BS EN 16020:2011

BSI Standards Publication

Explosion diverters

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 16020:2011.

The UK participation in its preparation was entrusted to Technical Committee EXL/23, Explosion and 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.

ISBN 978 0 580 69174 4

ICS 13.230

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2011.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 16020

July 2011

ICS 13.230

English Version

Explosion diverters

Dispositifs déviateurs d'explosion

Explosionsschlote

This European Standard was approved by CEN on 25 June 2011.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 16020:2011: E

Contents

Page

Foreword

This document (EN 16020:2011) 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of an identical text or by endorsement, at the latest by January 2012, and conflicting national standards shall be withdrawn at the latest by January 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document 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).

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

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

1 Scope

An explosion diverter is used to divert explosions propagating through ducts, thus preventing flame jet ignition and pressure piling in connected protected enclosures. It will reduce the risk of flame transmission.

This European Standard describes the basic design of a pipe-in-pipe diverter and specifies the testing requirements and the application of explosion diverters.

This European Standard covers:

— a test method for assessing the efficacy of explosion diverters;

— design rules for a type of pipe-in-pipe diverter;

— demands to venting device on diverter;

— installation requirements;

— maintenance requirements;

— marking.

This European Standard considers dust/air explosive atmospheres only.

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

EN 14034-1, *Determination of explosion characteristics of dust clouds — Part 1: Determination of the maximum explosion pressure p_{max} of dust clouds*

EN 14034-2, *Determination of explosion characteristics of dust clouds — Part 2: Determination of the maximum rate of explosion pressure rise $(dp/dt)_{max}$ of dust clouds*

EN 14460:2006, *Explosion resistant equipment*

EN 14491: *Dust explosion venting protective systems*

EN 14797, *Explosion venting devices*

EN 15089:2009, *Explosion isolation systems*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13237, EN 14797, EN 14491 , EN 15089:2009 and the following apply.

3.1
explosion venting device
part of the explosion diverter which opens under explosion conditions in a controlled manner

3.2
explosion diverter
passive mechanical device typically installed in a duct preventing flame jet ignition, pressure piling and reducing the probability of flame transmission into connected equipment

3.3
flame velocity
S_f
velocity of a flame front relative to a fixed reference point

[EN 15089:2009, 3.14]

3.4
pressure piling
condition during deflagration in which pressure increases in the unreacted medium ahead of the flame front as a result of the deflagration

3.5
flame jet ignition
ignition of unreacted pre-compressed and turbulent medium in an enclosure by a flame with a large surface area and high energy

3.6
installation distance
distance between the vessel and the connecting flange of the diverter

3.7
optimum explosion pressure
p_{opt}
explosion pressure in the vented or unvented vessel of the primary explosion which causes maximum flame velocity in the pipe at the inlet of the connected vessel, without diverter

4 Explosion Diverters

4.1 General

Explosion diverters are inline passive protective systems, installed in processes involving dust. They respond to and by means of internal explosion pressure in the duct in which they are installed.

The most common design of explosion diverters can be described as pipe in pipe arrangements (see Figure 1) causing a change of flow direction and fitted with an explosion venting device (see Figure 1 a) and Annex A). This type of diverter will typically have an inner inlet pipe and an outer outlet pipe. Other types of explosion diverters are described in Annex B.

In most cases, the installation of explosion diverters is closely related to pre-arranged planning and engineering. Subsequently, the installation will be executed as per agreed-upon general arrangement and detail drawings of the system of which the explosion diverter becomes a part.

In the case of an explosion propagating through a duct, the venting device opens and diverts flame and pressure. This shall be done into a safe area (see Figure 1 b)).

Explosion diverters shall ensure as a minimum that pressure piling and flame jet ignition are prevented beyond the diverter. They cannot completely stop the flame and pressure propagation under all conditions.

