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Thermal insulation and light weight fill products for civil engineering applications — Factory made products of extruded polystyrene foam (XPS) — Specification

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ICS 83.100; 93.010

National foreword

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Thermal insulation and light weight fill products for civil engineering applications - Factory made products of extruded polystyrene foam (XPS) - Specification

Produits isolants thermiques et de remblayage pour les applications de génie civil - Produits manufacturés en mousse de polystyrène extrudé (XPS) - Spécifications

Wärmedämmung und leichte Füllprodukte für Anwendungen im Tiefbau - Werkmäßig hergestellte Produkte aus extrudiertem Polystyrolschaum (XPS) - Spezifikation

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Foreword

This document (EN 14934:2007) 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of an identical text or by endorsement, at the latest by March 2008, and conflicting national standards shall be withdrawn at the latest by March 2008.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

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1 Scope

This European Standard specifies the requirements for factory made products of extruded polystyrene foam which are used for frost insulation of roads, railways, trafficked areas, light weight fill for reduction of horizontal and vertical earth pressure and other civil engineering applications.

The products are manufactured in the form of boards, which are also available with special edge and surface treatment (tongue & grooves, shiplap etc.). The standard also covers multilayered insulation boards.

This standard describes product characteristics and includes procedures for testing, evaluation of conformity, marking and labelling.

The standard does not specify the required level of a given property to be achieved by a product to demonstrate fitness for purpose in a particular application. The classes and levels required for a given application are to be found in regulations or non-conflicting standards.

For applications where thermal resistance is required, products with a declared thermal resistance lower than 0,25 m²·K/W or a declared thermal conductivity greater than 0,060 W/(m· K) are not covered by this standard. This standard does not cover in situ insulation products and products intended to be used for insulation of buildings, of building equipment and industrial installations or products intended for acoustic insulation.

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.

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 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 12086:1997, *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 12091, *Thermal insulating products for building applications — Determination of freeze-thaw resistance*

EN 12667, *Thermal performance of building materials and products — Determination of thermal resistance by means of guarded hot plate and heat flow meter methods — Products of high and medium thermal resistance*

EN 12939, *Thermal performance of building materials and products — Determination of thermal resistance by means of guarded hot plate and heat flow meter methods — Thick products of high and medium thermal resistance*

EN 13172:2001, *Thermal insulating products — Evaluation of conformity*

EN 13501-1, *Fire classification of construction products and building elements — Part 1: Classification using test data from reaction to fire test*

EN 13793, *Thermal insulating products for building applications — Determination of behaviour under cyclic loading*

EN 13823, *Reaction to fire tests for building products — Building products excluding floorings exposed to thermal attack by a single burning item*

EN ISO 1182, *Reaction to fire tests for building products — Non combustibility test (ISO 1182:2002)*

EN ISO 1716, *Reaction to fire tests for building products — Determination of the heat of combustion (ISO 1716:2002)*

EN ISO 9229:2007, *Thermal insulation — Vocabulary (ISO 9229:2007)*

EN ISO 11925-2, *Reaction to fire tests — Ignitability of building products subjected to direct impingement of flame — Part 2: Single-flame source test (ISO 11925-2:2002)*

ISO 12491, *Statistical methods for quality control of building materials and components*

3 Terms, definitions, symbols, units and abbreviated terms

3.1 Terms and definitions

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

3.1.1 Terms and definitions as given in EN ISO 9229:2007

3.1.1.1
extruded polystyrene foam
rigid cellular plastics insulation material expanded and extruded with or without a skin, from polystyrene or one of its copolymers and which has a closed cell structure

3.1.1.2
board
rigid or semi-rigid insulation product of rectangular shape and cross section in which the thickness is uniform and substantially smaller than the other dimensions

3.1.2 Additional definitions

3.1.2.1
level
given value which is the upper or lower limit of a requirement. The level is given by the declared value of the characteristic concerned

3.1.2.2
class
combination of two levels of the same property between which the performance shall fall

3.2 Symbols, units and abbreviated terms

Symbols and units used in this standard:

b	is the width	mm
d	is the thickness	mm
d_N	is the nominal thickness of the product	mm
d_s	is the thickness of test specimen	mm
D_i	is the relative compression after i number of cycles	%
$\Delta\varepsilon_b$	is the relative change in width	%
$\Delta\varepsilon_d$	is the relative change in thickness	%
$\Delta\varepsilon_l$	is the relative change in length	%
ε_{ct}	is the compressive creep	%
ε_t	is the total relative thickness reduction	%
$\varepsilon_{l,max}$	is the relative maximum deformation	%
ε_1	is the relative deformation after step A	%
ε_2	is the relative deformation after step B	%
k	is a factor related to the number of test results available	—
l	is the length	mm
$\lambda_{90/90}$	is the 90 % fractile with a confidence level of 90 % for the thermal conductivity	W/(m·K)
$\lambda_{90/90,\ 60d}$	is the 90 % fractile with a confidence level of 90 % for the thermal conductivity of foam at 60 days	W/(m·K)
$\lambda_{90/90>60d}$	is the 90 % fractile with a confidence level of 90 % for the thermal conductivity of foam older than 60 days	W/(m·K)
λ_D	is the declared thermal conductivity	W/(m·K)
λ_i	is one test result of thermal conductivity	W/(m·K)
λ_{mean}	is the mean thermal conductivity	W/(m·K)
$\lambda_{mean,\ a}$	is the mean thermal conductivity of aged values	W/(m·K)

$\lambda_{mean,\ 60d}$	is the mean thermal conductivity of values for 60 days old foam	W/(m·K)
$\lambda_{>\ 60d}$	is the measured value of the thermal conductivity of foam older than 60 days	W/(m·K)
μ	is the water vapour diffusion resistance factor	—
n	is the number of test results	—
$R_{90/90}$	is the 90 % fractile with a confidence level of 90 % for the thermal resistance	m^2·K/W
$R_{90/90,\ 60d}$	is the 90 % fractile with a confidence level of 90 % for the thermal resistance of foam at 60 days	m^2·K/W
$R_{90/90>60d}$	is the 90 % fractile with a confidence level of 90 % for the thermal resistance of foam older than 60 days	m2·K/W
R_D	is the declared thermal resistance	m^2·K/W
R_l	is one test result of thermal resistance	m^2·K/W
R_{mean}	is the mean thermal resistance	m^2·K/W
S_b	is the deviation from squareness on length and width	mm/m
S_{max}	is the deviation from flatness	mm/m
s_R	is the estimate of the standard deviation of the thermal resistance	m^2·K/W
s_λ	is the estimate of the standard deviation of the thermal conductivity	W/(m·K)
$s_{\lambda a}$	is the estimate of the standard deviation of the aged thermal conductivity	W/(m·K)
$s_{\lambda i}$	is the estimate of the standard deviation of the initial thermal conductivity within 90 days of production	W/(m·K) W/(m·K)
σ_2	is the compressive stress at 2 % deformation	kPa
σ_5	is the compressive stress at 5 % deformation	kPa
σ_{10}	is the compressive stress at 10 % deformation	kPa
σ_c	is the declared compressive stress	kPa
σ_i	is the compressive stress applied for resistance to cyclic compressive loading	kPa
σ_m	is the compressive strength	kPa
σ_b	is the bending strength	kPa
W_{dV}	is the water absorption by diffusion	% by volume
W_{it}	is the long term water absorption by total immersion	% by volume
W_V	is the water absorption by freeze-thaw after water absorption by diffusion	% by volume
Z	is the water vapour resistance	m^2·h·Pa/mg

BS	is the symbol of the declared level for bending strength
CC(i_1/i_2/y) σ_c	is the symbol of the declared level for compressive creep

CLR(i,z) σ_i is the symbol of the declared level for resistance to cyclic compressive loading with sinus load application

CLRT(i,z) σ_i is the symbol of the declared level for resistance to cyclic compressive loading with square wave load application

CS(10\Y) is the symbol of the declared level for compressive stress at 10 % deformation or compressive strength

CS(5\Y) is the symbol of the declared level for compressive stress at 5 % deformation or compressive strength

CS(2\Y) is the symbol of the declared level for compressive stress at 2 % deformation or compressive strength

DLT(2)5 is the symbol of the declared level of deformation under specified compressive load and temperature at conditions set 2 with a maximum of 5 % deformation

DS(T+) is the symbol of the declared value for dimensional stability at specified temperature

DS(TH) is the symbol of the declared value for dimensional stability under specified temperature and humidity

FTC is the symbol of the declared level for freeze-thaw resistance

MU is the symbol of the declared level for water vapour diffusion resistance factor

T is the symbol of the declared class for thickness tolerances

WD(V) is the symbol of the declared level for water absorption by diffusion

WL(T) is the symbol of the declared level for long term water absorption by total immersion

Z is the symbol of the declared value for water vapour resistance

Abbreviated terms used in this standard:

XPS is e**x**truded **p**oly**s**tyrene foam

4 Requirements

4.1 General

Product properties shall be assessed in accordance with Clause 5. To comply with this standard, products shall meet the requirements of 4.2, and the requirements of 4.3 as appropriate.

NOTE Information on additional properties is given in Annex E.

One test result for a product property is the average of the measured values on the number of test specimens given in Table 10.

4.2 For all applications

4.2.1 Length, width, squareness, flatness

Length, l, and width, b, shall be determined in accordance with EN 822, the squareness on length and width, S_b, in accordance with EN 824, and the flatness, S_{max}, in accordance with EN 825. No test result shall deviate from the declared values by more than the tolerances given in Table 1.

