BS EN 1457-2:2012

BSI Standards Publication

Chimneys — Clay/ceramic flue liners

Part 2: Flue liners operating under wet conditions — Requirements and test methods

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National foreword

This British Standard is the UK implementation of EN 1457-2:2012. Together with BS EN 1457-1:2012, it supersedes BS EN 1457:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/506/3, Chimneys and their components having inner linings of clay or ceramic.

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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Conduits de fumée - Conduits intérieurs en terre cuite/céramique - Partie 2: Exigences et méthodes d'essai pour utilisation en conditions humides

Abgasanlagen - Keramik-Innenrohre - Teil 2: Innenrohre für den Nassbetrieb - Anforderungen und Prüfungen

This European Standard was approved by CEN on 16 December 2011.

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 1457-2:2012) has been prepared by Technical Committee CEN/TC 166 “Chimneys”, the secretariat of which is held by ASI.

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of an identical text or by endorsement, at the latest by July 2012, and conflicting national standards shall be withdrawn at the latest by July 2012.

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 1457:1999.

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.

EN 1457 is made of two parts:

— EN 1457-1, *Chimney — Clay/ceramic flue liners — Part 1: Flue liners operating under dry conditions — Requirements and test methods*;

— EN 1457-2, *Chimney — Clay/ceramic flue liners — Part 2: Flue liners operating under wet conditions — Requirements and test methods*.

The main changes with respect to the previous edition are:

EN 1457 has been split in 2 parts: EN 1457-2 is a product standard for clay/ceramic flue liners operating under wet conditions.

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

1 Scope

This European Standard is a product standard for clay/ceramic flue liners operating under wet conditions with solid walls or walls with vertical perforations for use in the construction of multiwall chimneys and flue pipes which serve to convey products of combustion from fireplaces or heating appliances to the outside atmosphere by negative or positive pressure. It includes the flue liners used for domestic and industrial chimneys which are not structurally independent (free-standing). This European Standard specifies the performance requirements for factory made flue liners and chimney fittings. Testing including thermal testing with or without insulation, marking and inspection are covered by this standard. Flue liners that are specified to this standard will meet the requirements of EN 1457-1 with the same working temperature, pressure, designation and soot fire resistance.

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 312, *Particleboards — Specifications*

EN 1443:2003, *Chimneys — General requirements*

EN 10088-1, *Stainless steels — Part 1: List of stainless steels*

EN 13384-1:2002+A2:2008, *Chimneys — Thermal and fluid dynamic calculation methods — Part 1: Chimneys serving one appliance*

EN 14297:2004, *Chimneys — Freeze-thaw resistance test method for chimney products*

EN ISO 6946, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation method (ISO 6946)*

EN ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system (ISO 7500-1)*

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1443:2003 and the following apply.

3.1
nominal size
numerical designation of size which is a convenient round number equal to or approximately equal to either:

a) the internal diameter of circular flue liners;

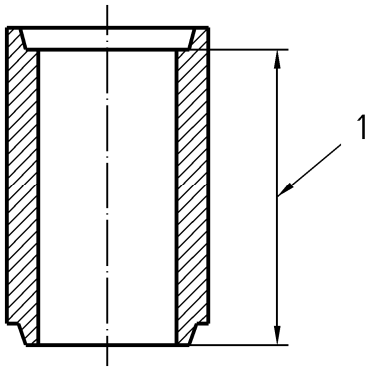
b) the internal width of square flue liners;

c) the internal width and breadth of the cross section of rectangular flue liners

NOTE The nominal length is expressed in millimetres.

3.2
nominal height
numerical designation of the internal height in millimetres of a straight flue liner which is a convenient round number approximately equal to the internal height of the flue liner

NOTE See Figure 1.



Key

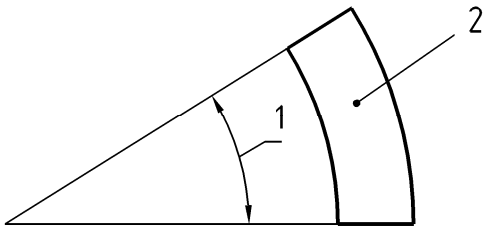
1 internal height

Figure 1 — Internal height

3.3
nominal angle of curvature
angle subtended by a curved flue liner at the centre of the curve

NOTE 1 The nominal angle is expressed in degrees.

NOTE 2 See Figure 2.



Key

1 angle of curvature
2 curved flue liner

Figure 2 — Angle of curvature

3.4
wet operating condition
condition when the chimney is designed to operate normally with the temperature of the inner surface of the flue liner at and below the water dew point

3.5
dry operating condition
condition when the chimney is designed to operate normally with the temperature of the inner surface of the flue liner above the water dew point

4 Flue liners and openings

4.1 Flue liner cross-sections

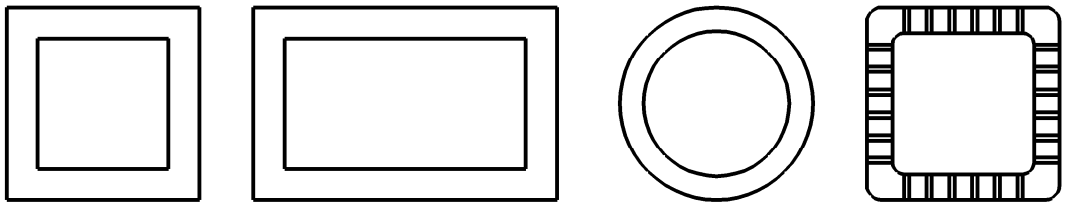
Flue liners shall be either:

a) circular or square in cross-section with rebated or spigot and socket ends;

b) square or rectangular in cross-section with rebated ends and rounded internal corners;

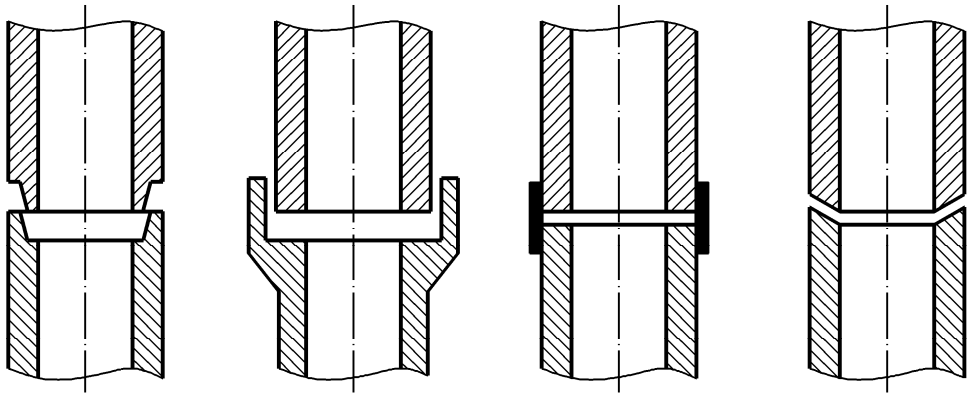
c) circular, square or rectangular in cross-section with butt joints and jointed with a sleeve;

d) circular or square in cross-section with taper joints.



a) Square **b) Rectangular** **c) Circular** **d) Wall with vertical perforations**

Figure 3 — Examples of cross-section configuration



a) Rebated **b) Spigot & socket** **c) Sleeve** **d) Tapered**

Figure 4 — Joint configuration

4.2 Inspection openings and chimney junctions

Inspection openings are used for inspection and cleaning of the inner liners of chimneys and for soot removal and shall meet the requirements of flue liners as appropriate.

All inspection openings shall have a door.

The inspection opening shall have a door with a separate humidity barrier or have two sheets.

Chimney junctions are used to connect flues from heat appliances to chimneys. Chimney junctions are purpose-made tee-pieces or inner liner sections with an opening to which branches are fitted. The branch angles can be 45° to 95° (α in Figure 5). At the position of junctions, the outer walls have corresponding openings.

Chimney junctions should have the same cross-sectional area as the flue liner. Reductions and expansions are acceptable provided that the resistance to the exhaust gases is not increased.

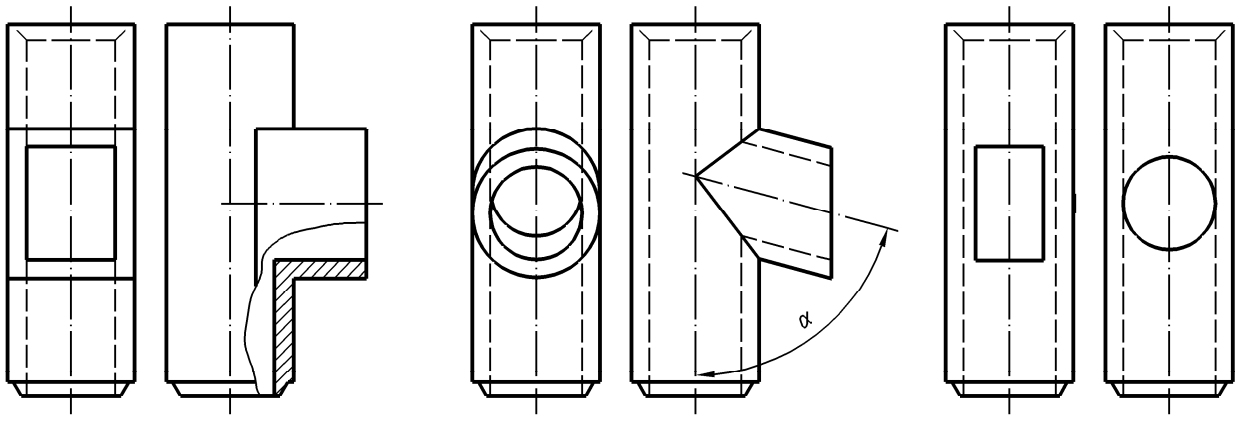


Figure 5 — Examples of inspection openings and chimney junctions

5 Types of flue liner

There are four main types of clay/ceramic flue liner dependent on working temperature, with sub-classes dependent on whether the flue liners are to be used in chimneys designed to work under negative or positive pressure or are to have soot fire resistance. A non exhaustive list abbreviated designations for flue liners according temperature, pressure, soot fire resistance and condensate resistance is given in Table 1. The suitability of each type of flue liner to be used in chimneys designed to operate under negative or positive pressure and wet conditions is also given.

NOTE A flue liner can be designated in one or more types provided that it complies with the appropriate requirements for each type.

Table 1 — Types of clay/ceramic flue liners, conditions of use, air test pressures and maximum leakage rates after thermal testing for operating under wet conditions

Types of flue liner	Temperature class	Pressure class	Soot fire resistance class	Test pressure Pa	Permitted leakage rate $m^3\ s^{-1}\ m^{-2} \cdot 10^{-3}$
A3 N2	600	Negative	Yes (G)	20	3
A3 N1	600	Negative	Yes (G)	40	2
A3 P1	600	Positive	Yes (G)	200	0,006
A4 N2	600	Negative	No (O)	20	3
A4 N1	600	Negative	No (O)	40	2
A4 P1	600	Positive	No (O)	200	0,006
B3 N2	400	Negative	Yes (G)	20	3
B3 N1	400	Negative	Yes (G)	40	2
B3 P1	400	Positive	Yes (G)	200	0,006
B4 N2	400	Negative	No (O)	20	3
B4 N1	400	Negative	No (O)	40	2
B4 P1	400	Positive	No (O)	200	0,006
C4 N2	300	Negative	No (O)	20	3
C4 N1	300	Negative	No (O)	40	2
C4 P1	300	Positive	No (O)	200	0,006
D4 N2	200	Negative	No (O)	20	3
D4 N1	200	Negative	No (O)	40	2
D4 P1	200	Positive	No (O)	200	0,006

6 Materials

Flue liners shall be manufactured from suitable clay/ceramic material which, when fired, meet the performance requirements given in this standard.

Flue liners may be unglazed or glazed on the interior and/or exterior. When glazed, they need not be glazed on the jointing surfaces.

