SLOVENSKI STANDARD
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Dimniki - Računske metode termodinamike in dinamike fluidov - 1. del: Dimniki za eno ogrevalno napravo

Chimneys - Thermal and fluid dynamic calculation methods - Part 1: Chimneys serving one heating appliance

Abgasanlagen - Wärme- und strömungstechnische Berechnungsverfahren - Teil 1: Abgasanlagen mit einer Feuerstätte

Conduits de fumée - Méthodes de calcul thermo-aéraulique - Partie 1: Conduits de fumée ne desservant qu'un seul appareil

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Contents

Page

Foreword

This document (prEN 13384-1:2013) has been prepared by Technical Committee CEN/TC 166 “Chimneys”, the secretariat of which is held by ON.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 13384-1:2002+A2:2008.

According to EN 13384-1:2002 + A2:2008 the following fundamental changes are given:

— editorial mistakes have been corrected;

— mistakes in equations have been corrected;

— for wood the rise of the dew point to take into account the acid condensation has been deleted;

— table for material characteristics in annex B5 has been adapted to EN 15287-1 and supplemented by radiation coefficients;

— in Calculation of thermal resistance according to annex A are linked to the method of EN 15287-1 for taking into account the temperature dependence has been added;

— for non-concentric ducts the calculation of the mean temperature of the air supply has been amended;

This European Standard “Chimneys — Thermal and fluid dynamic calculation methods” consists of three Parts:

— Part 1: Chimneys serving one heating appliance

— Part 2: Chimneys with multiple inlets and one inlet with multiple appliances

— Part 3: Methods for the development of diagrams and tables for chimneys serving one heating appliance

1 Scope

This European Standard specifies methods for the calculation of the thermal and fluid dynamic characteristics of chimneys serving one appliance.

The methods in this Part of this European Standard are applicable to negative or positive pressure chimneys with wet or dry operating conditions. It is valid for chimneys with heating appliances for fuels subject to the knowledge of the flue gas characteristics which are needed for the calculation.

The methods in this Part of this European Standard are applicable to chimneys with one inlet connected with one appliance. The methods in Part 2 of this European Standard are applicable to chimneys with multiple inlets and one inlet with multiple appliances. Part 3 describes methods for the development of diagrams and tables for chimneys serving one heating appliance.

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 1859, *Chimneys — Metal chimneys — Test methods*

EN 13502, *Chimneys — Requirements and test methods for clay/ceramic flue terminals*

EN 15287-1:2007+A1:2010, *Chimneys — Design, installation and commissioning of chimneys — Part 1: Chimneys for non-roomsealed heating appliances*

CEN/TR 1749, *European scheme for the classification of gas appliances according to the method of evacuation of the combustion products (types) part.*

3 Terms and definitions

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

3.1
heat output (Q)
amount of heat produced by a heating appliance per unit of time

3.1.1
nominal heat output (Q_N)
continuous heat output specified by the manufacturer of the heating appliance related to specified fuels

3.1.2
heat output range
range of output below the nominal heat output specified by the manufacturer over which the appliance can be used

3.2
heat input (Q_F)
amount of heat in unit time which is supplied to the heating appliance by the fuel based on its net caloric value H_u

3.3
efficiency of the heating appliance (η_W)
ratio of the heat output (Q) from the appliance to the heat input (Q_F)

3.4
flue gas mass flow ($\dot{m}$)
mass of flue gas leaving the heating appliance through the connecting flue pipe per time unit

3.5
effective height of the chimney (H)
difference in height between the axis of the flue gas inlet into the chimney and the outlet of the chimney

3.6
effective height of the connecting flue pipe (H_V)
difference in height between the axis of the flue gas chimney outlet of the heating appliance and the axis of the flue gas inlet into the chimney

In the case of open fire chimneys, H_V is the difference in height between the height of the upper frame of the furnace and the axis of the flue gas inlet into the chimney.

