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Eurocode 1 - Actions on structures - Part 1-7: General actions - Accidental actions

Eurocode 1 - Einwirkungen auf Tragwerke - Teil 1-7: Allgemeine Einwirkungen - Außergewöhnliche Einwirkungen

Eurocode 1 - Actions sur les structures - Partie 1-7: Actions générales - Actions accidentelles

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Eurocode 1 - Actions on structures - Part 1-7: General actions - Accidental actions

Eurocode 1 - Actions sur les structures - Partie 1-7: Actions générales - Actions accidentelles

Eurocode 1 - Einwirkungen auf Tragwerke - Teil 1-7: Allgemeine Einwirkungen - Außergewöhnliche Einwirkungen

This draft amendment is submitted to CEN members for unique acceptance procedure. It has been drawn up by the Technical Committee CEN/TC 250.

This draft amendment A1, if approved, will modify the European Standard EN 1991-1-7:2006. If this draft becomes an amendment, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for inclusion of this amendment into the relevant national standard without any alteration.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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Foreword

This document (EN 1991-1-7:2006/FprA1:2013) has been prepared by Technical Committee CEN/TC 250 "Structural Eurocodes", the secretariat of which is held by BSI.

This document is currently submitted to the Unique Acceptance Procedure.

1 Modification to 5.3, Principles for design

In Paragraph (1), replace the existing Note by the following one:

"NOTE The National Annex may give the procedures to be used for the types of internal explosions. Guidance on dealing with the following specific types of explosion is given in Annex D:

gas and vapour/air explosions in rooms and closed sewage basins;

dust explosions in rooms, vessels and bunkers;

gas and vapour/air explosions in road and rail tunnels;

dust, gas and vapour/air explosions in energy ducts.

The values presented in Annex D of this part may be considered as nominal values given that the explosion occurs.

When calculating the structural response, dynamic and nonlinear behaviour may be taken into account. A load duration of 0,2 s may be adopted and damage is acceptable provided it does not lead to disproportional collapse.

The load-time function may be assumed triangular. A sensitivity study on the load-time function should be performed to identify the peak load time within the 2,0 s duration.".

2 Modification to Annex D (informative), Internal explosions

Replace the existing Annex D with the following one:

"

Annex D (Informative)
Internal explosions

D.1 Natural gas explosions

(1) For buildings which might have piped natural gas installed, or where gas canisters can be present, the structure may be designed to withstand the effects of an internal natural gas explosion using a nominal equivalent static pressure given by Formulae (D.1) and (D.2):

$$p_d = 3 + p_{stat} \qquad \text{(D.1)}$$

or

$$p_d = 3 + p_{stat} / 2 + 0{,}04 / (A_v / V)^2 \qquad \text{(D.2)}$$

whichever is the greater;

where

p_d is the nominal equivalent static pressure to design the structure in [kN/m²];

p_{stat} is the uniformly distributed static pressure at which venting components will fail in [kN/m²];

A_v is the area of venting components in [m^2];

V is the volume of rectangular enclosure in [m^3].

Formulae (D.1) and (D.2) are valid for a single room up to 1 000 m³ total volume.

NOTE 1 The pressure due to deflagration acts effectively simultaneously on all of the bounding surfaces of the room.

NOTE 2 Multi-room explosions may give much higher pressures. The pressures are difficult to calculate as they are not simply limited by the strength of the vent panels; therefore, for this type of explosion, the strategy based on limiting the extend of localised failure (see Figure 3.1) should be adopted.

(2) Where building components with different p_{stat} values contribute to the venting area, the largest value of p_{stat} should be used. No value of p_d greater than 50 kN/m^2 need be taken into account.

(3) The ratio of the area of venting components and the volume should comply with Formula (D.3):

$$0{,}05 \text{ m}^{-1} \leq A_v / V \leq 0{,}15 \text{ m}^{-1} \qquad \text{(D.3)}$$

NOTE Natural gas is a gaseous fossil fuel consisting primarily of methane but including significant quantities of ethane, butane, propane, carbon dioxide, nitrogen, helium and hydrogen sulfide. Before natural gas can be used as a fuel, it undergoes extensive processing to remove almost all materials other than methane.

