BRITISH STANDARD

BS EN 14491:2006
Incorporating corrigendum September 2008

Dust explosion venting protective systems

ICS 13.230

British Standards

National foreword

This British Standard is the UK implementation of EN 14491:2006, incorporating corrigendum Sepember 2008.

The UK participation in its preparation was entrusted to Technical Committee FSH/23, Fire precautions in industrial and chemical plant.

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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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 14491

March 2006

ICS 13.230

Incorporating corrigendum September 2008

English Version

Dust explosion venting protective systems

Systèmes de protection par évent contre les explosions de poussières

Schutzsysteme zur Druckentlastung von Staubexplosionen

This European Standard was approved by CEN on 13 February 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This European Standard (EN 14491:2006) has been prepared by Technical Committee CEN/TC 305 “Potentially explosive atmospheres – Explosion prevention and protection”, 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of an identical text or by endorsement, at the latest by September 2006, and conflicting national standards shall be withdrawn at the latest by September 2006.

This European Standard 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) 94/9/EC.

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this European Standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, 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 and United Kingdom.

1 Scope

This European Standard specifies the basic requirements of design for the selection of a dust explosion venting protective system. The standard is one of a series including prEN 14797 *Explosion venting devices* and prEN 14460 *Explosion resistant equipment*. The three standards together represent the concept of dust explosion venting. To avoid transfer of explosions to other communicating equipment one should also consider applying prEN 15089 *Explosion Isolation Systems*.

This European Standard covers:

— vent sizing to protect an enclosure against the internal pressure effects of a dust explosion;

— flame and pressure effects outside the enclosure;

— recoil forces;

— influence of vent ducts.

This European Standard is not intended to provide design and application rules against effects generated by detonation reactions or runaway exothermic reactions. This European Standard does not cover fire risks arising from either materials processed, used or released by the equipment or materials that make up equipment and buildings. This European Standard does not cover the design, construction, testing and certification of explosion venting devices that are used to achieve explosion venting[1)].

2 Normative references

These following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references the latest edition of the referenced document (including any amendments) applies.

EN 1127-1:1997, *Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology*

EN 13237:2003, *Potentially explosive atmospheres — Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 1127-1:1997 and EN 13237:2003 and the following apply.

3.1
building
enclosed, roofed space that contains a working environment that may include process plant, offices and personnel, either separately or together, but is not, in itself, an item of process plant

3.2
enclosure
vessel that forms a distinct and identifiable part of a process plant and to which explosion protection by explosion venting can be applied as described in this European Standard

1) This is covered in the European Standard prEN 14797.

3.3
design pressure
p
design strength of the vessel/enclosure (explosion resistance)

3.4
hybrid mixture
mixture of flammable (combustible) substances with air in different physical states

NOTE An example for hybrid mixtures is a mixture of methane, coal dust and air.

[EN 1127-1:1997; 3.20]

3.5
K_{st} value
parameter, specific to the dust, that characterises the explosibility of a dust and which is calculated according to the cubic law

NOTE The K_{St} value is numerically equal to the value for the maximum rate of explosion pressure rise, $(dp/dt)_{max}$, measured in the 1 m^3 vessel under specified test conditions.

3.6
vent area
A
geometric vent area of vent

NOTE It is the minimum cross-sectional flow area of the vent opening taking into consideration the possible reduction of the cross section, e.g. by back pressure supports, retaining devices and parts of the explosion venting device which remain after bursting or venting.

3.7
cross sectional area
A_c
area of cross section of rectangular enclosure normal to longest dimension of this enclosure

3.8
required vent area
A_v
quotient of the geometric vent area *A* and the venting efficiency E_f for the venting device

NOTE The required vent area is used in making up the vent area for explosion venting.

3.9
effective enclosure area
A_{eff}
ratio of the total free volume of an enclosure and its height

3.10
maximum explosure overpressure
p_{max}
maximum overpressure occurring in a closed vessel during the explosion of an explosive atmosphere and determined under specified test conditions

[EN 1127-1:1997; 3.27]

3.11
pipeline
connection, which is at least 20 times longer than the diameter, carrying process material between two or more enclosures in a process plant and which cannot be explosion protected by the explosion venting methods for enclosures described in this European Standard

3.12
explosive atmosphere
mixture with air, under atmospheric conditions, of flammable (combustible) substances in the form of gases, vapours, mists or dusts, in which, after ignition has occurred, combustion spreads to the entire unburned mixture

3.13
maximum reduced explosion overpressure
$p_{\text{red, max}}$
maximum overpressure generated by an explosion of an explosive atmosphere in a vessel, protected by either explosion relief (venting) or explosion suppression

3.14
maximum rate of explosion pressure rise
$(\mathrm{d}p/\mathrm{d}t)_{\text{max}}$
maximum value of the pressure rise per unit time during explosions of all explosive atmospheres in the explosion range of a combustible substance in a closed vessel determined under specified test conditions

NOTE This parameter measured in a 1 m^3 vessel is numerically identical with the parameter K_{St}, if the test vessel is 1 m^3 in volume, but the unit of the latter is bar m s^{-1} whereas the unit of the $(\mathrm{d}p/\mathrm{d}t)_{\text{max}}$ is bar s^{-1}.

3.15
maximum value of the peak overpressure
p_{ext}
external maximum value of the peak overpressure generated by vented dust explosion

NOTE This maximum occurs at a distance R_{S} from the vent opening.

3.16
static activation overpressure
p_{stat}
overpressure that activates a rupture disk or an explosion door when a slow rate of pressure rise ($\leq$ 0,1 bar min^{-1}) is applied

4 Venting of enclosures

Explosion venting is a protective measure for enclosures by which unacceptably high internal explosion overpressures are prevented. Weak areas in the walls of the enclosure open at an early stage of the explosion, burning and/or un-burnt material and combustion products are released and the overpressure inside the enclosure is reduced. The vent area is the most important factor in determining the value of $p_{\text{red, max}}$, the maximum reduced explosion overpressure generated inside the enclosure by the vented explosion. Information required for calculation of the vent area includes the design pressure of the enclosure, the explosion characteristics of the dust, the shape and size of the enclosure, the static activation overpressure and other characteristics of the vent closure, and the condition of the dust cloud inside the enclosure.

Explosion venting shall not be performed if unacceptable amounts of materials that are classified as poisonous, corrosive, irritant, carcinogenic, teratogenic or mutagenic can be released. Either the dust or the combustion products can present a hazard to the immediate environment. If there is no alternative to explosion venting an endangered area shall be specified.

NOTE There is no direct guidance for estimating an endangered area for toxic or other harmful emissions, but the safe discharge area for flame calculated in 7.2 gives some indication of the area required in direct line from the vent.

Harmful emissions will be dispersed by air movements, however, and an extensive area in lateral directions may be required.

This European Standard shall be used together with prEN 14797 and prEN 14460.

Venting neither prevents or extinguishes an explosion; it only limits the explosion overpressure. Flame and pressure effects outside the enclosure and flying debris are to be expected and suitable precautions shall be taken. Fires inside the enclosure can also occur.

The increase of the length-to-diameter ratio of an enclosure results in an increase of the rate of flame propagation. This is taken into account in the equation for vent sizing (see Clause 5). Enclosures in this European Standard are limited to $L/D \leq 20$.

In a system consisting of connected enclosures, a dust explosion ignited in one enclosure can propagate through the connection, generating increased turbulence, perhaps causing some pre-compression and then acting as a large ignition source in a connected enclosure. This combination of effects can enhance the violence of the secondary explosion and the venting requirements of the system thus need to be increased, or the enclosures isolated (see 5.4).

