BS EN 539-2:2013

BSI Standards Publication

Clay roofing tiles for discontinuous laying — Determination of physical characteristics

Part 2: Test for frost resistance

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National foreword

This British Standard is the UK implementation of EN 539-2:2013. It supersedes BS EN 539-2:2006 which is withdrawn.

The UK committee advises, for UK climate and conditions, when using clause 5.5, tiles should exceed 400 cycles when tested.

The UK participation in its preparation was entrusted by Technical Committee B/542, Roofing and cladding products for discontinuous laying, to subcommittee B/542/3, Clay roofing tiles.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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NORME EUROPÉENNE

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English Version

Clay roofing tiles for discontinuous laying - Determination of physical characteristics - Part 2: Test for frost resistance

Tuiles de terre cuite pour pose en discontinu - Détermination des caractéristiques physiques - Partie 2: Essais de résistance au gel

Dachziegel für überdeckende Verlegung - Bestimmung der physikalischen Eigenschaften - Teil 2: Prüfung der Frostwiderstandsfähigkeit

This European Standard was approved by CEN on 14 March 2013.

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Foreword

This document (EN 539-2:2013) has been prepared by Technical Committee CEN/TC 128 “Roof covering products for discontinuous laying and products for wall cladding”, the secretariat of which is held by IBN.

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of an identical text or by endorsement, at the latest by November 2013, and conflicting national standards shall be withdrawn at the latest by November 2013.

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

This document supersedes EN 539-2:2006.

In comparison to the previous edition, modifications have been made in Clause 1, subclauses 3.1, 3.5, 3.6 and 3.8, Clause 5 and Annex A. The test methods A, B, C and D are withdrawn.

This part of EN 539 is preceded by:

— EN 539-1, *Clay roofing tiles for discontinuous laying — Determination of physical characteristics — Part 1: Impermeability test*

This part of EN 539 is one of a series of standards concerning clay roofing tiles, the list of which is indicated below:

— EN 1304, *Clay roofing tiles and fittings — Products definitions and specifications*

— EN 538, *Clay roofing tiles for discontinuous laying — Flexural strength test*

— EN 1024, *Clay roofing tiles for discontinuous laying — Determination of geometric characteristics*

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1 Scope

This European Standard specifies the test method for the determination of frost resistance of clay roofing tiles and fittings.

The test method is applicable in all CEN member countries in accordance with the required performance level of each member state.

2 Normative references

Not applicable.

3 Terms and definitions

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

3.1
pit
superficial fault consisting of a fraction of material detached from the body of the product on the visible surface of the product with a mean dimension of over 7 mm

Note 1 to entry: This is often due to the expansion of a particle of, for example, chalk or pyrites.

[SOURCE: EN 1304:2013, 3.5.18.2]

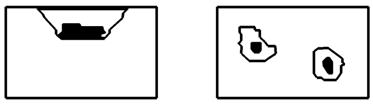


Figure 1 — Example of pit

3.2
hair crack
superficial crack having a width of not more than 0,20 mm

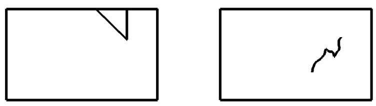


Figure 2 — Example of hair crack

3.3
nascent crack
crack formation at the edge, with the crack only penetrating slightly into the interior of the ceramic body

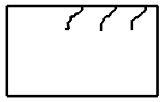


Figure 3 — Example of nascent crack

3.4
surface crack
crack more than 0,20 mm wide and with a length of more than 30 mm, which does not pass through the thickness of the product

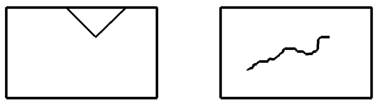


Figure 4 — Example of surface crack

3.5
surface damage
loss of a part of the ceramic body material from the surface of the product with the longest dimension greater than 15 mm together with the widest dimension perpendicular to the length greater than 5 mm

3.5.1
scaling
surface raising, nascent chipping, or crack, which initiates damage

