INTERNATIONAL STANDARD

ISO 16545

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Thermal insulating products for building applications — Determination of behaviour under cyclic loading

Produits isolants thermiques destinés aux applications du bâtiment — Détermination du comportement sous charge cyclique

Reference number
ISO 16545:2012(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 16545 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*.

ISO 16545 includes the original EN 13793 prepared by Technical Committee CEN/TC 88 “Thermal insulating materials and products”, with the following clauses modified to reflect the conditions for tropical countries:

— Clause 6.4: Conditioning of test specimens;

— Clause 7.1: Test conditions;

— Clause 10: Test report.

Introduction

ISO 16545 is one of a series of existing European Standards on test methods which were adopted by ISO. This group of International Standards comprises the following group of interrelated standards:

ISO	Title	Respective EN standard
12344	Thermal insulating products for building applications — Determination of bending behaviour	EN 12089
12968	Thermal insulation products for building applications — Determination of the pull-off resistance of external thermal insulation composite systems (ETICS) (foam block test)	EN 13495
29465	Thermal insulating products for building applications — Determination of length and width	EN 822
29466	Thermal insulating products for building applications — Determination of thickness	EN 823
29467	Thermal insulating products for building applications — Determination of squareness	EN 824
29468	Thermal insulating products for building applications — Determination of flatness	EN 825
29469	Thermal insulating products for building applications — Determination of compression behaviour	EN 826
29470	Thermal insulating products for building applications — Determination of the apparent density	EN 1602
29471	Thermal insulating products for building applications — Determination of dimensional stability under constant normal laboratory conditions (23 degrees C/50 % relative humidity)	EN 1603
29472	Thermal insulating products for building applications — Determination of dimensional stability under specified temperature and humidity conditions	EN 1604
29764	Thermal insulating products for building applications — Determination of deformation under specified compressive load and temperature conditions	EN 1605
29765	Thermal insulating products for building applications — Determination of tensile strength perpendicular to faces	EN 1607
29766	Thermal insulating products for building applications — Determination of tensile strength parallel to faces	EN 1608
29767	Thermal insulating products for building applications — Determination of short-term water absorption by partial immersion	EN 1609
29768	Thermal insulating products for building applications — Determination of linear dimensions of test specimens	EN 12085
29769	Thermal insulating products for building applications — Determination of behaviour under point load	EN 12430
29770	Thermal insulating products for building applications — Determination of thickness for floating-floor insulating products	EN 12431

29771	Thermal insulating materials for building applications — Determination of organic content	EN 13820
29803	Thermal insulation products for building applications — Determination of the resistance to impact of external thermal insulation composite systems (ETICS)	EN 13497
29804	Thermal insulation products for building applications — Determination of the tensile bond strength of the adhesive and of the base coat to the thermal insulation material	EN 13494
29805	Thermal insulation products for building applications — Determination of the mechanical properties of glass fibre meshes	EN 13496
16534	Thermal insulating products for building applications — Determination of compressive creep	EN 1606
16535	Thermal insulating products for building applications — Determination of long-term water absorption by immersion	EN 12087
16536	Thermal insulating products for building applications — Determination of long-term water absorption by diffusion	EN 12088
16537	Thermal insulating products for building applications — Determination of shear behaviour	EN 12090
16546	Thermal insulating products for building applications — Determination of freeze-thaw resistance	EN 12091
16544	Thermal insulating products for building applications — Conditioning to moisture equilibrium under specified temperature and humidity conditions	EN 12429
16545	Thermal insulating products for building applications — Determination of behaviour under cyclic loading	EN 13793

A further group of existing European Standards on test methods for products used to insulate building equipment and industrial installations comprises the following group of interrelated International Standards:

ISO 12623	Thermal insulating products for building equipment and industrial installations — Determination of short-term water absorption by partial immersion of preformed pipe insulation	EN 13472
ISO 12624	Thermal insulating products for building equipment and industrial installations — Determination of trace quantities of water soluble chloride, fluoride, silicate, sodium ions and pH	EN 13468
ISO 12628	Thermal insulating products for building equipment and industrial installations — Determination of dimensions, squareness and linearity of preformed pipe insulation	EN 13467
ISO 12629	Thermal insulating products for building equipment and industrial installations — Determination of water vapour transmission properties of preformed pipe insulation	EN 13469

Thermal insulating products for building applications — Determination of behaviour under cyclic loading

1 Scope

This International Standard specifies equipment and procedures for determining behaviour of test specimens under cyclic loading conditions. It is applicable to thermal insulating products.

