2 = 16\,t$ (240 mm ≤ $l_2$ ≤ 400 mm) |
| | | $L = l_1+2l_2+60$ |

**Figure A.1 — An example of a suitable test arrangement for applying load and measuring deflection for static bending and creep tests with test piece in position**

## A.5 Procedure

The test is carried out as specified in Clause 6 except that the rate of loading in the short-term bending test should be (300 ± 120) s, and the distance between the support rollers of both the static bending rig and the creep test arrangement is adjusted to within 1 mm of 300 mm plus 32 times the nominal thickness of the panel with a minimum length of 780 mm and a maximum length of 1 100 mm (see Figure A.1).

## A.6 Expression of results

As specified in Clause 7.

## A.7 Test report

As specified in Clause 8.

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