Internal dust explosions can endanger buildings or parts of buildings and venting may be applied to protect the integrity of the building. A separate method for calculating the venting requirements is given in 5.5.

5 Sizing of vent areas

5.1 General

Accurate sizing of vents is the most important aspect of vent design. The size of the vent depends on the explosion characteristics of the dust, the state of the dust cloud (concentration, turbulence and distribution), the geometry of the enclosure and the design of the venting device.

The two principal explosion characteristics of the dust are the maximum overpressure p_{max} and the dust explosion constant K_{St}. These are measured by standard test procedures that establish representative conditions of fuel concentration and dust cloud homogeneity and turbulence considered to encompass those in the majority of practical applications. For cubical enclosures, p_{max} and K_{St} are essentially independent of enclosure volume.

The volume of the enclosure and the length-to-diameter ratio L/D relevant to the shape of the enclosure and the position of the explosion vent are required for sizing vents. The design pressure of the enclosure $p_{red,\,max}$ is also required for vent sizing. All parts of the enclosure, e.g. valves, sight-glasses, man-holes and ducts, that are exposed to the explosion pressure shall be taken into account and the design pressure of the weakest part shall be taken as the design pressure for the enclosure.

The two principal vent device parameters are the static activation overpressure p_{stat} and the weight per unit area of the venting element. The maximum value of the tolerance range of the static activation overpressure shall be used when sizing vents. The weight per unit area of the venting element determines its venting effectiveness factor.

5.2 Venting of isolated enclosures

The following equation shall apply to single enclosures where appropriate measures (explosion isolation) have been taken to prevent flame propagation between enclosures.

For enclosures the following equations allow the calculation of the required vent area A_v. The required vent area can, in practical applications, be divided into several smaller areas as long as the total area equals the required vent area:

a) 0,1 bar overpressure ≤ $p_{red,\,max}$ < 1,5 bar overpressure

$$A = B\left(1 + C \times log\ L/D\right) \text{ in m}^2 \quad (1)$$

with

$$B = \left[3{,}264 \times 10^{-5} \times p_{max} \times K_{St} \times p_{red,\,max}{}^{-0{,}569} + 0{,}27 \times \left(p_{stat} - 0{,}1\right) \times p_{red,\,max}{}^{-0{,}5}\right] \times V^{0{,}753} \quad (2)$$

$$C = \left(-4{,}305 \times \log p_{red,\,max} + 0{,}758\right)$$

$$A_v = A/E_f \qquad (E_f\text{: venting efficiency}) \quad (3)$$

b) 1,5 bar overpressure ≤ $p_{red,\,max}$ ≤ 2,0 bar overpressure

$$A = B$$

$$A_v = A/E_f \qquad (E_f\text{: venting efficiency}) \quad (4)$$

The equations are valid for:

enclosures volume	0,1 m^3 ≤ V ≤ 10 000 m^3;
static activation overpressure of the venting device	0,1 bar ≤ p_{stat} ≤ 1 bar; for p_{stat} < 0,1 bar, use p_{stat} = 0,1 bar;
maximum reduced explosion overpressure	p_{stat} ≤ $p_{red,\,max}$ ≤ 2 bar. It is recommended that $p_{red,\,max}$ shall at least be 0,12 bar;
maximum explosion overpressure	5 bar ≤ p_{max} ≤ 10 bar for a dust specific parameter of 10 bar m s^{-1} ≤ K_{St} ≤ 300 bar m s^{-1};
maximum explosion overpressure	5 bar ≤ p_{max} ≤ 12 bar for a dust specific parameter of 300 bar m s^{-1} < K_{St} ≤ 800 bar m s^{-1};
atmospheric conditions	conditions of the surrounding medium where the atmospheric pressure can vary between 80 kPa and 110 kPa, the temperature between – 20 °C and 60 °C (the variation of temperature being less then 0,5 °C/min), the relative humidity between 5 % volume fraction and 85 % volume fraction and oxygen content (20,9 ± 0,2) % volume fraction;
length-to-diameter ratio	1 ≤ L/D ≤ 20 (Examples for calculating L/D are given in Annex A).

If one or more of the above conditions are not fulfilled the applicability of the above equation shall be proven.

A is the venting area that shall be fitted to the enclosure assuming the venting efficiency factor of the venting device is 1 and thus the effective venting area is equal to the physical venting area. Some venting devices have a venting efficiency factor less than 1, and the effective venting area is thus less than the geometric venting area. To compensate for the lower efficiency of the venting device the required venting area A_v shall be larger than the geometric vent area A.

5.3 Special dust cloud conditions

The equations in 5.2 are designed to calculate vent areas for most practical applications – an enclosure completely full of a turbulent dust cloud of optimum dust concentration.

In some practical applications, however, the test procedures specified in accepted European Standards may overstate or understate the explosion intensity compared to the actual processing environment.

In conditions of moderate and low turbulence, and in conditions where a non-homogeneous fuel-air mixture or low dust concentration is the norm, the procedure specified in accepted European Standards is likely to overstate the explosion hazard. In such circumstances a reduced vent area can be used but shall be based on either published or experimental data that has been obtained from representative explosion venting trials.

In conditions of particularly severe turbulence (e.g. in enclosures with turbulence inducing obstructions) there is a possibility that the explosion intensity is understated. In some plants there can be conditions that may generate severe turbulence, and in these cases the equations in 5.2 can underestimate the necessary vent area. In such specific circumstances an increased vent area shall be based on either published or experimental data that has been obtained from representative explosion venting trials.

5.4 Protection of pipelines and interconnected enclosures

The vent sizing methods in 5.2 are suitable for enclosures that are isolated and can be treated as single units. If an explosion can propagate from one enclosure to another through a connecting pipeline, increased turbulence, a relatively large flame jet and pressure piling effects may combine to give an explosion of increased violence.

Interconnected enclosure systems shall normally be protected by isolating each separate enclosure so that an explosion in one protected enclosure is stopped from propagating into a second one. Isolation methods have been discussed in prEN 15089.

The basis of safety for pipelines and interconnected enclosures rests on a combination of the strength of the pipeline, isolation of the explosion effect and explosion protection of the enclosures.

If the explosion begins following an ignition in a protected enclosure and the maximum reduced explosion overpressure $p_{red,\,max}$ does not exceed 0,5 bar the distance along a straight pipeline, L, at which a specified overpressure p_L will occur can be estimated from the equations:

for $K_{St} \leq 100$ bar m s^{-1}

$$L = D \times \left[324{,}8 \times \left(1 - e^{-0{,}1072 \times p_L} \right) \right]$$, applicable to (L/D) ratios no greater than 100; (5)

for $100 < K_{St} \leq 200$ bar m s^{-1}

$$L = D \times \left(88{,}57 - 81{,}99 \times e^{-0{,}1640 \times p_L} \right)$$, applicable to (L/D ratios) no greater than 50; (6)

for $200 < K_{St} \leq 300$ bar m s^{-1}

$$L = D \times \left(63{,}76 - 62{,}42 \times e^{-0{,}1484 \times p_L} \right)$$, applicable to (L/D) ratios no greater than 50. (7)

where D is the pipeline diameter between 0,2 m to 0,6 m. No guidance is available for other pipeline diameters.

Experimental data indicate that this guidance covers the range of flow velocities typical of pneumatic conveying systems.

