BS EN 13084-6:2015

BSI Standards Publication

Free-standing chimneys

Part 6: Steel liners — Design and execution

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National foreword

This British Standard is the UK implementation of EN 13084-6:2015. It supersedes BS EN 13084-6:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/506/14, Structural Chimneys and Flues.

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Contents

Page

European foreword

This document (EN 13084-6:2015) has been prepared by Technical Committee CEN/TC 297 "Free-standing industrial chimneys", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2016, and conflicting national standards shall be withdrawn at the latest by May 2016.

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 13084-6:2004.

This European Standard is part one of the package of standards listed below:

— EN 13084-1, *Free-standing industrial chimneys – Part 1: General requirements.*

— EN 13084-2, *Free-standing chimneys – Part 2: Concrete chimneys.*

— EN 13084-4, *Free-standing chimneys – Part 4: Brick liners – Design and execution.*

— EN 13084-5, *Free-standing chimneys – Part 5: Material for brick liners – Product specifications*

— EN 13084-6, *Free-standing chimneys – Part 6: Steel liners – Design and execution*

— EN 13084-7, *Free-standing chimneys – Part 7: Product specifications of cylindrical steel fabrications for use in single wall steel chimneys and steel liners*

— EN 13084-8, *Free-standing chimneys – Part 8: Design and execution of mast construction with satellite components*

— EN 1993-3-2, *Eurocode 3: Design of steel structures – Part 3-2: Towers, masts and chimneys – Chimneys.*

The main changes compared to the previous edition are:

a) all normative references were updated;

b) The reference in 6.1.3 was corrected to EN 1991-1-4:2005, 7.2.9.

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1 Scope

This document deals with special requirements and performance criteria for the design of lining systems made of steel for free standing chimneys. It specifies the requirements for cylindrical steel liners as stated in EN 13084-1.

This document covers the design of the following three basic types of liners located in a load bearing structure:

a) base supported liner;

b) sectional liner;

c) top hung liner.

Additionally this document applies to single wall chimneys whose surface is in contact with flue gases.

Liners built from prefabricated metal chimneys in accordance with EN 1856-1 and EN 1856-2 are installed as base supported liners with additional supports and guides as defined in this document.

2 Normative references

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

EN 1443, *Chimneys — General requirements*

EN 1856-1, *Chimneys — Requirements for metal chimneys — Part 1: System chimney products*

EN 1856-2, *Chimneys — Requirements for metal chimneys — Part 2: Metal flue liners and connecting flue pipes*

EN 1859:2009+A1:2013, *Chimneys — Metal chimneys — Test methods*

EN 1991-1-4:2005, *Eurocode 1: Actions on structures — Part 1-4: General actions — Wind actions*

EN 1993-1-6, *Eurocode 3 — Design of steel structures — Part 1-6: Strength and Stability of Shell Structures*

EN 1993-3-2:2006, *Eurocode 3 — Design of steel structures — Part 3-2: Towers, masts and chimneys — Chimneys*

EN 10028 (all parts), *Flat products made of steels for pressure purposes*

EN 10088 (all parts), *Stainless steels*

EN 10095, *Heat resisting steels and nickel alloys*

EN 13084-1:2007, *Free-standing chimneys — Part 1: General requirements*

EN 13084-7:2012, *Free-standing chimneys — Part 7: Product specifications of cylindrical steel fabrications for use in single wall steel chimneys and steel liners*

EN 62305-1, *Protection against lightning — Part 1: General principles (IEC 62305-1)*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 13084-1:2007 and the following, apply.

3.1
base supported liner
liner which is supported vertically only at the liner base

3.2
independent liner
base supported liner which has no other horizontal support or restraint

3.3
guided liner
liner which has horizontal supports and/or guides allowing free expansion

3.4
top hung liner
liner which is supported vertically at or near the top

3.5
sectional steel liner
liner with at least two independent vertically supported sections

3.6
liner support
load bearing component which supports the liner

3.7
duct entry
part of the liner which introduces the flue gases into the liner

3.8
gas flow
mass or volume of gas through the liner per unit of time

3.9
single wall chimney
liner which also is bearing wind or seismic actions

3.10
turning vanes
plates to lead the flue gas in another direction

3.11
prefabricated metal chimneys
prefabricated metal chimneys or liners in accordance with EN 1856-1 and EN 1856-2

4 Material

4.1 General

Materials used, shall be based upon chemical, thermal and mechanical effects and shall fulfil the requirements of EN 13084-1 and EN 1993-3-2.