Table 1 — Tolerances of length, width, squareness and flatness

Declared length or width	Tolerances		
	Length or width	Squareness on length and width	Flatness
mm	mm	S_b mm/m	S_{max} mm
less than 1 000	± 8	5	7,0
1 000 to 2 000	± 10	5	14,0
> 2 000 to 4 000	± 10	5	28,0
> 4 000	± 10	5	35,0

4.2.2 Thickness

Thickness, d, shall be determined in accordance with EN 823. No test result shall deviate from the nominal thickness, d_N, by more than the tolerances given in Table 2 for the labelled class.

Table 2 — Classes for thickness tolerances

Class	Tolerances mm		Thickness mm
T1	– 2	+ 2	< 50
	– 2	+ 3	$50 \leq d_N \leq 120$
	– 2	+ 8	> 120
T2	– 1,5	+ 1,5	< 50
	– 1,5	+ 1,5	$50 \leq d_N \leq 120$
	– 1,5	+ 1,5	> 120
T3	– 1	+ 1	< 50
	– 1	+ 1	$50 \leq d_N \leq 120$
	– 1	+ 1	> 120

4.2.3 Dimensional stability under specified temperature and humidity conditions

Dimensional stability under specified temperature and humidity conditions shall be determined in accordance with EN 1604. The test shall be carried out after storage for 48 h at (23 ± 2) °C and (90 ± 5) % relative humidity. The relative changes in length, $\Delta\varepsilon_l$, in width, $\Delta\varepsilon_b$, and in thickness, $\Delta\varepsilon_d$, shall not exceed 2 %.

This test shall not be performed when the more severe test, described in 4.3.2.2 is used.

4.2.4 Compressive stress at 10 % deformation or compressive strength

The compressive stress at 10 % deformation, σ_{10}, or the compressive strength, σ_m, shall be determined in accordance with EN 826. No test result for either the compressive stress at 10 % deformation, σ_{10}, or the compressive strength, σ_m, whichever is the greatest, shall be lower than the values given in Table 3 for the declared level.

Table 3 — Levels for compressive stress at 10 % deformation or compressive strength

Level	Requirement kPa
CS(10\Y) 100	>100
CS(10\Y) 200	≥ 200
CS(10\Y) 250	≥ 250
CS(10\Y) 300	≥ 300
CS(10\Y) 350	≥ 350
CS(10\Y) 400	≥ 400
CS(10Y) 450	≥ 450
CS(10\Y) 500	≥ 500
CS(10\Y) 600	≥ 600
CS(10\Y) 650	≥ 650
CS(10\Y) 700	≥ 700
CS(10\Y) 800	≥ 800
CS(10\Y) 900	≥ 900
CS(10\Y) 1000	≥ 1000

4.2.5 Reaction to fire

4.2.5.1 Reaction to fire classification

Reaction to fire classification (Euroclasses) shall be determined in accordance with EN 13501-1.

4.2.5.2 Continuous glowing combustion

Where subject to regulation, the continuous glowing combustion shall be declared. In the absence of a European test method which is under development, the existing relevant national test method applies.

4.3 For specific applications

4.3.1 General

If there is no requirement for a property described in 4.3 for a product in use, then the property does not need to be determined and declared by the manufacturer.

4.3.2 Dimensional stability under specified conditions

4.3.2.1 Dimensional stability at specified temperature

Dimensional stability at specified temperature shall be determined in accordance with EN 1604. The test shall be carried out after storage for 48 h at (70 ± 2) °C. The relative changes in length, $\Delta\varepsilon_l$, in width, $\Delta\varepsilon_b$, and in thickness, $\Delta\varepsilon_d$, shall not exceed 5 %.

4.3.2.2 Dimensional stability under specified temperature and humidity conditions

Dimensional stability under specified temperature and humidity conditions shall be determined in accordance with EN 1604. The test shall be carried out after storage for 48 h at (70 ± 2) °C and (90 ± 5) % relative humidity. The relative changes in length, $\Delta\varepsilon_l$, in width, $\Delta\varepsilon_b$, and in thickness, $\Delta\varepsilon_d$, shall not exceed 5 %.

4.3.2.3 Deformation under specified compressive load and temperature conditions

Deformation under specified compressive load and temperature conditions shall be determined in accordance with EN 1605. For the test condition the difference between the relevant deformation, ε_1, after step A and, ε_2, after step B as described in EN 1605 shall not exceed the value in percent given in Table 4 for the declared level.

Table 4 — Levels for deformation under specified compressive load and temperature conditions

Level	Test conditions	Requirement %
DLT(2) 5	load: 40 kPa temperature: (70 ± 1) °C time: (168 ± 1) h	≤5

4.3.3 Compressive stress at 2 % and 5 % deformation or compressive strength

The compressive stress at 2 % and/ or 5 % deformation, σ_2, and/or, σ_5, or the compressive strength, σ_m, shall be determined in accordance with EN 826. No test result for either the compressive stress at 2 % and/or 5 % deformation, σ_2, and/ or, σ_5, or the compressive strength, σ_m, whichever is the greatest, shall be lower than the values given in Table 5 and Table 6 for the declared level.

NOTE Although EN 826 does not specify the calculation of the compressive stress at 2 % and 5 % deformation, the calculation should be done in the same way.

Table 5 — Levels for compressive stress at 2 % deformation or compressive strength

Level	Requirement kPa
CS(2\Y) 100	>100
CS(2\Y) 200	≥200
CS(2\Y) 250	≥250
CS(2\Y) 300	≥300
CS(2\Y) 350	≥350
CS(2\Y) 400	≥400
CS(2\Y) 450	≥450
CS(2\Y) 500	≥500
CS(2\Y) 600	≥600
CS(2\Y) 650	≥650
CS(2\Y) 700	≥700
CS(2\Y) 800	≥800
CS(2\Y) 900	≥900
CS(2\Y) 1 000	≥1.000

Table 6 — Levels for compressive stress at 5 % deformation or compressive strength

Level	Requirement kPa
CS(5\Y) 100	>100
CS(5\Y) 200	≥200
CS(5\Y) 250	≥250
CS(5\Y) 300	≥300
CS(5\Y) 350	≥350
CS(5\Y) 400	≥400
CS(5\Y) 450	≥450
CS(5\Y) 500	≥500
CS(5\Y) 600	≥600
CS(5\Y) 650	≥650
CS(5\Y) 700	≥700
CS(5\Y) 800	≥800
CS(5\Y) 900	≥900
CS(5\Y) 1 000	≥ 1.000

4.3.4 Point load

The effects of foot traffic shall be assessed by means of determination of the compressive stress or the compressive strength in accordance with EN 826, see 4.2.4.

4.3.5 Compressive creep

Compressive creep, ε_{ct}, and total thickness reduction, ε_t, shall be determined after at least one hundred twenty two days of testing at a declared compressive stress, σ_c, given in steps of at least 1 kPa, and the results extrapolated thirty times, corresponding to ten years, to obtain the declared levels in accordance with EN 1606. Tests shall be done with samples that do not exceed the compressive stress or compressive strength according to the level of Table 3 by more than 10 %. Compressive creep shall be declared in levels, i_2 and the total thickness reduction shall be declared in levels, i_1, with steps of 0,5% at the declared stress. No test result shall exceed the declared levels at the declared stress.

NOTE 1 For building applications a total thickness reduction, ε_t, of 2 % and an exploration time of 50 years are generally required.

NOTE 2 Examples for declaration of levels for compressive creep.

Level	Test time days	Extrapolation time years	Declared stress kPa	Requirement %
$CC(i_1/ i_2 / 10)\sigma_c$	122	10	σ_c	$\varepsilon_t \leq i_1$ and $\varepsilon_{ct} \leq i_2$
$CC(i_1/ i_2 / 25)\sigma_c$	304	25	σ_c	$\varepsilon_t \leq i_1$ and $\varepsilon_{ct} \leq i_2$
$CC(i_1/ i_2 / 50)\sigma_c$	608	50	σ_c	$\varepsilon_t \leq i_1$ and $\varepsilon_{ct} i \leq_2$

NOTE 3 Referring to the designation code $CC(i_1/i_2/y)\sigma_c$, according to Clause 6, a declared level CC(2/1.5/50)100, for example, indicates a value not exceeding 1,5 % for compressive creep and 2 % for total thickness reduction after extrapolation at 50 years (i.e. 30 times six hundred eight days of testing) under a declared stress of 100 kPa.

4.3.6 Resistance to cyclic compressive loading

4.3.6.1 Resistance to cyclic compressive loading with square wave load application

The resistance to cycling compressive loading with square wave load application shall be determined in accordance with Annex D and shall be used specifically for railway applications. The relative compression, D_i, in %, shall be determined after a defined number of load cycles and the applied compressive stress, σ_i. The relative compression, D_i, shall be declared as level, i. No test result shall exceed the declared level of, D_i, after 2×10^6 load cycles at the declared stress.

NOTE For railway applications typically a relative compression, D_i, of 5 % after 2×10^6 load cycles at a compressive stress or compressive strength of 100 to 300 kPa are generally required.

4.3.6.2 Resistance to cyclic compressive loading with sinus load application

The resistance to cycling compressive loading with sinus load application shall be determined in accordance either with EN 13793. The relative deformation, $\varepsilon_{l,max}$, in percent shall be determined after a defined number of load cycles and the applied compressive stress, σ_i. The relative deformation, $\varepsilon_{l,max}$, shall be declared as level, i. No test result shall exceed the declared level at the declared number of load cycles and the declared stress.

4.3.7 Bending strength

Bending strength, σ_b, shall be determined in accordance with EN 12089.