If conditions in pipelines connected to a protected enclosure where ignition occurs are such that the pressure in the pipeline will reach 10 bar, then PN10 construction shall be used. When the plant design is such that high pressures are not likely, then PN6 or PN3 pipeline construction can be used, depending on the pressures likely to arise. If the diameter of the pipeline is ≤ 0,5 m and K_{St} ≤ 100 bar m s^{-1} and the length-to-diameter ratio of the pipeline exceeds L/D = 20 at least 3 bar shock resistant construction shall be used. Additional venting of straight pipelines constructed as described above is not necessary. However, if pipelines have bends or obstructions, venting at or near to the bends or obstructions shall be applied.

If enclosures are not isolated, interconnected systems require explosion protection either by containment (explosion resistant design for the maximum explosion pressure) or other means. For determination of the venting requirements of interconnected enclosures the Equations (1) to (4) shall not be used.

In systems of interconnected enclosures where only one of the vessels can be vented:

a) When the larger of the enclosures cannot be vented, then the entire system shall be designed for full containment, or, alternatively, the use of explosion suppression shall be considered.

b) When the smaller of the enclosures cannot be vented, then it shall be designed for containment or, alternatively, explosion suppression shall be applied and the vent area of the larger vessel shall be based on either published or experimental data that has been obtained from representative explosion venting trials.

c) When the enclosures are of equal size, and one enclosure cannot be vented, b) applies.

When both enclosures can be vented the venting requirement shall be based on either published or experimental data that has been obtained from representative explosion venting trials. In case such information is not available, the following simple rules shall be applied when enclosure volumes are ≤ 20 m^3:

d) For K_{St} values of 150 bar m s^{-1} or less, dimensionless vent areas of greater than 0,25 will limit the maximum reduced explosion overpressure to 0,5 bar.

e) For K_{St} values between 150 bar m s^{-1} and 250 bar m s^{-1}, dimensionless vent areas of 0,4 will limit the maximum reduced explosion overpressure to 0,5 bar.

The dimensionless vent area is defined as $A_v/V^{2/3}$ where A_v is the vent area and V is the enclosure volume. The total vent area shall be divided between the enclosures so that the dimensionless vent area has the same value in each enclosure.

When venting a system of interconnected enclosures, the venting devices shall be designed for a low static activation overpressure, p_{stat} ≤ 0,1 bar.

5.5 Protection of buildings

5.5.1 General

For buildings $p_{red, max}$ shall always exceed p_{stat} by at least 0,02 bar. The vent area shall be distributed as symmetrically and as evenly as possible over the available surface.

The course of an explosion in buildings will be affected by several parameters such as the shape of the building, the presence of equipment and structural elements, the possibility of propagation from room to room and the presence of flammable dust left to lie on surfaces such as window sills, pipework and floors etc. The dust explosion may be limited to a small part of the total volume. Pressure development will vary according to circumstances and a wide range of dust explosion loads can be expected.

Vent areas on buildings shall be distributed uniformly over the wall and roof areas. In estimating $p_{red, max}$ care shall be taken to ensure that the weakest structural element, as well as any equipment or other devices that can be supported by structural elements, is identified. All structural elements and supports shall be considered. For example, floors and roofs are not usually designed to be loaded from beneath. However, a lightweight roof can be considered sacrificial, provided its movement can be tolerated and provided ice or snow does not hinder its movement.

5.5.2 Calculating the vent area

The recommended venting equation for buildings is as follows:

$$A = C \times A_S \times p_{\text{red, max}}{}^{-0,5} \tag{8}$$

where

A	is the geometric vent area, in square-metres (m²);
A_v	is the required vent area $A_v = A/E_f$, in square-metres (m²);
E_f	is the venting efficiency;
C	is the venting equation constant: $0 < K_{St} \leq 100$: $C = 0{,}018^{\,0,5}$ bar; $100 < K_{St} \leq 200$: $C = 0{,}026^{\,0,5}$ bar; $200 < K_{St} \leq 300$: $C = 0{,}030^{\,0,5}$ bar;
A_S	is the internal surface area of enclosure, in square-metres (m²);
$p_{\text{red, max}}$	is the maximum explosion overpressure developed in a vented enclosure during a vented deflagration. $p_{\text{red,max}}$ in this application, is not to exceed an overpressure of 0,1 bar.

The form of the venting equation is such that there are no dimensional constraints on the shape of the room, provided the vent area is not applied solely to one end of an elongated enclosure. The vent area shall be applied as evenly as possible over the available wall area, but if it is restricted to the end of an elongated enclosure, the ratio of length-to-diameter of the enclosure should not exceed 3. For cross sections other than those that are circular or square, the effective diameter shall be taken by 4 (A_c/L_p), where A_c is the cross-sectional area normal to the longitudinal axis of the space and L_p is the perimeter of the cross section. Therefore, for enclosures with venting restricted to one end, the venting equation reflects constraints as follows:

$$L < 12 \times A_c \times L_p^{-1} \tag{9}$$

where

L	is the longest dimension of the building, in metre (m);
A_c	is the cross-sectional area normal to the longest dimension, in square-metres (m²);
L_p	is the perimeter of cross section, in metre (m).

5.5.3 Calculation of internal surface area

The internal surface area, A_S, is the total area that constitutes the perimeter surfaces of the enclosure that is being protected. Non-structural internal partitions that cannot withstand the expected overpressure are not considered to be part of the enclosure surface area. The enclosure internal surface area, A_S, includes the roof or ceiling, walls, floor, and vent area and can be based on simple geometric figures. Surface corrugations are neglected, as well as minor deviations from the simplest shapes. Regular geometric deviations such as sawtoothed roofs can be "averaged" by adding the contributed volume to that of the major structure. The internal surface of any adjoining rooms shall be included. Such rooms include adjoining rooms separated by a partition incapable of withstanding the expected overpressure.

The surface area of equipment and contained structures shall be neglected.

Increasing the value of $p_{red,\ max}$ can reduce A or A_v, the calculated vent area. The value of $p_{red,\ max}$ shall not be increased above 0,1 bar for the purpose of design under this clause.

5.6 Influences of vent ducts

Vent ducts are used to convey a vented explosion to an area where the flame can be discharged safely, for example, from equipment standing in a building to a discharge area outside. Because vent ducts impede the venting process the maximum reduced explosion overpressure in the protected equipment is generally increased.

For a straight vent duct, the effect on the maximum reduced explosion overpressure shall be calculated using the following equation:

$$\frac{p^1_{\text{red, max}}}{p_{\text{red, max}}} = 1 + 17{,}3 \left[\frac{A}{V^{0{,}753}} \right]^{1{,}6} l/d \tag{10}$$

where

$p^1_{\text{red, max}}$	is the maximum reduced explosion overpressure, with a vent duct in bar (bar);
$p_{\text{red, max}}$	is the maximum reduced explosion overpressure, without a vent duct, in bar (bar);
A	is the geometric vent area of the vent, in square-metre (m²);
V	is the enclosure volume, in cubic-metres (m³);
l	is the vent duct length;
d	is the vent duct diameter.

The equation is valid for:

— vessel volumes 0,1 $m^3 \leq V \leq$ 10 000 m³;

— static activation overpressure of the venting device 0,1 bar $\leq p_{stat} \leq$ 1 bar;

— maximum reduced explosion overpressure 0,1 bar < $p_{\text{red, max}} \leq$ 2 bar, with $p_{\text{red, max}} > p_{stat}$;

— maximum explosion overpressure 5 bar $\leq p_{max} \leq$ 12 bar;

— maximum product specific dust explosion constant 10 m bar $s^{-1} \leq K_{max} \leq$ 800 m bar s^{-1}.