The selection of the conditions of the test are derived from the specific requirements of the intended application.

2 Normative references

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

ISO 29469, *Thermal insulating products for building applications — Determination of compression behaviour*

ISO 29768, *Thermal insulating products for building applications — Determination of linear dimensions of test specimens*

3 Terms and definitions

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

3.1
thickness
d_s
initial thickness of the test specimen

3.2
compressive stress
σ_c
ratio of the compressive force to the initial surface area of the cross-section of the test specimen

σ_{min}: Lower stress level of one load cycle;

σ_{max}: Upper stress level of one load cycle.

3.3
deformation
X
reduction in thickness of the test specimen equal to $X_i - X_0$ both for $X_{i,min}$ and $X_{i,max}$

$X_{i,min}$: Reduction in thickness of the test specimen under the lower stress level, σ_{min}, at a given number of load cycles, i;

$X_{i,max}$: Reduction in thickness of the test specimen under the upper stress level, σ_{max}, at a given number of load cycles, i.

3.4
relative deformation
ε
ratio of the deformation of the test specimen, X, and its thickness d_s, measured in the direction of the loading

3.5
load cycle
cycle during which the compressive force is applied to the test specimen, starting at σ_{min}, to be increased to σ_{max} and then reduced back to σ_{min}, so that the cycle of loading and unloading describes a type of sine wave, where σ_{min} is the bottom and σ_{max} is the top of the wave

4 Principle

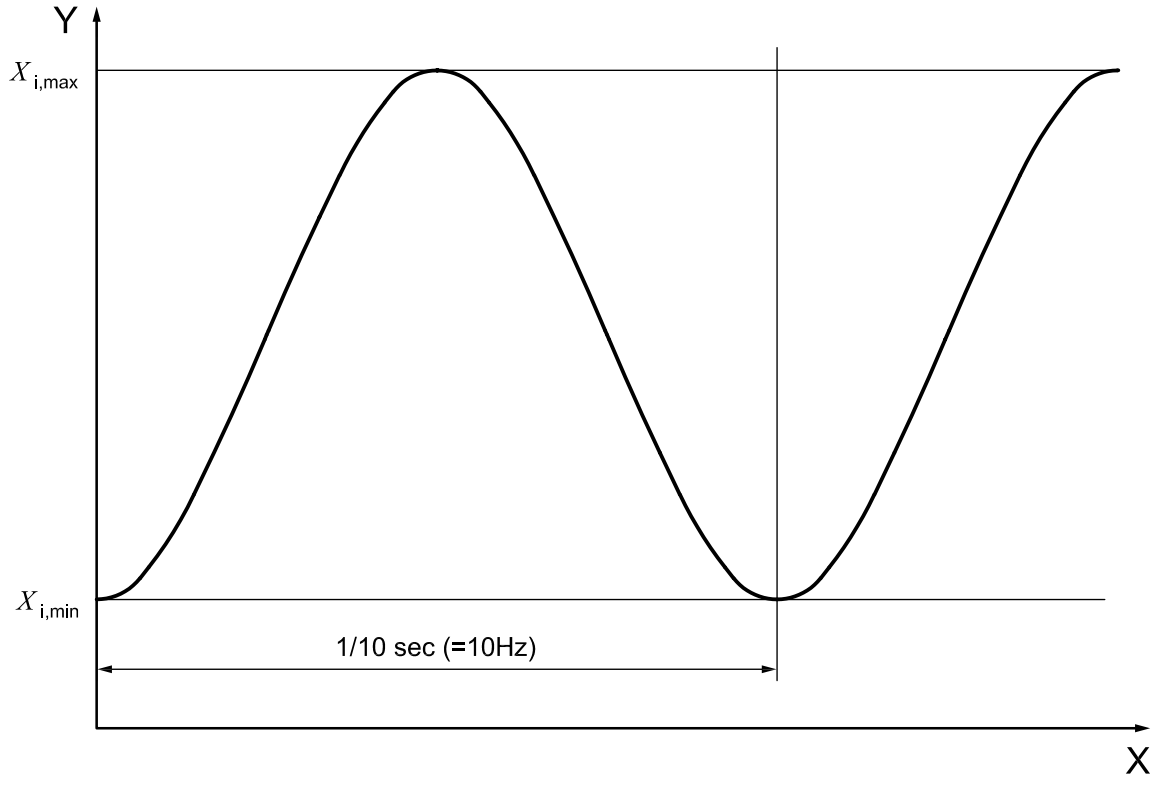
The vertical deformation of test specimens subjected to repetitive load cycles is determined.

