BS EN 16447:2014

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Explosion isolation flap valves

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National foreword

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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.

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Explosion isolation flap valves

Vanne à clapet d'isolation d'explosion

Rückschlagklappen zur explosionstechnischen Entkopplung

This European Standard was approved by CEN on 28 May 2014.

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Foreword

This document (EN 16447:2014) 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of an identical text or by endorsement, at the latest by January 2015 and conflicting national standards shall be withdrawn at the latest by January 2015.

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.

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1 Scope

This European Standard describes the general requirements for flap valves used for dust explosion isolation. An explosion isolation flap valve is a protective system, which prevents a dust explosion from propagating via connecting pipes or ducts into other parts of apparatus or plant areas.

An explosion isolation flap valve can only stop the propagation of a dust explosion when it propagates against the direction of the normal process flow. It does not stop explosions running in the normal process flow direction. This European Standard specifies methods for evaluating the efficacy of explosion isolation flap valves.

This European Standard is applicable only to explosion isolation flap valves which are intended to avoid explosion propagation from a vessel, into other parts of the installation via connecting pipes or ducts. The standard covers isolation of such vessels that are protected by explosion venting (including flameless venting), explosion suppression or explosion resistant design.

NOTE 1 This standard is only applicable to cases where the explosion starts in a vessel and not in pipes or ducting.

Explosion isolation flap valves are not designed to prevent the transmission of fire or burning powder transported by the normal process flow.

NOTE 2 It is necessary to take this into account in risk assessments.

This European Standard is only applicable for dust explosions.

This European Standard is not applicable for explosions of materials listed below, or for mixtures containing some of those materials:

a) gases, vapours and hybrid mixtures;

b) chemically unstable substances;

c) explosive substances;

d) pyrotechnic substances.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

EN 14373, *Explosion suppression systems*

EN 14460, *Explosion resistant equipment*

EN 15089, *Explosion isolation systems*

3 Terms and definitions

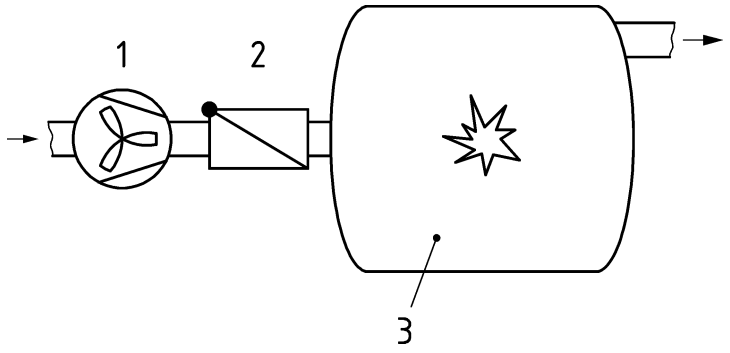
For the purposes of this document, the terms and definitions given in EN 13237, EN 14373, EN 15089 and the following apply.

3.1
explosion isolation flap valve
valve containing a flap which is fixed to the housing on an axis perpendicular to the flow direction, kept open by the process flow and able to stop explosions from propagating through pipelines in the direction opposite to the normal process flow through the valve

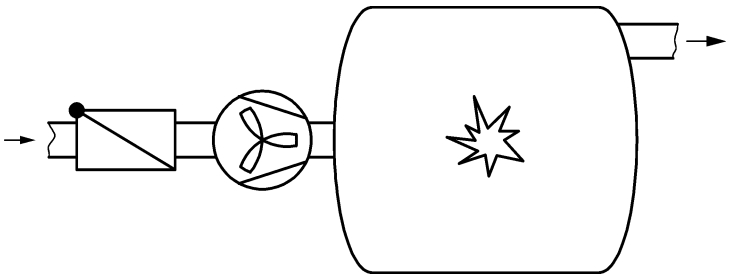
Note 1 to entry: This definition partially modifies that given in EN 13237.