XPS products may be tested in the extrusion direction or in the cross direction, depending on the application. No test result of, σ_b, shall be lower than the declared level, BS, chosen from the following levels: 300 kPa, 400 kPa, 500 kPa, 600 kPa, 700 kPa, 800 kPa, 900 kPa, 1 100 kPa, 1 300 kPa, 1 700 kPa, 1 900 kPa, 2 100 kPa, 2 300 kPa, 2 500 kPa, 3 000 kPa, 3 500 kPa, 4 000 kPa.

4.3.8 Thermal resistance and thermal conductivity

The thermal resistance and thermal conductivity shall be based upon measurements carried out in accordance with EN 12667 or EN 12939 for thick products. For light weight fill applications without thermal insulation requirements it is permitted to declare the maximum thermal conductivity value as defined in the Scope of this European Standard (0,060 W/(m·K)).

The thermal resistance and thermal conductivity shall be determined in accordance with Annex A and Annex C and declared by the manufacturer according to the following:

— the reference mean temperature shall be 10 °C;

— the measured values shall be expressed with three significant figures;

— the thermal resistance, λ_D, shall always be declared. The thermal conductivity, λ_D, shall be declared where possible;

— the declared thermal resistance, λ_D, and the declared thermal conductivity, λ_D, shall be given as limit values representing at least 90 % of the production, determined with a confidence level of 90 %;

— the value of thermal conductivity, $\lambda_{90/90}$, shall be rounded upwards to the nearest 0,001 W/(m·K) and declared as λ_D in levels with steps of 0,001 W/(m·K);

— the declared thermal resistance, λ_D, shall be calculated from the nominal thickness, d_N ,and the corresponding thermal conductivity value, $\lambda_{90/90}$, unless measured directly;

— the value of thermal resistance, $R_{90/90}$, when calculated from the nominal thickness, d_N , and the corresponding thermal conductivity, $\lambda_{90/90}$, shall be rounded downwards to the nearest 0,05 m²·K/W, and declared as λ_D in levels with steps of 0,05 m²·K/W;

— the value of, $R_{90/90}$, for those products for which only the thermal resistance is measured directly, shall be rounded downwards to the nearest 0,05 m²·K/W and declared as λ_D in levels with steps of 0,05 m²·K/W.

4.3.9 Water absorption

4.3.9.1 Long term water absorption by immersion

Water absorption by total immersion, W_{lt}, shall be determined in accordance with EN 12087 method 2A. No test result shall be higher than the value given in Table 7, for the declared level.

Table 7 — Levels for long term water absorption by total immersion

Level	Requirement % by volume
WL(T) 3	≤3
WL(T) 1,5	≤1,5
WL(T) 0,7	≤0,7
WL(T) 0,5	≤0,5

4.3.9.2 Long term water absorption by diffusion

Water absorption by diffusion, W_{dV}, shall be determined in accordance with EN 12088. No test result shall be higher than the value given in Table 8 for the declared level.

Table 8 — Levels for long term water absorption by diffusion

Level	Requirement % by volume
WD (V) 5	≤ 5
WD (V) 3	≤ 3

4.3.10 Freeze-thaw resistance

Freeze-thaw resistance shall be determined in accordance with EN 12091 using the test specimen from 4.3.9.2. The additional water absorption, W_V, shall be not higher than the value given in Table 9 for the declared level.

Table 9 — Levels for Freeze-thaw resistance

Level	Requirement % by volume
FTC 5	≤ 5
FTC 4	≤ 4
FTC 3	≤ 3
FTC 2	≤ 2
FTC 1	≤ 1

After the freeze-thaw test the reduction in compressive stress at 10 % deformation, σ_{10}, or the compressive strength, σ_m, of the dry specimens, when tested in accordance with EN 826 shall not exceed 10 % of the initial value.

4.3.11 Water vapour transmission

Water vapour transmission properties shall be determined in accordance with EN 12086, and declared as the water vapour diffusion resistance factor, μ, for homogeneous products and as the water vapour resistance, Z, for faced or non-homogeneous products.

No test result of, μ, shall be less than the declared level, MU, chosen from the following levels: 50, 80, 100, 150, 200, 250, 300. If, Z, is declared, no test result shall be less than the declared value.

4.3.12 Release of dangerous substances

NOTE See Annex ZA.

5 Test methods

5.1 Sampling

Test specimens shall be taken from the same sample, with a total area of not less than one board, sufficient to cover the needed tests.

5.2 Conditioning

No special conditioning of test specimens is needed unless otherwise specified in this standard. In case of dispute, conditioning of test specimens shall be stored at (23 ± 2) °C and (50 ± 5) % relative humidity for at least 6 h prior to testing unless otherwise specified in this standard.

5.3 Testing

5.3.1 General

Table 10 gives the dimensions of test specimens, the minimum number of measurements required to get one test result and any specific conditions which are necessary.

5.3.2 Thermal resistance and thermal conductivity

Thermal resistance and thermal conductivity shall be determined in accordance with EN 12667 or EN 12939 for thick products and under the following conditions:

— at a mean temperature of (10 ± 0,3) °C;

— after conditioning in accordance with 5.2;

— taking into account the effect of ageing according to Annex C.

NOTE Thermal resistance and thermal conductivity may also be measured at mean temperatures other than 10 °C, providing that the accuracy of the relationship between temperature and thermal properties is well documented.

Thermal resistance and thermal conductivity shall be determined directly at the measured thickness. In the event that this is not possible, they shall be determined by measurements on other thicknesses of the product providing that:

— the product is of similar chemical and physical characteristics and is produced on the same production unit;

— and it can be demonstrated in accordance with EN 12939 that the thermal conductivity does not vary more than 2 % over the range of thicknesses where the calculation is applied.

Table 10 — Test methods, test specimens and conditions

Dimensions in millimetres

Clause		Test method	Test specimen length and width[a]	Minimum number of measurements to get one test result	Specific conditions
No	Title				
4.2.1	Length and width	EN 822	Full size	1	-
4.2.1	Squareness on length and width	EN 824	Full size	1	-
4.2.1	Flatness	EN 825	Full size	1	-
4.2.2	Thickness	EN 823	Full size	1	Load: (250 ± 5) Pa
4.2.3	Dimensional stability under specified temperature and humidity conditions	EN 1604	200 x 200	2	Condition specimens for 45 days Test condition: 23 ºC, 90 % relative humidity
4.2.4	Compressive stress at 10% deformation or compressive strength	EN 826	100 x 100	5	Condition specimens for 45 days (Length and width of specimen shall be ≥ thickness of specimen)
			150 x 150	3	
4.2.5.1	Reaction to fire	See EN 13501-1			
4.2.5.2	Continuous glowing combustion	[b]			
4.3.2	Dimensional stability at specified temperature	EN 1604	200 x 200	2	Condition specimens for 45 days
	Dimensional stability under specified temperature and humidity conditions	EN 1604	200 x 200	2	Condition specimens for 45 days, Test condition: 70 °C, 90 % relative humidity

Table 10 *(continued)*

Clause		Test method	Test specimen length and width[a]	Minimum number of measurements to get one test result	Specific conditions
No	**Title**				
	Deformation under specified compressive load and temperature conditions	EN 1605	100 x 100	3	Condition specimens for 45 days
4.3.3	Compressive stress at 2 % and /or 5 % deformation or compressive strength	EN 826	100 x 100	5	Condition specimens for 45 days (Length and width of specimen shall be ≥ thickness of specimen)
			150 x 150	3	
4.3.4	Point load	EN 826	See 4.2.4		
4.3.5	Compressive creep	EN 1606	100 x 100	2	Test specimen selected from the mean compressive strength/ stress area of a board. Condition specimens for 45 days
			150 x 150	2	
4.3.6.1	Resistance to cyclic compressive loading with square wave load application	Annex D	400 x 400	2	Condition specimens for 45 days
4.3.6.2	Resistance to cyclic compressive loading with sinus load application	EN 13793	200 x 200	1	Condition specimens for 45 days
4.3.7	Bending strength	EN 12089	length: $5d_N$ (≤ 550) width:150 Thickness: max. 100	3	Method B
4.3.8	Thermal resistance -Thermal conductivity	EN 12667 or EN 12939	See EN 12667 or EN 12939 and Annex C	1	See Annex C
4.3.9.1	Long term water absorption by immersion	EN 12087	200 x 200	2	Method 2A
4.3.9.2	Long term water absorption by diffusion	EN 12088	500 x 500	2	-

Table 10 *(continued)*

Clause		Test method	Test specimen length and width[a]	Minimum number of measurements to get one test result	Specific conditions
No	**Title**				
4.3.10	Freeze-thaw resistance	EN 12091	500 x 500	1	Set A
			100 x 100 or	5	Set B_1 and B_2
			150 x 150	3	Set B_1 and B_2
4.3.11	Water vapour transmission	EN 12086	See 6.1 in EN 12086:1997	3	Conditions, Set A
4.3.12	Release of dangerous substances	[b]	-	-	-

[a] Always full-size product thickness, except for 4.3.8 and 4.3.7.
[b] Not yet available.

6 Designation code

A designation code for the product shall be given by the manufacturer. The following shall be included except when there is no requirement for a property described in 4.3:

— The extruded polystyrene foam abbreviated term XPS

— This European Standard number EN 14934

— Thickness tolerances Ti

— Compressive stress or compressive strength CS(2 or 5 or 10\Y) i

— Compressive creep CC(i_1/ i_2/y) σ_c

— Resistance to cyclic compressive loading with square wave load CLRT(i,z) σ_i

— Resistance to cyclic compressive loading with sinus load CLR(i,z) σ_i

— Bending strength BS i

— Dimensional stability at specified temperature DS(T+)

— Dimensional stability under specified temperature and humidity conditions DS(TH)

— Deformation under specified compressive load and temperature conditions DLT (i) 5

— Long term water absorption by immersion WL(T) i

— Long term water absorption by diffusion WD(V) i

— Water vapour transmission MUi or Zi

— Freeze-thaw resistance FTC i

where "i" shall be used to indicate the relevant class or level, "z" is the number of cycles and "σ_i" indicates the compressive stress applied for resistance to cyclic compressive loading . For compressive creep "σ_c" shall be used to indicate the compressive stress and "y" to indicate the number of years.