Materials used shall not have a negative influence upon each other.

If prefabricated metal chimneys are used the additional requirements of this document shall be fulfilled.

4.2 Steels

Steels commonly used are given in EN 13084-7.

Other steels shall meet the requirements of EN 1993-3-2 and EN 13084-1.

5 General design requirements

5.1 General

Gas flow calculations to determine the diameter of the liner are covered by EN 13084-1. Material expansion due to temperature shall be taken into account. For steel liners and prefabricated metal chimneys the class of chemical attack shall be in accordance with EN 13084-1.

5.2 Liner

The liner shall be designed in such a way that it is able to take the actions caused by:

— permanent action;

— pressure;

— temperature;

— the interaction with the supporting and guiding system;

— construction, transport and erection.

The expansion shall be based upon the temperature, and length or diameter of the liner.

For prefabricated metal chimneys the free movement of the liner shall be guaranteed.

5.3 Liner details

5.3.1 Supports and/or guides

Supports and/or guides shall be designed in such a manner that they are able to take the actions caused by:

— the lining system;

— the load bearing system;

— thermal transfer;

— construction, transport and erection.

For prefabricated metal chimneys the distance between horizontal supports shall not exceed 75 % of the manufacturers declared value as defined in EN 1856-1 and EN 1856-2 with a maximum of 3,0 m. Their free unsupported height above the last support shall not exceed 66 % of the manufacturers declared value as defined in EN 1856-1 and EN 1856-2 with a maximum of 2,0 m.

5.3.2 Openings

Where openings are cut into the liner, as for duct entries, instrumentation or inspection panels, the strength and the stability shall be verified including any imposed loads.

Openings in the liner shall have corners radiussed. See 6.3 for details.

If prefabricated metal chimneys are not able to fulfil the given criteria in 6.3 a welded inlet construction can be used according to the requirements of this document and EN 13084-7. The connection between the welded inlet construction and prefabricated metal chimney part shall be gas tight according to the class of the liner.

The size of openings shall be dimensioned according to their use.

Manholes shall have a minimum area of 0,28 m^2 and a minimum width of 0,45 m.

Cleaning and inspection openings shall be provided so that the bottom of the liner may be inspected and cleaned when necessary.

If openings are enclosed within the windshield they shall be to the same standard of gas tightness as the liner itself.

If a ventilated space is provided there shall be adequate provision for the inspection of this space.

5.3.3 Drainage system

Adequate means shall be provided to drain condensate.

The drainage system shall be dimensioned and fitted according to the operating conditions.

This code does not cover the removal and disposal of condensate or waste products from the termination point of the drainage system fitted by the chimney manufacturer. It should be noted that the condensate and waste products should not be allowed to freeze, nor cold air bleed back into the liner.

5.3.4 Seals, gaskets and jointing compounds

If seals, gaskets or jointing compounds are used their influence on the structure shall be considered.

5.3.5 Expansion joints

Expansion joints shall be designed to withstand movements due to thermal expansion, chimney and foundation movement, design pressures and flue gas composition in appropriate combinations.

Expansion joints shall be to the same standard of gas tightness as the liner itself.

5.3.6 Chimney cap

The chimney cap protects the space between liner(s) and windshield against the ingress of weather and flue gas.

Consideration shall also be given to the effects of chemical attack.

5.3.7 Insulation

Deviating from EN 13084-1:2007, 4.3.2, the insulation and/or cladding shall be sufficient to ensure that under normal operating conditions the surface temperature, not including solar gain, does not exceed 50 °C at an ambient temperature of 15 °C where personnel protection is required.

Insulation shall be adequately supported to stop it slipping and/or sagging. This can be achieved by pinning and/or banding.

Where insulation is not covered by cladding, it shall be covered with wire mesh, or cloth, or aluminium, foil etc.

Insulation shall be applied in such a manner as to minimise any gaps at the joints.

The influence of heat bridges on the liner system shall be taken into account.

5.3.8 Cladding

External cladding shall be designed, manufactured and fitted to allow for differentials in thermal expansion and to prevent the ingress of weather.

Cladding shall be adequately supported and fixed by riveting, screwing or other adequate means.

5.3.9 Internal protection

Internal protection, (such as refractory, insulation and cladding) may be required for one or more of the following reasons:

a) protection against chemical attack;

b) protection against high temperatures;

c) protection against internal fire.

Specialist advice should be sought when selecting and applying internal protection.

5.3.10 Lightning protection

Lightning protection shall be in accordance with EN 13084-1 and EN 62305-1.

