BRITISH STANDARD

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13084-8:2005

Free-standing industrial chimneys —

Part 8: Design and execution of mast construction with satellite components

The European Standard EN 13084-8:2005 has the status of a British Standard

ICS 91.060.40

National foreword

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The UK participation in its preparation was entrusted by Technical Committee B/525, Building And Civil Engineering Structures, to Subcommittee B/525/13, Structural Chimneys And Flues, which has the responsibility to:

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Summary of pages

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Free-standing industrial chimneys - Part 8: Design and execution of mast construction with satellite components

Cheminées auto-portantes - Partie 8: Conception et mise en oeuvre des mâts intégrant des conduits systèmes métalliques

Freistehende Schornsteine - Teil 8: Planung und Ausführung von Tragmastkonstruktionen mit angehängten Abgasanlagen

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Contents

Foreword

This document (EN 13084-8:2005) 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of an identical text or by endorsement, at the latest by October 2005, and conflicting national standards shall be withdrawn at the latest by October 2005.

This European Standard is part 8 of the package of standards listed below:

— EN 13084-1, *Free-standing 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*

Additionally applies:

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

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1 Scope

This document describes the method of specifying the design criteria and the installation method for a free-standing mast with satellite pipes using welded pipes in accordance with prEN 13084-7 or using prefabricated metal chimney elements in accordance with Table D.1 of EN 1856-1:2003.

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 1443:2003, *Chimneys - General requirements*

EN 1856-1:2003, *Chimneys - Requirements for metal chimneys - Part 1: System chimney products*

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

EN 1859:2000, *Chimneys - Metal chimneys - Test methods*

EN 1990, *Eurocode: Basis of structural design*

ENV 1991-2-4, *Eurocode 1: Basis of design and actions on structures - Part 2-4: Actions on structures - Wind actions*

ENV 1993-3-1, *Eurocode 3: Design of steel structures - Part 3-1: Towers, masts and chimneys - Towers and masts*

ENV 1993-3-2:1997, *Eurocode 3: Design of steel structures - Part 3.2: Towers, masts and chimneys - Chimneys*

EN 13084-1:2000, *Free-standing industrial chimneys - Part 1: General requirements*

EN 13084-6:2004, *Free-standing chimneys - Part 6: Steel liners – Design and execution*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1443:2003, EN 1856-1:2003, EN 1859:2000 EN 13084-1:2000, EN 13084-6:2004, and the following apply.

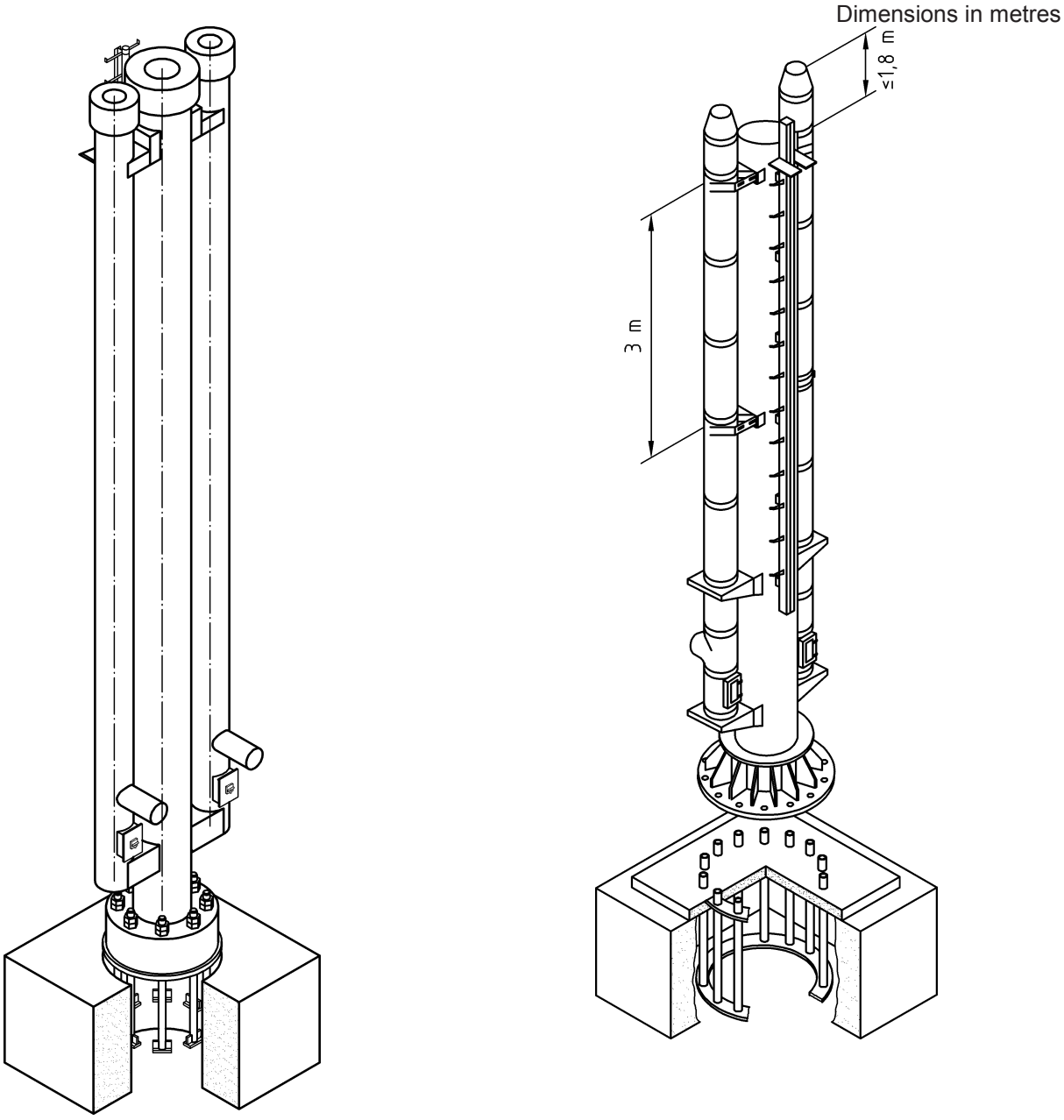
3.1
support mast construction
free-standing steel construction of a support mast and one or more attached satellite pipes (see Figure 1)