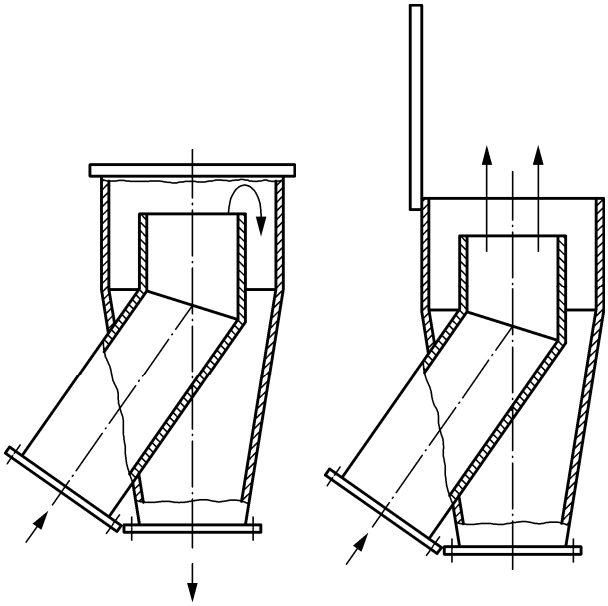


Figure 1 — Example of a pipe-in-pipe explosion diverter

4.2 Special requirements to explosion diverters

4.2.1 Explosion venting device

Venting devices shall comply with EN 14797 with the exception of the determination of the efficiency of the device. In addition, tests according to Clause 5 shall be undertaken to demonstrate their suitability for intended use on explosion diverters.

4.2.2 Mechanical integrity

Depending on the intended use, the loads caused by internal explosions will to a great extent depend on equipment connected to the device (vessel size, length of interconnecting pipes) and explosion properties of the dust (intended range of K_{St}, p_{max}).

Any part of an explosion diverter not designed to rupture shall be constructed such that it can withstand the loads imposed by any internal explosion that can be expected in accordance with its intended use, without rupturing. The construction can be either explosion-pressure resistant or explosion-pressure shock-resistant (see EN 14460).

If parts of or the entire explosion venting device detach during the explosion, the explosion diverter shall include a restraining arrangement e.g. a cage. The restraining arrangement is an integral part of the explosion diverter. The requirements pertaining to mechanical integrity include the elements of the restraining arrangement.

5 Verification of efficacy and mechanical integrity of the diverter by experimental testing

5.1 General

The testing shall reflect the intended use.

As a minimum the following information is necessary prior to testing:

— a general type description;

— intended use;

— installation and operating instructions (maximum allowable length of the pipes between explosion diverter and interconnected vessels and the presence of bends/pipe restrictions, location and position of the explosion diverter);

— part list;

— design and manufacturing drawings and layouts of parts etc.;

— results of design calculations made, examinations carried out, test reports;

— ambient and process conditions;

— dust type (K_{St}, p_{max}, metal dust yes/no);

— explosion resistance of the device;

— static activation pressure (p_{stat}) of the venting device;

— maximum explosion pressure in the connected vessels.

The smallest and largest size for devices with geometrical similarity (with respect to the material specifications, welding specifications and wall thickness) shall be tested. If the diameter ratio of largest to smallest size exceeds 5, an intermediate size shall be tested.

5.2 Test Modules

5.2.1 General

Two modules are available for experimental testing, The modules are referenced to as Module A and Module B. The mechanical integrity and explosion resistance of the diverter is tested in either of these two modules.

The test pressure required to prove the mechanical integrity and explosion resistance according to the intended use is material dependant and shall be according to EN 14460:2006, 6.3. Permanent deformation of the diverter body is allowed provided it does not fail in its function and will not give rise to dangerous effects to the surrounding. If permanent deformation is observed, the explosion resistance shall be documented as the explosion pressure shock resistance according to EN 14460.

5.2.2 Module A: Mechanical integrity testing

5.2.2.1 General

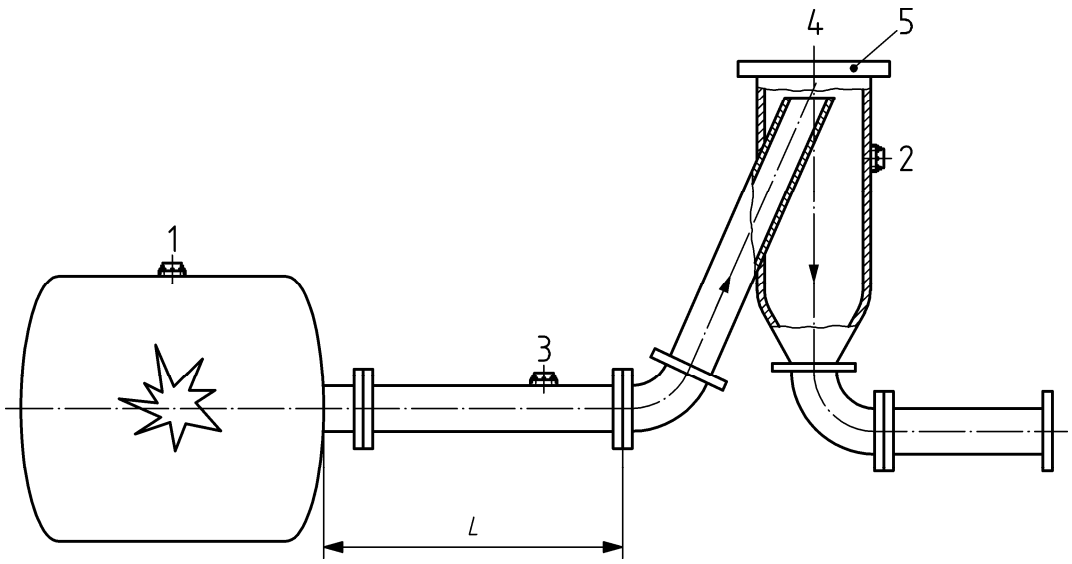
Module A (mechanical integrity testing only) is used for testing:

— pipe-in-pipe diverters according to Annex A;

— any other type of diverter which was previously tested and approved according to Module B but which did undergo changes which can affect the mechanical integrity and explosion resistance of the diverter. Changes to the geometry for instance will require retesting according to Module B. Furthermore, modification of the venting device or the introduction of a restraining cage needs testing according to Module B.

5.2.2.2 Test set-up

The explosion diverter shall be tested with a test rig as shown in Figure 2.



Key

1,2,3 pressure transducer (Pt)
4 explosion diverter body (ED)
5 explosion diverter venting device
L installation distance

Figure 2 — Test arrangement for mechanical and explosion resistance testing

The dimensions of the pipe (length and diameter), the pipe arrangement (e.g. horizontal/vertical), the volume of the test vessel, the maximum reduced explosion pressure in the test vessel and the explosion characteristics of the explosive atmosphere shall reflect the intended use of the diverter (see 5.1).

The length to diameter ratio of the vessel shall be equal to or smaller than 2,5 and the pipe volume up to the explosion diverter shall be smaller than the volume of the vessel. The explosion pressure generated within the diverter shall reflect the maximum allowable explosion pressure according to the intended use of the diverter.

If the intended use includes scenarios in which the explosion can propagate in both directions, the testing shall be repeated with the diverter reversed such that the outlet now becomes the inlet.

5.2.2.3 Measuring technique

The following parameter shall be measured:

— Pressure

The explosion pressure shall be measured by installing transducers in the explosion enclosure, the diverter and the interconnecting duct (see Figure 2). The pressure transducer shall have a sufficient short response time.

5.2.2.4 Testing method

Sufficient explosive dust shall be injected in the test vessel to generate an explosive dust/air mixture in the duct to support flame propagation into the diverter.

The generation of the dust cloud inside the test vessel shall be carried out according to EN 14034-1 and EN 14034-2.

Testing shall be carried out at maximum p_{red}, K_{St} and longest installation distance at which the maximum allowable explosion pressure as per the intended use of the diverter is reached.

Calibration tests shall be carried out without explosion diverter in the test rig according to Figure 2 to define the test parameters (dust concentration, ignition delay time, venting area) necessary to achieve the optimum explosion pressures (p_{opt}) according to the intended use and flame transmission and acceleration throughout the pipe (worst case condition). Dust injection in the duct can be necessary.

a) Number of tests

Only 1 test is required for mechanical integrity testing.

b) Evaluation of test

The mechanical integrity testing is successful if the diverter has withstood the intended explosion pressure and did not generate any flying parts.

5.2.3 Module B: Functional testing

5.2.3.1 General

Module B (functional testing) shall assess the efficacy of the explosion diverter according to the intended use as specified by the manufacturer and determine the maximum permissible length of the pipes L_1 and L_2 (Figures 3 and 4): maximum installation distances.

Module B has 4 subsets B1, B2, B3 and B4 depending on the intended use (see Table 1).

Table 1 — Different Modules for functional testing

Module	Ignition source location	Dust cloud generation [a, b]	Objective	Acceptance criteria	minimum number of valid tests required[c]
B1 (Figure 3)	Vessel V_1	Vessel V_1	Prevention of flame jet ignition and pressure piling in vessel V_2	**Flame velocity < 100 m/s and explosion pressure < 0,3 bar at inlet of vessel V_2**	**3** at p_{opt} [d]
B2 (Figure 3)	Vessel V_1	Vessel V_1	Prevention of flame propagation into vessel V_2	**No flame beyond the explosion diverter**	**10** at $p_{red} \leq 0,3$ bar
B3 (Figure 4)	Vessel V_2	Vessel V_2	Prevention of flame jet ignition and pressure piling in vessel V_1	**Flame velocity < 100 m/s and explosion pressure < 0,3 bar at inlet of vessel V_1**	**3** at p_{opt} [d]
B4 (Figure 4)	Vessel V_2	Vessel V_2	Prevention of flame propagation into vessel V_1	**No flame reaches the vessel V_1**	**10** at $p_{red} \leq 0,3$ bar

[a] In reference to EN 14034-1 and EN 14034-2.