5 Apparatus

5.1 Testing machine

A testing machine appropriate for the range of force and displacement involved with two rigid, polished, square or circular plane parallel plates of which the length of one side (or the diameter) is at least as large as the test specimen side (or diagonal) to be tested. One of the plates shall be fixed and the other movable with a centrally positioned ball joint, if appropriate, to ensure that only axial force is applied to the test specimen. The movable plate shall be capable of following a sinusoidal waveform displacement in accordance with the conditions described in Clause 7 and illustrated in Figure 1.

The load cycle should be considered as a sinusoidal waveform if the deviation of the actual curve compared to the theoretical sine curve at every point following the time axis does not exceed 5 % of the duration of one cycle.



Key
X time
Y displacement

Figure 1 — Illustration of a load cycle

5.2 Measurement of displacement

Device for the measurement of the displacement fitted to the compression testing machine which allows continuous measurement of the displacement of the movable plate or of the distance between the two plates and which permits reading to ± 5 % or ± 0,1 mm, whichever is the smaller (see 5.3).

5.3 Measurement of force

Sensor fitted to one of the machine plates to measure the force produced by the reaction of the test specimen upon the plates. This sensor shall be such that its own deformation during the course of the measuring operation is negligible compared with that being measured. If it is not sensor deformation shall be taken into account by calculation. The sensor shall allow the continuous measurement of the force permitting reading to ± 3 %.

5.4 Recording device

Device for the simultaneous recording of the force, F, and the displacement, X, which provides a curve of F as a function of X.

NOTE It is most likely that only those machines which incorporate a high precision aligned loading frame with a servo-hydraulic system control and a computer controlled actuator will comply with the required level of accuracy.

The measuring devices for displacement and force are likely to comprise electronic transducers and sensors. In order to achieve the maximum level of accuracy, it is desirable that all test controlling, data generation and data management (including all output of tables and plots) are concentrated in one computer system.

6 Test specimens

6.1 Dimensions of test specimens

The test specimens shall be at the original product thickness. The width of the test specimens shall not be less than the thickness. Products with integrally moulded skins which are retained in use shall be tested with these skins intact.

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

Test specimens shall be squarely cut and square with recommended cross-section areas as follows:

— 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 choice of dimensions to be used shall be as specified in the relevant product standard.

In the absence of a product standard or any other European technical specification, the dimensions of test specimens may be agreed between parties.

The linear dimensions shall be determined in accordance with ISO 29768 with a limit deviation of ± 0,5 %.

The tolerance on parallelism and flatness between the two faces of the test specimen shall not be greater than 0,5 % of the specimen side with a maximum of 0,5 mm.

If the test specimens are not flat, they shall be ground flat or an appropriate levelling layer shall be applied to prepare the surface for the test. No significant deformation shall occur in the levelling layer during the test.

In case that a gypsum levelling layer is used, the determination of the dimensions shall occur prior to the application of the layers.

NOTE The accuracy of the test result is reduced if the test specimens have a thickness of less than 20 mm.

6.2 Number of test specimens

The number of test specimens shall be as specified in the relevant product standard. In the absence of such a specification, five test specimens shall be used for each stress selected.

NOTE In the absence of a product standard or any other technical specification, the number of test specimens may be agreed between parties.

6.3 Preparation of test specimens

The test specimens shall be cut so that they do not include product edges. The test specimens shall be prepared by methods that do not change the original structure of the product. Any skins, facings and/or coatings shall be retained.