3.2
support mast
component manufactured from a hollow-section or profile-cross-section which is free-standing, supported by guy wires or a building to which are attached the satellite pipes (see Figure 1)

3.3
satellite pipe
component attached to the outside of the support mast carrying the flue gases (see Figure 1)

3.4
fixing band
fixed structural attachment between the support mast and satellite pipes to take the horizontal loads (see Figure 1)

3.5
guide
structural attachment between the support mast and satellite pipes which provides lateral support but also allows vertical movement of the satellite pipe (see Figure 1)



a) construction using welded pipes in accordance with prEN 13084-7

b) construction using prefabricated metal-chimneys elements in accordance with Table D.1 of EN 1856-1:2003

Figure 1 — Examples of support mast construction with attached satellite pipes

4 Requirements for components

4.1 Support mast

Design, materials and construction of the support mast shall comply with ENV 1993-3-1 and ENV 1993-3-2.

The steel construction shall be protected against corrosion in accordance with ENV 1993-3-1 and ENV 1993-3-2.

4.2 Satellite pipes

Welded pipes shall comply with prEN 13084-7.

Prefabricated metal chimneys elements for satellite pipes shall comply with EN 1856-1.

5 General design and structural design

5.1 General design

5.1.1 General

The inner diameter of satellite pipes shall be calculated in accordance with Annex A of EN 13084-1:2000. Up to a height of 20 m EN 13384-1 may be used.

The satellite pipes shall be attached to the mast without any offset.

Each satellite pipe shall be fitted with a cleaning door and drain point connection.

Each satellite pipe shall have only elements of the same type of pipe and same inner diameter.

The outer surface temperature shall conform with that stated in EN 13084-6.

Construction shall inhibit contact corrosion between different materials.

Bolted connections shall have a minimum bolt size of M 12.

5.1.2 Welded pipes

For welded satellite pipes the distance between the fixing bands/guides to the support mast and the length of free pipe above the last support/guide shall be defined by static calculation.

5.1.3 Prefabricated metal chimney elements

The maximum height of the complete construction with prefabricated metal chimney elements designed in accordance with EN 1856-1 shall not exceed 30 m above ground level.

The connection of prefabricated elements to the mast should be placed close to the joints of the elements and close the connecting tee and inspection element. The fixing bands or guides designed by manufacturer of the satellite pipe shall be used.

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 (maximum 1,5 m if no wind load test results from tests according to EN 1859 are available). 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 (maximum 1,0 m if no wind load test results from tests according to EN 1859 are available).

The maximum vertical unsupported height shall be declared by the manufacturer of the prefabricated metal chimney elements. Where necessary additional intermediate support shall be installed.