D.2 Dust explosions in rooms, vessels and bunkers

(1) The design value p_d for the maximum pressure developed in vented cubic and elongated rooms, vessels and bunkers for dust explosions within a single room may be determined from the empirical Formula (D.4):

$$A_v = [4{,}485 \times 10^{-8}\, p_{max}\, K_{st}\, p_d^{-0{,}569} + 0{,}027(p_{stat} - 10) p_d^{-0{,}5}] V^{\,0{,}753} \qquad \text{(D.4)}$$

where

A_v is the venting area [m^2];

V is the volume of room, vessel, bunker [m^3];

K_{St} is the deflagration index of a dust cloud [kN/m^2 (m/s)] (see Clause (2));

p_{max} is the maximum pressure of an explosion of the dust [kN/m^2] (see Clause (2));

p_{stat} is the static activation pressure of the vent areas [kN/m^2];

p_d is the design value of the pressure in the vented vessel [kN/m^2].

(2) Values for p_{max} and K_{St} may be experimentally determined by standard methods for each type of dust.

NOTE 1 The value of K_{St} depends on factors such as the chemical composition, particle size and moisture content. Indicative values for p_{max} and K_{St} are given in Table D.1.

NOTE 2 For standard methods, see for instance EN 14034-1:2004 and EN 14034-2:2006.

(3) Formula (D.4) is valid with the following restrictions:

– $0,1\ m^3 \leq V \leq 10\ 000\ m^3$;

– $L_3 / D_E \leq 2$, where L_3 is the largest dimension and $D_E = 2(L_1 \times L_2 / \pi)^{0,5}$, where L_1 and L_2 are the other two dimensions;

– 10 kN/m$^2 \leq p_{stat} \leq 100$ kN/m^2, rupture disks and panels with low mass which respond almost without intertia;

– 10 kN/m$^2 \leq p_d \leq 200$ kN/m^2;

– 500 kN/m$^2 \leq p_{max} \leq 1\ 000$ kN/m^2 for $1\ 000$ kN/m^2(m/s) $\leq K_{St} \leq 30\ 000$ kN/m^2(m/s) respectively;

500 kN/m$^2 \leq p_{max} \leq 1\ 200$ kN/m^2 for $30\ 000$ kN/m^2(m/s) $\leq K_{St} \leq 80\ 000$ kN/m^2(m/s).

(4) For elongated rooms with $L_3/D_E \geq 2$ the following increase for the venting area should be considered:

$$\Delta A_v = A_v\,(-\,4{,}305 \log p_d + 9{,}368) \log L_3/D_E \qquad \text{(D.5)}$$

where

ΔA_v is the increase for venting area in [m^2].

(5) For dust explosions pressure rise time to maximum pressure value of 20 ms to 50 ms should be considered. The decline depends on venting device and geometry of the enclosure.

NOTE In dust explosions, pressures reach their maximum value within a time span in the order of 20 ms to 50 ms. The decline to normal values strongly depends on the venting device and the geometry of the enclosure.

Table D.1 – p_{max} and K_{St} values for dust explosions

Type of dust	p_{max} kN/m^2	K_{St} kN/m^2 (m/s)
Brown coal	810 to 1 000	18 000
Cellulose	800 to 980	27 000
Coffee		9 000
Corn, corn crush		12 000
Corn starch		21 000
Grain		13 000
Milk powder	810 to 970	16 000
Mineral coal		13 000
Mixed provender		4 000
Paper		6 000
Pea flour		14 000
Pigment	650 to 1 070	29 000
Rubber	740	14 000
Rye flour, wheat flour		10 000
Soya meal		12 000
Sugar	820 to 940	15 000
Washing powder		27 000
Wood, wood flour	770 to 1 050	22 000

D.3 Explosions in road and rail tunnels

(1) In case of a detonation in road and rail tunnels, the pressure time function may be determined using Formulae (D.6) to (D.8), see Figure D.1(a):

$$p(x,t) = p_0 \exp\left\{-\left(t - \frac{|x|}{c_1}\right)/t_0\right\} \text{ for } \frac{|x|}{c_1} \le t \le \frac{|x|}{c_2} - \frac{|x|}{c_1} \tag{D.6}$$

$$p(x,t) = p_0 \exp\left\{-\left(\frac{|x|}{c_2} - 2\frac{|x|}{c_1}\right)/t_0\right\} \text{ for } \frac{|x|}{c_2} - \frac{|x|}{c_1} \le t \le \frac{|x|}{c_2} \tag{D.7}$$

$$p(x,t) = 0 \text{ for all other conditions} \tag{D.8}$$

where

p_0 is the peak pressure (= 2 000 kN/m^2 for a typical liquefied natural gas);

c_1 is the propagation velocity of the shock wave (~ 1 800 m/s);

c_2 is the acoustic propagation velocity in hot gasses (~ 800 m/s);

t_0 is the time constant (= 0,01 s);

$|x|$ is the distance to the centre of the explosion;

t is the time.