5.4 Gas tightness

The gas tightness class shall be specified in accordance with Table 1.

If the gas tightness class is not specified class H0 shall be used.

Table 1 — Gas tightness

Class	Rate of leakage $l\ s^{-1}\ m^{-2}$	Test pressure Pa	Comments	Maximum operating pressure Pa	Note
H0	0,000	5 000	No ventilated space necessary	According to design	-
H1	0,006	5 000	Ventilated space necessary	1 000	See EN 1443
H2	0,120	5 000	Not to be used in free-standing chimneys	-	See EN 1443
P1	0,006	200	Ventilated space necessary	40	See EN 1443
P2	0,120	200	Not to be used in free-standing chimneys	-	See EN 1443
N1	2,0	40	Not to be used in free-standing chimneys	-	See EN 1443
N2	3,0	20	Not to be used in free-standing chimneys	-	See EN 1443

NOTE 1 If a ventilated space is necessary then its efficiency will be verified by thermal and flow calculations. It is essential to prove that the ventilated flow is a minimum of 20 times the leakage rate shown in the table. The minimum width of the ventilated space needs to be 50 mm.

NOTE 2 If the inner surface of the windshield has a protective coating or is designed in accordance with EN 13084-7:2012, Table 4, then the maximum operating pressure can be increased by a factor of 2,5 however the test pressure and rate of leakage remain as shown in the table.

Class H0 can be achieved by the following means without the need of testing:

— seal welded joints;

— bolted joints with a maximum bolt spacing of 5 times the bolt diameter, a minimum flange thickness of 1,0 times the bolt diameter and a jointing compound.

If a jointing compound is used it shall be suitable for the liner design conditions at ambient and the design temperature.

Gaskets shall not be used, in structural joints unless specifically designed for the purpose.

5.5 Temperature classes

The temperature class shall be specified.

For temperature classes see EN 13084-7:2012, Table 5.

6 Structural design

6.1 Actions

6.1.1 General

Actions shall be calculated in accordance with EN 13084-1.

6.1.2 Permanent action

The permanent action is the weight of the liner and the weight of all components fitted to it.

Precautions due to long term adhesion of ash and dust to the liner and dislodged material falling to the bottom shall be taken into consideration.

6.1.3 Wind actions

Actions on the liner due to the deflection of the load bearing system shall be taken into consideration.

If the liner extends above the windshield the calculations shall include the wind actions due to this.

Wind suction in accordance with EN 1991-1-4:2005, 7.2.9, shall be taken into consideration.

6.1.4 Thermal actions

6.1.4.1 General

To calculate thermal effects see EN 13084-1.

Thermal actions shall be checked for all combinations of flue gas from the duct entry based on design conditions.

Due to differential temperatures in the flue gas, the liner can have a complex deformation with increasing stresses in the material especially at the duct entry. If the construction is not able to resist the stresses, the following changes can be made:

a) mixing the flue gases before the duct entry to minimise temperature differentials;

b) diverting flue gases into separate liners;

c) using special construction details to minimise stresses based on temperature;

If turning vanes or dividing plates are used to reduce the pressure drop, they will also reduce the mixing of flue gases.

6.1.4.2 Temperature difference

In the absence of clear information the liner shall be designed for a temperature of the liner internal surface which varies linearly around the circumference as shown in Figure 1. ΔT shall be taken as the lowest value of Formulae (1) or (2).

$$\Delta T = 0{,}1\ T_{\max} \text{ but at least } \Delta T = 15 \text{ K} \tag{1}$$

$$\Delta T = \Delta T' \frac{\pi}{2} D \tag{2}$$

where

T_{max} is the maximum internal surface temperature based on the design gas temperature, in °C;

$\Delta T'$ is the circumferential temperature gradient, in K/m

$$\Delta T' = 4 \frac{T_{\max}}{150} \text{ but at least } \Delta T = 4{,}0 \text{ K/m} \tag{3}$$

D is the diameter, in m.

In the case of flue gases with different temperatures, higher values of ΔT may occur. Informative Annex A gives one method of calculation.

The variation of the temperature differential over the height of the liner from the bottom of the duct entry to the top may be calculated according to informative Annex A.