5.2 Structural design

5.2.1 General

The basic design principles of EN 1990 shall apply. Calculation shall be undertaken for each assembly or design type.

The mast with attached satellite pipes shall be designed in their final state as well during construction phases in accordance with ENV 1993-3-1 and ENV 1993-3-2.

The attached satellite pipes shall be designed in accordance with EN 13084-6 and prEN 13084-7. Prefabricated metal chimney elements shall comply with the requirements of EN 1856-1 and be certified for the intended use.

5.2.2 Actions

5.2.2.1 General

EN 13084-1 applies.

The action of wind shall be calculated with the enveloping diameter D (see Figure 1 of Annex A.1).

5.2.2.2 Wind actions in the direction of the wind

Wind actions on the support mast construction in the direction of the wind shall be calculated in accordance with ENV 1991-2-4.

An aerodynamic force coefficient of c_f = 1,2 shall be used if no other value can be proven.

For attached satellite pipes the aerodynamic force coefficient c_f = 1,5 shall be used. If for prefabricated metal chimney elements the 3-second-wind-speed at top of the construction is more than 30 m/s additional evidence is required for the use of elements according to EN 1856-1 as they are tested according to EN 1859 with a maximum load of 1,5 kN/m^2.

The gust reaction factor φ_B shall be calculated using a logarithmic damping decrement of δ_B=0,1.

5.2.2.3 Vortex excitation

Wind induced vibrations due to vortex excitation shall be calculated in accordance with A.1 of Annex A.

5.2.2.4 Classical galloping

The stability of the support mast construction against classical galloping vibration has to be proved in accordance with A.2 of Annex A.

6 Installation requirements

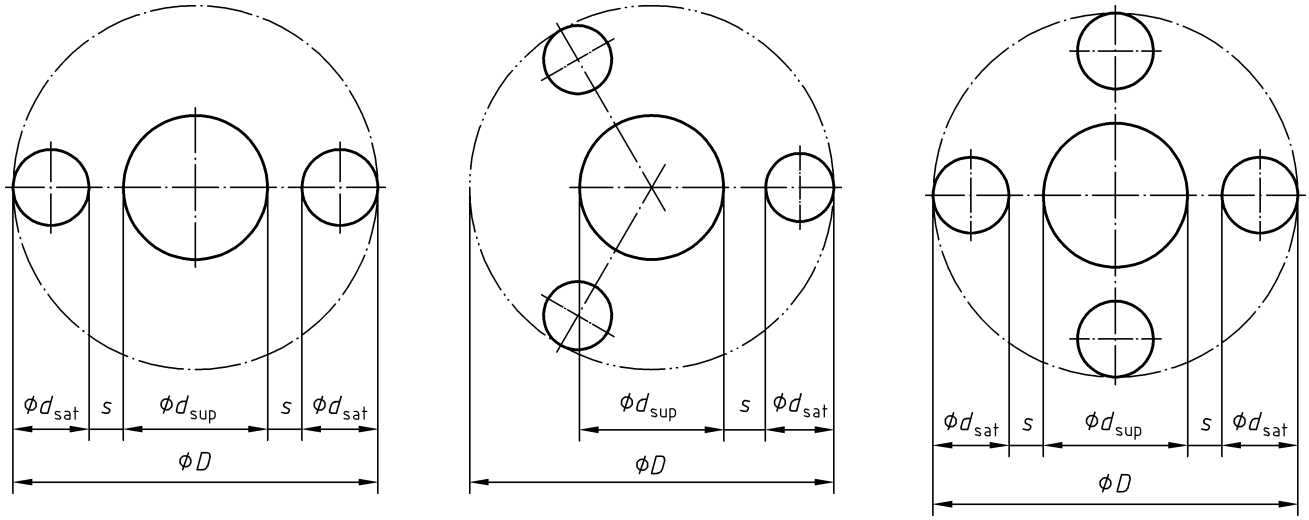
For site activities reference shall be made to ENV 1993-3-2 and EN 13084-1.

Manufacturers' installation instructions shall be taken into account when using prefabricated metal chimney elements.