NOTE The designation code for CE marking for an extruded polystyrene foam product is illustrated by the following example.

XPS-EN14934-T1-DLT(2)5-CS(10\Y)300-CC(2/1,5/50)100-CLRT(5/2x10^6)150-CLR(5/2x10^6)150-WD(V)3-WL(T)3 -MU 150 -FTC2

7 Evaluation of conformity

The conformity of the extruded polystyrene foam products with the requirements of this standard and with the stated values (including classes) shall be demonstrated by:

— initial type testing,

— factory production control by the manufacturer, including product assessment.

The manufacturer or his authorized representative shall be responsible for the conformity of his products with the requirements of this European Standard. The evaluation of conformity shall be carried out in accordance with EN 13172 and shall be based on factory production control and tests on samples taken at the factory.

If a manufacturer decides to group his products it shall be done in accordance with EN 13172 and Annex C.

The minimum frequencies of tests in the factory production control shall be in accordance with Annex B of this standard. When indirect testing is used, the correlation to direct testing shall be established in accordance with EN 13172.

8 Marking and labelling

Products conforming with this standard shall be clearly marked, either on the product or on a label or on the packaging with the following information:

— product name or other identifying characteristic;[1)]

— name or identifying mark and address of the manufacturer or his authorised representative;

— year of manufacture (the last two digits);

— shift or time of production and manufacturing plant or traceability code;

— reaction to fire class;

— declared thermal resistance;

— declared thermal conductivity;

— declared thickness;

— designation code as given in Clause 6;

— type of facing/coating, if any;

— declared length, declared width;

— number of pieces and area in the package, as appropriate.

NOTE For CE marking and labelling see ZA.3.

1) Preferably on the product.

Annex A
(normative)

Determination of the declared values of thermal resistance and thermal conductivity

A.1 Introduction

It is the responsibility of the manufacturer to determine the declared values of thermal resistance and thermal conductivity. He will have to demonstrate conformity of the product to its declared values, except if a tabulated thermal value is declared for applications, where no thermal values are required.

The declared values of thermal resistance and thermal conductivity of a product are the expected values of these properties during an economically reasonable working life under normal conditions, assessed through measured data at reference conditions.

A.2 Input data

The manufacturer shall have at least ten test results for thermal resistance and thermal conductivity, obtained from internal or external direct measurements in order to calculate the declared values in accordance with Annex C. The direct thermal resistance and thermal conductivity measurements shall be carried out at regular intervals, spread over a time period of the last twelve months. If less than ten test results are available the period may be extended until ten test results are obtained, but with a maximum period of three years, within which the product and production conditions have not changed significantly.

For new products the ten thermal resistance or thermal conductivity test results shall be carried out spread over a minimum period of ten days.

The declared values shall be calculated according to the method given in A.3 and shall be recalculated at a period not exceeding three months of production.

A.3 Declared values

A.3.1 General

The derivation of the declared values, R_D and λ_D, from the calculated values, $R_{90/90}$ and $\lambda_{90/90}$, shall use the rules given in 4.2.1 which include the rounding conditions.

A.3.2 Case where thermal resistance and thermal conductivity are declared

The declared values, R_D and λ_D, shall be derived from the calculated values, $R_{90/90}$ and $\lambda_{90/90}$, which are determined using the Equation A.1, A.2 and A.3.

$$\lambda_{90/90} = \lambda_{mean} + k \cdot s_\lambda \quad \text{(A.1)}$$

$$S_\lambda = \sqrt{\frac{\sum_{i=1}^{n} (\lambda_i - \lambda_{mean})^2}{n-1}} \quad \text{(A.2)}$$

$$R_{90/90} = d_D/\lambda_{90/90} \quad \text{(A.3)}$$

A.3.3 Case where thermal resistance alone is declared

The declared value shall be derived from the calculated value which is determined using the Equations A.4 and A.5.

$$R_{90/90} = R_{mean} - k \cdot s_R \quad \text{(A.4)}$$

$$S_R = \sqrt{\frac{\sum_{i=1}^{n}(R_i - R_{mean})^2}{n-1}} \quad \text{(A.5)}$$

Table A.1 — Values of k for one sided 90 % tolerance interval with a confidence level of 90 %

Number of test results	k
10	2,07
11	2,01
12	1,97
13	1,93
14	1,90
15	1,87
16	1,84
17	1,82
18	1,80
19	1,78
20	1,77
22	1,74
24	1,71
25	1,70
30	1,66
35	1,62
40	1,60
45	1,58
50	1,56
100	1,47
300	1,39
500	1,36
2.000	1,32
For other numbers of test results use ISO 12491 or linear interpolation.	

Annex B
(normative)

Factory Production Control

Table B.1 — Minimum product testing frequencies

Clause		Minimum testing frequency[a]
No	**Title**	
4.2.1	Length and width	1 per 2 h
4.2.1	Squareness	1 per 4 h
4.2.1	Flatness	1 per 8 h
4.2.2	Thickness	1 per 2 h
4.2.3	Dimensional stability under specified temperature and humidity conditions	1 per 5 years
4.2.4	Compressive stress at 10 % deformation or compressive strength	1 per 12 h
4.2.5.1	Reaction to fire	See Table B.2
4.2.5.2	Continuous glowing combustion	[b]
4.3.2.1	Dimensional stability at specified temperature	1 per 5 years
4.3.2.2	Dimensional stability under specified temperature and humidity conditions	1 per 5 years
4.3.2.3	Deformation under specified compressive load and temperature conditions	1 per 5 years
4.3.3	Compressive stress at 2 % and/or 5 % deformation or compressive strength	1 per 12 h
4.3.5	Compressive creep	1 per 5 years
4.3.6.1	Resistance to cyclic compressive loading with square wave load application (Annex D)	1 per 5 years
4.3.6.2	Resistance to cyclic compressive loading with sinus load application	1 per 5 years
4.3.7	Bending strength	1 per 5 years
4.3.8	Thermal resistance and thermal conductivity	Initial values: 1 per 24 h[c] Aged values: 1 per two years [c]
4.3.9.1	Long term water absorption by immersion	1 per 5 years

Table B.1 *(continued)*

Clause		Minimum testing frequency[a]
No	**Title**	
4.3.9.2	Long term water absorption by diffusion	1 per 5 years
4.3.10	Freeze-thaw resistance	1 per 5 years
4.3.11	Water vapour transmission	1 per 5 years
4.3.12	Release of dangerous substances	[b]

NOTE For initial type testing of long term thermal, mechanical and freeze-thaw properties test results of similar products produced at different plants will be recognized until testing is complete.

[a] The minimum testing frequencies shall be understood as the minimum for each production line under stable conditions. In addition to the testing frequencies given above, testing of relevant properties of the product shall be repeated when changes or modifications are made, that are likely to affect the conformity of the product.

[b] Frequencies are not given, as harmonized European test methods are not yet available.

[c] Only when thermal values are required.

Table B.2 — Minimum product testing frequencies for the reaction to fire characteristics

Clause		Minimum testing frequency[a]							
No	Title	Direct testing [b]		Indirect testing [c, f]					
				Product		Components [d, e]			
						Substantial		Non-substantial	
		Test method	Frequency	Test method	Frequency	Test method	Frequency	Test method	Frequency
4.2.5	A1	EN ISO 1182 and EN ISO 1716 (and EN 13823)	1 per 2 years and indirect testing	—	—	Manufacturer's method	1 per week	Loss on ignition or calorific potential	1 per week 1 per week
						Manufacturer's method	1 per week	Weight per unit area	1 per day
	A2	EN ISO 1182 or EN ISO 1716 and EN 13823	1 per 2 years and indirect testing	—	—	Manufacturer's method	1 per week	Loss on ignition or calorific potential	1 per week 1 per week
						Manufacturer's method	1 per week	Weight per unit area	1 per day
	B C D	EN 13823 and EN ISO 11925-2	1 per month or 1 per 2 years and indirect testing	EN ISO 11925-2	1 per day	Manufacturer's method	1 per day	Manufacturer's method	1 per day
			1 per week or 1 per 2 years and indirect testing	Manufacturer's method	1 per day	—	—	—	—

Table B.2 *(continued)*

Clause		Minimum testing frequency[a]							
No	Title	Direct testing [b]		Indirect testing [c, f]					
				Product		Components [d, e]			
						Substantial		Non-substantial	
		Test method	Frequency	Test method	Frequency	Test method	Frequency	Test method	Frequency
4.2.5	E	EN ISO 11925-2	1 per week or 1 per 2 years and indirect testing	Manufacturer's method	1 per day	—	—	—	—

NOTE Not all Euroclasses may apply for the products conforming to this standard.

[a] The minimum testing frequencies, expressed in test results, shall be understood as the minimum for a product or product group for each production unit/line under stable conditions. In addition to the testing frequencies given above, testing of relevant properties of the product shall be repeated when changes or modifications are made that are likely to affect the conformity of the product.

[b] Direct testing may be conducted either by third party or by the manufacturer.

[c] Indirect testing may be either on the product or on its components.