3.2
explosion source
vessel from which the explosion originates

3.3
push flow situation
situation where the fan is located upstream (with reference to the direction of the normal process flow) of the explosion source



a)



b)

Key

1 fan
2 explosion isolation flap valve
3 vessel

Figure 1 — Push flow situation

3.4
pull flow situation
situation where the fan is located downstream (with reference to the direction of the normal process flow) of the explosion source

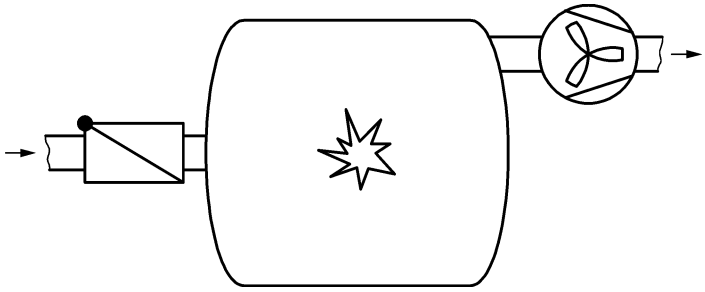


Figure 2 — Pull flow situation

4 Explosion isolation flap valves

4.1 General

An explosion isolation flap valve is a protective system, which prevents a dust explosion from propagating via connecting pipes or ducts into other parts of apparatus or plant areas. It is installed such that the normal process air flow passes in one direction through the valve and keeps it open. It closes when the air flow reverses due to a dust explosion event. The valve shall stay closed long enough to avoid flames from transmitting during an explosion event (see Note 1). Explosion isolation shall also be ensured during periods without process flow.

NOTE 1 Re-opening of the valve is possible e. g. due to pressure oscillations caused by the fan or the venting process.

Explosion isolation flap valves are designed to be connected to ducting. The valve housing is fitted with inlet and outlet connections to connect with the ducting.

NOTE 2 Adapters are often used to connect to an oversize valve.

4.2 Mechanical integrity

Any part of an explosion isolation flap valve shall be constructed such that it can withstand the loads imposed by any explosion that can be expected in accordance with its intended use, without losing its ability to perform its safety function. The construction can be either explosion-pressure resistant or explosion-pressure shock-resistant in accordance with EN 14460.

NOTE The explosion pressure acting on the explosion isolation flap valve may be higher than the (reduced) explosion pressure in the connected vessel as a result of pressure piling and/or flame acceleration through the ducting.

5 Experimental testing of efficacy and mechanical integrity

5.1 General

The testing shall reflect the intended use.

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

a) a general type-description;

b) intended use;

   1) ambient conditions external to the flap valve and process conditions internal to the flap valve (e. g. temperature range, flow velocity, maximum allowable dust concentrations in the process flow);

   2) dust combustion properties, specifically K_{St}, p_{max}, metal dust yes/no, MIE, MIT;

   3) explosion protection measure of the connected vessel venting (including type of explosion venting device (re-closing device / non-re-closing device), suppression, explosion pressure resistant construction);

   4) smallest and largest volume of the vessel in which the explosion starts ;

   5) specific product characteristics (such as sticky material, moisture content, abrasive, corrosive, toxic, tendency for product built-up);

   6) installation requirements (push-, pull flow situations; minimum and maximum installation distance; presence of bends/pipe restrictions; inclination);

c) installation and operating instructions;

d) part list;

e) approval drawings, system layout;

f) explosion resistance of the explosion isolation flap valve.

5.2 Test Modules

5.2.1 General

The experimental testing consists of three main modules:

Module A: Explosion resistance testing;

Module B: Flame transmission testing;

Module C: Functional testing.

Explosion isolation flap valves shall in principle be tested according to all three modules but where possible the modules can be combined. If a combination is chosen, the critical test conditions from the various modules shall be covered in the combination. For an untested new explosion isolation flap valve module C shall always be carried out.