If the maximum explosion overpressure, the dust explosion constant or the static activation overpressure are smaller than the ones stated for the validity range of Equation (10), the equation shall be used with the minimum values of the validity range given above.

The influence of vent ducts upon the maximum reduced explosion overpressure in the protected plant is most pronounced for vent duct ratios of:

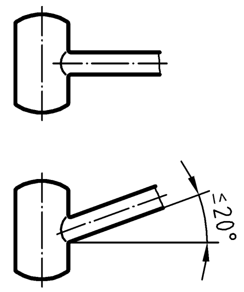
$$(l/d)_S = 4{,}564 \times p_{\text{red, max}}^{-0{,}37} \tag{11}$$

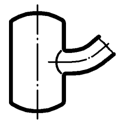
Vent duct/ratios $l/d > (l/d)_S$ do not result in additional pressure increases. Therefore, for l/d ratios exceeding $(l/d)_S$ the pressure increase due to vent ducts with a length-to-ratio of $(l/d)_S$ will be the maximum pressure increase to be considered.

<u>The above-mentioned Equation (11) is not valid for metal dusts.</u>

Equations (10) to (11) apply when Equation (1) has been used for the original vent sizing and the value of the vent static activation overpressure p_{stat} is ≤ 1 bar.

Vent duct configurations to which Equations (10) to (11) can be applied are shown in Figure 1.

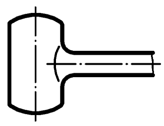




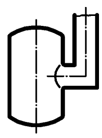
Vent duct with gradual bend.
(radius of curative/duct diameter) > 2

Figure 1 — Vent duct design to which Equations (10) to (11) apply

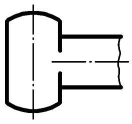
Vent duct configurations to which equations (10) to (11) cannot be applied are shown in Figure 2.



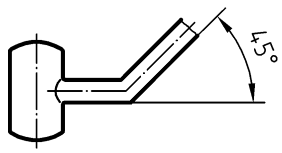
Vent duct areas less than vent area.



90° end



Vent duct area greater than vent area.



45° bend

Figure 2 — Vent duct designs to which Equations (10) to (11) do not apply

NOTE The vent duct designs in Figure 2 are not forbidden, it is only that Equations (10) to (11) do not apply to them. These and other designs can be used as long as the predictions of the effects of the vent duct on the maximum reduced explosion overpressure are based on either published or experimental data that has been obtained from representative explosion venting trials.

The method for estimating the effects of vent ducts published by the UK Institution of Chemical Engineers may be used as an alternative to Equations (10) and (11). This method can be applied to straight vent ducts and to vent ducts containing a single 45° bend or a single 90° bend. This method is published in *Dust explosion prevention and protection: A practical guide,* edited by J. Barton and published by the UK Institution of Chemical Engineers; it is a graphical method and the graphs can be used directly with the information used with and obtained from the vent sizing Equation (1).

5.7 Hybrid mixtures

A hybrid mixture can be ignitable if the concentration of one of the fuel components or even if all concentrations of each individual fuel component are below their respective lower explosion limits. If the gas and solvent vapour concentration everywhere in the vessel is below 20 % of the lower explosion limit ($LEL_{\text{gas, vapour}}$), the hybrid mixture shall be assessed using the explosion indices of the dust present in the mixture. If products, containing no more than 0,5 wt.-% flammable solvents, are handled after drying, a hybrid mixture is not expected.

If the gas or solvent vapour concentration exceeds 20 % of the $LEL_{\text{gas, vapour}}$ or the products handled contain more than 0,5 wt.-% flammable solvents Equation (1) shall be used. The combustible dust shall belong to the dust explosion class St 1 or St 2 and the explosion behaviour of the gas or solvent shall be similar to that of propane. The following values shall be entered into Equation (1):

— maximum explosion overpressure p_{max} = 10 bar;

— maximum dust explosion constant K_{St} = 500 bar m s^{-1}.

For hybrid mixtures made up with combustible dusts of the dust explosion class St 3 (K_{St} > 300 bar m s^{-1}) in the presence of flammable gases advice shall be sought from experts.

It may be necessary to determine the explosion characteristics of specific hybrid mixtures before the venting requirements can be assessed.

6 Positioning of vents

The effects of internal or external obstructions on venting effectiveness shall be taken into account. Recoil forces shall be taken into account when considering the location and distribution of the vent area. Explosion venting devices shall be positioned so that the effectiveness of the venting process is not impeded. Positioning shall be such that personnel and nearby plant will not be at risk from the venting action. If the enclosure is small and relatively symmetrical, one large vent can be as effective as several small vents of equal combined area. For large enclosures, the location of multiple vents to achieve uniform coverage of the enclosure surface to the greatest extent practicable is recommended. Rectangular vents are as effective as square or circular vents of equal area.

7 Supplementary design considerations

7.1 General

Successful application of explosion venting is not only a matter of specifying a sufficient vent area, but also of dealing effectively with the hazards that arise from the venting process.

These hazards include:

— explosion effects external to the vent;

— deformation of the vented enclosure.

7.2 Explosion effects external to the vent

7.2.1 General

A venting explosion ejects burned and unburned material and flames into the area outside the vent. Measures shall therefore be taken to ensure that nearby plant and personnel will not be at risk. The area into which the explosion is vented shall be sufficiently distant from other process equipment to prevent additional fire and explosions, and personnel shall not be allowed to enter this area when an explosion hazard is present.

7.2.2 Flame effects

The flame length external to a vent can be estimated using the following equations:

$$L_F = 10\,V^{1/3} \tag{12}$$

where

L_F	is the flame length, in metre (m);
V	is the enclosure volume, in cubic-metres (m^3).

Equation (12) applies to horizontally discharging explosion venting. For vertically discharging venting, the equation is:

$$L_F = 8\,V^{1/3} \tag{13}$$

The equations are valid for:

volume V:	$0{,}1\ m^3 \le V \le 10\ 000\ m^3$;
static activation overpressure, p_{stat}:	$0{,}1\ bar \le p_{stat} \le 0{,}2\ bar$;
maximum reduced explosion overpressure, $p_{red,\ max}$:	$0{,}1\ bar \le p_{red,\ max} \le 2\ bar$;
maximum explosion overpressure, p_{max}:	$5\ bar \le p_{max} \le 10\ bar$;
K_{St} value:	$10\ bar\ m\ s^{-1} \le K_{St} \le 300\ bar\ m\ s^{-1}$;
the L/D ratio of the enclosure:	$L/D < 2$.

In practice the flame length is not expected to exceed 60 m, even for large volumes, and this figure should be taken as the upper limit for any estimation of L_F.

For dusts with K_{St} values $\le 200\ bar\ m\ s^{-1}$, an estimate of the flame width for both horizontally and vertically discharging venting is given by

$$W_F \approx 1{,}3\,(10\,V)^{1/3} \tag{14}$$

where

W_F	is the flame width, in metre (m);
V	is the enclosure volume, in cubic-metres (m^3).

7.2.3 Pressure effects

Pressure and blast effects external to a vent arise from pressures generated by the vented explosion inside the plant and the explosion of the dust cloud in the area outside the vent.