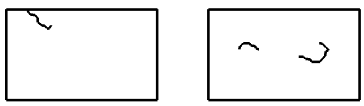


Figure 5 — Example of scaling

3.5.2
chip
loss of a fraction of the body material of the product

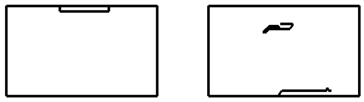


Figure 6 — Example of chip

3.5.3
peeling
loss of a part of the superficial layer of the product

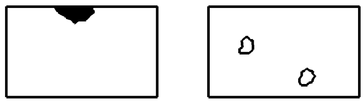


Figure 7 — Example of peeling

3.5.4
flaking
progressive loss of body material affecting parts or the whole thickness of the product

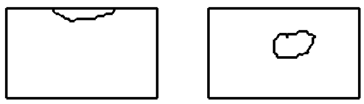


Figure 8 — Example of flaking

3.6
structural crack
structural fault consisting of a more or less regular crack running throughout the entire thickness of the product and visible to the naked eye

[SOURCE: EN 1304:2013, 3.5.17.2]

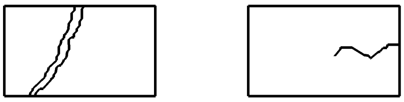


Figure 9 — Example of structural crack

3.7
loss of ribs
loss of body material from the interlocking ribs sufficient to influence their function

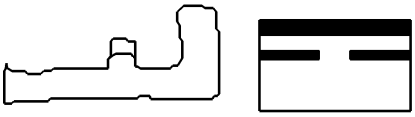


Figure 10 — Example of loss of ribs

3.8
break
structural fault consisting of a separation of the product into two or more fragments

[SOURCE: EN 1304:2013, 3.5.17.1]

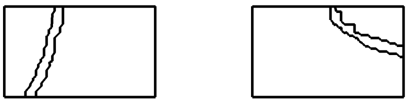


Figure 11 — Example of break

3.9
delamination
lamellar flaking which can lead to the delamination of the body in a succession of parallel layers

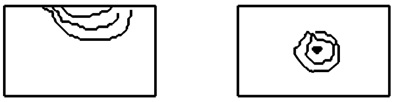


Figure 12 — Example of delamination

3.10
calibration device
roof tile or ceramic slab which may be specially made to possess the characteristics defined within 5.4.1.1 and which will not be damaged during the calibration

4 Test pieces

If the tiles or fittings are placed on the market with a ceramic coating and/or treatment, the tests shall be carried out on test pieces which have this same coating and/or treatment.

When the tiles or fittings are taken from a site or building, they shall be tested in the state in which they are found, but the interpretation of the test results shall take into account the stresses to which these installed products have been subjected.

5 Test method (European single test method)

5.1 Principle

Test pieces are progressively immersed in water for a period of seven days, then covered on their back with a damp cloth, and then placed in a freezing chamber where they are subjected to freeze/thaw cycles.

During these cycles, the products are frozen by air and thawed by water on all of their surfaces at the same time.

The damage that occurs during the test is recorded.

The number of cycles of each level is specified in this European Standard.

5.2 Apparatus

5.2.1 Freeze/thaw unit

The freeze/thaw unit shall consist of a freezing chamber, fan, cooling units, water level regulator, water drain and programme control unit. The freeze/thaw unit shall be closed on all sides. An example is given in Figure 13. The freeze/thaw unit shall be provided with a rack to hold the test pieces as specified in 5.4.2.5.