[b] In order to enable optimum flame propagation throughout the system, explosive dust concentration needs to be present in the pipe as well. It can be therefore necessary to feed dust into the pipe and/or into the second vessel (dust dosage according to Figure 3 and Figure 4).

[c] identical test conditions

[d] according to 5.2.3.4

If the intended use aims at stopping flame propagation, then B2 and/or B4 shall be performed in addition to B1 and/or B3.

5.2.3.2 Test set-up

The test rig is shown in Figures 3 and 4 and consists of 2 vessels (V_1 and V_2) connected by a pipe with the explosion diverter installed at a location representing the intended use (see 5.1).

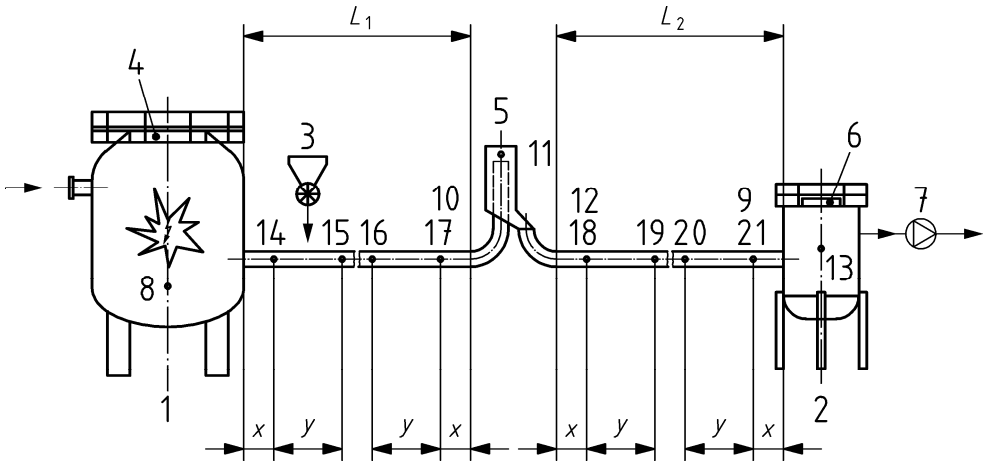
The dimensions of the pipe (length and diameter), the choice of the enclosure (closed or vented) and the explosion characteristics of the explosive atmosphere shall reflect the intended use of the diverter.

The test rig shall reflect the worst case situation of the intended use in terms of pressure and flame velocity.

The air flow velocity inside the interconnecting pipe shall reflect the intended use.

Dust will be sucked from source vessel V_1 into the pipe, however the dust concentration in the source vessel/pipe shall be sufficient to support flame propagation to the receiving vessel V_2. This can require additional dust dosage into the pipe.

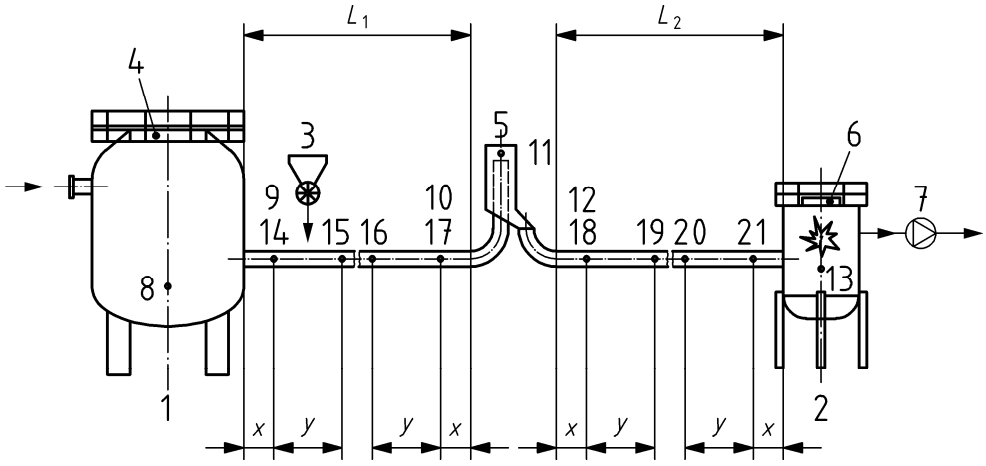
The length to diameter ratio of the vessels shall be equal to or smaller than 2,5 and the pipe volume up to the explosion diverter shall be smaller than the volume of the vessel where the ignition takes place.