7 Tolerances on dimensions

7.1 Transverse dimension

When tested in accordance with 16.1, the internal diameter of circular flue liners measured on any diameter shall not deviate more than ± 3 % of the manufacturer's stated nominal internal diameter.

The internal width or breadth of square or rectangular section flue liners shall not deviate more than ± 3 % of the manufacturer's stated nominal internal length of the side.

7.2 Height

When tested in accordance with 16.2, the height of a flue liner shall not deviate more than ± 3 % on the manufacturer's stated nominal height subject to a maximum value of 20 mm.

7.3 Angle of curvature

When tested in accordance with 16.3, the angle of curvature of curved flue liners shall not deviate more than ± 5° on the manufacturer's stated nominal curvature.

7.4 Straightness

When tested in accordance with 16.4, the permissible deviation from straightness of straight flue liners shall be 1 % of the test length.

7.5 Squareness of ends

When tested in accordance with 16.5, the permissible deviation from square of the ends of straight flue liners, shall be not greater than an angle of slope 30 mm/m.

7.6 Deviation from shape of cross section

When tested in accordance with 16.6, the permissible deviation from square of the angles of, and flatness of walls for square or rectangular shape straight flue liners, shall be not greater than 5 % of the manufacturer's stated nominal internal width or breadth.

7.7 Geometry of joints

The design and dimensions of the joints shall be as specified by the manufacturer to provide an adequate joint.

8 Proof load

8.1 Straight flue liners

When tested in accordance with 16.7, straight flue liners shall withstand an intensity of loading of 10 MN/m^2.

8.2 Curved flue liners

Where curved flue liners are fired in a plant alongside straight flue liners, using the same materials and firing process, the proof load of these curved flue liners is deemed to be that of the straight flue liners when tested in accordance with 16.7.

If curved flue liners are not normally fired alongside straight flue liners, straight flue liners or short lengths of straight flue liners made for test purposes, using the same materials and firing process as for curved flue liners, shall be tested for compliance with the requirements of 8.1.

8.3 Minimum load for inspection opening sections

When tested in accordance with 16.7, the minimum load of inspection opening sections shall be as given in Table 2.

Table 2 — Minimum load

Height of chimney in m	Minimum load in kN
≤12,5	25
> 12,5 ≤ 25	50
> 25 ≤ 50	100

For chimneys with area greater than 0,04 m^2 the following equation shall be used:

$$F = \chi \cdot H \cdot G/100$$

where

F is the minimum load in kilonewtons;

χ is the safety factor = 5;

H is the height of chimney in metres;

G is the weight per metre in kilograms per metre.

9 Gas tightness/leakage, thermal shock resistance and soot fire resistance for straight flue liners

9.1 Initial test

Prior to thermal testing a test flue constructed in accordance with 16.8.3 with N1 and N2 liners shall have a leakage rate not greater than 2 $m^3\ s^{-1}\ m^{-2} \times 10^{-3}$ of internal surface area tested at a differential pressure of (40 ± 2) Pa when tested as described in 16.8.5.

Prior to thermal testing a test flue constructed in accordance with 16.8.3 with P1 liners shall have a leakage rate not greater than 0,006 $m^{3\cdot}\ s^{-1}\ m^{-2\cdot}\ 10^{-3}$ of internal surface area tested at a differential pressure of (200 ± 10) Pa when tested as described in 16.8.5.

Where chimney fittings are fired in a plant alongside straight flue liners using the same material and firing process, the gas tightness/leakage, thermal shock resistance and soot fire resistance shall be deemed to be that of straight flue liners when tested in accordance with 16.8.3.

If the chimney fittings are not normally fired alongside straight flue liners, straight flue liners or short lengths of straight flue liner shall be made for test purposes using the same material and firing process as for chimney fittings shall be tested for complying with 9.2.1.

9.2 Final gas tightness after testing

9.2.1 General

When flue liners are tested for sootfire resistance, thermal shock testing need not be carried out.

9.2.2 Final gas tightness after sootfire testing

When tested in accordance with 16.8, flue liners A3, B3 shall have a leakage rate after sootfire testing not greater than the values given in Table 3 for the appropriate type of flue liner, test temperature and differential pressure. Flue liners shall be tested with insulation as described in 16.8.3 or they shall be tested without insulation. If they are tested with insulation, liners shall be marked "i". If tested without insulation, liners shall be marked "i".

The precision for the appropriate testing differential pressure is that given in 9.1.

9.2.3 Final gas tightness after thermal shock testing

When tested in accordance with 16.8 flue liners not included in 9.2 shall have a leakage rate after thermal shock testing not greater than the values given in Table 3 for the appropriate type of flue liner, test temperature and differential pressure. Flue liners shall be tested with insulation as described in 16.8.3 or they shall be tested without insulation. If they are tested without insulation they shall be marked accordingly.

Table 3 — Test temperature, test pressure and leakage rates

Type of flue liner	Test temperature °C	Test Pressure Pa	Permitted leakage rate $m^3\ s^{-1}\ m^{-2} \cdot 10^{-3}$
A3 N2	1 000	20	3
A3N1	1 000	40	2
A3 P1	1 000	200	0,006
A4 N2	700	20	3
A4N1	700	40	2
A4 P1	700	200	0,006
B3 N2	1 000	20	3
B3 N1	1 000	40	2
B3 P1	1000	200	0,006
B4 N2	500	20	3
B4 N1	500	40	2
B4 P1	500	200	0,006
C4 N2	350	20	3
C4 N1	350	40	2
C4 P1	350	200	0,006
D4 N2	250	20	3
D4 N1	250	40	2
D4 P1	250	200	0,006

10 Durability

10.1 Corrosion resistance

When tested in accordance with 16.9, the mass loss from any test piece shall not exceed a mass loss of 2 %.

NOTE This is an accelerated test to represent a corrosion resistance and practical installed life of at least 100 years.

10.2 Freeze/Thaw resistance

Where national regulations require freeze/thaw resistance of flue liners, they shall be tested according to EN 14297. The product shall not present any damage of type 7, 8, 9 and 10 in accordance with EN 14297:2004, Table 1.

11 Water absorption and bulk density

11.1 General

The flue liner body shall be tested for either water absorption or bulk density for production control.

11.2 Water absorption

When tested in accordance with 16.10, the mean water absorption values expressed as a percentage of five samples shall not vary more than ± 2,5 % from the mean value obtained from the last type test.

11.3 Bulk density

When tested in accordance with 16.11, the mean bulk density of five samples shall not vary more than ± 100 kg/m^3 from the mean value obtained from the last type test.

12 Abrasion resistance

When tested in accordance with 16.12, the mass of any material dislodged shall not exceed 0,03kg/m^2 of the total exposed area of the inner surface of the flue.

13 Condensate resistance and flow resistance

13.1 Condensate resistance

When tested after thermal testing and in accordance with 16.13, flue liners for wet conditions the rate of water vapour diffusion shall be measured and classified as given in Table 4.

Table 4 — Water vapour diffusion classes

Water vapour diffusion class	Rate of water vapour diffusion in g $h^{-1}m^{-2}$ of internal surface
WA	≤ 2
WB	>2 ≤ 5
WC	>5 ≤10
WD	> 10 ≤ 20

NOTE 1 Classes WB, WC and WD may be used only with specific care.

NOTE 2 If the determined rate of water vapour diffusion is higher than 20, liner is not suitable for wet applications.

13.2 Flow resistance

The mean roughness of flue liners is 0,001 5 m according to EN 13384-1. Other values may be declared and shall be determined in accordance with Annex C. This shall be done by determining either according to Annex C or declaring according to EN 13384-1:2002+A2:2008, Table B.4.

14 Thermal resistance

The values of thermal resistance of flue liners shall be declared by the manufacturer for a flue temperature of 200 °C. The reference calculation method for flue liners without cavities shall be as given in B.1, and the reference calculation method for flue liners with cavities shall be as given in B.2.

Materials used in products shall not release any dangerous substances in excess of the maximum permitted levels specified in a relevant European standard for the material, or permitted in the national regulations of the member state of destination.

15 Evaluation of conformity

15.1 General

The compliance of the clay/ceramic flue liners under wet conditions with the requirements of this standard and with the declared values (including classes) shall be demonstrated by:

— initial type testing;

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

15.2 Initial type testing

All characteristics are subject to Initial type testing.

It is also recommended to make reference to the use of historical data. “Tests previously performed on the same products in accordance with the provisions of this standard (same characteristic(s), test method, sampling procedure, system of attestation of conformity, etc.) may be taken into account".

Type tests relating to material composition shall be performed initially together with factory production control tests as given in Table 4. One test shall be carried out for each requirement.

The thermal testing shall be carried out on one size of flue liner for each geometrical configuration e.g. circular, square, rectangular. For circular flue liners the size to be tested shall be 200 mm ± 50 mm internal diameter. For other geometrical configurations the flue liner shall have an equivalent cross-sectional area range.

15.3 Further type tests

Type tests shall be performed when a change is made either in material composition, processing technique or the design or method of manufacture of the flue liner, but they may be performed more frequently by incorporation into a plan for monitoring the consistency of manufacture (see Table 4).

15.4 Factory production control

To achieve compliance with this standard the manufacturer shall establish and maintain an effective documented quality system.

Factory production control tests are carried out following manufacture to monitor the quality of product. (see Table 5).

Sampling and testing of any batch shall be completed prior to removal from the works and shall be in accordance with ISO 2859-1 at an AQL of 10 % and inspection level S2. Isolated batches of units shall be assessed in accordance with tightened inspection procedures, with a maximum batch size of 1 200 (see Annex A).

Batches rejected under the factory production control procedure may be resubmitted once, after removal of units with previously undetected visible defects, under the tightened inspection procedures, in respect only of the defect that caused initial rejection.

NOTE A quality system assessed by a certification body which complies with the requirements of EN 45012 can be applied to ensure that the requirements of EN ISO 9001:2008 and Clause 15 are complied with.

Table 5 — Factory production control and initial type tests

Item	Relevant requirement clauses	
	Factory production control 15.4 [a]	**Initial type tests 15.2 and 15.3**
Straight flue liners	7.1, 7.2, 7.4, 7.5, 7.6, 11	8.1, 9.2, 10, 12, and 13
Flue liner bends	7.1, 7.3, 11	8.2, 10
Opening section	7.1, 7.2, 11	8.3
[a] The tests carried out during FPC are intended to verify that the performance requirements assessed through the initial type testing are maintained.		

16 Test methods

16.1 Size

The maximum and minimum diameters of a clay/ceramic flue liner shall be those calculated from the tolerances given in 7.1. If direct measurement is to be carried out, two measurements should be taken at the observed maximum and minimum diameters.

The test also may be carried out by using two gauges whose diameters are set at the minimum and maximum diameters. The minimum gauges should be able to be turned through 360° within the ends of the flue liner. The maximum gauge should not be able to enter the flue liner when tested through a rotation of 360°.

For square and rectangular flue liners, the internal cross-section dimensions shall be measured between the mid-points of opposite sides of the flue liners.

16.2 Height

The maximum and minimum internal height of a clay/ceramic flue finer shall be those calculated from the tolerances given in 7.2. If direct measurement is to be carried out, two measurements should be taken at the observed maximum and minimum heights.

The test can also be carried out by using two gauges whose heights are set at the minimum and maximum internal heights. The minimum gauges should be not able to fit over the internal height of the flue liner (see Figure 4). The maximum gauge should be able to fit over the internal height of the flue liner (see Figure 4).