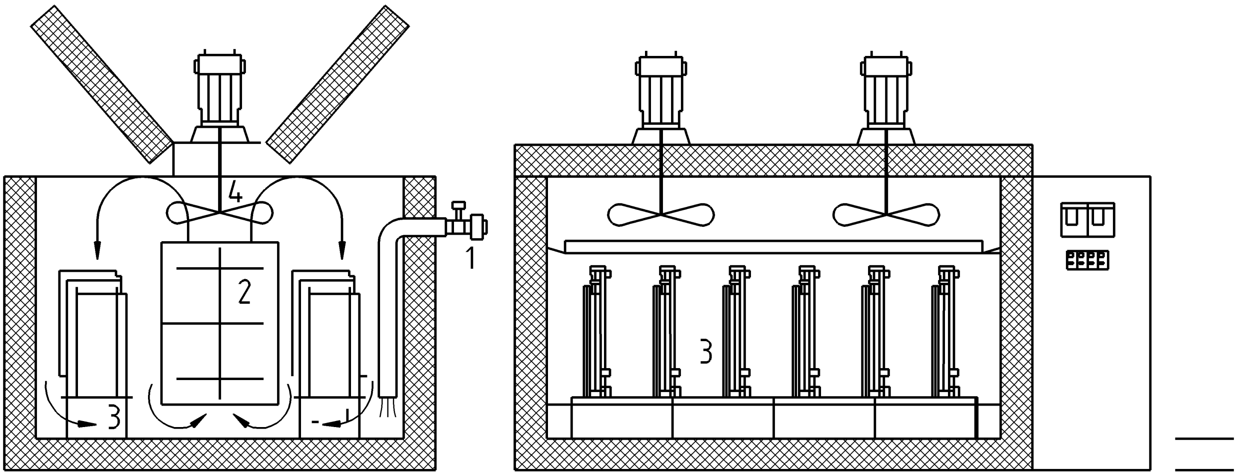
Temperature sensor(s) shall be fitted inside the freezing chamber to permit monitoring of the temperature distribution inside the chamber. The temperature sensor(s), e.g. measurement thermocouples or resistance thermometers and suitable recording instruments, shall have an error limit of ± 0,5 K. Tolerances are given by taking into account the uncertainty of the recording instruments.

If necessary, deflectors should be fitted to maintain a uniform temperature distribution.

It shall be possible to regulate the cooling capacity of the unit (see 5.2.2) to ensure that the cooling and ice formation rates as measured in a calibration tile are in accordance with the freeze/thaw curve given in Figure 14.

A water feed shall be provided to ensure that both surfaces of the tile are uniformly flooded by water. The water temperature shall be (11 ± 6) °C.

In order to achieve a steady and reproducible sequence of the freeze/thaw cycles, the freeze/thaw unit shall be equipped with a programme control unit to allow the cooling and the thawing processes to be carried out in the required time.



Key

1 water input

2 heat exchanger

3 roofing tile fixing

4 circulating fan

Figure 13 — Example of freeze/thaw unit

5.2.2 Regulation of the cooling capacity of the freeze/thaw unit

5.2.2.1 Methods of control

The method of regulating the cooling capacity of the freeze/thaw unit depends on whether or not the freeze/thaw unit has a fixed cooling capacity or a variable cooling capacity. The methods to be adopted for each of these two options are described in 5.2.2.2 and 5.2.2.3.

5.2.2.2 Freeze/thaw units with fixed cooling capacity

The cooling capacity of the unit is fixed or held constant and the mass and water content of the test pieces that is required to meet the freeze/thaw curve is established by test. Thereafter the freeze/thaw unit shall be loaded with a constant mass of tiles and water content to ensure that the freeze/thaw curve is achieved.

If the test pieces introduce a deficiency in the mass of tiles or water content then this shall be corrected by reducing the number of test pieces or by the addition of dummy test pieces and/or wet sponges in plastic bags.

5.2.2.3 Freeze/thaw units with variable cooling capacity

These units allow the air temperature to be regulated. The air temperature curve for the freeze/thaw unit is established when a set of calibration tiles are cooled in accordance with the freeze/thaw curve specified in Figure 14.

The development of the predetermined air temperature curve depends on the resistance to heat transmission between the air and the measured test pieces. This is related to the airflow speed, which is a characteristic of the design of the freeze/thaw unit. For this reason, the air temperature curve should be determined for each freeze/thaw unit separately.

5.3 Test sample

According to Table 1, the test sample shall consist of six test pieces free of unacceptable defects. All acceptable defects shall be recorded prior to testing.

