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Plamenske zapore – Zahtevane lastnosti, preskusne metode in omejitve uporabe

Flame arresters - Performance requirements, test methods and limits for use

Flammendurchschlagsicherungen - Leistungsanforderungen, Prüfverfahren und Einsatzgrenzen

Arrete-flamme - Exigences de performance, méthodes d'essai et limites d'utilisation

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Flame arresters - Performance requirements, test methods and limits for use

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This European Standard 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of an identical text or by endorsement, at the latest by July 2001, and conflicting national standards shall be withdrawn at the latest by July 2001.

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).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this 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, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European Standard is type C as stated in ENV 1070.

1 Scope

This standard specifies the requirements for flame arresters which prevent flame transmission when flammable gas/air- or vapour/air-mixtures are present. It establishes uniform principles for the classification, basic construction and marking of flame arresters and specifies test methods to verify the safety requirements and determine safe limits of use.

This standard does not cover the following:

– External safety-related measurement and control equipment which may be required to keep the operational conditions within the established safe limits.

– Flame arresters used for explosive mixtures of vapours and gases, which tend to self-decompose (e.g acetylene) or which are chemically unstable.

– Flame arresters used for carbon disulphide due to its special properties.

– Flame arresters used for gas or vapour mixtures containing more than the atmospheric oxygen concentration.

– Flame arrester test procedures for internal combustion, compression ignition engines. Refer to EN 1834-1 and EN 1834-2.

The safety factors incorporated into the tests specified in this standard mean that the uncertainty of measurement inherent in good quality, regularly calibrated measurement equipment is not considered to have any significant detrimental effect on the results and need not be taken into account when making the measurements necessary to verify compliance of the flame arrester with the requirements of this standard.

2 Normative references

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are included at the appropriate places in the text and the publications are listed. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1267
: Valves - Test of flow resistance using water as test fluid

prEN 1759-3:1994
: Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, class designated - Part 3: Copper alloy and composite flanges

prEN 1759-4:1997
: Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, class designated - Part 4: Aluminium alloy flanges

EN 1834-1
: Reciprocating internal combustion engines - Safety requirements for design and construction of engines for use in potentially explosive atmospheres - Part 1: Group II engines for use in flammable gas and vapour atmospheres

EN 1834-2
: Reciprocating internal combustion engines - Safety requirements for design and construction of engines for use in potentially explosive atmospheres - Part 2: Group I engines for use in underground workings susceptible to firedamp and/or combustible dust

ENV 1070
: Safety of machinery - Terminology

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

EN 1092-1
: Flanges and their joints - Circular flange*s* for pipes, valves and fittings - Part 1: Steel flanges, PN designated

EN 50014
: Electrical apparatus for potentially explosive atmospheres - General requirements

EN 50018
: Electrical apparatus for explosive atmospheres - Flameproof enclosures “d”

ISO 7005-1
: Metallic flanges - Part 1: Steel flanges

ISO 7-1
: Pipe threads where pressure-tight joints are made on the threads - Part 1: Dimensions, tolerances and designation

ISO 7-2
: Pipe threads where pressure-tight joints are made on the threads - Part 2: Verification by means of limit gauges

3 Terms and definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this standard, the following terms and definitions apply:

3.1.1
flame arrester
a device fitted to the opening of an enclosure or to the connecting pipework of a system of enclosures and whose intended function is to allow flow but prevent the transmission of flame

3.1.2
flame arrester element
that portion of a flame arrester whose principal function is to prevent flame transmission

3.1.3
flame arrester housing
that portion of a flame arrester whose principal function is to provide a suitable enclosure for the flame arrester element, and allow mechanical connections to other systems

3.1.4
stabilised burning
steady burning of a flame, stabilised at, or close to the flame arrester element

3.1.5
short time burning
stabilized burning for a specified time

3.1.6
endurance burning
stabilized burning for an unspecified time

3.1.7
explosion
abrupt oxidation or decomposition reaction producing an increase in temperature, pressure, or in both simultaneously [EN 1127-1:1997]

3.1.8
deflagration
explosion propagating at subsonic velocity [EN 1127-1:1997]

3.1.9
detonation
explosion propagating at supersonic velocity and characterised by a shock wave [EN 1127-1:1997]

3.1.10
stable detonation
a detonation is stable when it progresses through a confined system without significant variation of velocity and pressure characteristics

NOTE For atmospheric conditions, test mixtures and test procedures of this standard typical velocities range between 1600 m/s and 2200 m/s.