NOTE Special methods of preparation, when needed, are given in the relevant product standard or any other technical specification.

6.4 Conditioning of test specimens

The test specimens shall be stored for at least 6 h at (23 ± 5) °C. In case of dispute they shall be stored at (23 ± 2) °C and (50 ± 5) % relative humidity (RH), for the time specified in the relevant product standard, for a minimum of 6 h.

In tropical countries, different conditioning and testing conditions can be relevant. In this case, the conditions shall be (27 ± 5) °C and (65 ± 5) % RH, and be stated clearly in the test report.

7 Procedure

7.1 Test conditions

The test shall be carried out at (23 ± 2) °C. In case of dispute it shall be carried out at (23 ± 2) °C and (50 ± 5) % RH.

In tropical countries, different conditioning and testing conditions are relevant. In this case, the conditions shall be (27 ± 2) °C and (65 ± 5) % RH.

7.2 Stress selection

The test is carried out at one or more different stresses.

The different stresses, σ_{max}, for the cyclic load investigation shall be based on either the compressive strength, σ_m, or the compressive stress at 10 % deformation, σ_{10}, measured in accordance with ISO 29469, and shall be calculated as follows:

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

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

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

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

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

If appropriate, other values of σ_{max} may be chosen.

The corresponding stresses σ_{min} shall be 5 % of the respective σ_{max}.

7.3 Frequency selection

The test is carried out at a frequency within the range of 0,5 Hz to 10 Hz.

The frequency shall be selected so that any possible temperature increase in the centre of the test specimen will not affect the test result.

The load cycle, following a sinusoidal waveform, is applied at a required number of cycles per second. The frequency of the wave shall be given in the relevant product standard or may be agreed upon between parties within the range given above.

NOTE Different frequencies may lead to different results.

7.4 Number of load cycles

The number of load cycles shall be such that

— the relative deformation of the test specimen, at the maximum stress, reaches 5 % or

— failure occurs, if this should occur first.

In any event, the maximum number of load cycles shall not exceed 2×10^6.

If appropriate, other levels for the maximum relative deformation and/or the maximum number of load cycles may be chosen.

7.5 Test procedure

Determine the linear dimensions of the test specimen in accordance with ISO 29768 with a limit deviation of $\pm$ 0,5 %.

Place the test specimen centrally between the two parallel plane plates of the compression testing machine.

Preload the test specimen to $\sigma_{min} \pm 50$ %, record $X_{0,min}$, compress with the movable plate to reach the maximum stress $\sigma_{max} \pm 5$ %, record $X_{0,max}$, then reduce the load back to σ_{min} (one complete load cycle).

Continue testing at a constant load cycle frequency until the deformation limits or the maximum number of load cycles as defined in 7.4 are reached.

Read and continuously record the deformation $X_{i,min}$ and $X_{i,max}$ during the course of the test.

Record the number of load cycles at which the test specimens' relative deformations reach 1 %, 2 %, 3 %, 4 % and 5 % at σ_{max}.

If appropriate, other values of relative deformation may be chosen.

Terminate the test as soon as the specified maximum relative deformation of the test specimen is reached or when failure occurs or when the maximum number of load cycles is reached.

The test shall be deemed to be invalid if interrupted.

8 Calculation and expression of results

The test results shall be the mean value of the individual values. They shall be expressed to three significant figures.

Results shall not be extrapolated to any other thickness.

Tabulate the deformation values, $X_{i,min}$ and $X_{i,max}$, in millimetres, and the relative deformation values, $\varepsilon_{i,min}$ and $\varepsilon_{i,max}$, as percentages for each test specimen together with the respective number of load cycles.