5.4 Procedure

5.4.1 Calibration of the apparatus

5.4.1.1 Calibration ceramic device (tile)

Select a ceramic calibration device (tile) which is at the point of measurement 12 mm to 14 mm thick, having a dry density of (2,0 ± 0,3) kg/dm^3 (see Annex A) and a water absorption of (10,5 ± 0,5) % (see 5.4.2.1, 5.4.2.2 and 5.4.2.3).

In the calibration device (tile), drill a hole 50 mm long, parallel to its length.

A minimum body thickness of 3 mm on each side of the hole should be retained.

Insert a temperature sensor that reaches to the bottom of the hole and seal the hole with a flexible compound (silicone grease may be used).

5.4.1.2 Calibration of the freezing unit

To calibrate the freeze/thaw unit, use a calibration device (tile) which is fitted with a temperature sensor. The calibration device, covered with a sheet of cloth on its back, is placed in a rack, vertically on its short side (as shown in Figure 13) or on its long side.

Saturate the calibration device and/or tile by progressive saturation as described in 5.4.2.2 and calculate the water absorption.

In addition to the calibration device, it is important that all the racks in the freezing unit are filled with devices so that the mass of the devices is evenly distributed over the volume of the cooling unit. This will ensure that the cooling curve in Figure 14 is achieved throughout the cabinet.

Place the calibration device, covered with a sheet of cloth on its back, in the middle of the other devices when calibrating the freeze/thaw unit.

If the calibration of the unit is done in accordance with the procedure describe in 5.2.2.2 (freeze/thaw units with fixed cooling capacity), determine the total device mass and the total water content of all the devices.

If the calibration of the unit is done in accordance with the procedure described in 5.2.2.3 (freeze/thaw units with variable cooling capacity), other test pieces can be selected arbitrarily.

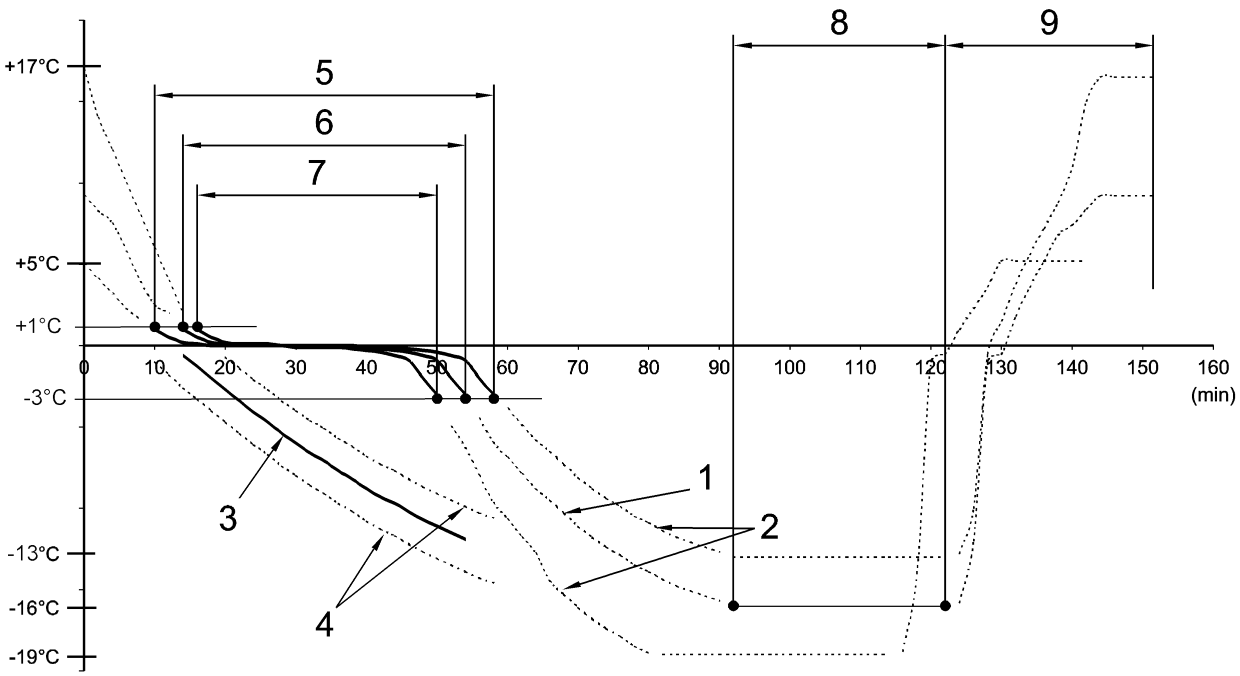
The calibration shall start with the thawing cycle and the starting thawing water temperature shall be recorded.