Annex A
(normative)

Methods for calculating cross-wind vibrations

A.1 Examples for the definition of the enveloping diameter



a) two satellite pipes b) three satellite pipes c) four satellite pipes

Key
d_{sat} Outer diameter of satellite pipes
s Gap between support mast and satellite pipe
d_{sup} Outer diameter of support mast
D The enveloping diameter of the complete installation

Figure A.1 — Definition of the enveloping diameter (D)

A.2 Vortex excitation

A.2.1 Critical wind velocity

The critical wind velocity v_{crit} , at which the frequency of vortex excitation equals the natural frequency of the whole support mast construction is given by

$$v_{crit} = \frac{f_e \cdot D}{St} \tag{A.1}$$

where

f_e is the natural frequency of first bending mode of the whole support mast construction

St is the Strouhal number according to Equation (A.8)

Resonant critical conditions cannot occur if:

$$v_{crit} > 1{,}25 \cdot v_m(z)$$

where

$v_m(z)$ is the mean wind velocity as defined in ENV 1991-2-4, calculated at the height z of the centre of the effective correlation length, where the vortex excitation occurs.

A.2.2 Determination of maximum oscillation amplitude ratio

The maximum oscillation amplitude ratio, max y_F/D, occurring at critical wind speed, shall be calculated as follows:

$$\frac{\max y_F}{D} = \frac{\varepsilon \cdot a}{\frac{Sc}{K}\frac{St^2}{K_W}} \quad \text{shall only be applied if max } y_F/D \le 0{,}3 \tag{A.2}$$

NOTE The simplified equations are based on linearization of aerodynamic values for vortex exited vibration amplitudes. There are limitations to these results.

With small amplitudes (max $y_F/D \le 0{,}1$) the values are overestimated and if max $y_F/D \ge 0{,}3$ the values may be underestimated.

Values of max $y_F/D \ge 0{,}3$ indicate that the structure could be unstable and measures such as increasing the damping or distance between the mast and flue gas pipe shall be considered.

where

max y_F is the maximum oscillation amplitude (calculated value for horizontal displacement)

ε is the slenderness-dependent reduction factor according to Equations A.3 to A.5

$$\varepsilon = 0 \qquad \text{for } \frac{h_F}{D} \le 7{,}1 \tag{A.3}$$

$$\varepsilon = -0{,}085 + 4{,}6 \cdot 10^{-6} \cdot \left(\frac{h_F}{D}\right)^5 \qquad \text{for } 7{,}1 < \frac{h_F}{D} < 11{,}9 \tag{A.4}$$

$$\varepsilon = 1{,}0 \qquad \text{for } \frac{h_F}{D} \ge 11{,}9 \tag{A.5}$$

h_F is the overall height

a is the parameter according to Table A.1

Sc is the Scruton number

$$Sc = \frac{2 \cdot m \cdot \delta}{\rho \cdot D^2} \tag{A.6}$$

m is the equivalent mass per length unit of the whole support mast construction according to ENV 1991-2-4. For simplification the mean mass per length unit in the upper third, including all attached components, may be used

δ is the logarithmic decrement of structural damping of the whole support mast construction

The logarithmic damping decrement shall be used as

$$\delta = \delta_{sup} + \sum_{i=1}^{n} \Delta\delta_{sat}(i) \tag{A.7}$$

The damping decrement δ_{sup} of a welded or preloaded high strength bolted support mast shall be assumed as δ_{sup} = 0,015.

For welded pipes the type of connection of satellite pipes to the support mast will decide the logarithmic damping decrement $\Delta\delta_{sat}$. Specialist advice should be sought.

For prefabricated metal chimney elements, the type of connection between the elements will decide the logarithmic damping decrement. The following values may be assumed:

— satellite pipes with positive-locking connections between elements $\Delta\delta_{sat}$ = 0,006

— satellite pipes with connections actuated by adherence between elements $\Delta\delta_{sat}$ = 0,008

n is the number of satellite pipes

ρ is the air density (1,25 kg/m³)

K is the mode shape factor see ENV 1991-2-4. For cantilevered structures K may be taken as 0,13.

St is the Strouhal number according to Equation (A.8)

$$St = St_0 + k \cdot \left(\frac{s}{d_{sat}} \right)^q \quad \text{for } 0 \le s/d_{sat} \le 0{,}8 \tag{A.8}$$

with St_0, k and q according to Table A.2

K_w is the effective correlation length factor according to ENV 1991-2-4. For cantilevered structures K_W may be determined by using Equation (A.9).

$$K_W = 3\frac{L/D}{h_F/D}\left[1 - \frac{L/D}{h_F/D} + \frac{1}{3}\left(\frac{L/D}{h_F/D}\right)^2\right] \quad \text{but at most } K_W = 0{,}6 \tag{A.9}$$