Key

1	explosion vessel V_1 (closed or vented)	L_1	installation distance
2	explosion vessel V_2 (closed or vented)	L_2	length of pipe downstream of explosion diverter
3	dust dosage	x, y	positions of the transducers with $x \leq 200$ mm, $y \leq 3\,000$ mm
4 to 6	venting areas A_1, A_2, A_3		
7	blower		
8 to 13	pressure transducers		
14 to 21	flame transducers		

Figure 3 — Test arrangement for the functional testing (Module B1 and B2) of explosion diverters. Ignition in the vessel V_1 – explosion propagates with the airflow



Key

1	explosion vessel V_1 (closed or vented)	L_1	installation distance
2	explosion vessel V_2 (closed or vented)	L_2	length of pipe downstream of explosion diverter
3	dust dosage	x, y	positions of the transducers with $x \leq 200$ mm, $y \leq 3\,000$ mm
4 to 6	venting areas A_1, A_2, A_3		
7	blower		
8 to 13	pressure transducers		
14 to 21	flame transducers		

Figure 4 — Test arrangement for the functional testing (Module B3 and B4) of explosion diverters. Ignition in the vessel V_2 – Explosion propagates against the airflow

5.2.3.3 Measuring technique

The following parameters shall be measured:

a) Pressure

The explosion pressure shall be measured by installing transducers within a distance of 200 mm from the inlet and the outlet (10, 12) of the diverter. Four other pressure transducers are to be located on the diverter (11), the pipe (9) and vessels V_1 and V_2 (8 and 13). The pressure transducer shall have a sufficient short response time.

b) Flame

The flame position shall be measured by installing two transducers (14, 15) at the beginning of the pipe, two before and after the diverter (16, 17, 18, 19) and two transducers (20, 21) at the inlet of the receiving vessel V_2. The transducers shall be located at discrete distances, not exceeding 3 m, to allow determination of the average flame velocity.

5.2.3.4 Testing method

The generation of the dust cloud inside the vessel in which the primary explosion will be ignited shall be carried out according to EN 14034-1 and EN 14034-2.

Sufficient dust shall be injected in the primary vessel to generate an explosive dust/air mixture in the pipe, to support flame propagation to the secondary vessel V_2.

Modules B1 and B3 (Flame jet ignition and pressure piling tests) shall be done at p_{opt}.

Modules B2 and B4 (flame transmission tests) shall be performed at $p_{red} \leq 0{,}3$ bar to ensure worst case conditions.

Calibration tests shall be carried out without explosion diverter in the test rig according to Figure 3 and/or 4, respectively to define the test parameters (dust concentration, ignition delay time, venting area) necessary to achieve the optimum explosion pressures (p_{opt}) according to the intended use and flame transmission and acceleration throughout the pipe.

In order to optimise flame propagation throughout the system, an explosive dust concentration needs to be present in the pipe as well which can require feeding additional dust into the pipe (dust dosage according to Figure 3 and 4).

a) Number of tests

— Calibration tests

A sufficient number of calibration tests shall be carried out without explosion diverter in the test rig in order to define the test parameters (dust concentration, ignition delay time, venting area) necessary to achieve the optimum explosion pressures (p_{opt}) according to the intended use and flame transmission and acceleration throughout the pipe (worst case condition).

— Functional tests

The number of tests depend on the desired intended use according to Table 1.

b) Evaluation of tests

The acceptance criteria are given in Table 1.

6 Test Report

The requirements in EN ISO 17025 shall be fulfilled. As a minimum, the following shall be reported:

a) Product characteristics:

1) nature of the sample;
2) sample pre-treatment;
3) characteristics data for particle size distribution and moisture content;
4) type of dust and all relevant safety characteristics (e.g., p_{max}, K_{St}).

b) Characteristics of the test rig:
1) dimensional sketch of the test rig;
2) enclosure and pipe volume, aspect ratio;
3) dust-dispersion system;
4) explosion characteristics of the dust (sample) in the test enclosures;
5) ignition delay time (turbulence index);
6) flow velocity.

c) Characteristics of the explosion diverter:
1) design documentation of the diverter;
2) type of venting device;
3) static activation pressure of the venting device;
4) location and position of the explosion diverter.

d) Results:
1) data of tests;
2) maximum pipe length in front of and behind the explosion diverter;
3) mechanical integrity and explosion resistance of the diverter.

e) Additional information;
1) The report shall include all pertinent observations and information, which are not fully described above.