16.3 Angle of curvature

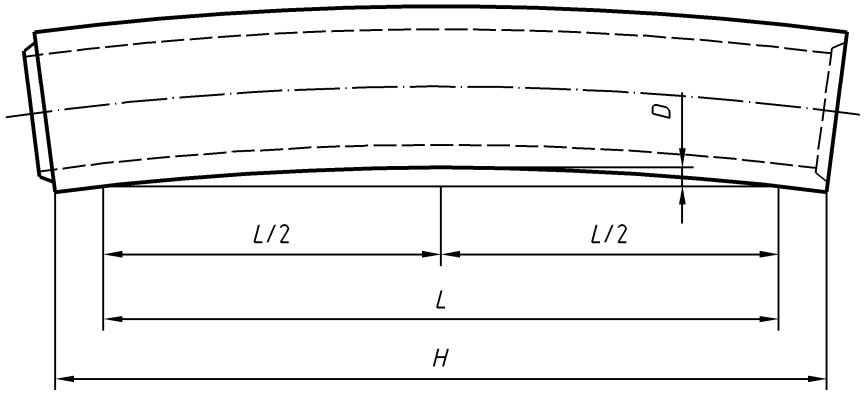
The maximum and minimum angles of curvature of a clay/ceramic flue liner shall be those calculated from the tolerances given in 7.3.

The angle of curvature test shall be carried out by standing one end of the curved flue liner on a flat surface. A straight steel rule shall be placed on the upper end of the flue liner so that its edge touches the highest and the lowest points of the end of the flue liner and its lower end also touches the flat surface. The angle of curvature is the angle subtended by the rule and the flat surface and shall be measured.

16.4 Straightness

The deviation from straightness (D) of a flue liner is the maximum distance from the centre of a straight line equal to the test length spanning any concave curve on the outside of the flue liner to the flue liner surface as shown in Figure 6. It is permissible to test for straightness using any suitable apparatus.

The test length shall be 150 mm less than the nominal height of the flue liner to allow for clearance at the shoulder of any socket.



Key

H nominal height of the flue liner, in millimetres

L test length, in millimetres

D deviation from straightness, in millimetres

H - L = 150 mm

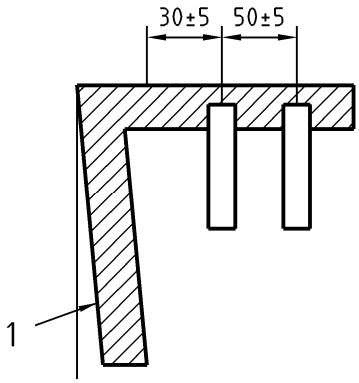
Figure 6 — Deviation from straightness

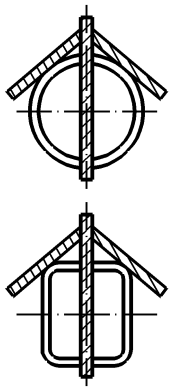
16.5 Squareness of ends

The test gauge as shown in Figure 7 with one arm set at a slope of 30 mm/m to the other shall be provided with two pairs of supports at (50 ± 5) mm centres. The end support shall be positioned so that there is a recess of (30 ± 5) mm from the inside of the angled arm. The slope of the supports shall be such as to provide a clearance of at least 5 mm under the test gauge. The angled arm shall be of such a length as to span the outside diameter/width of the flue liner.

The gauge shall be placed on the end of the flue liner, at the line of the longest external measurement of the flue liner. The slope of the end shall be checked against that of the gauge.

Dimensions in millimetres

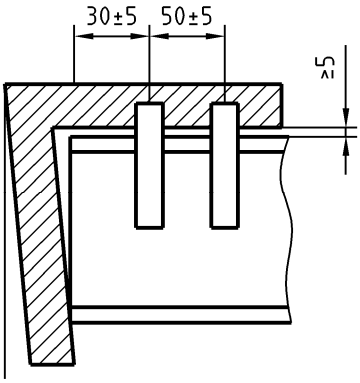


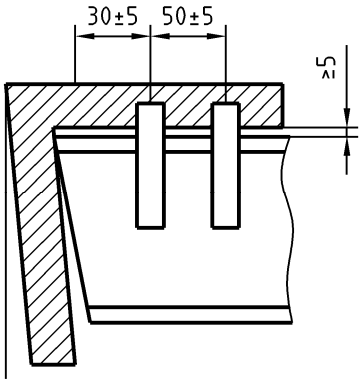


Key
1 30 mm/m slope

a) Longitudinal section of gauge

b) Cross section of gauge





c) Liner passing test

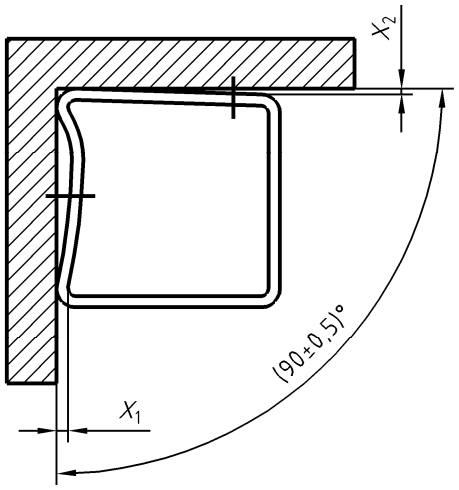
d) Liner failing test

Figure 7 — Squareness test for ends

16.6 Deviation from shape of cross-section

The test gauge shall be constituted of two arms, as shown in Figure 8, with one arm set at an angle of (90 ± 0,5)° to the other and both arms of the test gauge of such a length as to span the outside width of the flue liner under test.

Dimensions in millimetres



Key

X_1 deviation from shape
X_2 deviation from square

Figure 8 — Squareness test for angles and flatness of walls

The gauge shall be placed against two adjoining walls of square or rectangular straight flue liners and the distances x_1 and x_2 measured between the inner edge of the test gauge and the outside of the flue liner, excluding the rounded external corners, to an accuracy of ± 0,5 mm.

The percentage deviation from flatness shall be calculated as:

$$\frac{x_1 \times 100}{Lx_1} \quad (1)$$

The percentage deviation from squareness shall be calculated as:

$$\frac{x_2 \times 100}{Lx_2} \quad (2)$$

where

x_1 is the deviation from flatness of the wall, in millimetres;

x_2 is the deviation from squareness of the wall, in millimetres;

Lx_1 is the manufacturer's stated nominal internal length of the wall; against which x1 is measured, in millimetres;

Lx_2 is the manufacturer's stated nominal internal length of the wall; against which x2 is measured, in millimetres.

16.7 Proof load

16.7.1 Test specimen

The test specimen shall be cut from a flue liner and shall not include any part of a joint. The test specimen shall not be less than 150 mm high with flat and parallel ends on the full cross section of the flue liner.

16.7.2 Testing equipment

The testing machine shall be substantial and rigid throughout, so that the distribution of load will not be affected appreciably by the deformation or yielding of any part. The machine shall be capable of applying the load at the rate specified in 16.7.3 and its accuracy shall be verified by the means detailed in EN ISO 7500-1.

The bearing faces of the thrust plates and thrust packers located between the specimen and the thrust plates shall be larger than the outside dimensions of the flue liner under test.

The thrust plates shall consist of metal, free from warping or twisting and be centrally located and of sufficient dimensions so as not to distort under load. One thrust plate shall be free to tilt in any direction so that it can align with the surface of its associated thrust packer.

The thrust packers shall consist of 18 mm thick moisture resistant flooring grade chipboard in accordance with EN 312 which shall be flat pressed with the surface as pressed and be concentric to the thrust plates. New packers shall be used for each test.

16.7.3 Test procedure

Ensure that the bearing surfaces of the machine and specimen are clean and free from any loose particles.

The specimen, together with a thrust packer at each end, shall be placed between the thrust plates. The test specimen shall be placed in the machine so that the load is applied through its longitudinal axis.

The load shall be applied to the test specimen without shock and increased at a maximum rate of 14 MN/m^2 per minute until the required intensity of loading as specified in 8.1 is reached.

The proof load required to produce the specified intensity of loading is calculated by one of the following methods, as appropriate to the type of flue liner.

a) For circular flue liners:

$$\text{Proof load (N)} = \frac{10{,}0\pi\left(D_1^2 - D_2^2\right)}{4} \qquad (3)$$

where

D_1 is the mean external diameter of the test piece, in millimetres;

D_2 is the mean internal diameter of the test piece, in millimetres.

The mean diameter is the average of two measurements diametrically opposite each other.

b) For square flue liners:

$$\text{Proof load (N)} = 10{,}0\ (W_1^{\,2} - W_2^{\,2}) \qquad (4)$$

where

W_1 is the actual mean external width of the test piece (excluding rounded corners), in millimetres;

W_2 is the actual mean internal width of the test piece (excluding rounded corners), in millimetres.

c) For rectangular flue liners:

Proof load (N) = 10,0 ($L_1 \times B_1$-$L_2 \times B_2$) (5)

where

L_1 is the actual mean external width of the cross-section of the test specimen (excluding rounded corners), in millimetres;

B_1 is the actual mean external breadth of the cross-section of the test specimen (excluding rounded corners), in millimetres;

L_2 is the actual mean internal width of the cross-section of the test specimen (excluding rounded corners), in millimetres;

B_2 is the actual mean internal breadth of the cross-section of the test specimen (excluding rounded corners), in millimetres.

d) For flue liners with vertical perforations:

Proof load (N) = 10,0 A (6)

where

A is the net cross-sectional area of flue liner in square millimetres.

16.8 Thermal testing

NOTE The thermal testing to 1 000 °C is a method to assess the flue liner for its ability to resist sootfire.

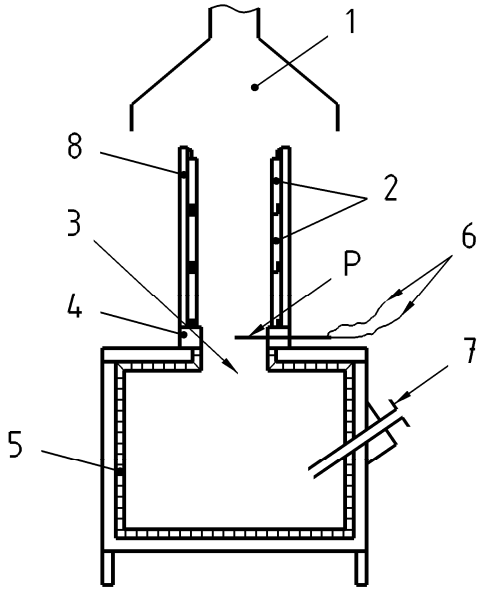
16.8.1 Test flue

The test flue shall consist of two flue liners.

16.8.2 Test equipment

Equipment suitable for heating the flue is shown in Figure 9. The box furnace shall be heated by a high-velocity gas burner where combustion is essentially completed within the burner body. The burner shall be angled downwards so that the hot gases do not impinge directly onto the exhaust port in the roof of the furnace. The burner shall be fired by a gaseous fuel (natural gas, propane or butane). The capacity rating of the burner should not be less than 150 kW.

NOTE As an alternative the box furnace could be heated by two smaller capacity high-velocity burners.



Key

1 exhaust gas canopy
2 test flue
3 outlet
4 refractory collar
5 ceramic fibre
6 thermocouple
7 gas burner
8 insulation (if required)
P temperature measurement point

Figure 9 — Hot air generator

In order to obtain the required rate of heating, the box furnace should be of light-weight construction, i.e. of low thermal mass. The internal dimensions of the box furnace are approximately 700 mm long x 700 mm deep x 700 mm high and the box is lined with 100 mm of ceramic fibre. The burner shall be placed centrally on one side of the box furnace.

The exhaust port shall be fitted with a 300 mm ± 50 mm high outlet having the same internal cross-sectional dimensions as that of the test flue. This outlet shall be supported on a collar of cast refractory concrete with an opening of the same shape as the internal cross-section of the flue.

For liners with thermal insulation to be tested, the flue shall be insulated with a flexible material having a thermal resistance of 0,4 m^2 K/W ± 0,04 m^2 KW at a temperature of 300 °C. The insulation material shall be capable of withstanding a temperature of 1 000 °C.