[d] Definition as given in the Euroclasses Decision 2000/147/EC:

— Substantial component: A material that constitutes a significant part of a non-homogeneous product. A layer with a mass per unit area $\geq 1{,}0$ kg/m^2 or a thickness $\geq 1{,}0$ mm is considered to be a substantial component.

— Non-substantial component: A material that does not constitute a significant part of a non-homogeneous product. A layer with a mass per unit area $< 1{,}0$ kg/m^2 and a thickness $< 1{,}0$ mm is considered to be a non-substantial component.

[e] In case of certified component, no testing is required.

[f] Indirect testing is only possible in the case of products falling within the system 1 for attestation of conformity of reaction to fire, or by having a notified body verifying the correlation to the direct testing.

Annex C
(normative)

Determination of the aged values of thermal resistance and thermal conductivity

C.1 Scope

The ageing procedure shall be used for XPS products which are produced with the aid of blowing agents which have a lower thermal conductivity than air and which stay in the foam for an appreciable time. The ageing procedure which represents a time average value of about 25 years of use, shall be used for XPS products with and without diffusion tight laminates with thicknesses from 20 mm to 200 mm.

XPS Products that are produced with CO_2 technology are not covered by this Annex C.

These products shall be measured at the full thickness without laminates, 90 days after production and after conditioning at (23 ± 2) °C, and (50 ± 5) % relative humidity.

C.2 Procedure for XPS foam without diffusion tight laminates

C.2.1 Principle

The procedure involves slicing of the test specimen to increase the rate of gas exchange and thus simulates a long period of use.

C.2.2 Sample preparation

Prepare the test specimen from product of not less than 1 day and not more than 90 days old.

Cut each test specimen into slices of (10 ± 1) mm, retaining the surface skins, when present.

The slice package shall include the aged slices over the board thickness and shall contain the outermost 10 mm thick layers on both sides of the test specimen. A remaining central slice with less than 10 mm thickness can be discarded.

Mark the edges of the test sample to ensure correct realignment of the stack of the test specimens (slices) after cutting.

NOTE The cutting technique should not significantly damage the surface of the slices. A fine toothed band saw, hot wire cutting or surface grinding may provide suitable methods.

C.2.3 Procedure

Store the individual slices at (23 ± 2) °C, and (50 ± 5) % relative humidity for the following time periods:

($90\,^{+2}_{-2}$) days for XPS foam thicknesses of 20 mm to 70 mm,

($50\,^{+2}_{-1}$) days for foam thicknesses of >70 mm to 120 mm and

($30\,^{+2}_{-0}$) days for foam thicknesses >120 mm.

Assemble a test specimen of aged slices including the surface representative of the thickness to be tested. If any part of the cut specimen is discarded, evidence shall be available that the aged thermal conductivity is not adversely affected.

Measure the thermal conductivity of the final entire assembly in accordance with EN 12667 and EN 12939 for thick products.

The correction of the thermal conductivity due to damaged surface shall be done for XPS products without skin by deducting 0,000 7 W/(m·K) from the measured aged thermal conductivity. For XPS products with skin the correction shall be done by deducting 0,001 W/(m·K) from the measured aged thermal conductivity. This value of 0,001 W/(m·K) includes the correction for the damaged surface and the correction for the elimination of the skin from the ageing process.

C.3 Procedure for XPS foam for use with diffusion tight facings on both sides

C.3.1 Principle

The basis of the declared value of XPS foam which is laminated on both sides of the foam is the thermal value of the foam at the time of lamination with diffusion tight facings.

C.3.2 Ageing procedure

Store the full size board (non-sliced) without the facings at (23 ± 2)°C and (50 ± 5)% relative humidity for a time period of 60 days after production.

Then cut a test specimen with the dimensions of 500 mm × 500 mm and measure the thermal conductivity in accordance with EN 12667 or EN 12939 for thick products and with 5.3.2.

For products which are laminated more than 60 days after production, as an exceptional case, the declaration of thermal conductivity and thermal resistance shall be based on measuring the thermal conductivity at the time of lamination. To the measured value of the thermal conductivity, $\lambda_{>60d}$, the conventional correction of 0,001 W/(m·K) shall be added to take into account the statistical variation of that production batch in order to arrive at the fractile value of $\lambda_{90/90>60d}$.

In order to consider the effect of edges and the degree of diffusion tightness of facings on an increase of the thermal conductivity after lamination, the thermal conductivity as determined according to this clause of the board without the facings shall be increased by 0,001 W/(m·K) when diffusion tight facings like aluminium foils with minimum thickness of 50µm or facings, that show an equivalent performance are used.

Aluminium foil with thicknesses less than 50 µm and other facings can be considered as diffusion tight, when the thermal conductivity of a faced product with a maximum size of the sample of 800 mm × 800 mm and maximum thickness of 50 mm does not increase more than 0,001 W/(m·K), when stored for (175 ± 5) days at 70 °C.

The panel dimensions of products laminated with diffusion tight facings shall not be less than 600 mm × 800 mm.

NOTE The initial diffusion tight property of a facing can also be proven, if the oxygen diffusion level is less than 4,5 cc per 24 h per m^2 when measured at 20 °C in accordance with ASTM 3985:1995, *Standard test method for oxygen gas transmission rate through plastic film and sheeting using a coulometric sensor.*

C.4 Calculation of aged value

C.4.1 Calculation of aged value for XPS products without diffusion tight facings on both sides

C.4.1.1 General

The aged values of the thermal conductivity, $\lambda_{90/90}$, /thermal resistance, $R_{90/90}$, shall be calculated in accordance with 4.3.8, Annex A, C.2 and this clause.

The statistical values k, s_λ and s_R as required in Annex A shall be calculated using either aged or initial values within 90 days after production.

For the calculation of, λ_{mean}, as required according to Annex A, aged values determined according to C.2 shall be used, representing $\lambda_{mean,a}$.

A minimum of 10 values per declared product or product group shall be available every year, based on either aged or initial values within 90 days of production.

C.4.1.2 Calculation of $\lambda_{90/90}$ and $R_{90/90}$ values with aged values

$$\lambda_{90/90} = \lambda_{mean,a} + k \cdot s_{\lambda,a} \quad \text{(C.1)}$$

$$R_{90/90} = d_N/\lambda_{90/90} \quad \text{(C.2)}$$

C.4.1.3 Calculation of $\lambda_{90/90}$ and $R_{90/90}$ values with initial values

$$\lambda_{90/90} = \lambda_{mean,a} + k \cdot s_{\lambda,I} \quad \text{(C.3)}$$

$$R_{90/90} = d_N/\lambda_{90/90} \quad \text{(C.4)}$$

C.4.2 Calculation of aged value for XPS products for use with diffusion tight facings on both sides

C.4.2.1 General

The aged value of the thermal conductivity $\lambda_{90/90}$ or the thermal resistance $R_{90/90}$ shall be calculated in accordance with 4.3.8, Annex A, C.3 and this clause.

The symbols $\lambda_{90/90}$ and $R_{90/90}$ of 4.3.8 and Annex A are replaced for the standard case by $\lambda_{90/90,60d}$ and $R_{90/90,60d}$ and for the exceptional case by $\lambda_{90/90,>60d}$ and $R_{90/90,>60d}$.

The statistical variation k, s_λ and s_R as required in Annex A shall be calculated using either values at 60 days after production or initial values within 60 days of production at full product thickness. For λ_{mean} for the standard case an aged value $\lambda_{mean,60d}$ and for the exceptional case $\lambda_{>60d}$ determined according to C.3 shall be used.

A minimum of 10 values per declared product or product group shall be available for the standard case every year, determined either at 60 days after production or from initial values within 90 days of production.

C.4.2.2 Calculation of $\lambda_{90/90}$ and $R_{90/90}$ values for faced products with aged values

$$\lambda_{90/90,60d} = \lambda_{mean,60d} + k \cdot s_{\lambda 60d} + 0{,}001 \text{ W/(m·K) (edge effect)} \quad \text{(C.5)}$$

$\lambda_{90/90,>60d} = \lambda_{>60d}$ + 0,002 W/(m·K) (standard deviation and edge effect) (C.6)

$R_{90/90,60d} = d_N/\lambda_D$ (C.7)

C.4.2.3 Calculation of $\lambda_{90/90}$ and $R_{90/90}$ values for faced products with initial values

$\lambda_{90/90,60d} = \lambda_{mean,60d} + k \cdot s_{\lambda t}$ + 0,001 W/(m·K) (edge effect) (C.8)

The thermal conductivity of sandwich panels with diffusion open facings shall be determined according to C.2.

NOTE The ageing method according to C.2 is based on ISO 11561, *Ageing of thermal insulation materials — Determination of the long-term change in thermal resistance of closed cell plastics (accelerated laboratory test methods).*

C.5 Blowing agent

The manufacturer shall state the blowing agent used for the product, when requested.

NOTE The blowing agent may be identified by the method of gas chromatography.

C.6 Product grouping

The manufacturer shall declare either

— separate thermal values for each single product and each single thickness and then determine the $\lambda_{90/90}$ value on each thickness for each product or

— thermal values for a product or product group including all or a range of thicknesses using the $\lambda_{90/90}$ value of the product or product group for the corresponding thickness range. Separate product groups shall be established for XPS products for use with diffusion tight laminates.

The manufacturer shall decide whether he will create groups and the size of the groups. Determined thermal values of thin, medium and thick products shall be included in the statistics of a product or product group which covers a complete or a thickness range.

A minimum of 10 aged values shall be determined per product or product group.

Annex D
(normative)

Determination of behaviour under cyclic square wave load

D.1 Scope

This method specifies procedures for determining the compressive deformation of cellular plastic during a fatigue test carried out under cyclic compressive loading with a square-wave load. The method is primarily designed for material intended for use in railway embankments.