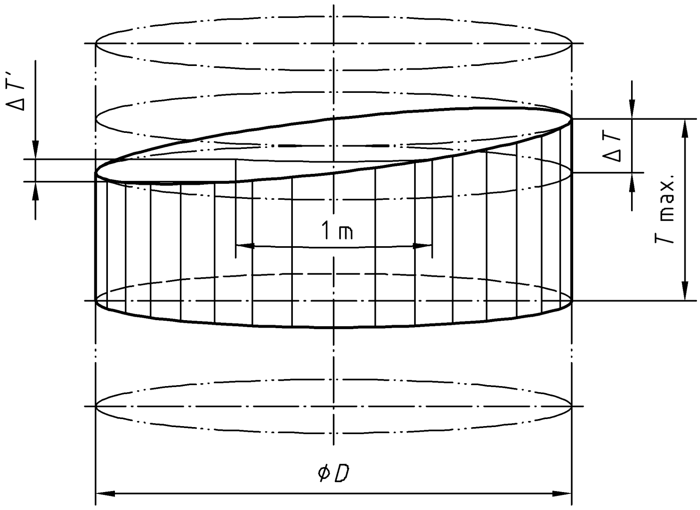

Figure 1 — Linear temperature differential

6.1.4.3 Soot fire

The action of a soot fire is considered to be of a short-term duration. To meet the requirements of this characteristic the designer will specify which one of the following three criteria shall be met:

a) testing in accordance with EN 1859:2009+A1:2013, 4.5.3.2.

b) thermal calculation in accordance with EN 13084-1 using the conditions given below.

c) manufacture to the four following minimum conditions:

- liner with a load bearing outer shell;
- liner made of steel according to EN 10028, EN 10088 or EN 10095 as given in Table 1, with a minimum corroded thickness of 1,5 mm;
- the liner insulated with mineral wool of 50 mm thickness. The mineral wool shall be resistant up to 650 °C and shall have a density of at least 80 kg/m^3 and be covered with wire mesh;
- a 30 mm minimum airspace between the insulation and the outer shell.

If soot fire resistance is calculated according to b), the temperature of the flue gas shall increase within 10 min from 20 °C up to 1 000 °C. The time assumed for this higher temperature shall be 30 min. The temperature of the outer surface of the flue shall not be higher than 80 °C.

6.1.5 Internal pressure at design conditions

To calculate internal pressure actions see EN 13084-1:2007, Annex A.

Additional internal pressure actions can occur due to a sudden interruption and/or pulsation of the flue gas stream. The client is obliged to report the possibility of these actions occurring.

If flue gas pulsation does occur the client should be advised, to investigate the cause and effects.

6.2 Verification

6.2.1 General

The effects of actions in both horizontal and vertical sections of the liner shall be calculated according to EN 1993-3-2.

Liners not affected directly by wind loads shall be designed to the reliability class "1" in accordance with EN 1993-3-2.

6.2.2 Mechanical characteristics

Yield stress shall be in accordance with EN 13084-7:2012, Table 1.

Elastic-Modulus shall be in accordance with EN 13084-7:2012, Table 2.

For thermal expansion coefficients see EN 13084-7:2012, Table 3.

6.3 Openings in the liner

Corners of openings in the liner shall be radiused in accordance with Table 2.

Table 2— Minimum radius of corners of openings in liner

<table>
<tr><td rowspan="2">The maximum design stress (bending or fatigue) is</td><td>> 75 %</td><td>> 50 %</td><td>> 35 %</td><td>> 10 %</td><td>≤ 10 %</td></tr>
<tr><td colspan="5">of the maximum allowable stress</td></tr>
<tr><td rowspan="2">Minimum radius R of the corners
The higher value shall prevail</td><td>10 t</td><td>8 t</td><td>5 t</td><td>2 t</td><td>-</td></tr>
<tr><td colspan="4">10 mm</td><td>5 mm</td></tr>
<tr><td colspan="6">t = wall thickness of the liner</td></tr>
</table>

7 Construction

7.1 Tolerances

The permitted fabrication tolerances for the shell in accordance with EN 1993-3-2 and EN 1993-1-6 shall be given by the designer.

Other fabrication tolerances for welded constructions given in EN ISO 13920 should be agreed with the client.

7.2 Surface protection against chemical attack

The exterior and interior surfaces of a steel liner may be protected from environmental influences and corrosive gases by various methods: coatings, metallic layer, corrosion allowance, refractory, cladding, selection of non-corroding materials etc.

The method of protection shall be specified based on prior knowledge or specialist advice.

For the corrosion allowance of surfaces in contact with flue gases (internal corrosion), see EN 13084-7:2012, Table 4.

For external corrosion allowances see EN 1993-3-2:2006, Table 4.1.