5.2.2 Module A: Explosion resistance testing

Explosion resistance shall be confirmed by explosion testing according to the following procedure:

1) Test arrangement:

   - The explosion isolation flap valve is mounted to a test vessel according to Figure 3. The explosive atmosphere inside the test vessel and the pipe connecting the valve may be of any type (gas or dust), provided the pressure generated is sufficient to subject the valve to the required pressure. The

valve shall be held in fully open position and released at the moment of ignition and shall close due to the explosion;

2) Test assignment/records:

- As a minimum, the maximum pressure recorded at the location of the valve;

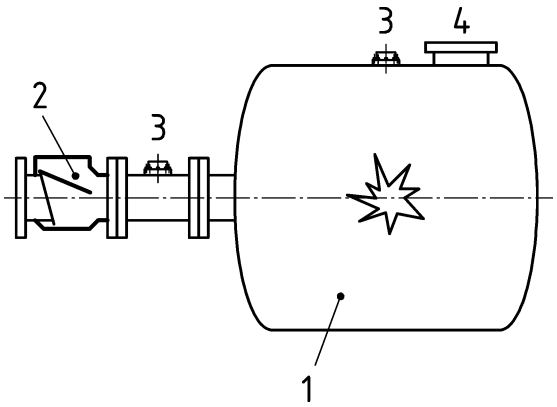
3) Number of tests:

- Minimum 1 per size tested. For devices constructed in the same way (with respect to the geometrical similarity, material specifications, welding specifications or specifications of other ways of connecting parts, and wall thickness) only the largest size needs to be tested;

4) Evaluation:

- Permanent deformation is allowed provided the valve does not fail in its function and will not give rise to dangerous effects to the surrounding. No permanent deformation is allowed for brittle material.

- The maximum pressure recorded at the location of the valve corrected according to EN 14460.



Key

1	Test vessel	3	Pressure Transducer (Pt)
2	Explosion Isolation Flap Valve	4	Explosion vent

Figure 3 — Test arrangement for explosion pressure resistance testing

5.2.3 Module B: Flame transmission testing

The main objective of the flame transmission testing is to verify that the explosion isolation flap valve is able to prevent explosion flames from propagating past the explosion isolation flap valve. The tests shall expose the explosion isolation flap valve to the maximum reduced explosion overpressure as indicated in the intended use and a lower one (see “3) number of tests”) and shall include conditions where the valve is open and closed. If there is a locking mechanism it shall not be locked in the closed position before ignition.

1) Test arrangement:

- The test arrangement shall be similar to the one shown in Figure 4. The size of the vessel shall reflect the intended use of the device. The explosive atmosphere in the vessel shall represent an explosibility similar to the highest K_{St} as specified by the intended use. It has to be assured that the flame reaches the position of the valve. The test arrangement shall include a duct in case it is expected that ducting on the side not exposed to the dust explosion of the valve will affect the closing time of the valve. No additional tests with elbows or restrictions are required if the intended use

specifies a straight duct (with a length of at least 5 times the diameter) on the explosion isolation flap valve side which is not exposed to the dust explosion.

- In addition to the pressure sensor as indicated in Figure 4 a minimum of one flame detector (Ft) on the duct between the vessel and explosion isolation flap valve and one for monitoring flame transmission located max. 100 mm away from the valve on the side not exposed to the dust explosion are used provided a duct is mounted at the explosion isolation flap valve side not exposed to the dust explosion. It shall be assured that this flame detector only detects flames and sparks (burning particles) passing the valve.

- If no duct is mounted on the explosion isolation flap valve side which is not exposed to the dust explosion cameras can be used but then it shall be assured that any flame or sparks passing the device are not obscured by dust. At a minimum two cameras positioned with different angles of view with respect to the device shall then be used.

2) Test assignment/records:

- The presence of flames and/or sparks on the explosion isolation flap valve side which is not exposed to the dust explosion shall be recorded.

3) Number of tests:

- Only the largest size for devices constructed in the same way (with respect to the geometrical similarity, material specifications, welding specifications or specifications of other ways of connecting parts, and wall thickness) needs be tested. The test programme shall include variation of the maximum reduced overpressure (at least two maximum reduced overpressures values including the maximum expected and a relatively low value by varying e.g. the size of a vent opening), variation of the ignition source position (2 positions: one far away from the duct and one close to the duct) and the position of the flap at the moment of ignition (open and closed but not locked).