NOTE This method is essentially based on the Swedish test method SP 2687, *Resistance to cyclic compressive loading with square-wave load.*

D.2 Definitions

For the purposes of this annex, the following definitions apply:

D.2.1
thickness, t_0
thickness of the test specimen (mean value from the four corners) before testing at 100 % of the maximal compressive stress, σ_{max}

D.2.2
compressive deformation, l_{1i}
compressive deformation of the test specimen after i number of cycles at 100 % of the maximum compressive stress, σ_{max}, when four gauges are used take mean value from the four corners

D.2.3
compressive stress
σ_{min}: Lower stress level of one stress cycle

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

D.2.4
relative compressive deformation, D_i
relative reduction in thickness (%) of the test specimen after i number of cycles

D.2.5
stress 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 an almost square wave, where σ_{min} is the bottom and σ_{max} is the top of the wave

D.2.6
resistance to cyclic compressive load, D
resistance to cyclic compressive load is defined as the relative compressive deformation after $2 \cdot 10^6$ cycles of a specific square wave-type alternating compressive load

D.3 Principle

A test specimen is subjected to a cyclic compressive load of constant amplitude. The compressive load is applied axially with a cyclic variation between two prescribed values and a frequency of 4 Hz. The variation in load is almost a square wave oscillating between two constant compressive loads. The duration of the test is $2 \cdot 10^6$ cycles. At certain intervals the compressive deformation of the specimen is measured while keeping the specimen under a steady compressive load equal to 100 % of the maximum applied load. At the end of the test the total compressive deformation is measured and then divided by the initial thickness of the specimen at 100 % of the max. test load to obtain the relative compressive deformation.

D.4 Testing equipment

D.4.1 Cutting tool

Cutting tool providing smooth and perpendicular surfaces and preventing melting of the material during cutting.

D.4.2 Length measuring equipment

Instrument for measuring the test specimen length and width to an accuracy of ± 1,0 mm and instrument for measuring the test specimen thickness to an accuracy of ± 0,1 mm.

D.4.3 Steel plate

Stainless steel plate for load distribution, with the following dimensions: (400 x 400 x 50) mm ± 1,0 mm. The lower surface shall be face-ground.

D.4.4 Measuring gauges

Measuring gauges for measuring deformation, with an accuracy of ± 0,01 mm within the range of use for this test or corresponding instruments, with same accuracy, for measuring the compression of the specimen.

D.4.5 Apparatus

Load cell equipped hydraulic testing machine, with rigid construction, capable of applying cyclic loading in accordance with the requirements below:

a) Frequency of the loading cycle at least 4 Hz.

b) Almost square-wave load cycle, with a pulse rise time of $\leq$ 20 ms from the minimum up to 90 % of the maximum load, as shown in Figure D.1.

c) Force control within ± 1 % of the maximum applied force.

The load shall be transferred to the specimen through a spherical coupling connected to the load cell, as shown in the test set-up in Figure D.3.

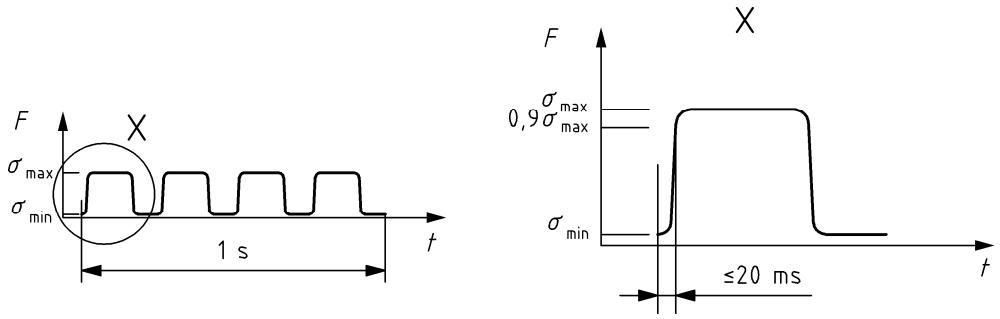


Figure D.1 — Required load cycle during the fatigue test

D.5 Test specimens

D.5.1 Dimensions of test specimens

Test specimens with dimensions (400 x 400) mm ± 1,0 mm shall be taken from the middle of the cellular plastic boards. A test specimen consists of *one* unit of the chosen thickness.

D.5.2 Number of test specimens

At least two test specimens shall be tested for each type and quality of cellular plastic. The test specimens shall be taken from different cellular plastic boards.

D.5.3 Conditioning of test specimens

After cutting, the test specimens shall be conditioned for at least 45 days at the temperature of (22 ± 2) °C and the relative humidity of (50 ±10) %. The testing shall be carried out during the same climatic conditions.

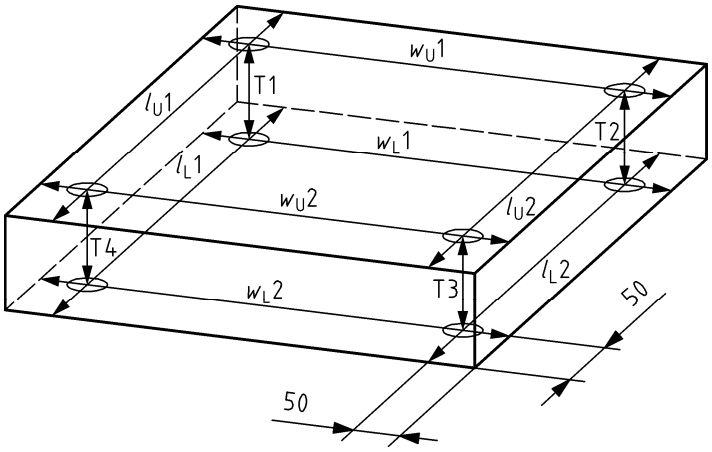
D.6 Procedure

D.6.1 Test conditions

The test shall be carried out at (22 ± 2) °C and (50 ± 10) % relative humidity.

D.6.2 Test procedure

Measure the lengths and widths 5 mm from upper and 5 mm from lower surface and 50 mm from side edges, total 8 measurements, see Figure D.2. Calculate the area of the load-bearing surfaces (upper and lower surface) and take mean value from the two areas. Measure the thickness of the test specimen in 4 points T1-T4 and take mean value from readings. Place the test specimen (one board) on the lower machine plate.



Key

Area upper surface = $(l_U1+l_U2)/2*(w_U1+w_U2)/2$
Area lower surface = $(l_L1+l_L2)/2*(w_L1+w_L2)/2$
Measuring of lengths l and widths w shall be done 5 mm from upper and lower surface and 50 mm from side edges, total 8 measurements

Figure D.2 — Dimensions of the test specimen

Place the test specimen concentric with the load axis and place the steel load-distribution plate on top (see Figure D.3). Both test specimen and steel plate shall be carefully centred to ensure concentric application of the load.

Place the measuring gauges to record the movements of the upper surface of the load-distribution plate at four points located close to the four corners (see Figure D.3). The readings on the measuring gauges indicate the vertical deformation of the sample. Mark the exact location of each measuring point on the steel plate to ensure the repeatability of the measurements throughout the test.

An alternative method for measuring the compression of the test specimen is to use one measuring gauge in the middle of the test specimen.

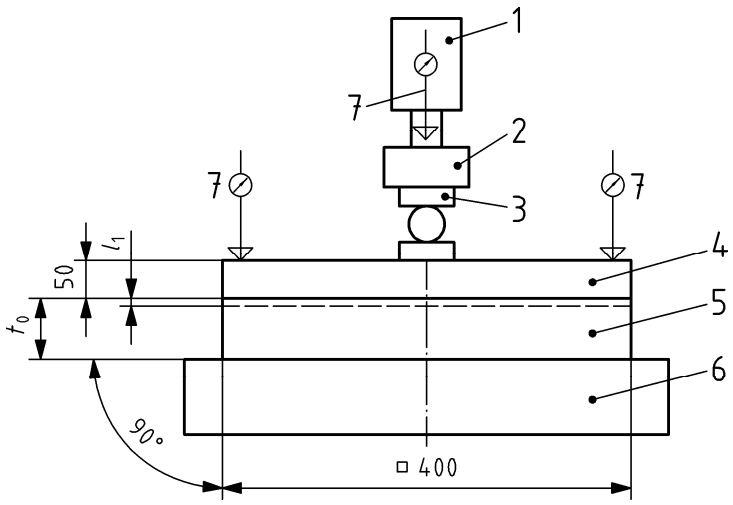
Apply a steady compressive stress of 100 % of the maximum test load. The maximum test load is the load from the weight of the steel plate itself, plus the load from the test machine. Reset the measuring gauge(s) and measure the thickness of the specimen (t_0) rounded to the nearest 0,1 mm, the thickness shall be the mean value from the four corners.

Start the cyclic loading as a uniaxial concentric compression with constant amplitude and frequency (see Figure D.1). Required characteristics of the load cycle are:

— The frequency is 4 Hz.

— The stress-time relationship is described by an almost square-wave cycle, with a pulse rise time ≤ 20 ms from the minimum compression level to 90 % of the maximum compression level (see Figure D.1).