Calculate the relative deformation, $\varepsilon_{i,min}$ and $\varepsilon_{i,max}$, as percentages using Equations (1) and (2):

$$\varepsilon_{\mathrm{i,min}} = \frac{X_{\mathrm{i,min}} - X_{\mathrm{0,min}}}{d_{\mathrm{s}}} \times 100 \quad (1)$$

$$\varepsilon_{\mathrm{i,max}} = \frac{X_{\mathrm{i,max}} - X_{\mathrm{0,max}}}{d_{\mathrm{s}}} \times 100 \quad (2)$$

where

X_{i} is the deformation at σ_{min} and σ_{max} after the cyclic loading, in mm;

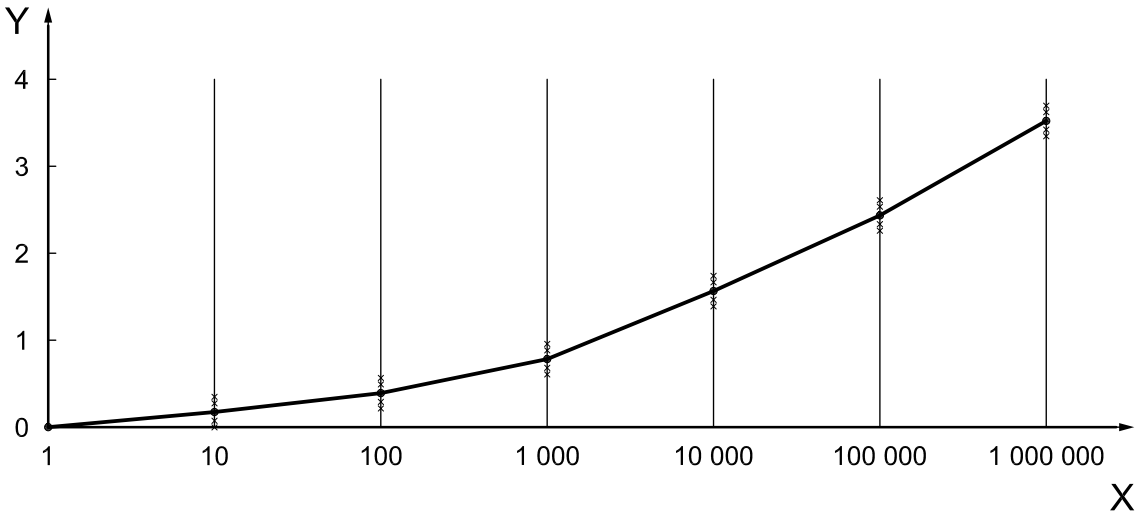
X_0 is the deformation at σ_{min} and σ_{max} before the cyclic loading, in mm;

d_{s} is the initial thickness of the test specimen, in mm.

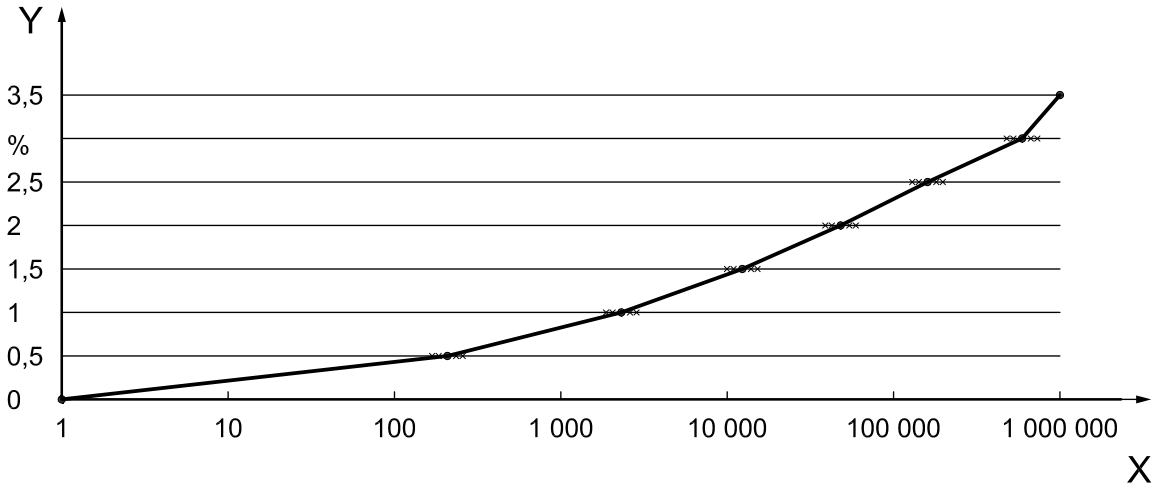
The relative deformation for each test specimen and the mean value of the relative deformation of the test specimens for each chosen stress level shall be plotted in one or more linear/logarithmic (number of load cycles) diagrams, and the results of the 1 % to 5 % relative deformation intermediate readings shall be indicated on the plots [see Figures 2a) and 2b)].