7 Information for use

All explosion diverters shall be at least accompanied by instructions that include:

a) venting devices to be used in combination with the explosion diverter;

b) description of the intended use of the explosion diverter:

— all details of operational requirements,

— external effects in case of an explosion,

NOTE Explosion venting should 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 should be specified.

— safe arrangement,

— mechanical integrity and explosion resistance of the diverter;

c) information marked on the product;

d) instructions for installation:

— general arrangement plan of the explosion diverter,

— recoil forces;

e) requirements for maintenance:

— periodic inspection checks shall be made to ensure that the explosion diverter capability does not deteriorate and the diverter would continue to react as originally designed in the event of an explosion,

— list of spare parts,

— venting devices to be used in combination with the explosion diverter;

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

8 Marking

The marking shall include at least the following:

— name and address of the manufacturer;

— year of construction;

— designation of series or type, if any;

— serial or identification number;

— type of explosion venting device.

The process flow direction shall be clearly indicated on the device.

Annex A
(normative)

Constructional design of pipe-in-pipe diverters

For a pipe-in-pipe explosion diverter according to Figure A.1, the testing can be limited to Module A, since with this geometry a comprehensive large scale test program was carried out and documented [6] [11]. The use of these pipe-in-pipe diverters is restricted to the avoidance of pressure piling and flame jet ignition as described in the Modules B1 and B3 in Table 1. Additional testing is required if safe prevention of flame propagation according to Modules B2 and B4 is required.

Due to the 180°-change of flow direction, the internal pipe leads into a tubing extension (see Figure A.1). The conveying air flows through the cross-section area A_1 of the internal pipe, a cylindrical surface A_2 (calculated from the diameter of this pipe and the distance h_1 between the open end of this pipe and the pressure relief area) and then the cross-section area A_3 of the annulus between internal pipe and tubing extension.

On the basis of fluid mechanics the cross section surfaces are chosen to be 2 A_1 = A_2 = A_3 [5]. Considering this geometry the distance h_1 between the end of the internal pipe and the venting element is typically

$$h_1 = 0{,}5 \times d_1$$

where

d_1 is the diameter of the internal pipe [4].

The length of the vertical pipe, h_2, is of no importance. The angle between outlet and inlet shall not be more than 30°.The outlet of the inner pipe shall be parallel to the venting device. Venting direction shall be vertical.

A restraining cage can affect the effectiveness of the diverter and therefore its influence shall be tested according to Module B unless the following criteria are fulfilled:

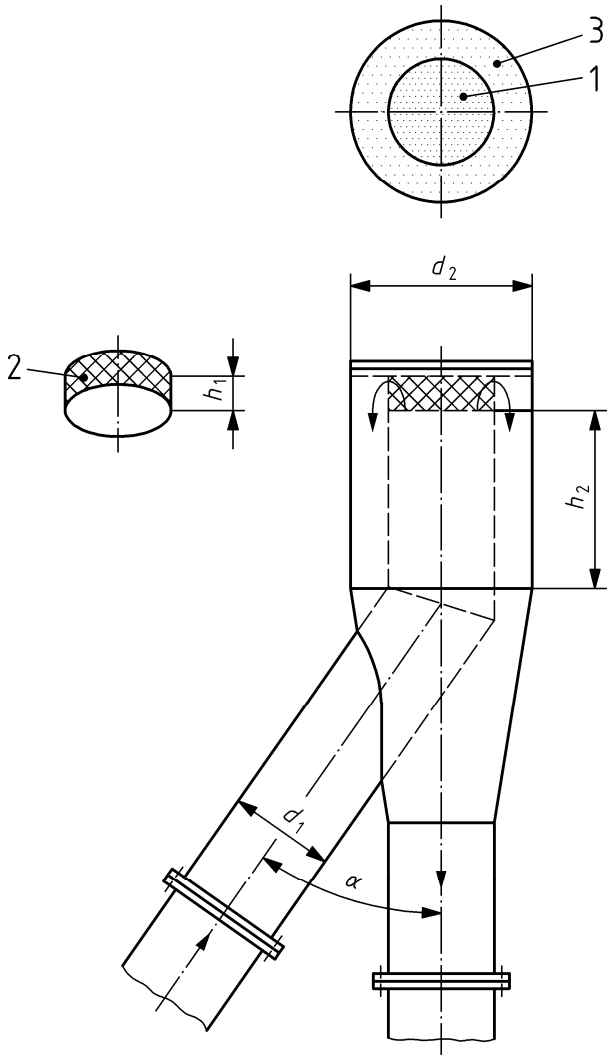
— the diameter of the restraining cage shall be larger than 1,5 d_2;

— the height of the restraining cage shall be larger than 2 d_2, and

— the free flow area of the restraining cage shall be at least 90 % of the restraining cage surface area.