During calibration, the cooling capacity of the unit shall be adjusted to ensure that the temperature curve of the calibration device is in compliance with the cooling curve specified in Figure 14.

Record the air temperature curve used to achieve the specified cooling curve given for the calibration device in Figure 14. The air temperature should be reduced in a continuous and smooth manner.

The ice formation period between +1 °C and -3 °C and measured inside the calibration devices shall be at minimum 34 min (7 K/h) and at maximum 48 min (5 K/h).

Freezing shall be terminated after the temperature of the calibration device has been maintained at (-16 ± 3) °C for at least 30 min.



Key

1 temperature inside the calibration tile with period of ice formation – cooling rate (as specification)
2 permissible variation inside the calibration device (as specification)
3 air temperature (as example)
4 permissible air temperature variation (as example)
5 max. 48 min = 5 K/h
6 mean 40 min = 6 K/h
7 min. 34 min = 7 K/h
8 at least 30 min
9 30 min

Figure 14 — Cooling curve (with permissible deviation) for reference tile

5.4.2 Conditioning the test pieces

5.4.2.1 Drying the test pieces

Dry the test pieces for 24 h at (110 ± 5) °C. Cool the test pieces in the ambient air of the laboratory and weigh each test piece with an accuracy of 1 g (dry mass m_{dr}).

5.4.2.2 Pre-saturation of test pieces

Place the test pieces in an open container of water so that 1/5 of the height of the test pieces is under water. After 24 h add sufficient water so that 2/5 of the height of the test pieces is under water. Repeat the same process during three days until the test pieces are covered by water. On the fifth day when the full height of the test pieces is covered, add an extra 50 mm of water to the container and let the test pieces soak for 72 h.

5.4.2.3 Calculation of water absorption

Wipe the test pieces with a damp sponge and weigh them (wet mass m_w).

Calculate the water absorption, W_u for each test piece as a percentage of the dry mass from the following formula:

$$W_u = [(m_w - m_{dr}) \times 100/m_{dr}] \text{ in } \% \quad (1)$$

where

m_w is wet mass;

m_{dr} is dry mass.

5.4.2.4 Covering the back of the test piece

Before testing, cover the back of each test piece with a sheet of cloth made of linen (density (350 ± 50) gm^{-2}). The cloth shall be wet before being placed on the test piece. Prior to soaking, cut each cloth to match the size and shape of the test piece. The cloth may be used several times. The cloth is laid in close contact with the back of the test piece and shall be maintained in position during the whole test time with the help of copper wires or rubber bands etc. (see Figures 15 and 16).