L is the correlation length according to ENV 1991-2-4

Table A.1 —Parameter a for the determination of the maximum oscillation amplitude ratio max y_F/D in the case of vortex excitation

gap ratio	2 satellite pipes d_{sat} / d_{sup}			3 satellite pipes d_{sat} / d_{sup}			4 satellite pipes d_{sat} / d_{sup}		
s / d_{sat}	0,42	0,56	0,80	0,42	0,56	0,80	0,42	0,56	0,80
0,0	0,11	0,33	0,44	0,22	0,45	0,55	0,45	0,45	0,45
0,1	0,055	0,17	0,28	0,55	0,66	0,77	0,45	0,45	0,45
0,2	0,055	0,17	0,28	0,45	0,50	0,55	0,45	0,45	0,45
0,3	0,055	0,055	0,17	0,17	0,45	0,45	0,45	0,45	0,45
0,4	0,055	0,055	0,055	0,17	0,33	0,33	0,22	0,22	0,22
0,5	0,055	0,055	0,055	0,17	0,22	0,22	0,22	0,22	0,22
0,6	0,055	0,055	0,055	0,17	0,17	0,17	0,17	0,17	0,17
0,7	0,055	0,055	0,055	0,17	0,17	0,17	0,17	0,17	0,17
0,8	0,055	0,055	0,055	0,17	0,17	0,17	0,17	0,17	0,17
s, d_{sat}, d_{sup} see Fig. A.1. Intermediate rate shall be interpolated linearly.									

Table A.2 — Parameters St_0, k and q for the determination of the Strouhal number St.

Parameters Source for Equation A.6	2 satellite pipes d_{sat} / d_{sup}			3 satellite pipes d_{sat} / d_{sup}			4 satellite pipes d_{sat} / d_{sup}		
	0,42	0,56	0,80	0,42	0,56	0,80	0,42	0,56	0,80
St_0	0,16	0,16	0,16	0,13	0,13	0,13	0,17	0,17	0,17
k	0,18	0,53	0,82	0,15	0,21	0,33	0,24	0,27	0,27
q	1,0	1,7	2,0	1,0	1,0	1,0	1,0	1,0	1,0
d_{sat}, d_{sup} see Fig. A.1. Intermediate rate shall be interpolated linearly									

A.2.3 Verification

A.2.3.1 Attached components

Satellite pipes and all components connected to the support mast shall be checked for oscillation in accordance with ENV 1991-2-4. Proof of fatigue for dynamically stressed components shall be in accordance with ENV 1993-3-2.

If prefabricated metal chimney elements in accordance with EN 1856-1 are used and the requirements of this annex are complied with, the above calculations need not to be undertaken for these components.

A.2.3.2 Support mast

Calculations for dynamically stressed components shall be in accordance with ENV 1993-3-2:1997 Annex C.

A.3 Classical galloping

A.3.1 Onset velocity for classical galloping

For configurations with three or four satellite pipes according to Figure A.1 classical galloping may occur.

NOTE In the case of two satellite pipes, classical galloping has not been observed. In the case of more then 4 satellite pipes or other geometrical forms as shown in Table A.1 specialist advice should be sought.

The onset velocity v_{CG} for classical galloping may be estimated by

$$v_{CG} = \frac{2 \cdot Sc}{a_G} f_e \cdot D \qquad \text{(A.10)}$$

Where f_e, D and Sc are defined in A.1 and a_G is the factor of instability given by Equations (A.11) to (A.14):

For a mast construction with 3 satellite pipes:

$$a_G = 0{,}4 - 0{,}6 \cdot \frac{s}{d_{sat}} \quad \text{for} \quad 0 \le \frac{s}{d_{sat}} \le 0{,}67 \qquad \text{(A.11)}$$

$$a_G = 0 \quad \text{for} \quad \frac{s}{d_{sat}} > 0{,}67 \qquad \text{(A.12)}$$

For a mast construction with 4 satellite pipes:

$$a_G = 0{,}7 - 3{,}0 \cdot \frac{s}{d_{sat}} \quad \text{for} \quad 0 \le \frac{s}{d_{sat}} \le 0{,}23 : \qquad \text{(A.13)}$$

$$a_G = 0 \quad \text{for} \quad \frac{s}{d_{sat}} > 0{,}23 \qquad \text{(A:14)}$$

A.3.2 Verification

It should be ensured that:

$$v_{CG} \ge 1{,}25 \cdot v_m(z)$$

where

$v_m(z)$ is the mean wind velocity as defined in ENV 1991-2-4, calculated at the height z, where the galloping excitation is expected, that is mostly the point of maximum amplitude of oscillation.

Bibliography

EN 13384-1, *Chimneys – Thermal and fluid dynamic calculation methods – Part 1: Chimneys serving one appliance.*

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