3.7
draught
positive value of the negative pressure in the flue

3.8
theoretical draught available due to chimney effect (P_H)
pressure difference caused by the difference in weight between the column of air equal to the effective height outside a chimney and the column of flue gas equal to the effective height inside the chimney

3.9
pressure resistance of the chimney (P_R)
pressure which is necessary to overcome the resistance of the flue gas mass flow which exists when carrying the flue gases through the chimney

3.10
wind velocity pressure (P_L)
pressure generated on the chimney due to wind

3.11
minimum draught at the flue gas inlet into the chimney (P_Z)
difference between the minimum theoretical draught and the sum of the maximum pressure resistance of the chimney and the wind velocity pressure

3.12
maximum draught at the flue gas inlet into the chimney (P_{Zmax})
difference between the maximum theoretical draught and the minimum pressure resistance in the chimney

3.13
minimum draught for the heating appliance (P_W)
difference between the static air pressure of the room of installation of the heating appliance and the static pressure of the flue gas at the chimney outlet of the appliance which is necessary to maintain the correct operation of the heating appliance

3.14
maximum draught for the heating appliance (P_{Wmax})
difference between the static air pressure of the room of installation of the heating appliance and the static pressure of the flue gas at the outlet of the appliance which is the maximum allowed to maintain the correct operation of the heating appliance

3.15
effective pressure resistance of the connecting flue pipe (P_{FV})
static pressure difference between the axis of the inlet of the connecting flue pipe and the axis of the chimney outlet due to the theoretical draught and pressure resistance

3.16
effective pressure resistance of the air supply (PB)
difference between the static pressure in the open air and the static air pressure in the room of installation of the heating appliance at the same height

3.17
minimum draught required at the flue gas inlet into the chimney (P_{Ze})
sum of the minimum draught required for the heating appliance and the draught required to overcome the effective pressure resistance of the connecting flue pipe and the effective pressure resistance of the air supply

3.18
maximum allowed draught at the flue gas inlet into the chimney (P_{Zemax})
sum of the maximum draught allowed for the heating appliance and the draught required to overcome the effective pressure resistance of the connecting flue pipe and the effective pressure resistance of the air supply

3.19
maximum positive pressure at the flue gas inlet into the chimney (P_{ZO})
difference of the maximum pressure resistance and the minimum theoretical draught of the chimney added by the wind velocity pressure

3.20
minimum positive pressure at the flue gas inlet into the chimney (P_{ZOmin})
difference of the minimum pressure resistance and the maximum theoretical draught of the chimney

3.21
maximum differential pressure of the heating appliance (P_{WO})
maximum difference between the static pressure of the flue gas at the chimney outlet of the appliance and the static pressure of the air at the inlet to the heating appliance specified for its correct operation

3.22
minimum differential pressure of the heating appliance (P_{WOmin})
minimum difference between the static pressure of the flue gas at the outlet of the appliance and the static pressure of the air at the inlet to the heating appliance specified for its correct operation. This can be a negative value.

3.23
maximum differential pressure at the flue gas inlet into the chimney (P_{ZOe})
difference between the maximum differential pressure of the heating appliance and the sum of the effective pressure resistance of the connecting flue pipe and the effective pressure resistance of the air supply

3.24
secondary air
ambient air added to the flue gas in addition to the nominal flue gas mass flow

3.25
minimum differential pressure at the flue gas inlet into the chimney (P_{ZOemin})
difference between the minimum differential pressure of the heating appliance and the sum of the effective pressure resistance of the connecting flue pipe and the effective pressure resistance of the air supply

3.26
secondary air device
draught regulator or a draught diverter

3.27
draught regulator
component which automatically supplies ambient air to the chimney, the connecting flue pipe or the heating appliance

3.28
draught diverter
device, placed in the combustion products passage of the heating appliance, that is intended to maintain the quality of combustion within certain limits and to keep the combustion stable under certain conditions of up draught and down draught

3.29
temperature limit of the inner wall (T_g)
allowed minimum temperature of the inner wall of the chimney outlet

3.30
air-flue gas system
system of concentric or non-concentric ducts for transport of combustion air from the open air to the heating appliance and products of combustion from the heating appliance to the open air

3.31
air-supply duct
component or components parallel to the chimney (separate or concentric) that conveys combustion air from the outside atmosphere to the inlet of the connecting air supply pipe

3.32
balanced flue chimney
chimney where the point of air entry to the air supply duct is adjacent to the point of discharge of combustion products from the flue, the inlet and outlet being so positioned that wind effects are substantially balanced

3.33
chimney segment
calculation part of a chimney

3.34
condensate mass flow ($\Delta\dot{m}_D$)
mass of water vapour of the flue gas condensed in the heating appliance, connecting flue pipe or the chimney per time unit

3.35
connecting air supply pipe
component or components connecting the air supply duct outlet with the room-sealed heating appliance combustion air inlet

3.36
condensation factor (f_K)
proportion of the theoretical maximum condensation mass flow usable in the calculation

4 Symbols and abbreviations

The symbols given in this clause can be completed by one or more indices to indicate location or materials if necessary.