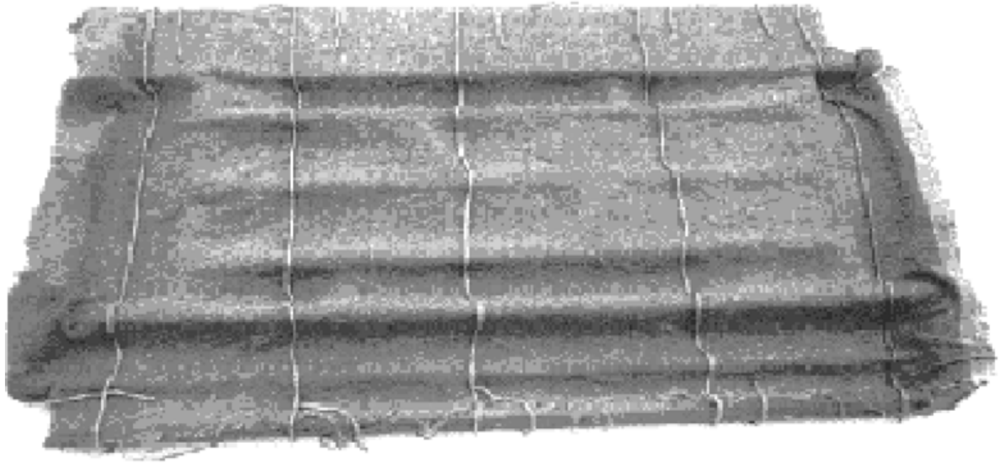


Figure 15 — Example of a tile covered with a sheet of cloth

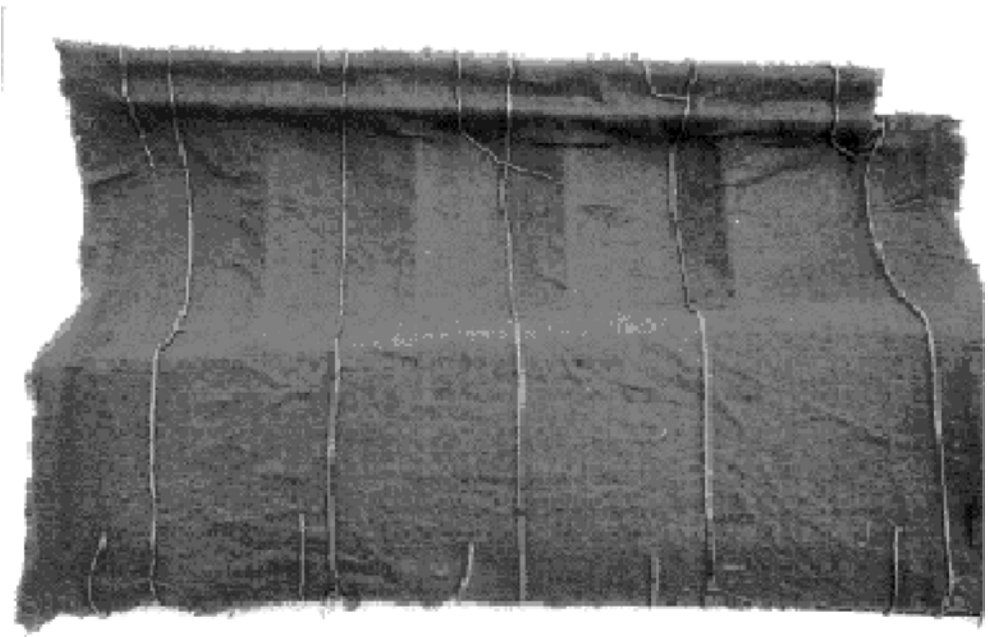


Figure 16 — Example of a tile covered by a sheet of cloth

5.4.2.5 Placing the test pieces in the freeze/thaw unit

Place the test pieces in the freezing unit on a rack as shown in Figure 13. Tiles with a length of less than 300 mm may be placed on their short side whereas longer tiles may be placed on their long side. The minimum distance between the test pieces and between the test pieces and the side of the unit shall be 60 mm.

When the control of the freeze/thaw unit is in accordance with 5.2.2.2 (freeze/thaw with fixed cooling capacity), the total mass of the test pieces including their water content should be verified and compared with the values obtained during the calibration procedure. Differences in the mass should be compensated for by either reducing the number of test pieces or by adding whole or parts of dummy test pieces. Items such as wet sponges in plastic bags may be used to compensate for the water content.

5.4.2.6 Freeze/thaw of test pieces

The air temperature of the freeze/thaw unit shall be controlled to ensure that the air temperature curve established during calibration shall be achieved.

5.4.2.7 Thawing of test pieces

After freezing, thaw the test pieces by uniformly covering with water. The water shall have a temperature of 5 °C to 17 °C and shall be within 3 K of the recorded starting thawing water temperature of the calibration test.

Adjust the volume of water from the bottom of the unit to ensure that the test pieces are covered by at least 50 mm of water in a time less than or equal to 15 min; the whole cycle time to be between 25 min and 40 min.