The temperature of the products of combustion shall be measured by a Type K (Nickel-Chromium/ Nickel-Aluminium) thermocouple with an unsheathed junction located in the centre of the opening at the base of the flue. The gas and air supply to the burner shall be adjustable and a gauge shall be fitted to measure the volume flow rate of air supplied.

For permeability testing before and after subjecting the flue to a thermal test, a fan or other device capable of producing at least the required differential pressure, a flow meter and a manometer shall be used.

The air supply for the test shall be measured by a flow meter with an accuracy of ± 5 % of full scale. The full scale reading shall be approximately the flow rate for the maximum air permeability rate for the appropriate type of flue liner.

16.8.3 Assembly of test flue

Two flue liners shall be assembled to form a straight vertical flue located on the outlet of the gas fired furnace. The maximum height of the flue shall be 1,5 m. The flue shall contain two flue liners, the top and bottom joint sections may be removed, or sections cut from one flue liner of approximately the same length. Prior to assembly the samples shall be dried to constant mass at a temperature of (110 ± 5) °C.

The two flue liners or sections and their normal designed joint shall be the test flue. The joint between the test flue liners or sections shall be made using a mortar in accordance with the manufacturer's instructions for the appropriate temperature type. The joint between the test flue and the outlet shall be made so that the test flue assembly can be removed for air permeability testing if desired without damage.

After construction the flue shall be left at ambient temperature 15 °C to 30 °C for a minimum period of 24 h to allow the mortar to cure or in accordance with the manufacturer's instructions for the mortars.

Prior to thermal testing, a test flue shall be tested for permeability in accordance with the requirements of 9.1.

If the permeability rate specified in 9.1 is exceeded the test flue shall be examined and the joint re-made if necessary or the flue liners with thermal insulation have to be replaced. The leakage rate shall be remeasured after further drying.

Having satisfied the requirements of 9.1 the test flue and the outlet for flue liners tested with insulation shall be insulated prior to thermal testing. If required, insulation shall be placed around the flue so that it is kept in close contact throughout the test. It should be held in place with bands each not greater than 25 mm wide and at spacing not closer than 250 mm centres.

16.8.4 Thermal conditioning

The temperature of the products of combustion entering the test flue, measured at position P (see Figure 9), shall be regulated by adjustment of the gas supply to the burner(s) as far as practicable at a constant rate, to the temperature and the time from start of heating given in Table 6 as appropriate to the type of flue liner. The temperature shall then be maintained at this value for a further period of 30 min.

During heating the velocity of air at an ambient temperature of 15 °C to 30 °C supplied to the burner shall be maintained at a rate allowing the hot gas flow in the test flue to have the velocity given in Table 6 according to the test temperature and pressure class.

NOTE When firing the burner by gaseous fuels (natural gas, propane or butane) the volume of products of combustion for a given temperature will be similar.

After heating, the test flue shall be allowed to cool to room temperature without forced ventilation and with the thermal insulation retained in position if present.

Table 6 — Test temperature and time to test temperature

Type of flue liner	Test temperature °C	Tolerance on test temperature °C	Time to test temperature from start of heating min
A3 N2	1 000	± 25	10
A3 N1	1 000	± 25	10
A3 P1	1 000	± 25	10
A4 N2	700	± 25	7
A4 N1	700	± 25	7
A4 P1	700	± 25	7
B3 N2	1 000	± 25	10
B3 N1	1 000	± 25	10
B3 P1	1 000	± 25	10
B4 N2	500	± 25	5
B4 N1	500	± 25	5
B4 P1	500	± 25	5
C4 N2	350	± 25	3,5
C4 N1	350	± 25	3,5
C4 P1	350	± 25	3,5
D4 N2	250	± 25	2,5
D4 N1	250	± 25	2,5
D4 P1	250	± 25	2,5

16.8.5 Measurement of leakage rate

When the flue has cooled, any insulation shall be removed and the leakage determined at the differential pressure given in Table 3 as appropriate to the type of flue liner.

The test flue shall be sealed and the flue connected to a suitable fan or other device. The delivery of air at an ambient temperature of 15 °C to 30 °C from the fan shall be controlled to maintain the required differential pressure measured in the flue. The volume of air being delivered to the flue over 1 min shall be measured and the permeability rate calculated in terms of square metres internal surface area of test flue.

All permeability rate measurements shall be carried out without any insulation of the flue.

16.8.6 Expression of results

The permeability rate at the specified test pressure shall be expressed in terms of cubic metres of air per second per square metre of internal surface area of test [$m^{3.}\ s^{-1.}\ m^{-2}$].

16.9 Corrosion resistance

16.9.1 Test specimens

The test specimens shall be six freshly broken pieces of flue liner or the inner wall of a liner with vertical perforations about (50×10^3) mm^3 ± (10×10^3) mm^3 in volume free from cracks or shattered edges.

The thickness (E) of the test specimen should be measured first (correct to ± 1,0 mm).

The plan area of test specimen equals approximately $\frac{50000}{E}$ mm^2.

The length of side for a square sided specimen equals approximately $\sqrt{\frac{50000}{E}}\,mm.$

EXAMPLE Wall thickness of flue liner 12 mm

Plan area $\frac{50\,000}{12}\ \text{mm}^2 = 4\,167\ \text{mm}^2$

Length of side $\sqrt{4\,167}$ mm^2 = approximately 65 mm

16.9.2 Test equipment

16.9.2.1 A ventilated oven, capable of maintaining a temperature of 110 °C ± 5 °C.

16.9.2.2 A balance, with an accuracy of ± 0,01 g when loaded with 200 g.

16.9.2.3 A boiling water bath.

16.9.2.4 A 2 l beaker.

16.9.2.5 A supply of distilled water.

16.9.2.6 Sulphuric acid solution, $c(H_2S0_4)$ = 70 % by mass (density at 20 °C =1,610 kg/m^3).

16.9.2.7 Barium chloride drops (concentration 50 g per litre).

16.9.3 Test procedure

The test specimens shall be cleaned in de-ionized water using a soft brush to remove any loose particles and dried at a temperature of 110 °C ± 5 °C until no further loss of mass (± 0,01 g) is noted on successive weighings at 24h intervals. The dry weight of the specimen shall be recorded in grams (M_1).

The dried test specimens shall be placed in a 2l beaker and immersed for 6 h ± 0,1 h in 1,5l of sulphuric acid solution. The beaker shall be covered by a watch glass to limit evaporation of the acid. During this time the beaker shall stand in a bath of gently boiling water.

On removal from the acid solution, each specimen shall be placed in a separate beaker and shall be washed by immersion in de-ionized water for 30 min, the water being heated to boiling in 15 min and held at boiling for a further 15 min.

The presence of sulphate shall be tested by adding of a few drops of bariumchloride solution on a test-tube sample taken from the rinsing bath. The barium chloride solution shall be made of 50 g of barium chloride per 1 l of de-ionized water.

The washing cycle shall be repeated, changing the rinsing water after each cycle, until the water no longer becomes turbid when a few drops of barium chloride are added or a maximum of 100 washing cycles (approximately 50 h of rinsing).

After washing the test specimens shall be dried at a temperature of 110 °C ± 5 °C until no further loss of mass (± 0,01 g) is noted on successive weighings. The final dry weight of the specimen shall be recorded in grams (M_2).

16.9.4 Expression of results

The loss of acid soluble matter in each of the test pieces shall be calculated as a percentage of the dry mass as follows:

$$\text{Percentage loss in dry mass} = \frac{(M_1 - M_2) \times 100}{M_1} \quad (7)$$

16.10 Water absorption

16.10.1 Test specimen

A test specimen shall be a sample of the flue liner having a dry mass of between 0,25 kg and 0,4 kg.

16.10.2 Test equipment

16.10.2.1 A ventilated oven, capable of maintaining a temperature of (110 ± 5) °C.

16.10.2.2 A balance, with an accuracy of ± 0,1 g.

16.10.2.3 A water boiling tank, with a capacity to immerse the whole specimen in water.

The tank shall be fitted with a grid on which to support the specimen to ensure free circulation of water around all surfaces of the specimen.

16.10.2.4 A desiccator, containing silica gel or a more active desiccant.

16.10.3 Test procedure

The test specimen shall be dried to a constant mass in a ventilated oven at a temperature of (110 ± 5) °C (W_1). The mass in grams (W_1) shall be determined after cooling the sample to room temperature in a desiccator containing a desiccant.

The dry test specimen shall be placed in water at ambient temperature. The water shall be brought to the boil and maintained at the boiling point for 1 h, all the sample being kept immersed during this period. After the end of boiling, the sample shall remain immersed in the water for a further 4 h. The test specimen shall then be removed from the tank, surface water removed by wiping with a damp cloth and the sample weighed in grams (W_2) immediately.

16.10.4 Expression of results

The water absorption of the test specimen shall be determined as the ratio of the increase in mass of the saturated test specimen to the mass of the dry specimen. The ratio shall be expressed in percentage terms to the nearest 0,1 %.

$$\frac{W_2 - W_1}{W_1} \times 100\ \% \quad (8)$$

16.11 Bulk density

16.11.1 Test specimen

A test specimen shall be a sample of the flue liner having a dry mass of between 0,25 kg and 0,4 kg.

16.11.2 Test equipment

16.11.2.1 A ventilated oven, capable of maintaining a temperature of (110 ± 5) °C.

16.11.2.2 A balance, with an accuracy of ± 0,1 g.

16.11.2.3 A water boiling tank, with a capacity to immerse the whole specimen in water.

The tank shall be fitted with a grid on which to support the specimen to ensure circulation of water around all the surfaces of the specimen.

16.11.2.4 A bridge, to be placed over the load bearing scale pan of the balance.

16.11.2.5 A container, with adequate capacity to freely suspend the whole specimen submerged in water.

16.11.2.6 A suspension, thread/wire not more than 0,3mm in diameter.

16.11.2.7 A desiccator, containing silica gel or a more active desiccant.

16.11.3 Test procedure

The test sample shall be dried to a constant mass in a ventilated oven at a temperature of (110 ± 5) °C (W_1). The mass in grams (W_1) shall be determined after cooling the sample to room temperature in a desiccator containing a desiccant.

The dry sample shall be placed in water at ambient temperature. The water shall be brought to the boil and maintained at the boiling point for 1 h, all the sample being kept immersed during this period. After the end of boiling, the sample shall remain immersed in the water for a further 4 h before being weighed freely suspended in water at ambient temperature (20 ± 5) °C (W_2 in grams).

The sample shall then be removed from the water, surface water removed by wiping with a damp cloth and the sample weighed immediately (W_3 in grams). The difference in the two weights in grams (W_3-W_2) gives the volume of the sample in cubic centimetres.

16.11.4 Expression of results

The dry density of the specimen shall be determined by dividing the dry mass of the specimen by the volume (obtained by subtracting the mass of the specimen when weighed under water from that when weighed in air immediately after immersion). The bulk density shall be expressed to the nearest 10 kg/m^3.

$$\text{Bulk density} = \frac{W_1}{W_3 - W_2} \times 1\ 000\ \left(\text{kg/m}^3\right) \tag{9}$$

16.12 Abrasion resistance

16.12.1 Test flue

The test flue shall be as specified in 16.8.1 and shall have been subjected to the appropriate thermal test specified in 16.8.3.

16.12.2 Test equipment

A tight fitting metal sleeve attached to a catchment funnel shall be fitted into the top opening of the test flue. A tight fitting metal sleeve attached to a plate which has an opening matching the area of the opening of the flue liner shall be fitted into the bottom opening of the test flue, as shown in Figure 10.

The bottom plate shall be supported directly over a collection box positioned to collect any material which is dislodged during the test, and which is of sufficient depth to allow the brush to pass through the complete length of the test flue.

If the test flue is to be weighed, a balance with an accuracy of ±1,0 g capable of weighing two flue liner.

The sweeping brush shall have flat spring-steel bristles of stainless steel in accordance with EN 10088-1, grade X9 CR NI 18-8, steel number 1,4310, with a cross-section of 2,0 mm × 0,3 mm ± 0,1 mm.