4) Evaluation:

- The test is successful if there is no occurrence of sparks/flames on the side of the explosion flap valve not exposed to the dust explosion (and the valve remains closed sufficiently long avoiding flame transmission). When successful the explosion isolation device can be applied for any dust having a maximum experimental safe gap (MESG) equal to or larger than the dust used for testing.

  NOTE For dusts MESG (mm) is calculated from MIE (mJ) and MIT (°C) using the following equation (Eckhoff, 2003):

$$MESG = 1{,}01 * \left(MIE * \left(MIT + 273\right) / 273\right)^{0{,}157}$$

5.2.4 Module C: Functional testing

The aim of functional testing is to assess the efficacy of the flap valve as a protective system according to the intended use as specified by the manufacturer. The test involves testing of the ability of the valve to stop explosion and the verification/determination of the minimum and the maximum installation distance of the flap valve from the vessel in which the explosion originates.

a) Test set-up:

The test rig including test vessel shall reflect the specified intended use (volume range) in combination with a pipe (see Figure 4). This includes presence of restrictions and/or elbows, fan etc. in pipe, inclination of flap valve and push or pull flow situation through the test vessel. No additional tests with elbows or restrictions are required if the intended use specifies a straight duct (with a length of at least 5 times the diameter) on the

explosion isolation flap valve side which is not exposed to the dust explosion. The minimum vessel volume of the intended use shall be the volume of the test vessel.

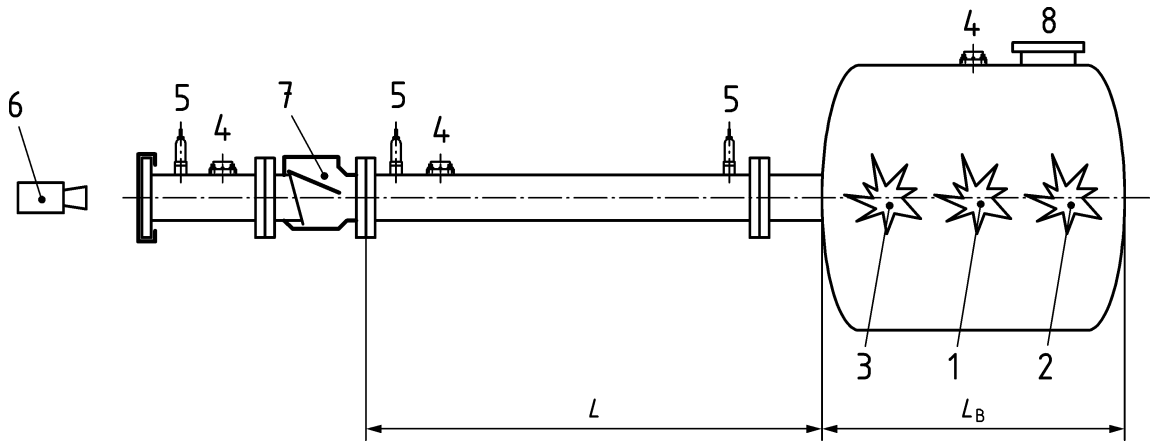
The explosive atmosphere shall be present in the vessel and the connecting duct and shall represent an explosibility as specified in Table 1. The dust cloud generation process shall not affect the closing of the flap valve. The explosion characteristics of the dust cloud generated in the test vessel shall reflect the intended use.

The testing shall involve all process flow configurations (push and pull flow situations) according to the intended use of the protective device. For details see 5.2.4 c) 2). The push and pull flow conditions shall be generated using a fan positioned in accordance with Figure 1a), Figure 1b) and/or Figure 2.

The tests shall expose the explosion isolation flap valve to both low and high explosion pressure over the full range of explosion pressure as indicated in the intended use. For details see 5.2.4 c) 1). If testing is performed with the vessel protected by explosion venting, the results are applicable to vessels protected by both explosion venting and suppression. If testing is performed with the vessel protected by explosion suppression the results are only applicable to vessels protected by explosion suppression.