5.4.2.8 Freeze/thaw cycle interruptions

Carry out freeze/thaw cycles without interruption, if possible, but if an interruption is necessary or unavoidable, leave the test pieces in water. If the interruption exceeds two hours, restart the process with a thawing phase as described above before carrying out a new freezing cycle. The interruption shall not last more than one week.

5.5 Evaluation of the test pieces

After the test, examine the test pieces on all sides with the naked eye at a distance of 30 cm to 40 cm, under normal lighting.

Record the type, position and extent of any damage that may have appeared during the test, using the definitions given in Clause 3.

After any intermediate examination, carefully replace the cloth and start the cycle with a thawing phase to ensure that the test pieces do not dry.

The sample will have passed the test at:

— Level 1 (150 cycles): minimum 150 cycles. If after 150 cycles none of the tiles shows any of the damage described as unacceptable according to Table 1.

— Level 2 (90 cycles): minimum 90 cycles. If after 90 cycles none of the tiles shows any of the damage described as unacceptable according to Table 1.

— Level 3 (30 cycles): minimum 30 cycles. If after 30 cycles none of the tiles shows any of the damage described as unacceptable according to Table 1.

Table 1 — Interpretation of the result

		Front	Back
1	pit	–	–
2	hair crack	–	–
3	nascent crack	–	–
4	surface crack	X	X[a]
5	surface damage (scaling, chip, peeling, flaking)	X	X[a]
6	structural crack	X	X
7	loss of interlocking ribs	X	X
8	break	X	X
9	delamination	X	X
10	loss of all nibs		X

X = unacceptable – = acceptable

NOTE The degree of damaging can be demonstrated through a change in the impermeability and/or flexural strength of the product.

[a] Where the degree of damage indicates that the functional performance of the product would not be assured.

Nibs shall be checked to see whether they have retained their ability to fulfil their function. If the tiles have been designed in such a way that they have one or several nibs, at least one nib shall be undamaged after the freeze/thaw test.

Frost damage constituting failure of the freeze/thaw test is any damage identified as unacceptable in Table 1, clearly visible to the “naked eye”. Different types of damage shall be evaluated according to the definitions.

Surface damage due to air entrainment and clay folds near the interlocks are not regarded as frost damage; nor shall pits, whatever their dimension, due to the expansion of granular inclusions (e.g. of lime) as a result of chemical processes be considered as unacceptable freeze/thaw damage.

5.6 Test report

The test report shall include:

a) designation of the sample tested including the description and identification of the test pieces including the type;

b) test method used;

c) name of the test laboratory;

d) water content after soaking W_u for each of the test pieces;

e) number of freeze/thaw cycles carried out;

f) type and extent of any frost damage according to Table 1;

g) comments, where required;

h) signature of the person in charge of the test.

Annex A
(normative)

Determination of the dry density by hydrostatic weighting

Dry the test pieces for 24 h in an oven at (110 ± 5) °C.

If the test is carried out on kiln fresh test pieces, this drying procedure is not necessary.

Remove the test pieces from the oven and allow them to cool down in an ambient temperature of 18 °C to 28 °C.

Weight the test pieces with an accuracy of 1 g (dry mass, m_{dr}).

To measure the volume (V_u), immerse the product in water and determine its mass (W_1) while under water as soon as a stable situation has been reached, i.e. when changes in mass are less than 0,1 % per minute.

Remove the test piece from the water, wipe off any excess surface water with a damp cloth and determine the mass (W_2) immediately.

Calculate the volume by subtracting the mass of the test piece when weighted under water (W_1) from the mass obtained when weighting the damp product in the air (W_2) as follows:

$$V_u = W_2 - W_1 \quad (2)$$

Express the volume in cubic centimetres to the nearest 1 cm^3.

The dry density (ρ_u) of a test piece is calculated as follows:

$$\rho_u = \frac{m_{dr}}{V_u} \text{ kg/dm}^3 \quad (3)$$

Bibliography

[1] EN 1304:2013, *Clay roofing tiles and fittings — Product definitions and specifications*

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