The following estimate shall be made for the maximum external peak pressures for dust/air mixtures ignited in a compact vented enclosure:

$$p_{\text{ext}} = 0{,}2 \times p_{\text{red, max}} \times A^{0{,}1} \times V^{0{,}18} \tag{15}$$

where

p_{ext}	is the maximum external overpressure, in bar (bar);
$p_{red,\ \text{max}}$	is the maximum reduced explosion overpressure, in bar (bar);
A	is the geometrical vent area, in square-metres (m²);
V	is the vessel volume, in cubic-metres (m³).

The maximum external overpressure, p_{ext} can be expected at a distance

$$R_{\text{S}} = 0{,}25 \times L_{\text{F}} \tag{16}$$

where

L_{F}	is the flame length, m, calculated by Equation (12) or (13) in 7.2.2.

At larger distances, r ($r > R_{\text{s}}$), from the vent, the external pressure P_{R} decrease according to:

$$p_R = 1{,}24 \times \left(1{,}13 \times A^{0{,}5} / r\right)^{1{,}35} / \left[1 + (\alpha / 56)^2\right] \times p_{\text{red, max}} \tag{17}$$

where

r	is the distance from the vent area, in metres (m);
A	is the vent area, in square-metres (m²);

with

α = 0° means in front of the vent area;

α = 90° means sideways from the vent area;

α = 180° means behind the vent area.

The equations are valid for:

vessel volume:	0,1 m³ ≤ V ≤ 250 m³;
static activation overpressure of vent:	$p_{\text{stat}} \leq 0{,}1$ bar;
maximum reduced explosion overpressure:	0,1 bar < $p_{\text{red, max}} \leq 1{,}0$ bar;
distance from the vent area:	$r > R_{\text{s}}$;

maximum explosion overpressure:	$p_{max} \leq 9$ bar;
K_{St}-value:	$K_{St} \leq 200$ bar m s^{-1};
length-to-diameter ratio:	$L/D < 2$;
p_R:	0,2 bar $\leq p_R \leq$ 1,0 bar;
α:	0° to 180°.

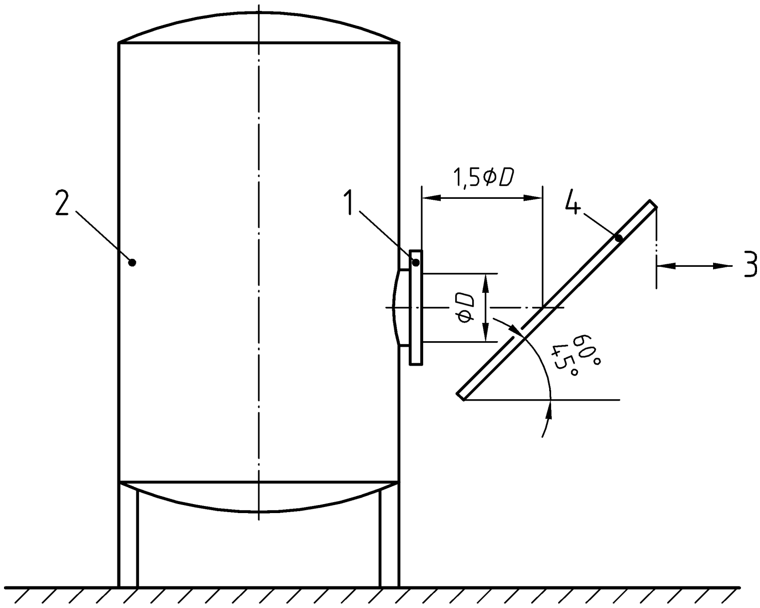
7.2.4 Deflectors

Deflectors can limit the extent of the external flame produced by a vented explosion. A possible design of deflector plate, and its installation, is shown in Figure 3.

The area of the plate shall be at least three times the area of the vent, and its dimensions shall be at least 1,6 times the dimensions of the vent. The plate shall be inclined at least 45° to 60° to the horizontal to deflect the ejected flame upwards. The axis crossing the centre of the vent opening shall also cross the centre of the deflector plate. The plate shall be installed at a sufficient distance from the vent to ensure that it does not act as an obstacle to the venting process and so cause an increase in the maximum reduced explosion overpressure inside the enclosure. Neither shall the plate be installed at too great a distance from the vent; the distance of 1,5 *D* given in Figure 3, where *D* is the diameter of the vent, has been shown to be satisfactory in explosion trials, but may need to be modified in practice, depending on circumstances. The plate should be mounted so that it can withstand the force exerted by the vented explosion, which can be calculated by multiplying the maximum reduced explosion overpressure by the area of the plate.

The plate limits the length of the flame along the axis of the vent. Explosion trials show that a deflector plate, positioned as in Figure 3, approximately halves the length of the flame compared to when the plate is absent. A hazardous area shall be specified beyond the deflector from which personnel are excluded while the plant is operating. The plate deflects flame sideways and the lateral extent of the hazardous area shall be sufficient to avoid harm from this sideways deflection.

Deflectors shall not normally be installed when the enclosure volume is greater than 20 m³.



Key

1 explosion panel

2 enclosure

3 exclusion distance

4 strongly mounted deflector plate

Figure 3 — Design of a blast deflector plate

7.2.5 Effects of flameless explosion venting devices

Flameless explosion venting devices are attached to vents and are designed to prevent the flame from the venting explosion extending beyond the device. The hazardous area external to the vent is therefore reduced substantially. Even with complete retention of flame and particles, however, the immediate area surrounding the vent can experience overpressure and radiant energy. Venting indoors has an effect on the building that houses the protected equipment due to increased pressurisation of the surrounding volume. Expected overpressures shall be compared to the building design and building venting should be considered to limit overpressures.

7.3 Deformation of the vented enclosure

7.3.1 Recoil forces

Recoil forces are generated during explosion venting by ejection of material from the vent opening. These forces can cause vented enclosures to deform or, in the worst case, to collapse.

The maximum recoil force can be calculated using the equation:

$$F_{\text{Rmax}} = 119 \times A \times p_{\text{red, max}} \qquad (18)$$

where

F_{Rmax} is the recoil force, in kN;

A	is the geometric area of the vent, in square-metres (m²);
$p_{red, max}$	is the maximum reduced explosion overpressure, in bar (bar).

The total recoil force can be considered as a force applied at the geometric centre of the vent. Installation of vents of equal area on opposite sides of a vessel may in some instances compensate for recoil forces. Imbalances may occur due to non-simultaneous opening of the vents and these shall be considered when designing.

Knowing the duration of the recoil forces can aid in the design of certain support structures for vented vessels. The duration calculated by the following equation is a conservative estimate:

$$t_R = \left(10^{-4}\right) K_{St}\ V/A\ p_{red,\,max} \tag{19}$$

where

t_R	is the duration of the pulse, in seconds (s);
K_{St}	is the dust explosibility characteristic, in bar m s^{-1};
$p_{red, max}$	is the maximum reduced explosion overpressure, in bar (bar);
A	is the geometric area of the vent, in square-metres (m²).

The impulse transmitted by the recoil force can be approximated by a rectangular impulse equal in area to the recoil force-time variation. The height of this rectangular impulse is given by:

$$F_R = 0{,}52 \times 119 \times A \times p_{red,\,max} \tag{20}$$

The impulse transmitted by the recoil force is given, approximately, by:

$$I_R = F_R \times t_R \tag{21}$$

where

I_R	is the impulse, in kN s.

7.3.2 Vacuum breakers

When explosion doors that close the vent area after the explosion are used, the cooling of the hot gases of combustion can create a vacuum in the vessel, resulting in its deformation. In order to prevent this from happening, vacuum breakers shall be provided.