The design of the venting device plays an important role in the efficacy of the explosion diverter. The specific mass shall not exceed 10 kg/m^2. The static activation overpressure p_{stat} shall be below 100 mbar and the mechanical integrity of the diverter shall be such that it can withstand any expected steep pressure rise.

The diameter of the explosion venting element shall not be smaller than d_2.



Key

1 cross-section area A_1 of the internal pipe
2 cylindrical surface A_2
3 cross-section area A_3 of the annulus between internal pipe and tubing extension
d_1 diameter of the internal pipe
d_2 diameter of the explosion venting element
h_1 distance between the end of the internal pipe and the venting element
h_2 length of vertical, internal pipe
α ≤ 30°

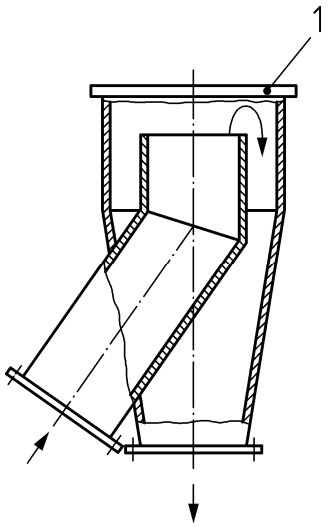
Figure A.1 — Details of the pipe-in-pipe explosion diverters

Annex B
(informative)

Explosion diverter types

B.1 Single pipe-in-pipe explosion diverter

Figure B.1 shows the principle constructional characteristics of this explosion diverter. The pipe-in-pipe diverter in A.1 is a special version of B.1. Of great importance is the diverting angle, the distance between inner pipe end and venting device and ratio of pipe diameters [2]. The highest efficacy of this diverter is achieved at a diverting angle of close to 180° [11]. Tests with 110°-diverters have shown that both the probability of flame transmission and the flame velocity downstream the diverter are much higher compared to a diverter with a diverting angle of 180° [2], [3].



Key

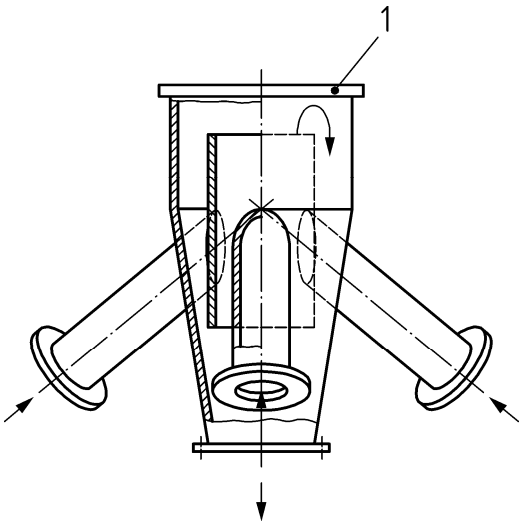
1 venting device

Figure B.1 — Example of a single pipe-in-pipe explosion diverter

B.2 Multiple pipe-in-pipe explosion diverter

Figure B.2 shows a typical arrangement of this diverter type whereby several inlet pipes enter a common outlet pipe.

The diameter of the explosion diverter venting element should not be larger than 3 times the cross section of a smallest inlet pipe.



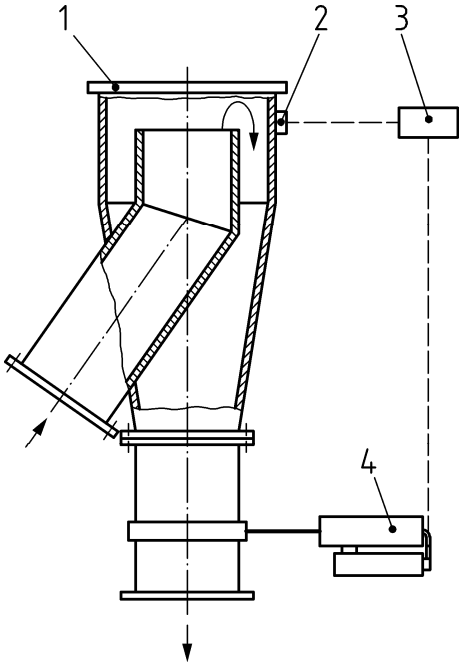
Key

1 venting device

Figure B.2 — Typical arrangement of a multiple pipe-in-pipe explosion diverter with 3 inlet pipes

B.3 Combination systems

When flame isolation has to be guaranteed, a combination of a diverter with an explosion isolation system can be applied (see Figure B.3). Such combinations will be certified on basis of testing according to Module A and the relevant parts of EN 15089.