3.1.11
unstable detonation
a detonation is unstable during the transition of a combustion process from a deflagration into a stable detonation. The transition occurs in a limited spatial zone where the velocity of the combustion wave is not constant and where the explosion pressure is significantly higher than in a stable detonation

NOTE The position of this transition zone depends, among others on the pipe diameter, pipe configuration, test gas and explosion group and may be established by experiment in each case.

3.1.12 Characteristic safety data of explosive mixtures

3.1.12.1
ignition temperature
the lowest temperature of a heated wall as determined under specified test conditions, at which the ignition of a combustible substance in the form of gas or vapour mixture with air will occur [EN 1127-1:1997]

NOTE IEC 60079-4 standardizes the test method

3.1.12.2
maximum experimental safe gap
the maximum gap of the joint between the two parts of the interior chamber of a test apparatus which, when the internal gas mixture is ignited and under specified conditions, prevents ignition of the external gas mixture through a 25 mm long joint, for all concentrations of the tested gas or vapour in air. The MESG is a property of the respective gas mixture [EN 1127-1:1997]

NOTE IEC 60079-1 A standardizes the test apparatus and the test method.

3.1.13
bi-directional flame arrester
a flame arrester which prevents flame transmission from both sides

3.1.14
deflagration flame arrester
a flame arrester designed to prevent the transmission of a deflagration. It can be end-of-line (3.1.22) or in-line (3.1.23)

3.1.15
detonation flame arrester
a flame arrester designed to prevent the transmission of a detonation. It can be end-of-line (3.1.22) or in-line (3.1.23)

3.1.16
endurance burning flame arrester

a flame arrester which prevents flame transmission during and after endurance burning

3.1.17
static flame arrester
a flame arrester designed to prevent flame transmission by quenching gaps

3.1.17.1
measurable type (static flame arrester)
a flame arrester where the quenching gaps of the flame arrester element can be technically drawn, measured and controlled

3.1.17.2
non-measurable type (static flame arrester)
a flame arrester where the quenching gaps of the flame arrester element cannot be technically drawn, measured or controlled (e.g random structures such as knitted mesh, sintered metal and gravel beds)

3.1.18
high velocity vent valve
a pressure relief valve designed to have nominal flow velocities which exceed the flame velocity of the flammable mixture thus preventing flame transmission

3.1.19
flow controlled aperture
an aperture designed to be used with flow velocities which exceed the flame velocity of the flammable mixture thus preventing flame transmission

3.1.20
liquid product detonation flame arrester
a flame arrester, in which the liquid product is used to form a liquid seal as a flame arrester medium to prevent flame transmission of a detonation. There are two types of liquid product detonation flame arrester for use in liquid product lines,

a) liquid seals
b) foot valves

3.1.20.1
liquid seal
a flame arrester designed to use the liquid product to form a barrier to flame transmission

3.1.20.2
foot valve
a flame arrester designed to use the liquid product combined with a non return valve to form a barrier to flame transmission

3.1.21
hydraulic flame arrester
a flame arrester designed to break the flow of a flammable mixture into discrete bubbles in a water column, thus preventing flame transmission

3.1.22
end-of-line flame arrester
a flame arrester which is fitted with one pipe connection only

3.1.23
in-line flame arrester
a flame arrester which is fitted with two pipe connections one on each side of the flame arrester element

3.1.24
pre-volume flame arrester
a flame arrester which prevents flame transmission from inside a vessel to the outside or into connecting pipework. It may be end-of-line (3.1.22) or in-line (3.1.23)

3.1.25
integrated temperature sensor
a temperature sensor to indicate a stabilized flame and integrated into the flame arrester by the manufacturer