Table 1 — Symbols, terminology and units

Symbol	Terminology	Unit
A	cross section area	m^2
c	specific heat capacity	J/(kg · K)
c_p	specific heat capacity of flue gas	J/(kg · K)
d	thickness of the section	m
D	diameter	m
D_h	hydraulic diameter	m
E	heat flux ratio	–
H	effective height of the chimney	m
k	coefficient for heat transmission	$W/(m^2 \cdot K)$
K	coefficient of cooling	–
L	length	m
$\dot{m}$	flue gas mass flow	kg/s
Nu	Nusselt number	–
p	static pressure	Pa
p_L	external air pressure	Pa
P_B	pressure resistance of the air supply for a flue gas mass flow	Pa
P_E	pressure resistance due to friction and form resistance of the chimney	Pa
P_{FV}	effective pressure resistance of the connecting flue pipe	Pa
P_G	difference in pressure caused by change of velocity of flue gas in the chimney	Pa
P_H	theoretical draught available due to chimney effect	Pa
P_{HV}	theoretical draught available due to chimney effect of the connecting flue pipe	Pa
P_L	wind velocity pressure	Pa
P_{NL}	draught required for secondary air devices	Pa
P_R	pressure resistance of the chimney	Pa
P_{RV}	pressure resistance of the connecting flue pipe	Pa
P_W	minimum draught for the heating appliance	Pa
P_{Wmax}	maximum draught for the heating appliance	Pa
P_{WO}	maximum differential pressure of the heating appliance	Pa
P_{WOmin}	minimum differential pressure of the heating appliance	Pa
P_Z	minimum draught at the flue gas inlet into the chimney	Pa
P_{Zmax}	maximum draught at the flue gas inlet into the chimney	Pa
P_{Ze}	minimum draught required at the flue gas inlet into the chimney	Pa
P_{Zemax}	maximum allowed draught at the flue gas inlet into the chimney	Pa
P_{ZO}	maximum positive pressure at the flue gas inlet into the chimney	Pa
P_{ZOmin}	minimum positive pressure at the flue gas inlet into the chimney	Pa
P_{ZOe}	maximum differential pressure at the flue gas inlet into the chimney	Pa
P_{ZOemin}	minimum differential pressure at the flue gas inlet into the chimney	Pa
Pr	Prandtl number	–
q_C	heat transfer from the flue to the outer surface	W
Q	heat output	kW

Table 1 *(continued)*

Symbol	Terminology	Unit
Q_F	heat input	kW
QN	nominal heat output	kW
r	mean value for roughness of the inner wall	m
R	gas constant of the flue gas	J/(kg · K)
R_L	gas constant of the air	J/(kg · K)
Re	Reynolds number	–
s	cross section	m
S_E	flow safety coefficient	–
S_H	correction factor for temperature instability	–
t	temperature	°C
T	temperature, absolute	K
T_g	temperature limit	K
T_{io}	inner wall temperature at chimney outlet	K
T_{iob}	inner wall temperature at the chimney outlet at temperature equilibrium	K
T_L	external air temperature	K
T_m	mean temperature of the flue gas	K
T_p	water dew point	K
T_{sp}	condensing temperature	K
T_u	ambient air temperature	K
T_{ub}	ambient air temperature of the boiler room	K
T_{uh}	ambient air temperature for heated areas	K
T_{ul}	ambient air temperature for areas external to the building	K
T_{uo}	ambient air temperature at the chimney outlet	K
T_{uu}	ambient air temperature for unheated areas inside the house	K
T_W	flue gas temperature of the appliance	K
T_{WN}	flue gas temperature of the appliance at nominal heat output	K
T_{Wmin}	flue gas temperature of the appliance at the lowest possible heat output	K
U	internal chimney segment parameter	m
w	mean velocity within a cross section	m/s
w_m	mean velocity over a defined length	m/s
y	form value	–
z	height above sea level	m
α	coefficient of heat transfer	$W/(m^2 \cdot K)$
β	ratio of the combustion air mass flow to the flue gas mass flow	–
γ	angle between flow directions	°
δ	wall thickness	m
ε	proportion of black body radiation emitted by a surface	–
ζ	coefficient of flow resistance due to a directional and/or cross sectional and/or mass flow change in the flue	–
η	dynamic viscosity	$N \cdot s/m^2$
η_W	efficiency of the heating appliance	–
η_{WN}	efficiency of the heating appliance at nominal heat output	–
λ	coefficient of thermal conductivity	W/(m · K)
ρ	density	kg/m^3
ρ_L	density of the external air	kg/m^3