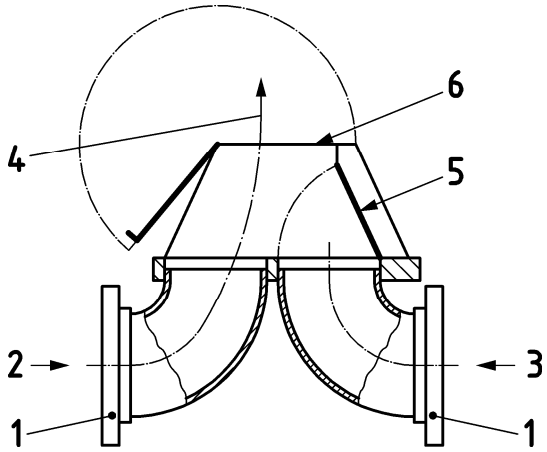
Key

1 venting device
2 detector
3 CIE/Control and Indication
4 isolation device

Figure B.3 — Example of a combination of single pipe explosion diverter and explosion isolation device

B.4 Diverter with integrated internal closure (flap)

Some explosion diverters are equipped with an internal shutoff flap that, upon activation of the hinged closure is released (see Figure B.4) creating a physical barrier preventing flame transmission. This device has been designed for flame propagation against the process flow direction.



Key

1 pipe flanges
2 backflash
3 process flow
4 flame front diversion
5 positive shutoff flap
6 hinged closure

Figure B.4 — Diverter with integrated internal closure

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 Equipment and protective systems intended for use in potentially explosive atmospheres (ATEX).

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the 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

Clause(s)/sub-clause(s) of this EN	Essential Requirements (ERs) of Directive 94/9/EC		Qualifying remarks/Notes
4, Annex A	1.0.2	Design considerations	
7	1.0.3	Special checking and maintenance conditions	
8	1.0.5	Marking	
7	1.0.6	Instructions	
whole document	1.2.1	Technological knowledge of explosion protection for safe operation	
4.2.2., 5, Annex A	3.1.2	Withstanding shock wave effects of explosions	
4.2.2, 5, Annex A	3.1.3	Accessories to withstand maximum pressure of explosions	
whole document	3.1.4	Planning protective systems to take account of pressures on pipe work, etc.	
4.2.2, 5.2.3	3.1.5	Pressure relief systems	
whole document	3.1.7	Explosion decoupling systems	

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

Bibliography

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

[2] Bartknecht, W.: *Explosionsschutz, Grundlagen und Anwendung*. Berlin, Heidelberg, New York: Springer-Verlag 1993, pp. 740 - 745.

[3] Steen, H.: (Eds.): *Handbook of Explosion Prevention and Protection*. Weinheim: WILEY-VCH Verlag 2004, pp. 578 & 667 - 669.

[4] Eckhoff, R. K.: *Dust Explosions in the Process Industries.* Butterworth-Heinemann, 2nd Edition 1997, pp. 77 - 79.

[5] Faber, M.: *Explosionstechnische Entkopplung.* VDI-Berichte Nr. 701. Düsseldorf: VDI-Verlag 1989, pp. 659 - 680.

[6] Radandt, S.: *Explosionsabläufe in Rohrleitungen in Abhängigkeit von Betriebsparametern.* VDI-Berichte Nr. 701. Düsseldorf: VDI-Verlag 1989, pp. 801 - 818.

[7] Radandt, S., Vogl, A.: *Brand- und Explosionsgefahren, Staubexplosionen in Kleinsilos.* Heidelberg: Roland Asanger Verlag 1992, pp. 78 - 102.

[8] Vogl, A.: *Ablauf von Staubexplosionen in pneumatischen Saug-Flug-Förderanlagen,* D 82 (Diss. RWTH Aachen), Heidelberg: Roland Asanger Verlag 1995, pp. 68 - 77

[9] VDI-Richtlinie 3673, Blatt 1: *Druckentlastung von Staubexplosionen*. 2002-11

[10] Vogl, A., Schepp, P., Radandt, S.: *Wirksamkeit von Entlastungsschloten,* VDI-Berichte Nr. 1873, Düsseldorf: VDI-Verlag 2005, pp. 135 - 151

[11] Vogl, A., Schepp, P., Radandt, S.: *Neue Erkenntnisse über Entlastungsschlote für die explosionstechnische Entkopplung,* TÜ Bd. 46 (2005-09) Nr. 9.

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™