3.2 Symbols and abbreviations

I	=	explosion group (1,14 mm ≤ MESG)
IIA	=	explosion group (0,9 mm < MESG)
IIB	=	explosion group (0,5 ≤ MESG ≤ 0,9 mm)
IIC	=	explosion group (MESG < 0,5 mm)
A_5	=	elongation at rupture (%)
A_0	=	free area of a static flame arrester element (mm^2)
D	=	nominal pipe diameter (mm)
L_i	=	pipe length on the unprotected side (m)
L_m	=	max. length without undamped oscillations (m)
L_{ni}	=	pipe length on the protected side (m)
L_1, L_2, L...	=	pipe length in the flow test (m)
MESG	=	Maximum Experimental Safe Gap (mm)
p_T	=	pressure in the flow test of an end-of-line flame arrester (Pa)
p_t	=	pressure in the pressure test (Pa)
p_{md}	=	time average value of the detonation pressure in the time interval of 200 µs after arrival of the detonation shock wave (Pa)
p_e	=	value of deflagration pressure when the flame first arrives at a defined position close to the flame arrester (Pa)
p_{mu}	=	average value of the detonation pressure in the time interval of 200 µs from the peak pressure of an unstable detonation (Pa)
p_i	=	pressure before ignition (Pa)
p_0	=	maximum operational pressure (Pa)
Δp	=	pressure drop in the flow test of an in-line flame arrester (Pa)
R_A	=	ratio of the area of the flame arrester element to pipe cross sectional area
R_m	=	tensile strength (N/mm^2)
T_m	=	max. operational temperature of a flow controlled aperture (°C)
T_i	=	temperature of the flame arrester before ignition (°C)
T_0	=	operational temperature of the flame arrester (°C)
v_l	=	laminar burning velocity (m/s)
v_{max}	=	max. flow velocity during the volume flow-pressure drop measurement (flow test) (m/s)
v_{min}	=	min. flow velocity during the volume flow-pressure drop measurement (flow test) (m/s)
$\dot{V}$	=	volume flow rate (m^3/h)
$\dot{V}_c$	=	critical volume flow rate (m^3/h)
$\dot{V}_0$	=	min. volume flow rate for endurance burning on high velocity vent valves (m^3/h)
$\dot{V}_E$	=	max. volume flow rate for endurance burning on high velocity vent valves (m^3/h)
$\dot{V}_K$	=	max. volume flow rate for high velocity vent valves at the set pressure (m^3/h)
$\dot{V}_m$	=	volume flow rate which led to max. temperature (m^3/h)
$\dot{V}_{max}$	=	safe volume flow rate (m^3/h)
$\dot{V}_s$	=	safe volume flow rate including a safety margin (m^3/h)
$\dot{V}_t$	=	max. volume flow rate which led to flame transmission (m^3/h)
Z_{Rmin}	=	the minimum water seal immersion depth at rest (mm) above the outlet openings of the immersion tubes
Z_R	=	the immersion depth at rest (mm) = Z_{Rmin} + the manufacturer's recommended safety margin
Z_{0min}	=	the minimum operational water seal immersion depth (mm) when the mixture flow displaces the water from the immersion tubes - $Z_{0min} > Z_{Rmin}$
Z_0	=	the operational immersion depth (mm) = Z_{0min} + the manufacturer's recommended safety margin

4 Hazards and flame arrester classifications

4.1 Flame transmission: Deflagration, stable and unstable detonation

The ignition of an explosive mixture will initiate a deflagration. A flame arrester covering only this hazard is classified as a deflagration flame arrester.

A deflagration when confined in a pipe may accelerate and undergo transition through an unstable to a stable detonation provided a sufficient pipe length is available.

A flame arrester tested according to 6.3.3.2 is classified as a stable detonation flame arrester and is suitable for deflagrations and stable detonations.

A flame arrester tested according to 6.3.3.3 is classified as an unstable detonation flame arrester and is suitable for deflagrations, stable detonations and unstable detonations.

Unstable detonations are a specific hazard requiring higher performance flame arresters than for stable detonations.

These hazards relate to specific installations and in each case the flame arrester successfully tested at p_i is suitable for operational pressures $p_0 \leq p_i$ and the application is limited to mixtures with an MESG equal to or greater than that tested.

The detailed hazards covered by this standard, the classification and testing required for the appropriate flame arrester are listed in Table 1.

Table 1 - Flame arrester classification for deflagration, stable and unstable detonation

Application	Flame arrester classification	Test required
(a) An unconfined deflagration into an enclosure or vessel	End-of-line deflagration	6.3.2.1
(b) A confined deflagration propagating along a pipe into connecting pipework	In-line deflagration	6.3.2.2
(c) A deflagration confined by an enclosure or pipework (length to diameter ratio < 5) to the outside atmosphere or into connecting apparatus	Pre-volume deflagration	6.3.2.3
(d) A stable detonation propagating along a pipe into connecting pipework	In-line stable detonation	6.3.3.2
(e) An unstable detonation propagating along a pipe into connecting pipework	In-line unstable detonation	6.3.3.3
(f) A stable detonation into an enclosure or vessel	End-of-line stable detonation	7.3

4.2 Flame transmission: Stabilised burning

Stabilised burning after ignition creates additional hazards in applications where there could be a continuous flow of the flammable mixture towards the unprotected side of the flame arrester. The following situations have to be taken into account:

– The flow of the flammable mixture can be stopped[1]) within 1 min.