Annex A
(informative)

Calculation method for combined flue gases with different temperatures

The determination of the variation of temperature differential over the liner height and circumference is a very complex problem. In absence of exact methods, the following approximation may be used (see Figure A.1):

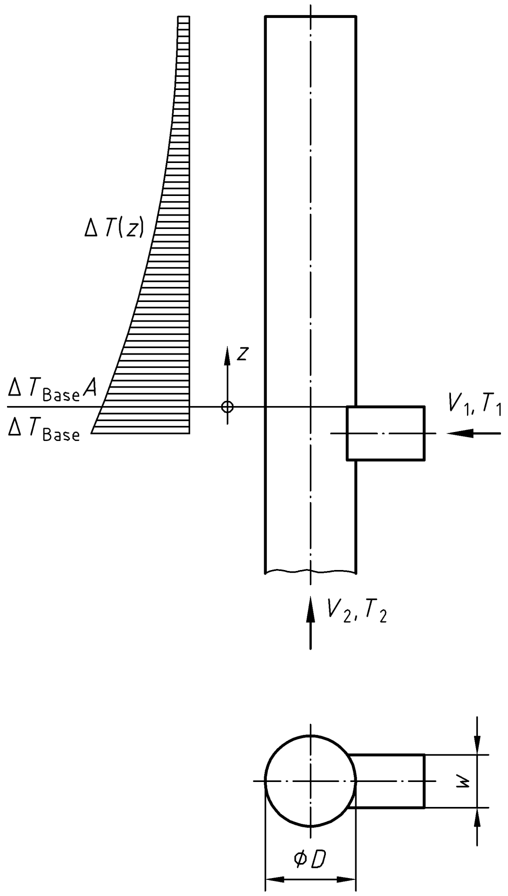

Figure A.1 — Variation of temperature difference over the height of the liner

The variation of the temperature differential ΔT(z) over the height of the liner may be determined using the Formula (A.1):

$$\Delta T(z) = \Delta T_{\mathrm{Base}} \cdot A \cdot e^{(-\mathrm{B\,K\,z/D})} \qquad \text{(A.1)}$$

where

ΔT_{Base} is the absolute value of the maximum temperature difference of all of the flows;

$\Delta T_{\mathrm{Base}} = |T_1 - T_2|$ but the minimum value of ΔT according to Formula (1) or (2) respectively;

A is the heat transfer correction parameter according to Table A.1;

B is the volume parameter according to Table A.2;

K is the duct width parameter according to Table A.3 depending on the duct width ratio D / w;

z is the height above top of duct entry;

D is the diameter of the liner;

d is the width of the duct entry;

V_1, V_2 is the volume of flow 1 and flow 2 respectively;

T_1, T_2 is the temperature of flow 1 and flow 2 respectively.

Formula (A.1) also may also be used for one flow. Therefore the following values should be used:

ΔT_{Base} = minimum value of ΔT according to Formula (1) and (2)

$V_1 / V_2 = 1$

Table A.1 — Heat transfer correction parameter *A*

ΔT_{Base} K	**Heat transfer correction parameter** *A*
0	1,00
50	0,96
100	0,92
150	0,86
200	0,79
250	0,74
300	0,69
350	0,65
400	0,62

The heat transfer correction parameter *A* may be determined with the following formula:

$$A = 1 - 5{,}792 \times 10^{-4} \times \Delta T_{\mathrm{Base}} - 3{,}392 \times 10^{-6} \times \Delta T_{\mathrm{Base}}^2 + 6{,}195 \times 10^{-9} \times \Delta T_{\mathrm{Base}}^3 \quad (A.2)$$

Table A.2 — Volume parameter *B*

Volume flow ratio V_1 / V_2	**Volume parameter** *B*
1,0	0,40
0,8	0,48
0,6	0,57
0,4	0,65

The volume parameter *B* may be determined with the following formula:

$$B = 0{,}82 - 0{,}42 \times V_1 / V_2 \quad (A.3)$$

Table A.3 — Duct width parameter *K*

Duct width ratio D/d	**Duct width parameter** K
1,0	1,00
1,2	1,03
1,4	1,07
1,6	1,10
1,8	1,13
2,0	1,17
2,2	1,20

The duct width parameter K may be determined with the following formula:

$$K = 0{,}832 + 0{,}168 \times D / d \qquad \text{(A.4)}$$

Bibliography

[1] EN ISO 13920, *Welding — General tolerances for welded constructions — Dimensions for lengths and angles — Shape and position (ISO 13920)*

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