If more than one stress level has been chosen, the compressive stress versus number of load cycles for different relative deformations shall be plotted in a linear/logarithmic (number of load cycles) diagram for each relative deformation (see Figure 3).

Results obtained under different test conditions shall not be compared.



a) Selected number of load cycles



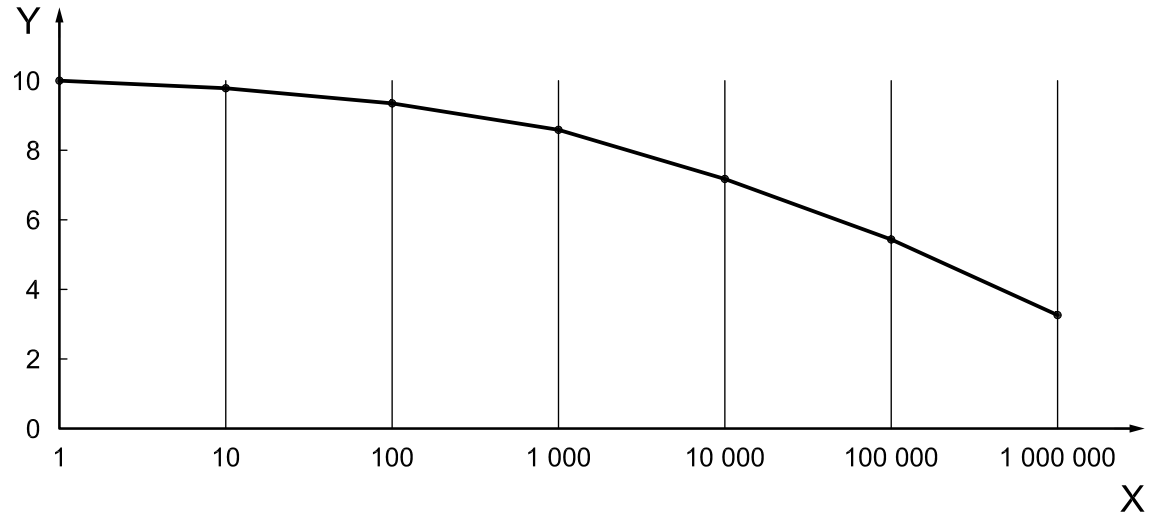
b) Selected percentage of relative deformation

Key

X number of load cycles

Y relative deformation at σ_{max}, in %

Figure 2 — Examples of relative deformation versus number of load cycles at one fixed stress



Key

X number of load cycles

Y compressive stress at σ_{max}, in kPa

Figure 3 — Example of compressive stress versus number of load cycles for a fixed relative deformation of 4 %

9 Accuracy of measurement

NOTE It has not been possible to include a statement on the accuracy of the measurements in this edition of this International Standard, but it is intended to include such a statement when this International Standard is next revised.

10 Test report

The test report shall include the following information:

a) Reference to this International Standard, i.e. ISO 16545:2012;

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. who sampled and where;

2) conditioning;

3) any deviation from Clauses 6 and 7;

4) date of testing;

5) number of test specimens;

6) conditioning and testing conditions in tropical countries, if applicable;

7) selected stress levels, σ_{min} and σ_{max}, frequency and number of load cycles;

8) general information relating to the test;

9) events which may have affected the results;

Information about the apparatus and identity of the technician should be available in the laboratory, but need not be recorded in the report.

d) Results

1) tabulated values of the deformations and the relative deformations;

2) $\varepsilon_{i,min}$ and $\varepsilon_{i,max}$ after the specified number of load cycles, or the number of load cycles at which $\sigma_{i,max}$ and 5 % relative deformation occurred together with the corresponding value for $\sigma_{i,min}$;

3) if available, linear/logarithmic diagrams showing stress versus number of load cycles at 1 %, 2 %, 3 %, 4 % and 5 % relative deformation for each test specimen;

4) if failure occurs, report the stress level and the number of load cycles.

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