The overall dimension of the brush shall be (25 ± 5) mm greater than the internal dimension of the flue, as shown in Figure 10. The bristles shall be arranged so that there are five per 10 mm length of the perimeter of the plan area of the brush.

The brush shall be attached to a rod.

16.12.3 Test procedure

The brush shall be pushed down and pulled up through the total length of the test flue and this represents one cycle. Any material dislodged by the first 20 cycles of these movements shall be discarded. A test number of 100 cycles shall be completed.

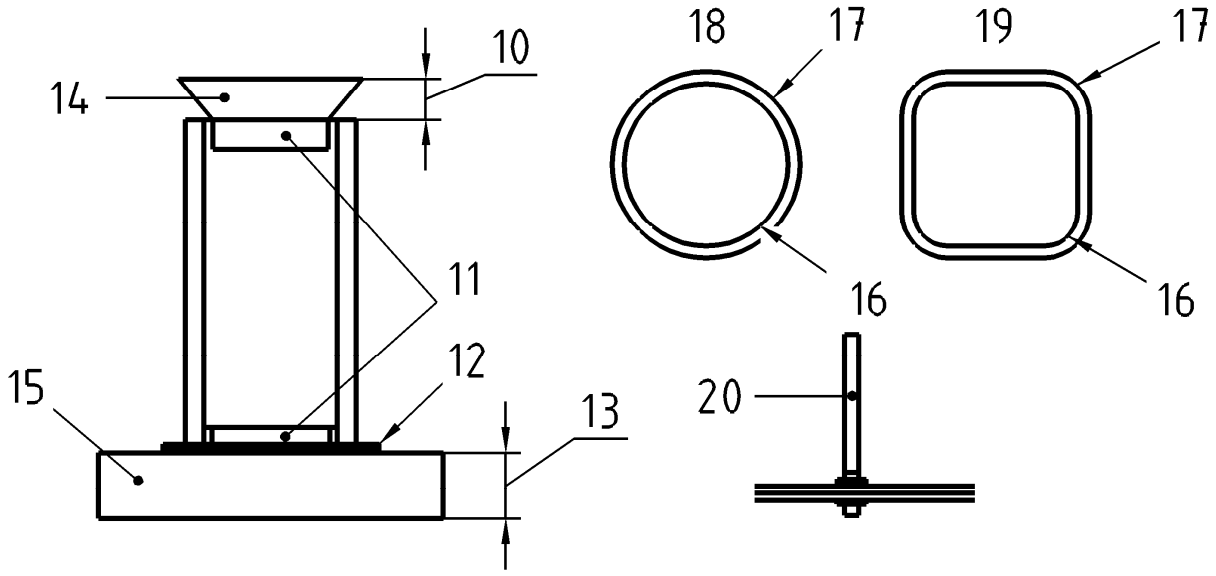
The weight of the material dislodged from the inner surface of the test assembly shall be recorded.

The area of the inner surface of the test assembly, between the steel sleeves shall be calculated. The loss of material per square metre shall then be calculated.

An alternative measurement procedure is that the test flue shall be weighed to ± 0,1g after 20 cycles and 100 cycles and the difference in mass between the two weighings will be the mass of material abraded during the test and this shall be recorded. The area of the inner surface of the test assembly shall be calculated. The loss of material per square metre shall then be calculated.

16.12.4 Expression of results

The recorded mass of material abraded from the inside surface of the test flue over 20 to 100 sweeping cycles shall be expressed in terms of kilograms per square meter of the total exposed area of the inner surface of the flue.



Key

10 height of funnel not less than 200 mm
11 tight fitting sleeve projecting 20 mm into opening
12 bottom plate attached to bottom sleeve
13 height sufficient to allow brush to pass through bottom of test assembly
14 catchment funnel attached to sleeve
15 collection box
16 plan of liner opening area
17 plan of brush area
18 round liner
19 square or rectangular liner
20 rod

Figure 10 — Test assembly for abrasion resistance test

16.13 Test method for the determination of water and vapour flow (indirect method)

16.13.1 Test installation

Position the sample in an airtight test pipe (e.g. stainless steel or glass pipe). The air gap between the test sample and the air tight test pipe shall be closed by means of air tight caps on both ends. Provision shall be made that full saturated water vapour of a temperature not more than 70 °C and a mass flow of 20 g/s can be provided to the test Installation.

The room temperature in the test room shall be between 20 °C ± 5 °C. The tolerance of the test temperature shall not exceed ± 2 K.

Ventilated air in the air gap between the test sample and the test pipe shall be exhausted from the air gap through ventilation openings. The temperature of the ventilation air shall be 20 °C ± 5 °C and the relative humidity shall < 10 %.

16.13.2 Test sample

The test sample shall consist of at least a flue liner or flue blocks with an internal diameter of 0,14 m or 0,14 m x 0,14 m in square or the next commercially available diameter or square. The test sample shall have a height of 1,0 m ± 0,1 m consisting of flue liner material and mortar for connections (e.g. special mortar resistant against acids) in accordance with the manufacturers specifications.

The test sample, regardless of the length of the flue liner, should have at least one joint. Flue liners with a length of > 1 m may be cut to provide for one joint.

16.13.3 Position of measuring points and records

16.13.3.1 General

The following data shall be recorded:

16.13.3.2 Ventilated air in the test sample

a) Ventilated air at the entrance into the flue liner (air saturated with water vapour):

   1) temperature;

   2) relative humidity;

   3) velocity of air flow for determination of the mass flow rate;

b) ventilated air at the outlet of the flue liner (air saturated with water vapour);

   1) temperature;

   2) relative humidity.

16.13.3.3 Test sample

Measure the inner wall temperature of the test sample at 4 different positions (18, 19, 20, 21), enabling the determination of the average value of the inner wall temperature. In case of test samples with wall thickness of ≤ 0,02 m the average value of the outside temperature instead of inside temperature (in this case, the inner wall temperature may be used to calculate the values of the outside temperature of the test sample) can be used. The measuring points for temperature shall be positioned as shown in Figure 11.

16.13.3.4 Humidity in the test equipment

Ventilated air in the air gap:

a) air at the entrance in the air gap:

   1) temperature;

   2) relative humidity;

   3) mass flow velocity for determination of mass flow;

b) air at the outlet of the air gap:

   1) relative humidity;

   2) temperature.

16.13.3.5 Testroom

The room temperature is to measure in a position of 1,5 m above floor and minimum 1 m distance from the test rig.

16.13.3.6 Description of the test sample

a) Flue liner, flue block (data to be taken after the test):

   1) description of the flue liner;

   2) dimensions;

   3) density;

   4) water absorption;

b) mortar for flue liner connections to be checked that it is the test sample that was provided by the manufacturer:

   1) description;

   2) density.

16.13.4 Test procedure

16.13.4.1 Drying phase

The test sample shall be dried before the test over a period of at least 72 h at and at a temperature equal to the maximum operating temperature, but not exceeding 200 °C.

16.13.4.2 Temperature and humidity demand for the test sample, test Figure 11

The test sample shall be tested after installation in the test rig Figure 11:

— with air of a flow velocity of 1 m/s ± 0,1m/s and a temperature of 55 °C ± 2 °C;

— water shall be added to the air through the test sample to such extent that the humid air in the centre of the test sample shall have a relative humidity of 95 % minimum.

The disposal of humid air in the air gap shall be by means of ventilation openings, the humid air mass flow in the air gap shall be controlled to such extend that at the outlet of the air gap a relative humidity of 60 % shall be maintained. Where the temperature and humidity values are in equilibrium the values shall be taken according to 3.2. The mass flow of humid air has to be calculated with the knowledge of air mass flow and the existing relative humidity between inlet and outlet of the air gap.

When temperature and humidity values are in equilibrium the values listed in 16.13.3.1, 16.13.3.2 and 16.13.3.4 shall be measured in addition.

Temperature is in equilibrium when the measured value of humid air mass flow in 3 succeeding measurements while 24 h does not change within 1 K or the test has lasted for at least 3 weeks.

Humidity equilibrium is achieved when the measured value of the humid air mass flow in 3 succeeding measurements while 24 h doesn‘t change more than 10 % or if the test has lasted for at least 3 weeks.

16.13.4.3 Characteristic values of the test sample

After completion of the test procedure, the data are determined according to 16.13.3.5.

16.13.5 Results

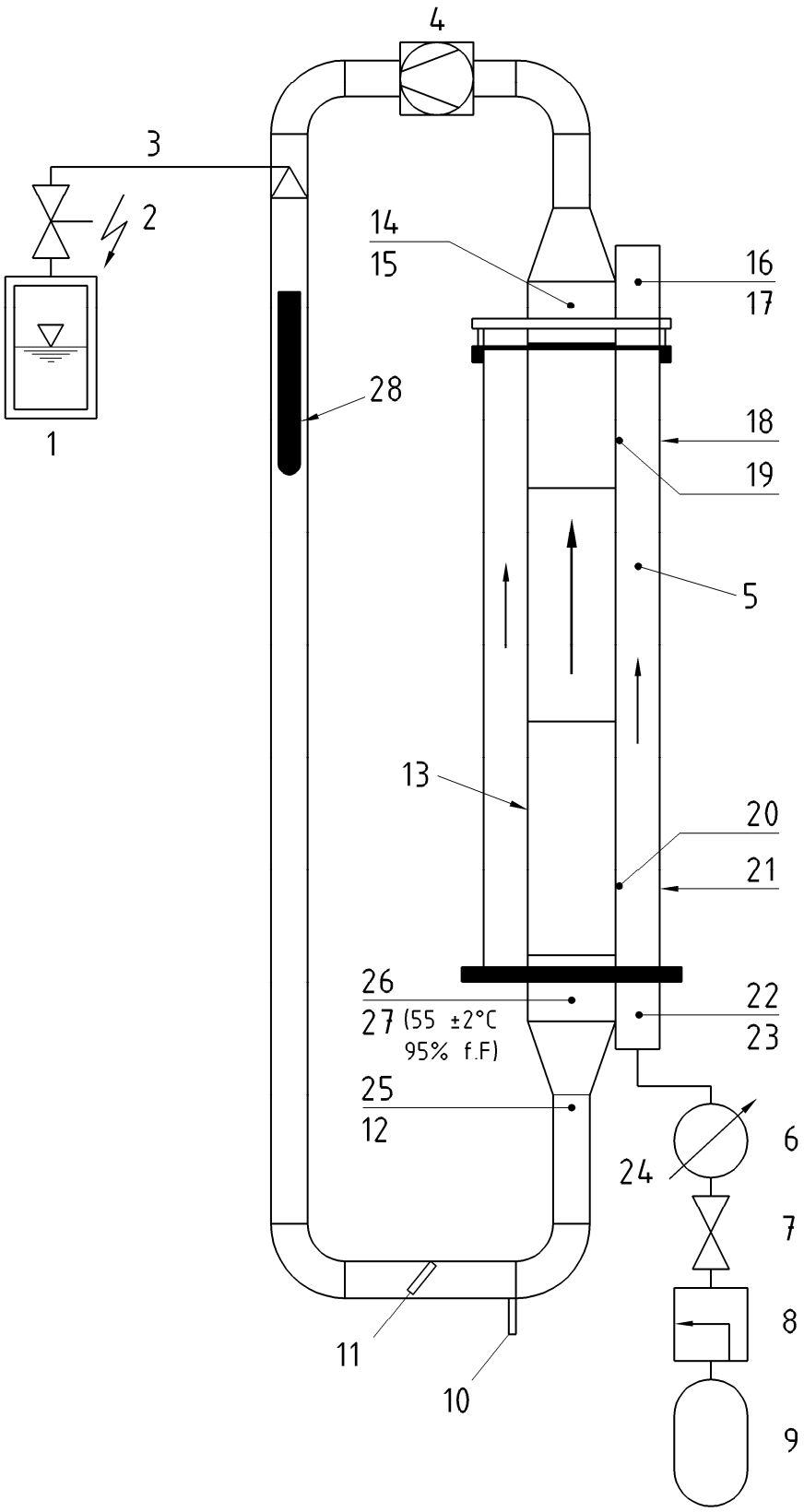
The mass flow of the humid air through the flue liner related to the inner surface taking the values of the test in linear interpolation will be calculated for a normal inner wall temperature of 50 °C.