(2) In case of a deflagration in road and rail tunnels, the following pressure time characteristic may be taken into account, see Figure D.1(b):

$$p(t) = 4 p_0 \frac{t}{t_0}(1 - \frac{t}{t_0}) \text{ for } 0 \le t \le t_0 \quad \text{(D.9)}$$

where

p_0 is the peak pressure (= 100 kN/m^2 for a typical liquefied natural gas);

t_0 is the time constant (= 0,1 s);

t is the time.

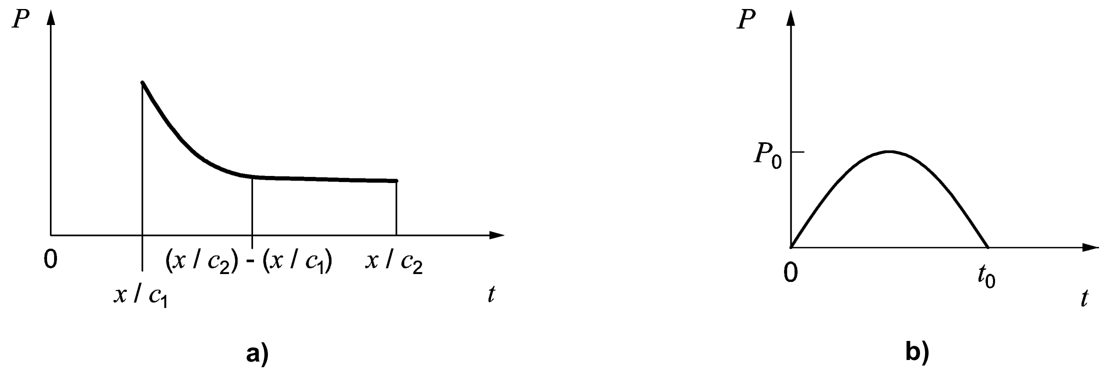

Figure D.1 — Pressure as time function for (a) detonation and (b) deflagration

D.4 Dust, Gas and vapour/air explosions in energy ducts

D.4.1 General

(1) Ducts including pipelines, cables, etc. for transport and distribution of gases, water, compressed air or electricity for the supply of industry, traffic and/or population which are normally accessible for maintenance should normally be designed to resist the anticipated overpressure of a possible explosion.

(2) Pipes and ducts for transport and distribution of dusts for the supply of industry, which normally are accessible for maintenance, should normally be designed to resist the anticipated overpressure of a possible dust explosion.

NOTE 1 Dust explosions and gas explosions in energy ducts have a similar behaviour concerning the pressure. In general, gas explosions result in higher maximum pressures. Turbulence-producing devices have a greater influence on the increase of the pressure for gas than for dust explosions.

NOTE 2 Ducts (and elongated vessels) are characterised with length-to-diameter rations equal or greater than 5.

NOTE 3 The measurements of the duct (cross-section, length) as well as the layout of the duct (closed at both sides, open at both sides, open at one side, closed at the other) and whether obstacles are built in the duct influence the combustion and the resulting pressures.

NOTE 4 Especially high pressure is reached when the pressure wave of a detonation is moving directly against walls or other fixed structures (for example the end wall of a duct). The pressure wave will be reflected. The pressure at the flange will be up to three times as high as the pressure at the side wall of a straight duct.

D.4.2 Vent area

(1) The venting area should be taken as equal to the cross-sectional area of the duct at each venting location at distances less than the critical distance *L* (see D.4.3*).* Multiple venting locations within the critical distance *L* are possible. The area of several openings may be added.

(2) The effective diameter *D* of non-circular venting areas in D.4.3 may be determined as *D* = 4 *A*/*U*, where *A* is the venting area and *U* the venting perimeter.