Take readings from the measuring gauge(s), at i = 10 cycles, i = 10,000 and as close as possible to 100,000, 300,000, 600,000, 1,500,000 and 2,000,000 cycles, while keeping the test specimen under a steady compressive load of 100 % of the maximum test load. Note the readings in mm to two decimals.



t_o = Thickness of test specimen (mean four corners) before cyclic load

l_1 = The compressive deformation after $2 \cdot 10^6$ compressive loads

Key

1 Actuator
2 Load cell
3 Spherical
4 Steel
5 Specimen (1 board)
6 Machine
7 Measuring gauge(s) for compressive deformation of the specimens: one in each corner, one in the middle of the test

Figure D.3 — Test set-up

D.7 Calculation and expression of results

The relative compressive deformation at each test level is calculated according to the following equation and shall be expressed to two significant figures.

$$D_i = 100 \times \frac{l_{1i}}{t_0} \ (\%) \qquad \text{(D.1)}$$

where:

t_0 The thickness of the test specimen (mean value from the four corners) before testing at 100 % of the maximum test load.

l_{1i} The compressive deformation of the test specimen after i number of cycles at 100 % of the maximum test load, when four gauges are used take mean value from the four corners.

D_i The relative compressive deformation (%) after i number of cycles.

The relationship between deformation - number of cycles shall be presented in a diagram from 0 to $2 \cdot 10^6$ cycles.

The result is the relative compressive deformation D (%) after $2 \cdot 10^6$ cycles.

D.8 Accuracy of measurement

Under cyclic loading the accuracy of the maximum applied load has to be within ± 1 %. The measuring gauge(s), for measuring the compression of the test specimen, shall have an accuracy within ± 0,01 mm. The accuracy in measuring the test specimen width shall be within ± 1 mm. The accuracy in measuring the test specimen height before testing shall be within ± 0,1 mm.

D.9 Test report

The test report shall include the following information, if relevant:

— reference to this European Standard;

— name and address of the testing laboratory;

— identification number of the test report;

— name and address of the organization or the person who ordered the test;

— purpose of the test;

— method of sampling and other circumstances (date and person responsible for the sampling);

— name and address of the manufacturer or supplier of the tested product;

— name or other identification of the product;

— description of the tested product;

— date of supply of the tested product;

— date of the testing;

— test method and selected stress levels, σ_{min} and σ_{max};

— any deviation from the test method;

— test results lengths, widths and thickness before testing, the relationship between deformation - number of cycles and the relative compressive deformation D (%) after $2 \cdot 10^6$ cycles;

— any other information that could influence the assessment of the test result;

— accuracy of the test result;

— date and signature.

Annex E
(informative)

Additional properties

E.1 General

The manufacturer may choose to give information on the following additional properties (see Table E.1). This information, where appropriate for the product and the application should be given as limit values for each test result obtained from the referenced test method, sampling and conditioning as given in Table E.1.

E.2 Compressive modulus of elasticity

Modulus of elasticity in compression, E, should be determined perpendicular to the faces of the product in accordance with EN 826. If the modulus of elasticity in compression is declared, no test result should be lower than the declared value CM.

E.3 Determination of volume percentage of open and closed cells

Closed cell content of a product should be tested in accordance with EN ISO 4590. If the closed cell content is declared, no test result should be lower than the declared level of closed cells CV.

E.4 Determination of shear strength

Shear strength, τ, should be determined in accordance with EN 12090.

XPS products may be tested in the extrusion direction or in the cross direction, depending on the application. No test result of, τ, shall be lower than the declared level, SS.

Table E.1 — Test methods, test specimens, conditions and minimum testing frequencies

Dimensions in millimetres

Clause		Test method	Test Specimens length and width[a]	Minimum Number of measurements to get one test result	Specific Conditions	Factory production Control Minimum product testing frequencies[b]
No	Title					
E.2	Compressive modulus of elasticity	EN 826	100 × 100	5	condition specimen for 45 days	1 per 5 years
			150 × 150	3		
E.3	Determination of volume percentage of open and closed cells	EN ISO 4590	30 × 30 × 50	5	Method 2 with corrections, condition specimen for 45 days	1 per 5 years
E.4	Determination of shear strength	EN 12090	250 x 50 x thickness, (max.50 thick)	5	Single Specimen	1 per 5 years
			200 x 100 x thickness (max.50 thick)	3	Double Specimen	

[a] Unless stated otherwise the dimensions include the declared thickness.

[b] Only relevant in case of declaration of the property.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 89/106/EEC, EU Construction Products Directive

ZA.1 Scope and relevant characteristics

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

The clauses of this European Standard, shown in the table below, meet the requirements of the Mandates M 103, its addendum M 138 and Mandates M 126 and M 130 given under the EU Construction Products Directive (89/106/EEC).

Compliance with these clauses confers a presumption of fitness of the construction product covered by this annex for the intended uses indicated herein; reference shall be made to the information accompanying the CE marking.

WARNING — Other requirements and other EU Directives, not affecting the fitness for intended uses, can be applicable to the construction product falling within the scope of this European Standard.

NOTE 1 In addition to the specific clauses relating to dangerous substances contained in this standard, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the EU Construction Products Directive, these requirements need also to be complied with, when and where they apply.

NOTE 2 An informative database of European and national provisions on dangerous substances is available at the Construction web site on EUROPA accessed through http://europa.eu.int/comm/enterprise/construction/internal/dangsub/dangmain.htm).

This annex establishes the conditions for the CE marking of the extruded polystyrene foam intended for the uses indicated in Table ZA.1 and shows the relevant clauses applicable.

This annex has the same scope as Clause 1 of this standard and is defined by Table ZA.1.

Table ZA.1 — Relevant clauses

Construction Products: **Factory made extruded polystyrene foam products (XPS) as covered by the scope of this standard** Intended uses: **Thermal insulation and light weight fill products for civil engineering applications**			
Requirement/Characteristics from the mandate	**Requirement clauses in this European Standard**	**Mandated classes or levels**	**Technical classes or levels or limit values** [a]
Reaction to fire	4.2.5.1 Reaction to fire	Euroclasses	—
Continuous glowing combustion	4.2.5.2 Continuous glowing combustion	Glowing classes	
Resistance to dynamic loads	4.3.6 Resistance to cyclic compressive loading	-	Limit values
Water permeability	4.3.9 Water absorption	—	Levels
Release of dangerous substances to the indoor environment	4.3.12 Release of dangerous substances	—	—
Thermal resistance	4.3.8 Thermal resistance — thermal conductivity	—	Limit values
	4.2.2 Thickness	—	Classes
Water vapour permeability	4.3.11 Water vapour transmission	—	Levels/ limit values
Compressive strength	4.2.4/4.3.3 Compressive stress or compressive strength [b]	—	Levels
Tensile/Flexural strength	4.3.7 Bending strength	—	Levels
Durability of reaction to fire against heat, weathering, ageing/degradation	— [c]	—	—
Durability thermal resistance against heat, weathering, ageing/degradation, freeze/thaw	4.3.8 Thermal resistance — thermal conductivity	—	Limit values
	4.2.3 Dimensional stability under specified temperature and humidity conditions	—	Limit value [d]
	4.3.2.1 Dimensional stability under specified temperature	—	Limit value [d]
	4.3.2.2 Dimensional stability under specified temperature and humidity conditions	—	Limit value [d]
	4.3.2.3 Deformation under specified compressive load and temperature conditions	—	Levels

Table ZA.1 *(continued)*

Construction Products: **Factory made extruded polystyrene foam products (XPS) as covered by the scope of this standard** Intended uses: **Thermal insulation and light weight fill products for civil engineering applications**			
Requirement/Characteristics from the mandate	**Requirement clauses in this European Standard**	**Mandated classes or levels**	**Technical classes or levels or limit values** [a]
	4.3.10 Freeze-thaw resistance	—	Levels
	Annex C: Ageing procedure for test specimens for the determination of thermal properties	—	Limit value
Durability of compressive strength against ageing/degradation	4.3.5 Compressive creep	—	Limit values
	4.3.10 Freeze-thaw resistance	—	Levels
Durability of resistance to dynamic loads	4.3.6 Resistance to cyclic compressive loading		Limit values
Durability against chemicals and biological attack	[e]	—	—

[a] The 'no performance determined' (NPD) option may be used when and where the characteristic, for a given intended use, is not subject to regulatory requirements.

[b] This characteristic also covers handling and installation.

[c] No change in reaction to fire properties for extruded polystyrene foam products.

[d] For thickness only.

[e] Durability of polystyrene foam against chemicals and biological attack as a result of natural occurrence is given.

The requirement on a certain characteristic is not applicable in those Member States (MSs) where there are no regulatory requirements on that characteristic for the intended use of the product. In this case, manufacturers placing their products on the market of these MSs are not obliged to determine nor declare the performance of their products with regard to this characteristic and the option "No performance determined" (NPD) in the information accompanying the CE marking (see ZA.3) may be used. The NPD option may not be used, however, where the characteristic is subject to a threshold level.

ZA.2 Procedures for the attestation of conformity of extruded polystyrene foam products

ZA.2.1 Systems of conformity

For products having more than one of the intended uses specified in the following families, the tasks for the approved body, derived from the relevant systems of attestation of conformity, are cumulative.

The system of attestation of conformity for the factory made XPS products indicated in Table ZA.1 in accordance with the decision of the European Commission decision 95/204/EC of 30.04.95 revised by decision 99/91/EC of 25.01.99 and by the Commission Decision 2001/596/EEC as given in Annex III of the mandate M103 as amended by mandates M126 and M130 is shown in Table ZA.2 for the indicated intended uses and relevant levels or classes.

Table ZA.2 — System(s) of attestation of conformity

Product(s)	**Intended use(s)**	**Level(s) or class(es)** ***(reaction to fire)***	**Attestation of conformity system(s)**
Thermal insulation and light weight fill products used in civil engineering applications	For uses subject to regulations on reaction to fire	A1[a], A2[a], B[a], C[a] A1[b], A2[b], B[b], C[b], D, E (A1 to E) [c], F	1 3 3 (with 4 for RtF)
	Any	-	3
System 1: See Directive 89/106/EEC (CPD) Annex III.2.(i), without audit testing of samples. System 3: See Directive 89/106/EEC (CPD) Annex III.2.(ii), Second possibility. System 4: See Directive 89/106/EEC (CPD) Annex III.2.(ii), Third possibility.			