16.13.6 Measuring equipment — Composition, measuring range, uncertainty

Table 7

Measuring value/device	range	uncertainty
1 ventilated air		
Hot gas temperature		
– thermocouples	Up to 100 °C	± 1,5 °C
relative humidity		
– measuring device with relevant capacity	0 to 100 %	± 2 % r.h.
mass flow of hot gas		
– venturi pipe	up to 5 m/s	± 0,1 m/s
2 test sample		
wall temperature – thermocouples	up to 100 °C	± 1,5 °C
3 humidity mass flow		
air temperature		
– thermocouples	up to 100 °C	± 1,5 °C
relative humidity		
– measuring device with relevant capacity	0 to 100 %	± 2 % r.h.
4 ambient air in the test room		
temperature		
– thermocouples	up to 100 °C	± 1,5 °C
5 characteristic values		
dimensions of the test sample		
– length measuring device, micrometer		± 1/0,1 mm
density	Up to 6kg	± 0,1 g
– weighing device		

16.13.7 Test rig



Key

1	vapor generator		8	pressure reducer	
2	magnetic valve		9	compressed air	
3	vapor		10	condensate drain	
4	fan		11	throttle	
5	ventilation air gap		12	pitot pipe	
6	flowmeter		13	test specimen	
7	needle valve				
14	temperature test sample – outlet	[°C]	21	wall temperature test pipe – lower outside	[°C]
15	rel. Humidity test sample – outlet	[%]	22	temperature air gap – inlet	[°C]
16	temperature air gap – outlet	[°C]	23	rel. humidity air gap - inlet	[%]
17	rel. Humidity air gap – outlet	[%]	24	mass flow of air	[l/h]
18	wall temperature test pipe – upper oustide	[°C]	25	mass flow hot gas	[m/s]
19	wall temperature ceramic pipe – upper outside	[°C]	26	temperature test sample - inlet	[°C]
20	wall temperature ceramic pipe – lower outside	[°C]	27	rel. humidity test sample - inlet	[%]
			28	heating	

Figure 11

17 Designation

The following shall be used for the designation of flue liners:

— denomination;

— standard number;

— nominal size;

— type or types (if tested without insulation declare “Tested without insulation”);

— nominal angle of curvature (where applicable);

— condensate class.

— corrosion class.

EXAMPLE

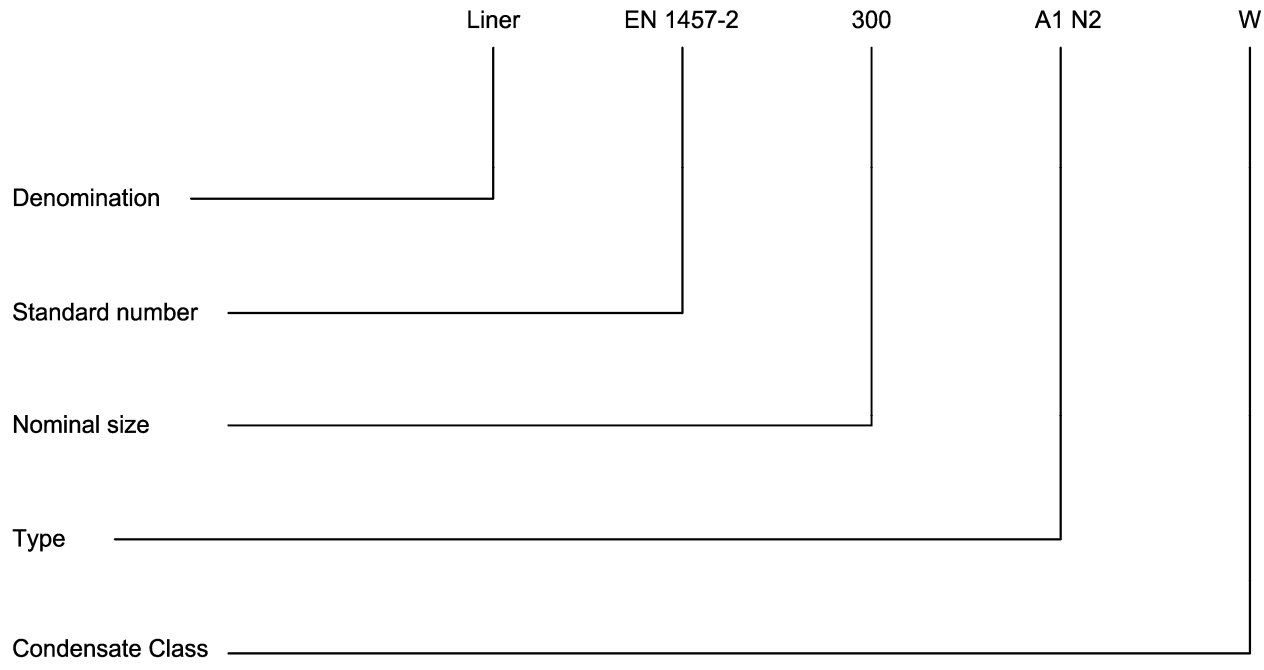


Figure 12

18 Marking

All flue liners shall be marked with:

— EN 1457-2;

— manufacturer's identification and date of manufacture;

— type number or type numbers.

NOTE For CE marking and labelling, Clause ZA.3 in Annex ZA applies.

Annex A
(normative)

Sampling procedures for an AQL of 10 % and inspection level S2

A.1 Acceptability determination

NOTE Single or double sampling can be used.

A.1.1 Single sampling

If the number of defectives found in the sample is equal to or less than the acceptance number, the batch shall be accepted.

If the number of defectives is equal to or greater than the rejection number, the batch shall be rejected.

When reduced inspection is in effect and the acceptance number has been exceeded, but the rejection number has not been reached, the batch shall be accepted and normal inspection reinstated. If the rejection number has been reached or exceeded, the batch shall be rejected and normal inspection reinstated.

A.1.2 Double sampling

The number of sample units shall be equal to the first sample size in the plan. If the number of defectives found in the first sample is equal to or less than the first acceptance number, the batch shall be accepted. If the number of defectives found in the first sample is equal to or greater than the first rejection number, the batch shall be rejected. If the number of defectives found in the first sample is between the first acceptance and rejection numbers, the second sample of the size given in the plan shall be inspected.

The number of defectives found in the first and second samples shall be accumulated. If the cumulative number of defectives is equal to or less than the second acceptance number, the batch shall be accepted. If the cumulative number of defectives is equal to or greater than the second rejection number, the batch shall be rejected. If this occurs on reduced inspection, normal inspection shall be reinstated for the next batch.

When reduced inspection is in effect and, after the second sample, the acceptance number has been exceeded but the rejection number has not yet been reached, the batch shall be accepted and normal inspection reinstated.

A.2 Normal inspection

The sample size appropriate to the batch size and the acceptance and rejection values for numbers of defectives shall be in accordance with Table A.1. Sample units shall be selected at random.

Table A.1 — Sampling plans for normal inspection

Batch size	Single sampling			Double sampling					
	Sample size	Accept number	Reject number	First sample size	Accept number	Reject number	Second sample size	Accept number	Reject number
2 to 1 200	5	1	2	3	0	2	3	1	2
1 201 to 20 000	8	2	3	5	0	3	5	3	4

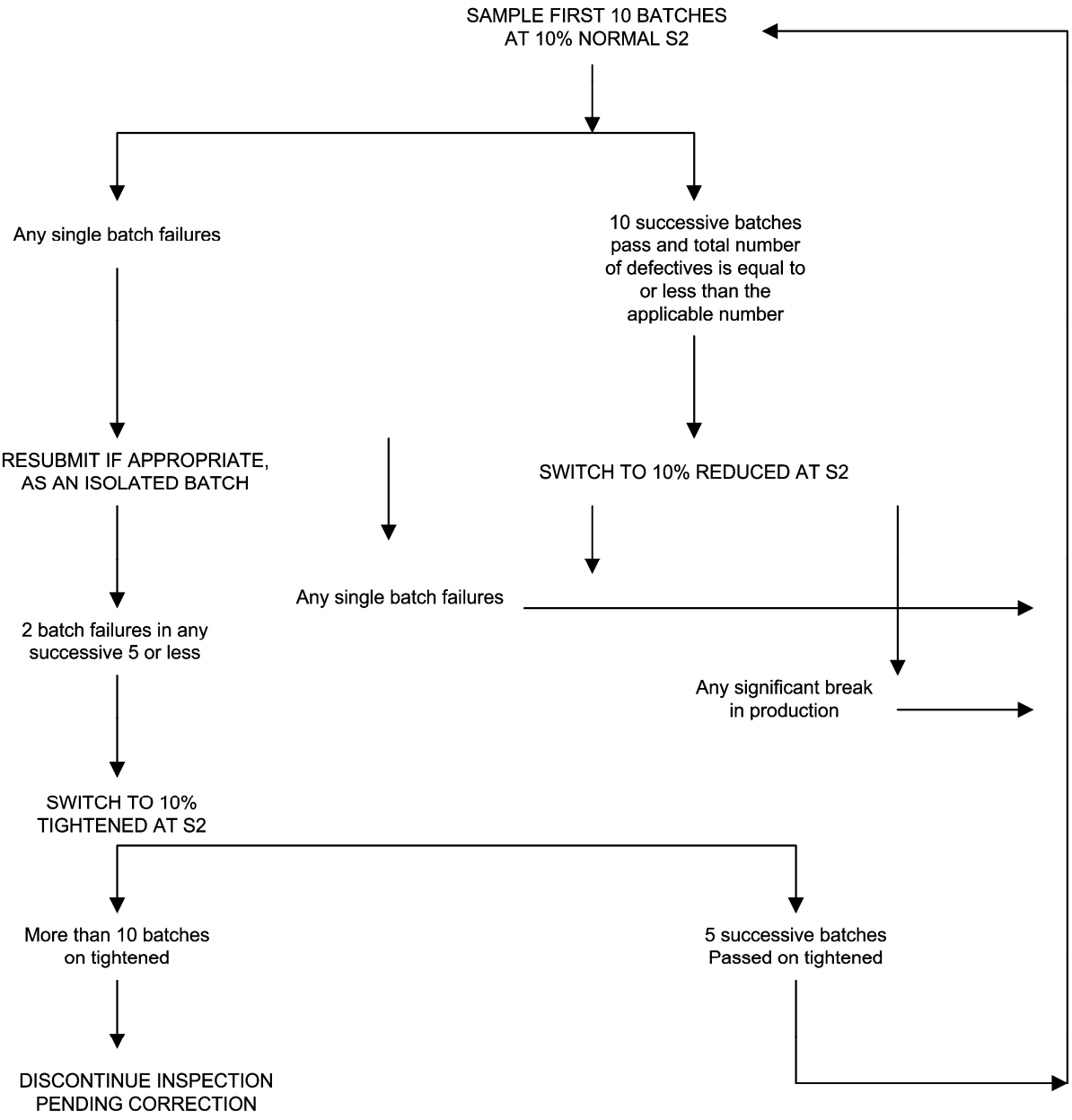


Figure A.1 — Summary of sampling procedures (Continuous batches)

A.3 Normal to reduced inspection

A reduced inspection level as shown in Table A.2 shall be used when normal inspection is in effect, provided that the following conditions are satisfied.

a) The preceding ten batches have been on normal inspection, and none has been rejected on original inspection.

b) The total number of defectives in the samples from the ten preceding batches (or such other number required by Table A.3) is equal to or less than the limit number given in Table A.3.

When double sampling is in use, all samples inspected should be included, not first samples only.