An inadmissible high vacuum is prevented if the vacuum breaker is sized in accordance with Equation (22) which describes the correlation of the required suction area with the size of the protected enclosure and its collapsing resistance.

$$A_{suc} = \left[-0{,}00219 \times \ln\left(p_{vac}\right) + 0{,}014\right] \times V^{\left(-0{,}0207 \times \ln\left(p_{vac}\right) + 0{,}8147\right)} \tag{22}$$

where

A_{suc}	is the effective suction area, in square-metres (m²);
p_{vac}	is the vacuum (collapsing) resistance of vessel, in mbar (mbar);
V	is the vessel (silo) volume, in cubic-metres (m³).

The equation is valid for:

— vessel volume 5 m³ ≤ V ≤ 5 000 m³;

— vacuum resistance 25 mbar ≤ p_{vac} ≤ 500 mbar.

8 Information for use

8.1 Marking

All products protected against the consequences of internal dust explosions by explosion venting designed according to this European Standard shall be marked on the main part in a visible place. This marking shall be legible and durable taking into account possible chemical corrosion.

Marking shall include:

a) name and address of the manufacturer;

b) manufacturer's type identification;

c) year of construction;

d) serial number.

8.2 Accompanying documents

All powder handling equipment that is explosion protected by means of explosion venting shall be accompanied by instructions that include:

a) information marked on the product;

b) all details of operational requirements;

c) method used to assess the vent area;

d) maximum reduced explosion overpressure $p_{red, max}$, bar;

e) upper value of the vent static activation overpressure p_{stat}, bar;

f) upper limit of the explosibility characteristics of the dust p_{max}, bar and K_{St}, bar m s^{-1};

g) full description of procedures to be followed after an explosion.

In addition the instructions for maintenance shall include:

h) periodic inspection
Periodic inspection checks should be made to ensure that the explosion venting capability does not deteriorate and would continue to react as originally designed in the event of an explosion.

i) extraordinary inspection
If an explosion occurs an inspection of the equipment is necessary. After completion of any repairs and before the equipment goes back into service, it is the responsibility of the user to satisfy himself that the equipment is safe and the explosion venting precautions are suitable for the equipments intended use.

Annex A
(informative)

Estimating the *L*/*D* ratio when calculating vent areas for elongated enclosures

The length-to-diameter ratio (*L/D*) of an elongated enclosure is needed if Equation (1) is to be applied. This value of *L/D* depends on the shape of the enclosure and the position of the vent, and need not necessarily equal the physical value of *L/D* evident from the design of the enclosure.

The worst case condition to which Equation (1) can be applied is an enclosure with a vent at one end, because the flame can travel the entire length of the enclosure before it vents. If, in such a case, the enclosure is cylindrical, for example, then the value of *L/D* can be calculated directly from physical dimensions. If the enclosure does not have a simple shape, however, or the vent is not at one end, the appropriate value of *L/D* can only be obtained by estimating, based on the enclosure design, the maximum distance a flame can travel inside the enclosure before venting and the volume through which the flame travels.

A simple procedure has been devised for calculating *L/D* ratios for any shape of elongated enclosure and for any vent position:

a) estimate the maximum possible flame path along which the flame can travel before reaching the vent, H;

b) calculate the volume of that part of the enclosure through which the flame can pass as it travels along the maximum flame path, V_{eff}[2)];

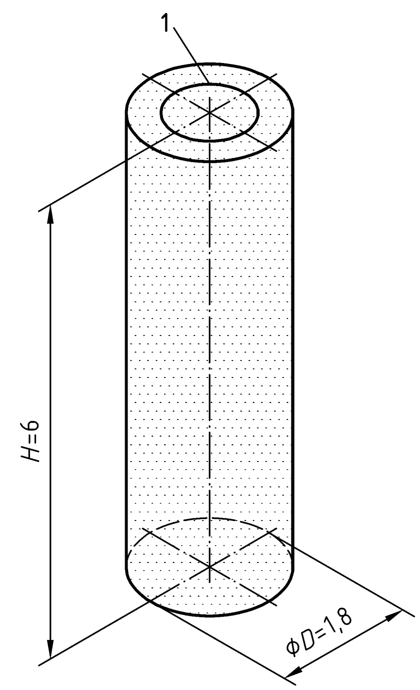
c) divide V_{eff}[2)] by H to produce an effective enclosure area, A_{eff};

d) calculate an effective enclosure diameter from A_{eff} , D_{eff}.

Examples of *L*/*D* calculations are given in Figures A.1 to A.7.

2) V_{eff} is not always the volume that should be used in calculating the vent area.

Dimensions in metres



Key

1 vent

a) In this example, L/D equals the physical length to diameter ratio of the enclosure. H equals the vertical height of the enclosure;

b) $V_{\text{eff}} = \dfrac{\pi D^2}{4} \times H = \dfrac{\pi\,(1{,}8)^2}{4} \times 6 = 15{,}27\ \text{m}^3$

V_{eff} is the shaded region in the diagram;

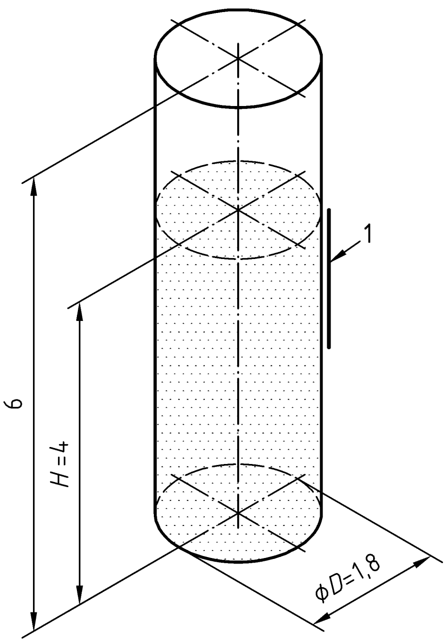
c) $A_{\text{eff}} = \dfrac{V_{\text{eff}}}{H} = \dfrac{\pi\ D^2}{4} = \dfrac{15{,}27}{6} = 2{,}545\ m^2$;

d) $D_{\text{eff}} = \sqrt{\dfrac{4\,A_{\text{eff}}}{\pi}} = \sqrt{\dfrac{4 \times 2{,}545}{3{,}142}} = 1{,}8\ \text{m}$;

e) $\dfrac{L}{D} = \dfrac{H}{D_{\text{eff}}} = \dfrac{6}{1{,}8} = 3{,}333$.

Figure A.1 — Cylindrical enclosure with a vent in the roof

Dimensions in metres



Key

1 vent

a) In this example, L/D does not equal the physical length-to-diameter ratio of the enclosure. H equals the distance from the enclosure floor to the top of vent, H = 4 m;

b) $V_{\text{eff}} = \dfrac{\pi D^2}{4} \times H = \dfrac{\pi \times (1{,}8)^2 \times 4}{4} = 10{,}18\,\text{m}^2$;

V_{eff} is the shaded region in the diagram;

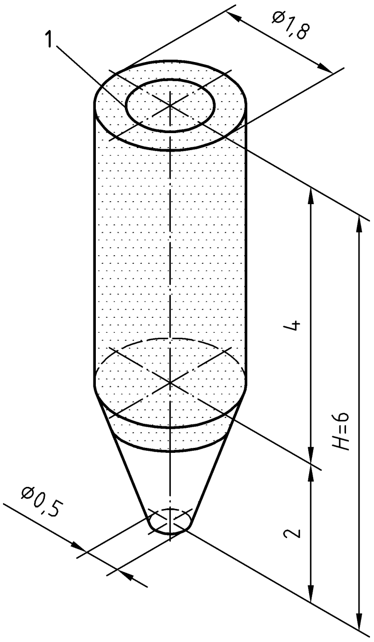
c) $A_{\text{eff}} = \dfrac{V_{\text{eff}}}{H} = \dfrac{\pi D^2}{4} = \dfrac{10{,}18}{4} = 2{,}545\,\text{m}^2$;

d) $D_{\text{eff}} = \sqrt{\dfrac{4\,A_{\text{eff}}}{\pi}} = \sqrt{\dfrac{4 \times 2{,}545}{3{,}142}} = 1{,}8\ \text{m}$;

e) $\dfrac{L}{D} = \dfrac{H}{D_{\text{eff}}} = \dfrac{4}{1{,}8} = 2{,}22$.