[a] Products/materials for which a clearly identifiable stage in the production process results in an improvement of the reaction to fire classification (e.g. an addition of fire retarders or a limiting of organic material)

[b] Products/materials not covered by footnote 1

[c] Products/materials that do not require to be tested for reaction to fire e.g. (Products/materials of classes A1 according to the Decision 96/603/EC, as amended).

The attestation of conformity of the thermal insulation products for civil engineering applications in Table ZA.1 shall be based on the evaluation of conformity procedures indicated in Table(s) ZA.2.1 to ZA.2.2 resulting from application of the clauses of this or other European standard indicated therein.

Where more than one table applies for the product (i.e. because its intended use makes different characteristics relevant), Table ZA.2.1 has to be read in conjunction with subsequent tables in order to determine which characteristics assigned to the manufacturer in Table ZA.2.1 are type tested by a notified test lab (system 3) and which by the manufacturer (system 4).

Table ZA.2.1 — Assignment of evaluation of conformity tasks for products under system 1

Tasks		Content of the task	Evaluation of conformity clauses of EN 13172 to apply in addition to Clause 7 and Annex B of this standard
Tasks for the manufacturer	Factory production control (FPC)	Parameters related to all relevant characteristics of Table ZA.1	Clauses 1 to 5, annexes B and C of EN 13172:2001 Annex B of this standard
	Further testing of samples taken at factory	All relevant characteristics of Table ZA.1	Annex B of this standard
	Initial type testing	Those relevant characteristics of Table ZA.1 not tested by the notified body	Clause 6 of EN 13172:2001
Tasks for the notified body	Initial type testing	- Reaction to fire - Thermal resistance - Release of dangerous substances [a] - Compressive strength (for load bearing applications) - Water permeability - resistance to dynamic load	Clause 6 of EN 13172:2001
	Initial inspection of factory and of FPC	Parameters related to all relevant characteristics of Table ZA.1, in particular reaction to fire	Annex B and C of EN 13172:2001 and Annex B of this standard
	Continuous surveillance, assessment and approval of FPC.	Parameters related to all relevant characteristics of Table ZA.1, in particular reaction to fire	Annex B and C of EN 13172:2001 and Annex B of this standard

[a] No test method available as yet.

Table ZA.2.2 — Assignment of evaluation of conformity tasks for products under system 3 and 3 (with 4 for RtF)

Tasks		Content of the task	Evaluation of conformity clauses of EN 13172 to apply in addition to Clause 7 and Annex B of this standard
Tasks under the responsibility of the manufacturer	Factory production control (FPC)	Parameters related to all relevant characteristics of Table ZA.1	Annex B of this standard and Clauses 1 to 5 of EN 13172:2001 and: For system 3 Annex C of EN 13172:2001 For system 3 (with 4 for RtF) Annex C & D of EN 13172:2001
	Initial type testing by the manufacturer	"Those relevant characteristics of Table ZA.1 not tested by the notified body" including reaction to fire for system 3 & 4)	Clause 6 of EN 13172:2001
	Initial type testing by a notified test laboratory	- Reaction to fire (system 3) - Thermal resistance - Release of dangerous substances [(a)] - Compressive strength (for load bearing applications) - Water permeability - resistance to dynamic load	Clause 6 of EN 13172:2001

[(a)] No test method available as yet.

ZA.2. 2 EC certificate and declaration of conformity

(In case of products under system 1 or (1 and 3): When compliance with the conditions of this annex is achieved, the certification body shall draw up a certificate of conformity (EC Certificate of conformity), which entitles the manufacturer to affix the CE marking. The certificate shall include:

— name, address and identification number of the certification body;

— name and address of the manufacturer, or his authorised representative established in the EEA, and place of production;

NOTE 1 The manufacturer may also be the person responsible for placing the product onto the EEA market, if he takes responsibility for CE marking.

— description of the product (type, identification, use, ...);

— provisions to which the product conforms (e.g. Annex ZA of this EN);

— particular conditions applicable to the use of the product (e.g. provisions for use under certain conditions, etc.);

— number of the certificate;

— conditions and period of validity of the certificate, where applicable;

— name of, and position held by, the person empowered to sign the certificate.

In addition, the manufacturer shall draw up a declaration of conformity (EC Declaration of conformity) including the following:

— name and address of the manufacturer, or his authorised representative established in the EEA;

— name and address of the certification body;

— description of the product (type, identification, use, ...), and a copy of the information accompanying the CE marking;

NOTE 2 Where some of the information required for the Declaration is already given in the CE marking information, it does not need to be repeated.

— provisions to which the product conforms (e.g. Annex ZA of this EN);

— particular conditions applicable to the use of the product (e.g. provisions for use under certain conditions, etc.);

— number of the accompanying EC Certificate of conformity;

- name of, and position held by, the person empowered to sign the declaration on behalf of the manufacturer or of his authorised representative.

(In case of products under system 3 or (3 and 4)): When compliance with the conditions of this annex is achieved, the manufacturer or his agent established in the EEA shall prepare and retain a declaration of conformity (EC Declaration of conformity), which entitles the manufacturer to affix the CE marking. This declaration shall include:

— name and address of the manufacturer, or his authorised representative established in the EEA, and place of production;

NOTE 3 The manufacturer may also be the person responsible for placing the product onto the EEA market, if he takes responsibility for CE marking.

— description of the product (type, identification, use,...), and a copy of the information accompanying the CE marking;

NOTE 4 Where some of the information required for the Declaration is already given in the CE marking information, it does not need to be repeated.

— provisions to which the product conforms (e.g. Annex ZA of this EN);

— particular conditions applicable to the use of the product, (e.g. provisions for use under certain conditions, etc);

— name and address of the notified laboratory(ies);

- name of, and position held by, the person empowered to sign the declaration on behalf of the manufacturer or his authorised representative.

The above mentioned declaration and certificate shall be presented in the official language or languages of the Member State in which the product is to be used.

The validity of the declaration/certificate shall be verified at least once a year.

ZA.3 CE Marking and labelling

The manufacturer or his authorised representative established within the EEA is responsible for the affixing of the CE marking. The CE marking symbol to affix shall be in accordance with Directive 93/68/EC and shall be shown on the extruded polystyrene foam (or when not possible it may be on the accompanying label, the packaging or on the accompanying commercial documents e.g. a delivery note).The following information shall accompany the CE marking symbol:

- identification number of the certification body (only for products under systems 1),
- name or identifying mark and registered address of the manufacturer,
- last two digits of the year in which the marking is affixed,
- number of the EC Certificate of conformity or factory production control certificate (if relevant),
- reference to this European Standard,
- description of the product: generic name, material, dimensions, … and intended use,
- information on those relevant essential characteristics listed in Table ZA.1:
  - declared values and, where relevant, level or class (including “pass” for pass/fail requirements, where necessary) to declare for each essential characteristic as indicated in "Notes" in Table ZA.1.1 to ZA.1.n,
  - “No performance determined” for characteristics where this is relevant,
  - as an alternative, a standard designation (as defined in Clause 6 of this standard) which shows some or all of the relevant characteristics (where the designation covers only some characteristics, it will need to be supplemented with declared values for other characteristics as above).

The “No performance determined” (NPD) option may not be used where the characteristic is subject to a threshold level. Otherwise, the NPD option may be used when and where the characteristic, for a given intended use, is not subject to regulatory requirements in the Member State of destination.

Figure ZA.1 gives an example of the information to be given on the product, label, packaging and/or commercial documents.

CE 01234	*CE conformity marking, consisting of the "CE"-symbol given in Directive 93/68/EEC.* *Identification number of the certification body (for system 1)*
AnyCo Ltd, PO Box 21, B-1050 **07** 01234-CPD-00234	*Name or identifying mark and registered address of the producer* *Two last digits of the year for affixing CE marking (ITT)* *Certificate number (where relevant)*
EN 14934 Extruded polystyrene foam, intended to be used in civil engineering applications XPS-EN14934-T1-DLT(2)5-CS(10\Y)300-CC(2/1,5/50)100-CLRT(5/2x10^6)150-CLR(5/2x10^6)150-WD(V)3-WL(T)3 -MU 150 -FTC2 Other mandated characteristics: Reaction to fire: Euroclass F Continuous glowing combustion g0 Thermal resistance R_D = 2,60 $m^2 \cdot K/W$ Thermal conductivity λ_D = 0,036 W/(m · K)	*No. of European Standard* *Description of product* *Information on regulated characteristics*

Figure ZA.1 — Example CE marking information

In addition to any specific information relating to dangerous substances shown above, the product should also be accompanied, when and where required and in the appropriate form, by documentation listing any other legislation on dangerous substances for which compliance is claimed, together with any information required by that legislation.

NOTE 1 European legislation without national derogations need not be mentioned.

NOTE 2 Affixing the CE marking symbol means, if a product is subject to more than one directive, that it complies with all applicable directives.

Bibliography

[1] EN ISO 4590, *Rigid cellular plastics — Determination of the volume percentage of open cells and of closed cells (ISO 4590:2002)*

[2] EN 12090, *Thermal insulating products for building applications — Determination of shear behaviour*

[3] ISO 11561, *Ageing of thermal insulation materials – Determination of the long-term change in thermal resistance of closed-cell plastics (accelerated laboratory test methods)*

[4] SP 2687, *Resistance to cyclic compressive loading with square-wave load.*

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