Table A.2 — Sampling plans for reduced inspection

Batch size	Single sampling			Double sampling					
	Sample size	Accept number	Reject number	First sample size	Accept number	Reject number	Second sample size	Accept number	Reject number
2 to 1 200	2	0	2	Not applicable					
1 201 to 20 000	3	1	3	2	0	3	2	0	4

Table A.3 — Limit number of defectives for normal to reduced inspection

Number of samples from last ten batches	Limit number of defectives
20 to 29	0
30 to 49	0
50 to 79	2
80 to 129	4

A.4 Reduced to normal inspection

When reduced inspection is in effect, normal inspection shall be reinstated if a batch is rejected, or if a batch is accepted without either acceptance or rejection criteria having been made (see A.1.1 and A.1.2).

A.5 Tightened inspection

Tightened inspection as shown in Table A.4 shall be used either when inspecting a new product or when two or more batches have been rejected in any five consecutive batches of normal inspection or for inspecting a batch which has previously been rejected after removal of units with previously undetected visible defects.

Table A.4 — Sampling plans for tightened inspection

Batch size	Single sampling			Double sampling					
	Sample size	Accept number	Reject number	First sample size	Accept number	Reject number	Second sample size	Accept number	Reject number
8 to 20 000	8	1	2	5	0	2	5	1	2

A.6 Tightened to normal inspection

Tightened inspection shall continue until five consecutive batches are accepted when normal inspection shall be resumed.

A.7 Discontinuation of inspection

If ten consecutive batches remain on tightened inspection, the provision of these sampling plans shall be discontinued pending action to improve the quality of the submitted batches.

Annex B
(normative)

Thermal resistance

B.1 Method 1: simplified calculation for flue liners without cavities

The thermal resistance shall be determined approximately in accordance with the following equations if specific material properties and layer thicknesses are known:

a) with knowledge of the thermal resistances of the individual pipe shells:

$$R = D_h \sum_n \left[R_n \cdot \frac{1}{D_{h,n}} \right] \text{ in } m^2.k/W \quad \text{(B.1)}$$

b) with knowledge of the coefficients of thermal conductivity of the layers:

$$R = y \sum_n \frac{D_h}{2.\lambda_n} \cdot \left(\frac{D_{h,n+1}}{D_{h,n}} \right) \text{ in } m^2.k/W \quad \text{(B.2)}$$

where

R is the thermal resistance of a pipe shell, referring to its internal surface in m2.K/W;

y is the coefficient of form;

y is equal to 1,0 for round and oval cross-sections;

y is equal to 1,10 for square and rectangular cross-sections up to a ratio of sides equal to or less than 1,5;

D_h is the internal hydraulic diameter in m;

$D_{h,n}$ is the hydraulic diameter of the inside of each layer in m;

λ_n is the coefficient of thermal conductivity of the material of the layer at 200 °C in W/(m.K).

B.2 Method 2: thermal resistance of flue liners with or without cavities

B.2.1 General

This Annex deals with the calculation of the thermal resistance of flue liners made of one or several materials using a computer program.

This calculation is based on the transformation of the heat equation in a finite difference equation.

The "finite difference" form is developed for a network in the block where the dimensions are chosen according to each type of flue liner. This network is in two co-ordinated directions (x, y).

B.2.2 Data

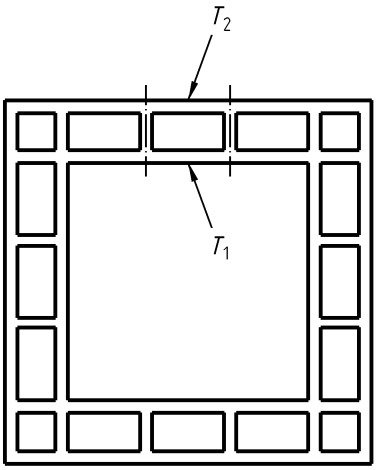
B.2.2.1 Thermal properties of the material

Either use the thermal conductivity of the clay in two directions (x, y) given by the manufacturer or use the thermal conductivity given in Table B.1 depending on the clay density.

Table B.1 — Thermal conductivity of the clay

Density kg/m^3	**Thermal conductivity** W/(m.K)
1 000	0,27
1 100	0,30
1 200	0,33
1 300	0,36
1 400	0,40
1 500	0,43
1 600	0,47
1 700	0,51
1 800	0,55
1 900	0,60
2 000	0,64
2 100	0,69
2 200	0,74
2 300	0,79
2 400	0,84

B.2.2.2 Boundary conditions



Key

T_i internal temperature, i.e. flue gas temperature
h_i internal heat transfer coefficient
T_1, T_2 internal surface temperature of the cavity

Figure B.1 — Boundary conditions

— Internal conditions:

T_i = 200 °C

h_i = 16,67 W/(m^2.K)

— External conditions:

T_e = 50 °C

h_e = 9,09 W/(m^2·K)

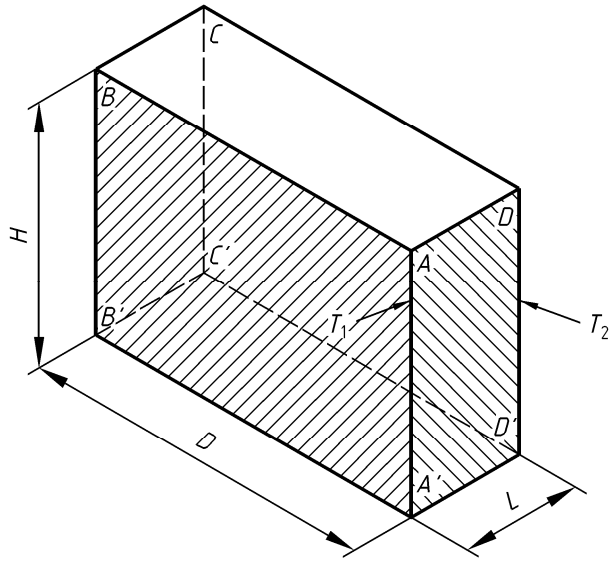
B.2.3 Specific conditions for the cavities

B.2.3.1 General

The cavities are considered like materials with thermal equivalent characteristics. It is considered that the heat flux transmitted by convection-conduction and the heat flux transmitted by radiation are reduced to a conduction problem.

The thermal equivalent conductivity of the cavity is calculated by a specific computer program unconnected with the program of the thermal resistance of the flue liner.

The following notation scheme is used for the cavity:



Key

L width of the cavity in metres

H height of the flue liner in metres

D length of the cavity in metres

Figure B.2 — Notation scheme used for the cavity

The views ABB'A' and DCC'D' are respectively at the temperatures T_1 and T_2.

The views ADD'A' and BCC'B' are supposed adiabatic.

B.2.3.2 Heat transmitted by conduction-convection in the air

$$\Phi_c = h_c.(H.D).(T_1\text{-}T_2) \text{ in W} \quad \text{(B.3)}$$

where

h_c is the convection coefficient in W/(m2.K);

h_c = λair/L in conduction only for the air at 170 °C, λair = 0,0366 W/(m.K);

λair is the air thermal conductivity in W/(m.K).

The transition between conduction and convection occurs at the following value of Gr : (Grashof number):

$Gr = 4007 \,.\, A^{4/9}$

for $Gr > 4007 \,.\, A^{4/9}$, we will take:

$$h_c = \frac{4{,}6 \cdot 10^{-3} \cdot Gr^{1/4}}{L_A^{1/9}} \quad \text{(B.4)}$$

for $Gr < 4007 \,.\, A^{4/9}$, we will take $h_c = 0{,}0366/L$

with $A = H/L$ and

$$Gr = \frac{\rho^2 \cdot g \cdot \beta}{\mu^2} \cdot L^3 \cdot (T_1 - T_2) \quad \text{(B.5)}$$

where

μ is the air dynamic viscosity (kg. $m^{-1}.s^{-1}$);

ρ is the air density $kg.m^{-3}$;

$$\beta = \frac{1}{T}; \quad \text{(B.6)}$$

β is the coefficient of thermal volumetric expansion in K^{-1};

g = 9,81 $m.s^{-2}$;

g is the acceleration due to gravity in $m.s^{-2}$;

For the air at 170 °C

$$Gr = 2{,}34 \times 10^7 . L^3 (T_1 - T_2) \quad \text{(B.7)}$$

B.2.3.3 Heat transmitted by radiation

$$\Phi_r = h_r .(H.D).(T_1 - T_2) \text{ in W} \quad \text{(B.8)}$$

where

h_r is the radiation coefficient in $W/(m^2.K)$;

Φ_r is the thermal flow transmitted by radiation in W.

$$h_r = \frac{4 \cdot \sigma \cdot T_m^3}{2 \cdot \left[1/\varepsilon - \frac{F_{12}}{1 + F_{12}} \right]} \quad \text{(B.9)}$$

where

T_m = $(T_1 + T_2)/2$;

T_m is the mean temperature in K;

σ is the Stefan-Boltzmann constant;

ε is the clay emissivity equal to 0,9;

F_{12} is the form factor of the face 1 towards face 2;

$X = H/L$;

$Y = D/L$.

$$F_{12} = \frac{2}{\pi \cdot X \cdot Y}\left\{\ln\left[\frac{(1+X^2)(1+Y^2)}{1+X^2+Y^2}\right]^{1/2} + X\sqrt{1+Y^2}\tan^{-1}\frac{X}{\sqrt{1+Y^2}} + Y\sqrt{1+X^2}\tan^{-1}\frac{Y}{\sqrt{1+X^2}} - X\tan^{-1}X - Y\tan^{-1}Y\right\} \quad \text{(B.10)}$$

B.2.3.4 Equivalent thermal conductivity

$$h = h_c + h_r \quad \text{(B.11)}$$

where

h is the overall thermal transfer coefficient in W/(m^2.K);

$\lambda_e = h.L.$

where

λ_e is the equivalent thermal conductivity of the cavity in W/(m.K).

The equivalent thermal conductivity of a non rectangular cavity is determined to be that of a rectangular cavity having the same area and dimension ratio, in accordance with EN ISO 6946.

B.2.4 Calculations

B.2.4.1 General

The calculation is made on a cross section perpendicular to the flue gas flow.

B.2.4.2 Numerical resolution

The result of the 2D numerical calculation is the heat flux (Φ) in Watt per meter of the height flue liner:

$$U_i = \frac{\Phi}{(T_i - T_e)\cdot p_i} \quad \text{(B.12)}$$

where

U_i is the internal thermal transmission coefficient in W/(m^2.K);

p_i is the internal perimeter of the flue liner in m.

$$R_i = \frac{1}{U_i} - \frac{1}{h_i} - \frac{1}{h_e}\cdot\left(\frac{p_i}{p_e}\right) \quad \text{(B.13)}$$

R_i is the internal thermal resistance of the flue liner in m^2.K/W;

p_e is the external perimeter of the flue liner in m.

B.3 Method Approximate thermal resistance values

Table B2 gives the approximate thermal resistance values for clay/ceramic flue liners.