Figure A.2 — Cylindrical enclosure with a vent in the side

Dimensions in metres



Key

1 vent

a) Since the flame does not spread in an optimum way in the cone the flame length inside the vessel is 1/3 of the height of the cone plus the height of the cylindrical part = 1/3 cone height + height cylindrical part = 0,667 + 4 = 4,667 m;

b) V_{eff} equals the total free volume of the enclosure which consists of 1/3 of the cone volume and the volume of the cylindrical part.

The volume of the cylindrical part =

$$\frac{\pi\,(1{,}8)^2}{4}\times 4 = 10{,}18\ \mathrm{m}^3$$

1/3 of the volume of the hopper =

$$\frac{\pi\ 2}{3}\left(\frac{0{,}9^2+0{,}9\times 0{,}25+0{,}25^2}{3}\right)=0{,}77\ \mathrm{m}^3$$

$$V_{\text{eff}} = 0{,}77+10{,}18 = 10{,}95\ \mathrm{m}^3$$

V_{eff} is the shaded region in the diagram;

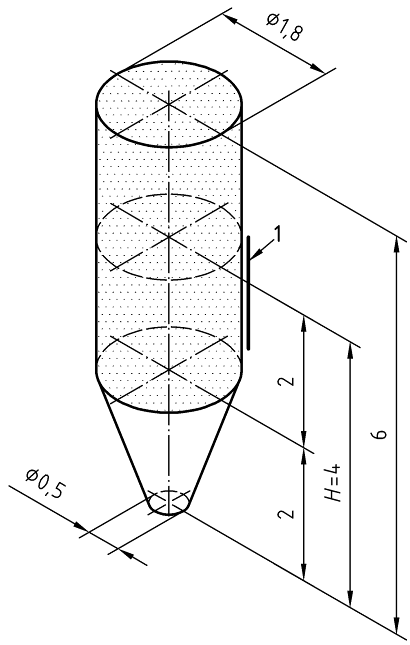
c) $A_{\text{eff}} = \dfrac{V_{\text{eff}}}{H} = \dfrac{10{,}95}{4{,}667} = 2{,}346\ \mathrm{m}^2$;

d) $D_{\text{eff}} = \sqrt{\dfrac{4\ A_{\text{eff}}}{\pi}} = 1{,}728\ \mathrm{m}$;

e) $\dfrac{L}{D} = \dfrac{H}{D_{\text{eff}}} = \dfrac{4{,}667}{1{,}728} = 2{,}70$.

Figure A.3 — Cylindrical enclosure with a hopper and vented in the roof

Dimensions in metres



Key

1 vent

a) H equals the vertical distance from the roof of the cylindrical part to the bottom end of the vent = 4 m;

b) V_{eff} equals the volume of the cylinder to the bottom end of the vent, i.e. the volume of the cylinder.

Volume of the cylindrical parts =

$$V_{\text{eff}} = \frac{\pi\,(1{,}8)^2}{4}\times 4 = 10{,}18\ \mathrm{m}^3$$

V_{eff} is the shaded region in the diagram;

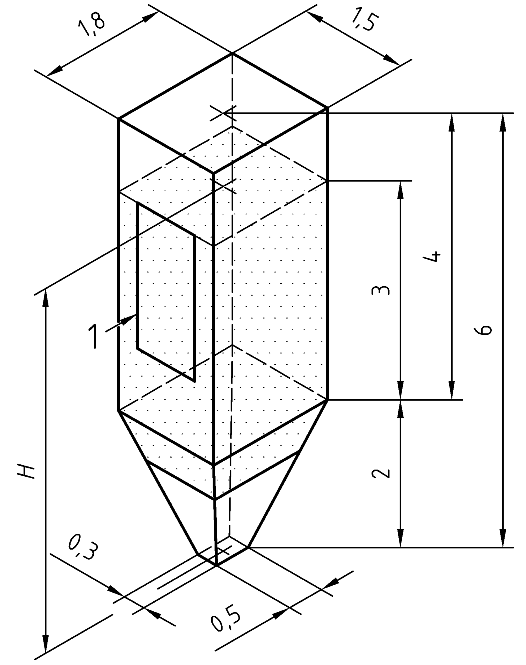
c) $A_{\text{eff}} = \dfrac{V_{\text{eff}}}{H} = \dfrac{10{,}18}{4} = 2{,}55\ \mathrm{m}^2$;

d) $D_{\text{eff}} = \sqrt{\dfrac{4\,A_{\text{eff}}}{\pi}} = 1{,}80\ \mathrm{m}$;

e) $\dfrac{L}{D} = \dfrac{H}{D_{\text{eff}}} = \dfrac{4}{1{,}80} = 2{,}22$.

Figure A.4 — Cylindrical enclosure with a hopper and vented at the side

Dimensions in metres



Key

1 vent

a) *H* equals the flame length inside the vessel which is 1/3 of the height of the hopper plus the height of the rectangular part up to the top of the vent = 1/3 hopper height + height rectangular part = 0,667 m + 3 m = 3,667 m;

b) V_{eff} equals the 1/3 of volume of the hopper plus the volume of the rectangular vessel (to the top of the vent);

c) The volume of the rectangular part = 1,8 m × 1,5 m × 3 m = 8,1 m³;

d) 1/3 of the volume of the hopper = 1/3 × (0,5 × 2 × (1,5 – 0,3)/2 +
0,3 × 2 (1,8 – 0,5)/2 +
2 (1,8 – 0,5) × (1,5 – 0,3)/3 +
0,5 × 0,3 × 2) = 1/3 × 2,33 = 0,777 m³
V_{eff} = 8,1 + 0,777 = 8,877 m³;

e) A general formula for calculating the volume for a rectangular hopper is given with Figure A.7;

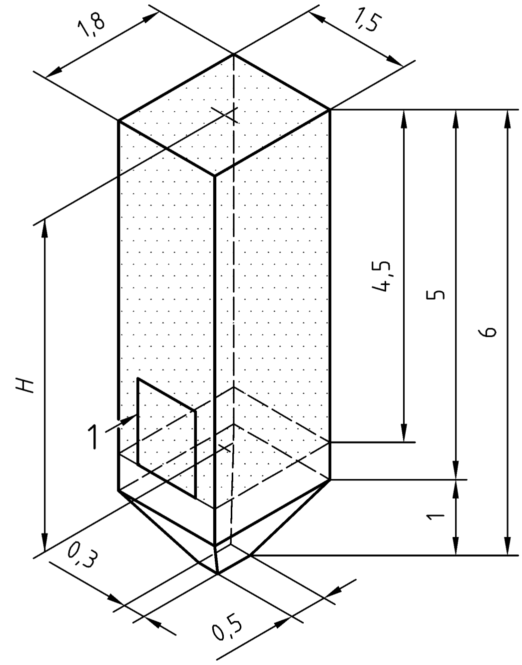
f) $A_{eff} = \frac{V_{eff}}{H} = \frac{8,877}{3,667} = 2,42 \text{ m}^2$;

g) D_{eff} = the hydraulic diameter of area A_{eff} assuming A_{eff} is square = $(2,42)^{0,5}$ = 1,56 m;

h) $\frac{L}{D} = \frac{H}{D_{eff}} = \frac{3,667}{1,56} = 2,35$.