Table 1 *(continued)*

Symbol	Terminology	Unit
ρ_m	mean density of flue gas averaged over a defined length and over the cross section	kg/m^3
σ (CO_2)	volume-concentration of CO_2	%
σ (H_2O)	volume-concentration of H_2O (vapour)	%
σ_{Rad}	black body radiation number	W/(m^2 · K^4)
ψ	coefficient of flow resistance due to friction of the flue	–
$\left(\frac{1}{\Lambda}\right)$	thermal resistance	m^2 · K/W

Table 2 — Additional subscripts

Subscript	Terminology	Unit
a	outside	–
A	flue gas	–
b	equilibrium temperature condition	–
B	combustion air	–
e	entrance	–
G	change in velocity	–
i	inside	–
L	open air (outside)	–
m	mean value	–
M	mixture	–
n	counting index	–
N	nominal value	–
NL	secondary air	–
o	chimney outlet	–
O	positive pressure	–
tot	totalized over all sections (segments)	–
u	ambient air	–
V	connecting flue pipe	–
W	heating appliance	–

5 Calculation method for non-balanced flue chimneys

5.1 General principles

The calculation of inside dimensions (cross section) of negative pressure chimneys is based on the following four criteria:

— the minimum draught at the flue gas inlet into the chimney shall be equal to or greater than the minimum draught required at the flue gas inlet into the chimney;

— the minimum draught at the flue gas inlet to the chimney shall be equal to or greater than the effective pressure resistance of the air supply;

— the maximum draught at the flue gas inlet into the chimney shall be equal to or less than the maximum allowed draught at the flue gas inlet into the chimney;

— the temperature of the inner wall at the outlet of the chimney shall be equal to or greater than the temperature limit.

The calculation of inside dimensions (cross section) of positive pressure is based on the following four criteria:

— the maximum positive pressure at the flue gas inlet into the chimney shall be equal or less than the maximum differential pressure at the flue gas inlet into the chimney;

— the maximum positive pressure in the connecting flue pipe and in the chimney shall not be higher than the excess pressure for which both are designated;

— the minimum positive pressure at the flue gas inlet into the chimney shall be equal or greater than the minimum differential pressure at the flue gas inlet into the chimney;

— the temperature of the inner wall at the chimney outlet of the chimney shall be equal to greater than the temperature limit.

NOTE The pressure requirements for maximum draught or minimum positive pressure are only required if there is a limit for the maximum draught for the negative pressure heating appliance or a minimum differential pressure of the positive pressure heating appliance.

In order to verify the criteria two sets of external conditions are used:

— the calculation of the minimum draught and maximum positive pressure is made with conditions for which the capacity of the chimney is minimal (i.e. high outside temperature); and also

— the calculation of the maximum draught and minimum positive pressure and of the inner wall temperature with conditions for which the inside temperature of the chimney is minimal (i.e. low outside temperature.

5.2 Pressure requirements

5.2.1 Negative pressure chimneys

The following relationships shall be verified:

$$P_Z = P_H - P_R - P_L \geq P_W + P_{FV} + P_B = P_{Ze}, \text{ in Pa} \quad (1)$$

$$P_Z \geq P_B, \text{ in Pa} \quad (2)$$

and if appropiate

$$P_{Zmax} = P_H - P_R \leq P_{Wmax} + P_{FV} + P_B = P_{Ze\,max}, \text{ in Pa} \quad (2a)$$

where

P_B is the effective pressure resistance of air supply (see 5.11.3), in Pa;

P_{FV} is the effective pressure resistance of the connecting flue pipe, in Pa;

P_H is the theoretical draught available due to chimney effect, in Pa;

P_L is the wind velocity pressure, in Pa;

P_R is the pressure resistance of the chimney, in Pa;