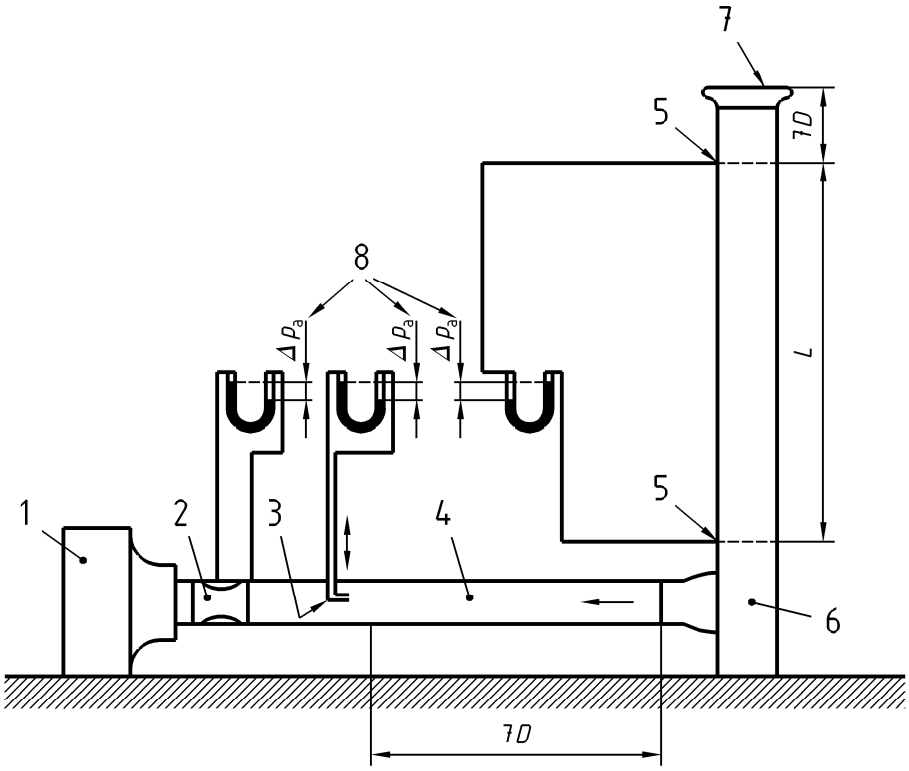
Table B.2 — Thermal resistance of clay/ceramic flue liners

Perforations	**Overall wall thickness** mm	**Insulation**	**R** $(m^2.K)/W$
Without	up to 50	without	0,05
With 1 row	up to 30	without	0,08
With 1 row	from 30 to 60	without	0,12
With 2 rows	from 60	without	0,2
With 1 row	from 30 to 60	added	0,46
With 2 rows	from 60	integrated	0,55

Annex C
(normative)

Measurement of the coefficient of friction of chimneys

Measurement of the coefficient of jointed flue liners shall be done using the measuring set up shown in Figure C.1.



Key

1 fan
2 measuring device
3 pressure manometer
4 test tube
5 static pressure manometer
6 test chimney
7 intake guide
8 differential pressure measurements

Figure C.1 — Roughness measuring rig

Measuring Procedure

Air is drawn in by a fan through the test length into a measuring pipe fixed at its end. The static pressure loss over a stated length is measured with an accuracy of 1 Pa. The air velocity in the test length can be measured by a measuring nozzle in terms of volume with an accuracy of ± 2,5 %.

The friction coefficient is calculated following the equation:

$$\psi = \frac{2 \times D_h \times \Delta p}{\rho \times w \times L}$$

where

ψ	coefficient of friction	-;
D_h	hydraulic diameter	in m;
Δp	pressure loss	in Pa;
ρ	density of air	in kg/m$^{3;}$
w	velocity of air	in m/s.

The mean roughness of the inner wall can be obtained by using the following equation:

$$\frac{1}{\sqrt{\psi}} = -2\log\left(\frac{2.51}{R_e\sqrt{\psi}} + \frac{\tau}{3.71 D_h}\right)$$

where

D_h	hydraulic diameter	in m;
τ	mean value of roughness of the inner wall	in m;
R_e	Reynolds number	-;
ψ	coefficient of friction of the flue	-.

For Reynolds numbers below 2 300 take the coefficient appropriate to the Reynolds coefficient equal of 2 300.

Annex ZA
(informative)

Clauses of this European Standard addressing the provisions of the EU Construction Products Directive

ZA.1 Scope and relevant characteristics

This European standard has been prepared under Mandate M/105 'Chimneys, flues and specific products' as amended by mandates M/117, M/130, M/442 and M/447 given to CEN by the European Commission and the European Free Trade Association.

The clauses of this European Standard shown in this annex meet the requirements of the mandates given under the EU Construction Products Directive (89/106/EEC).

Compliance with these clauses confers a presumption of fitness of the flue liners and fittings covered by this European Standard for their 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 use may be applicable to a construction product falling within the scope of this standard.

NOTE 1 In addition to any 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://ec.europa.eu/enterprise/construction/cpd-ds/ .

This annex establishes the conditions for the CE marking of the Clay ceramic flue liners intended for the uses indicated in Table ZA.1 and shows the relevant clauses applicable.

This annex has the same scope as the relevant part in Clause 1 of this standard related to the aspect covered by the mandate and is defined by Table ZA.1.

Table ZA.1 — Scope and relevant clauses

Construction product:	Straight or curved clay/ceramic flue liners (including flue pipes and fittings), with or without inspection openings, as covered in Clause 1 of this standard
Intended uses:	Chimneys

Performance characteristic	Requirement clauses in this standard	Mandated levels and/or classes	Notes
Gas tightness/leakage	9.2.2 Gas tightness/leakage after thermal shock testing	None	Pass/fail subject to a threshold value
Flow resistance	13 Flow resistance	None	Declared mean roughness (in metres)
Thermal resistance	14 Thermal resistance	None	Declared value of thermal resistance
Resistance to fire	9.2 Gas tightness/leakage after sootfire	G	Soot fire resistance class (non soot fire resistance products are classified O)
Compressive strength	8 Proof load	None	Declared load (subject to a threshold value)
Durability against Acid	10.1 Corrosion resistance	None	Pass/fail criteria subject to a threshold value
Durability against Freeze/Thaw	10.2 Freeze/Thaw resistance	None	Pass/fail criteria
Durability against Abrasion	12 Abrasion resistance	None	Pass/fail criteria subject to a threshold value
Durability: Condensate	13 Condensate resistance	None	Pass/fail criteria subject to a threshold value
Dangerous substances	ZA.1 Notes 1 and 2	None	As indicated in last paragraph and note in ZA:3, after example

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 Procedure of attestation of conformity of clay/ceramic flue liners and fittings

ZA.2.1 System of attestation of conformity

The system of attestation of conformity for clay/ceramic flue liners and fittings indicated in Table ZA.2, in accordance with the decision of the Commission 95/467/EC of 24 October 1995 (OJEU L 268 10.11.1995 p.29), as amended by the Commission Decisions 2001/596/EC of 8 January 2001 (doc. L209 page 33 of 2.8.2001) and 2002/592/EC of 15 July 2002 (doc. L192 page 57 of 20.7.2002), and as given in Annex III of the Mandate M/105, as amended, is shown in Table ZA.2 for the indicated intended use.

Table ZA.2 — Attestation of conformity system

Product	Intended use	Level or class *(Reaction to fire)*	Attestation of conformity system
Flue liners (elements and blocks)	Chimneys	Any	2+
System 2+: See CPD Annex III.2.(ii), First possibility, including certification of the factory production control by an approved body on the basis of its continuous surveillance, assessment and approval.			

The evaluation of conformity of the products in Table ZA.1 shall be based on the evaluation of conformity procedure resulting from the clauses of this EN indicated in Table ZA.3.

Table ZA.3 — Assignment of evaluation of conformity tasks

Tasks			Content of the task	Clauses to apply
Tasks for the manufacturer	Factory production control (FPC)		Parameters related to EC of Table ZA.1 relevant for the intended use which are declared	15.4 and Annex A
	Initial type testing		All characteristics of Table ZA.1	15.2
	Further testing of samples taken at factory according to the prescribed test plan		EC of Table ZA.1 relevant for the intended use which are declared	15.3
Tasks for the notified body	Certification of FPC on the basis of	Initial inspection of factory and of FPC	Parameters related to EC of Table ZA.1, relevant for the intended uses which are declared i.e. compressive strength. Documentation of the FPC	15.4
		Continuous surveillance, assessment and approval of FPC		15.3 ,15.4 and Annex A

ZA.2.2 EC Certificate and Declaration of conformity

When compliance with the conditions of this Annex is achieved, and once the notified body has drawn up the certificate mentioned below, the manufacturer or his agent established in the EEA shall prepare and retain a 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 the 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, ...), 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 EN 1457-2:2012);

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

— the number of the accompanying factory production control certificate;

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

The declaration shall be accompanied by a factory production control certificate, drawn up by the notified body, which shall contain, in addition to the information above, the following:

— name and address of the notified body;

— the number of the factory production control certificate;

— conditions of validity of the certificate, where applicable;

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

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.

ZA.3 CE Marking and labelling

The manufacturer or his authorised representative established within the EU or EFTA is responsible for the affixing of the CE marking.

The CE conformity symbol to affix shall be in accordance with 93/68/EEC together with the identification number of the notified body, as well as the name or identifying mark of the producer and the product designation, and shall be shown on at least 20 % of the flue liners or fittings in each consignment.

In addition, the CE marking shall appear on the packaging and/or on the accompanying documents, together with the following information:

— identification number of the notified body;

— name or identifying mark of the producer;

— the last two digits of the year in which the marking is affixed;

— registered address of the producer;

— number of the certificate of the factory production control;

— reference to this European Standard;

— description of the product: product type (e.g. A1N2);

— information on the relevant essential characteristics in Table ZA.1, expressed as:

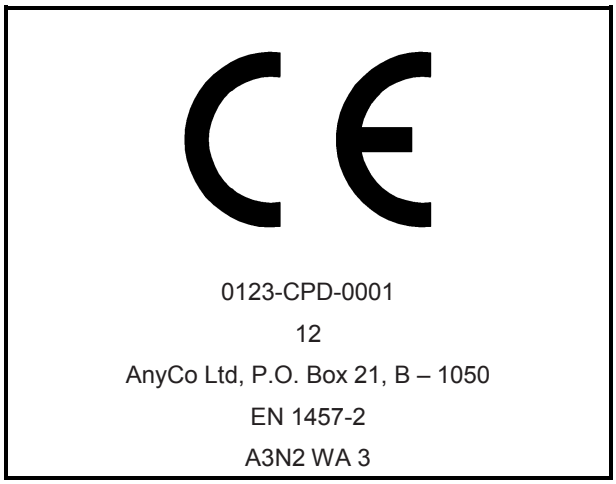
— values presented as standard designation(s) see Clause 17;

— values and, where relevant, level to declare for each essential characteristic not included in the designation as indicated in "Notes" in Table ZA.1;

— the “No performance determined” (NPD) option where relevant.

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.

Figure ZA.1 and Figure ZA.2 give a example of the information to be given on the product, packaging and/or accompanying documents.



CE conformity marking consisting of the ‘CE’ symbol given in directive 93/68/EC

Identification number of the notified body

Last two digits of year of affixing of CE marking

Name or identifying mark and registered address of the producer

Number of European Standard

and appropriate designation according to Clause 17

Figure ZA.1 — Example of CE marking on the product

Other information defined in ZA.3 and not given with Figure ZA.1 shall be given in the accompanying documents.

CE	CE conformity marking consisting of the 'CE' symbol given in Directive 93/68/EC
0123-CPD-0001	Identification number of the notified body
12	Last two digits of year of affixing of CE marking
AnyCo Ltd, P.O. Box 21, B – 1050 1234	Name or identifying mark and registered address of the producer Number of FPC certificate
EN 1457-2 2012	Number of European Standard with the date of the version
Clay/ceramic flue liner A3 N2 Flow resistance: - Mean roughness .....0.0015 m Resistance to fire .....G Compressive strength 10 MN/m^2 Thermal resistance ..... .0,07 m^2K/W Durability: - Corrosion resistance .....3 % - Freeze/Thaw resistance .....NPD - Abrasion resistance .....PASS - Condensate resistance .....W	Definition of the product and appropriate designation according to Clause 17 Information on mandated characteristics (those not included in the designation) or threshold values to be given (see Table ZA.1)

Figure ZA.2 — Example of CE marking information in the accompanying documents

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 1457-1, *Chimney — Clay/ceramic flue liners — Part 1: Flue liners operating under dry conditions — Requirements and test methods*

[2] EN 45012, *General requirements for bodies operating assessment and certification/registration of quality systems (ISO/IEC Guide 62:1996)*

[3] EN ISO 9001:2008, *Quality management systems — Requirements (ISO 9001:2008)*

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