Figure A.5 — Rectangular enclosure with a hopper and vented at the side

Dimensions in metres



Key

1 vent

a) *H* equals the vertical distance from the top of the rectangular vessel to the bottom of the vent. *H* is the longest flame path possible because the vent is closer to the hopper bottom than it is to the vessel top = 4,5 m;

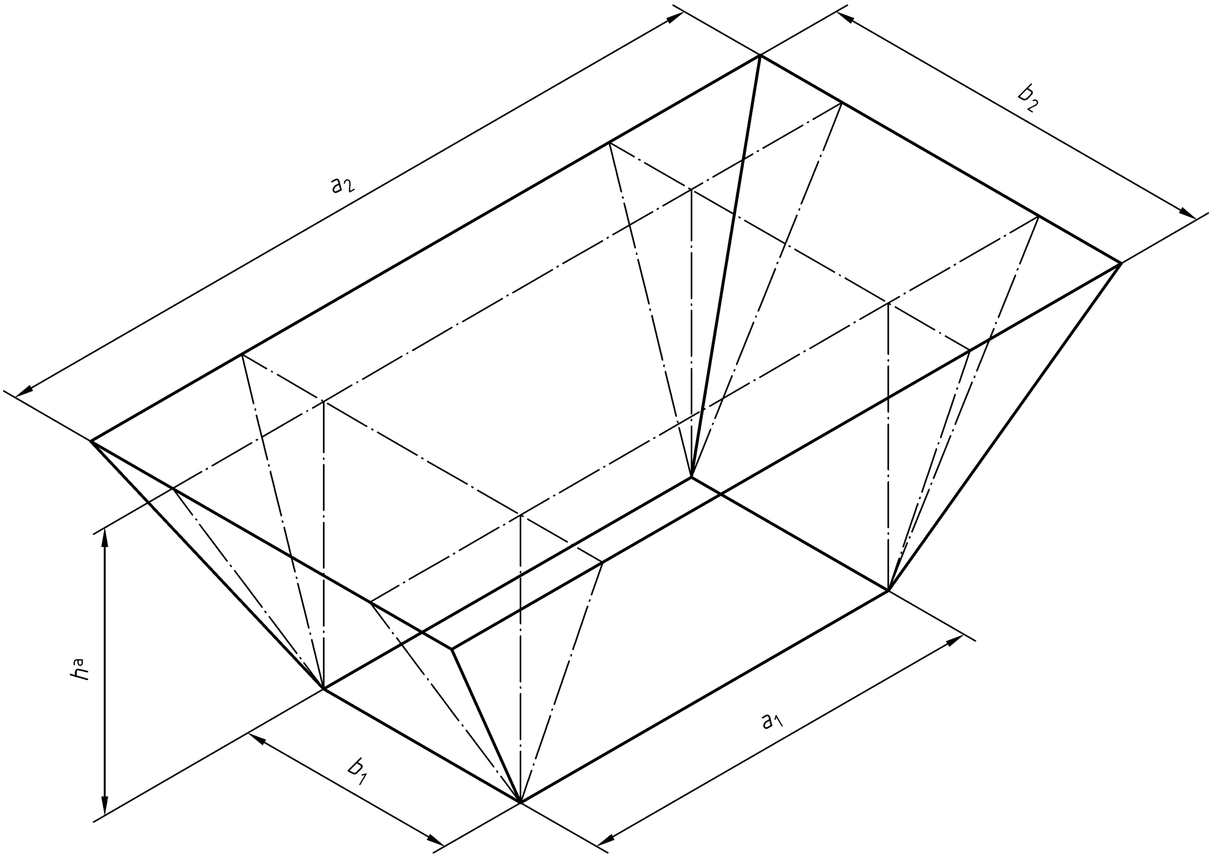
b) V_{eff} equals the volume from the top of the rectangular vessel to the bottom of the vent = 4,5 m × 1,8 m × 1,5 m = 12,15 m³
V_{eff} is the shaded region in the Figure;

c) $A_{eff} = \frac{V_{eff}}{H} = \frac{12,15}{4,5} = 2,7 \text{ m}^2$;

d) D_{eff} = the hydraulic diameter of area A_{eff} = (0,5 × (1,8 + 1,5)) = 1,65 m;

e) $\frac{L}{D} = \frac{H}{D_{eff}} = \frac{4,5}{1,65} = 2,73$.

Figure A.6 — Rectangular enclosure with a hopper and vented at the side, close to the hopper



$V = (a_1)\ (h_a)\ (b_2 - b_1) / 2 + (b_1)\ (h_a)\ (a_2 - a_1) / 2 + h_a\ (a_2 - a_1)\ (b_2 - b_1) / 3 + (a_1)\ (b_1)\ h_a$;

Key

a_1 length of the base

b_1 width of the base

h_a height of the rectangular hopper

a_2 length of the top

b_2 width of the top

V Volume

Figure A.7 — Calculation of a volume of a rectangular hopper

For a conical hopper V is:

$$V = \pi\,(h)\left(D_1^2 + D_1\,D_2 + D_2^2\right)/12$$

where

D_1 is the diameter of the base;

D_2 is the diameter of the top.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 94/9/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 94/9/EC of 23 March 1994 concerning equipment and protective systems intended for use in potentially explosive atmospheres.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 94/9/EC

Essential Requirements (ERs) of EU Directive 94/9/EC		**Clauses of this EN**	**Reference in other standards**
1.0	General requirements	whole document	
1.0.1	Principles of integrated explosion safety	whole document	
1.0.3	Special checking and maintenance conditions	8	
1.0.4	Surrounding area conditions	6, 7	
1.0.5	Marking	8.1	
1.0.6	Instructions	8.2	
1.1	**Selection of materials**		
1.1.2	Limits of operating	5, 6, 7	
1.2	**Design and construction**		
1.2.1	Technological knowledge of explosion protection for safe	whole document	prEN 14797
1.2.2	Safe functioning of replacement components		prEN 14797
1.2.3	Enclosed structures and prevention of leaks		prEN 14797
1.4	**Hazards rising from external effects**		
1.4.1	Safe functioning	8	prEN 14797
1.4.2	Mechanical and thermal stresses and withstanding attack by existing or on foreseeable aggressive substances		prEN 14797
2.1.2	Explosive atmospheres caused by air/dust mixtures	whole document	
2.2.2	Explosive atmospheres caused by air/dust mixtures	whole document	
2.3.2	Explosive atmospheres caused by air/dust mixtures	whole document	

Table ZA.1 (*continued*) — **Correspondence between this European Standard and Directive 94/9/EC**

Essential Requirements (ERs) of EU Directive 94/9/EC		**Clauses of this EN**	**Reference in other standards**
3	**Supplementary requirements in respect of protective systems**		
3.0	General requirements	whole document	
3.0.1	Dimension of protective systems safety level	5, 6, 7	prEN 14797
3.1.5	Pressure relief systems	whole document	
3.1.7	Explosion decoupling systems	5.4	

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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