Flame arresters which prevent flame transmission during that period of stabilised burning are suitable for that hazard. This type of flame arrester is classified as safe against short time burning.

– The flow of the flammable mixture cannot be stopped or for operational reasons is not intended to be stopped. Flame arresters which prevent flame transmission during stabilised burning are suitable for that hazard. This type of flame arresters is classified as safe against endurance burning.

5 General requirements

5.1 Construction

All parts of the flame arrester shall resist the expected mechanical, thermal and chemical loads for the intended use.

When a flame arrester element has no intrinsic stability, it shall be secured in a rigid case or housing which cannot be dismantled without destruction.

Production flame arresters shall have flame quenching capabilities no less than the tested flame arrester.

Light metal alloys shall not contain more than 6 % magnesium.

Coatings of components which may be exposed to flames during operation shall not be damaged in such a way that flame transmission is possible.

Flame arresters for short time burning shall be fitted with one or more integrated temperature sensors, taking into account the intended orientation of the flame arrester.

5.2 Housings

In-line flame arrester housing materials shall have an elongation at rupture of $A_5 \geq 12$ % and a tensile strength of $R_m \geq 350$ N/mm^2.

End-of-line flame arrester housing materials shall have an elongation at rupture of $A_5 \geq 5$ % and a tensile strength of $R_m \geq 160$ N/mm^2.

Thread gaps, which shall prevent flame transmission shall be in accordance with EN 50018.

5.3 Joints

All joints shall be constructed and sealed in such a way that flame cannot bypass the flame arrester element and also flame is prevented from propagating to the outside of the flame arrester.

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[1]) By-passing, sufficient diluting or inerting are measures equivalent to stopping the flow.

5.4 Joints to adjacent pipework

All flanges shall be in accordance with prEN 1759-3:1995, prEN 1759-4:1997 or ISO 7005-1.

All screwed connections shall be in accordance with ISO 7-1 and ISO 7-2.

Ends prepared for welding shall be in accordance with EN 1092-1.

5.5 Pressure test

Pressure testing of in-line and end-of-line detonation flame arresters shall be carried out at not less than 10 times p_0 and all in-line deflagration flame arresters at not less than 10^6 Pa for not less than 3 min. All in-line deflagration and detonation flame arresters and end-of-line detonation flame arresters of welded construction need only be type tested, but flame arresters with any subsequent alteration to the design, affecting its strength, shall be retested. No permanent deformation shall occur during the test.

End-of-line deflagration and endurance burning flame arresters need not be pressure tested.

5.6 Leak test

Flame arresters shall be leak tested with air at 1,1 times p_0, with a minimum of 150 kPa absolute for not less than 3 min. No leak shall occur.

The leak test is not required for end-of-line flame arresters of welded construction.

5.7 Flow measurement (air)

The pressure drop shall be checked for one flow rate in the middle of the flow rate/pressure drop curve (± 20 %) before and after all tests (flame transmission and endurance burning). The deviation from the manufacturer's data shall not exceed 10 % before the tests and be within 10 % of this figure after the tests.

The flow capacity of in-line flame arresters shall be recorded according to A.2.

The flow capacity of end-of-line flame arresters shall be recorded according to A.3.

The flow capacity of end-of-line flame arresters combined with or integrated into pressure and/or vacuum valves shall be recorded according to A.3. Pressure and/or vacuum valves manufactured for different pressure settings shall be tested at the lowest and the highest set pressure (vacuum) and for intermediate set pressures ≤ 1 kPa apart.

The flow capacity of high velocity vent valves shall be recorded according to A.3.

In addition all high velocity vent valves shall be tested for undamped oscillations according to A.4.

5.8 Flame transmission test

5.8.1 General

All flame arresters shall be type tested against flame transmission. Housings shall not have visible deformations during the tests.

The tests shall be specific for the basic types of operation (as defined in 3.1.17, 3.1.18, 3.1.19, 3.1.20 and 3.1.21) and shall be carried out according to clauses 6, 7, 8, 9 or 10. If not otherwise stated, tests for detonation (stable and unstable), short time burning and endurance burning are optional. One flame arrester shall be used throughout all deflagration or detonation flame transmission tests. No replacement parts or modifications shall be made to the flame arrester during these tests.

Short time and endurance burning tests shall be carried out in the orientation to be used in service. Bi-directional flame arresters shall only be tested from one side if the protected and unprotected sides are identical.