Calibration tests shall be performed to assure that flames reach the foreseen position of the explosion isolation flap valve and also propagate through the duct passing the position of the explosion isolation flap valve. If not, an increased dust concentration shall be generated in the duct.

For determination of flame transmission flame sensors or cameras can be used.



Key

1	Location of ignition source, *Z1*, 50 %	6	Camera
2	Location of ignition source, *Z3*, 90 %	7	Explosion isolation flap valve
3	Location of ignition source, *Z2*, 10 %	8	Explosion vent
4	Pressure transducer (Pt)	*L*	Installation distance
5	Flame transducer (Ft)		

NOTE The ignition source locations *Z1*, *Z2* and *Z3* are all located on the axis through the connected pipeline. *Z1* is located at a distance of 50 % of the distance between pipe entrance and opposite side of the test vessel from the pipe entrance. *Z2* is located at a distance of 10 % of the distance between pipe entrance and opposite side of the test vessel from the pipe entrance and *Z3* is located at a distance of 90 % of the distance between pipe entrance and opposite side of the test vessel from the pipe entrance.

Figure 4 — Test arrangement for functional testing for explosion flap valves

b) Measuring technique

The following parameters shall be measured:

1) Pressure, minimum one transducer (Pt) in the test vessel and one in the pipe close to the explosion isolation flap valve side exposed to the dust explosion.

   Flame, a minimum of one detector (Ft) on the duct between vessel and explosion isolation flap valve. For monitoring flame transmission the readings of a second detector located max. 100 mm away from the valve on the explosion isolation flap valve side which is not exposed to the dust explosion are used if a duct is mounted at the explosion isolation flap valve side not exposed to the dust explosion It shall be assured that this flame detector only detects flames and sparks (burning particles) passing the valve.

   In case no duct is installed on the side of valve not exposed to the explosion cameras can be used but then it shall be assured that any flame or sparks passing the device are not obscured by dust. At a minimum two cameras positioned with different angles of view with respect to the device shall then be used.

2) To determine whether the flap valve remains closed during the explosion an appropriate detection device shall be installed (e.g. proximity switch, angle transmitter)

c) Execution of test

1) Explosive atmosphere in the vessel

   The explosive atmosphere is generated as described under a). The explosive atmosphere in the vessel shall represent explosibilities ranging from the highest K_{St} as specified by the intended use and a lowest value of K_{St} = 50-100 bar · m · s^{-1}.

   The protective measures applied during the test for the maximum K_{St} and $p_{red,max}$ (e.g. vent opening size, suppression system design) shall not be changed for the lower K_{St} test.

2) Atmosphere in the duct

   i) All push flow situations shall be tested as follows:

      Dust shall be introduced in the process flow such that the dust passes the explosion isolation flap valve with a concentration aiming at maximum dust concentration according to the intended use.

      The flow velocity shall be similar or higher than the maximum flow velocities the explosion isolation flap will be used for according to its intended use.

   ii) Pull flow situations: Test as push flow situations, see ii) or according to the following alternative method:

      The alternative method is: Dust cloud shall be generated as determined during calibration tests, in the vessel and in the duct, see 5.2.4 a). The explosion isolation flap valve shall be held in open position and released after a time where the reversal of the flow into the test vessel is due to the developing explosion.

      The alternative method is only applicable for venting with non-reclosing vent devices (this excludes e.g. suppression and venting with reclosing vent devices).

3) Functionality and determination of the minimum and maximum installation distance

Table 1 shows all test conditions which shall be used for verification/determination of the functionality and the minimum and maximum installation distances.

Table 1 — Test conditions for verification/determination of the functionality and installation distances

Ignition source location in test vessel	Installation distance	Max. K_{St} and $p_{red, max}$	K_{St} of 50-100 bar m s^{-1}
Close to pipe (Z2)	L_{min}	X	X
Ignition source location resulting in maximum pressure equal to $p_{red, max}$	L_{max}	X	-
$p_{red, max}$ for venting or suppression according to intended use $p_{red, max} = p_{max}$ for explosion resistant design according to intended use X required test condition			

d) Number of tests

A minimum of two tests (see evaluation) is required for each test condition.

The smallest and largest size for devices constructed in the same way (with respect to the geometrical similarity, material specifications, welding specifications and wall thickness) shall be tested. If the ratio between the diameter of the largest size and the smallest size exceeds 5 additional testing of a middle size is required.

e) Evaluation

The test is successful if there is no occurrence of sparks/flames on the side of the explosion flap valve not exposed to the dust explosion (and the valve remains closed sufficiently long avoiding flame transmission).

The following shall be recorded regarding the intended use:

1) maximum pressure:

i) in the test vessel;

ii) in the pipe close to the explosion isolation flap valve side exposed to the dust explosion;

iii) in the pipe, if present, close to the explosion isolation flap valve side not exposed to the dust explosion;

2) maximum of installation distance with reference to the strength of the device;

3) minimum of installation distance.

5.3 Testing report

As a minimum the following shall be reported:

a) Test dust 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) test vessel and pipe volume, aspect ratio, surface area;

3) dust-dispersion system;

4) explosion characteristics of the fuel (sample) in the test vessels;

5) ignition delay time;

6) flow velocity;

c) Characteristics of the explosion flap valve:

1) installation (e.g. inclination);

d) Results:

1) data and observations of tests;

2) minimum and maximum installation distances of the flap valve;

3) maximum allowable explosion pressure;

e) Additional information;

1) the report shall include all pertinent observations and information, which are not fully described above;

2) test reports shall be signed on behalf of the testing establishment, numbered and dated.

6 Information for use

Explosion flap valves shall be at least accompanied by instructions that include:

a) description of the intended use of the explosion flap valve:

— all details of operational requirements such as:

— protection method of connected vessel;

— p_{max}, $p_{red\ max}$;

— safety characteristics of dusts (pmax, KSt, MIE and MIT);

— max. dust concentration in duct where device will be installed;

— process flow direction;

- minimum installation distance L_{min};
- maximum installation distance L_{max};
- max and min operating temperature;
- process flow situation (push or pull flow);
- range of applicable volumes;
- inclination of flap valve;
- explosion resistance of flap valve.

b) information marked on the product;

c) requirements for installation;

d) requirements for commissioning;

e) requirements for inspection and maintenance;

Periodic inspection checks shall be specified to ensure that the explosion isolation capability does not deteriorate (e.g. due to corrosion, abrasion, dust built up on the flap, dust build up inside the body of the flap valve) and would continue to react as originally designed in the event of an explosion. The frequency of the inspections shall be sufficient to avoid hazardous situations (situations affecting the functionality of the device).

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

7 Marking

The marking shall be placed on a clearly visible spot. This marking shall include as a minimum the following:

a) name and address of the manufacturer;

b) serial number of the explosion isolation flap valve;

c) explosion resistance pressure or explosion shock resistance pressure for the flap valve;

d) the number of this standard.

For products intended to be put on the market in the EEA, CE marking as defined in the applicable European Directives, followed by the sign  is required.

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.

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
whole document	1.0.1	Principles of integrated explosion safety	
4	1.0.2	Design consideration	
6	1.0.3	Special checking and maintenance conditions	
7	1.0.5	Marking	
6	1.0.6 a)	Instructions	
5, 6	1.1.2	Limits of operating	
whole document	1.2.1	Technological knowledge of explosion protection for safe	
5.2.3, 5.2.4	1.2.9	Flameproof vessel systems	
whole document	3.0	General requirements	
5.2.2, 5.2.4	3.1.2	Withstanding shock wave effects of explosions	
5.2.2, 5.2.4	3.1.3	Accessories to withstand maximum pressure of explosions	
whole document	3.1.4	Planning protective systems to take account of pressures on pipework, etc.	
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.

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