PROTEGO® Technology

Section 1

- Flame Arresters
- Valves
- Tank Accessories

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How to use this catalog

The PROTEGO® catalog has a modular structure.

Section 1 introduces the company with “Technical Fundamentals” and “Safe Systems in Practice” and provides a basic explanation of the operation and use of PROTEGO® devices.

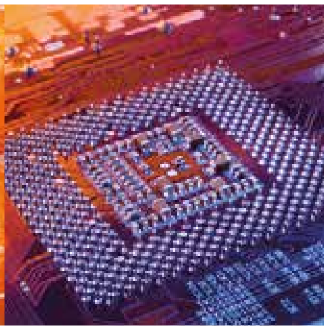
Sections 2-9 describe the products in detail.












Typical Applications

- Storage Tanks and Loading Facilities
- Vapor-return at Petrol Stations
- Combustion Systems
- Chemical and Pharmaceutical Processing Systems
- Cryogenic Applications (LNG, LIN, LOX)
- Landfill and Biogas Systems
- Wastewater Treatment Systems

Exotic Applications

- Nitrous Oxide Supply in Clinical Applications
- Explosion-proof Surface Drain at Heliports
- Storage of Whisky Barrels
- Production of Brandy

Special Applications

- Food Sterilization under Vacuum
- Wafer Production in IT Industry
- Methane Extraction Fan of Mines
- Vitamin Production
- Production of Toothpaste and Mouthwash

Contents

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PROTEGO
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Corporate Video

Our Vision & Mission

We think ahead – with enthusiasm

PROTEGO® Vision: Excellence in Safety and Environment.

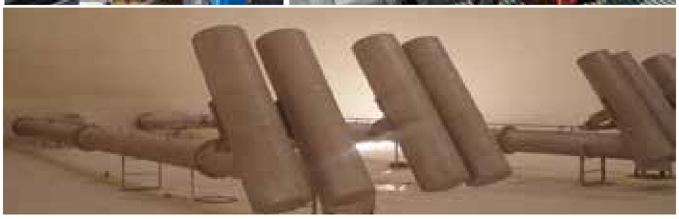
PROTEGO® Mission: A profitable, independent, international family business that, while developing and manufacturing safety valves and equipment, is the top-notch competence source for technology, quality, availability, services, engineering, and consultancy. Our field of operation is explosion protection as well as environmental protection through pressure maintenance and relief in the exploration, processing, and storage of flammable liquids and gases.

PROTEGO® World Team

Providing first-class performance

- Solution-oriented
- High-quality standards
- Consultative
- Environmentally friendly

PROTEGO® is a world market leader operating with a large global network of subsidiaries and representatives. The PROTEGO® team includes 11 distribution and after-sales service companies, as well as 120 representatives on all continents.



Competences *Maintenance & Service* *Contact*

Competence is Top Priority

What can you expect from us? The full range.

PARC´s: PROTEGO® Authorized Repair Centers (PARCs) assist with maintenance on site. PARCs, being certified service partners, meet the requirements of the PROTEGO® Works Standard in the fields of human resources, organization, workshop equipment, and machinery, as well as quality and environmental management.

Spare Parts Service: All our centers hold in stock genuine spare parts for you. Genuine parts and periodical maintenance, geared to the particular field service conditions, guarantee trouble-free operation.

Consultancy: Experienced PROTEGO® experts are available to assist with the various and differentiated application issues. They are trained to consider engineering tasks from a safety point of view.

Maintenance: We can provide you with our trained field service technicians for installation and maintenance, or you can rely on our authorized workshops. All trained personnel have been intensively prepared for their tasks at the manufacturer's plant.

Our Research & Development Center – the largest in the world

We develop with enthusiasm and success

Our products are developed in close cooperation with users, technical institutes, and notified bodies. The PROTEGO® Research & Development Center – the largest of its kind in the world - not only serves to improve and upgrade our products, but it is also available for general research projects and tailor-made special development work. This includes investigations and testing with nominal sizes up to DN 1000 / 40", as well as higher pressures, temperatures, and oxygen enrichment.

National and international notified bodies are regularly reassured of our high standards and consult us for support.

From the very beginning, we have developed our products in accordance with the QM system EN ISO 9001:2015 and 14001:2015, which guarantees superior product quality for our customers.

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Development

Flame arresters protect systems subject to explosion hazards from the effects of explosions. Ever since methane gas explosions in the mining industry at the beginning of the 19th century were successfully suppressed by the development of the Davy screen mining lamp, solutions have been found for making systems safer in modern hydrocarbon chemistry where much more hazardous gases are used.

In addition, filling stations became necessary with the introduction of the automobile. With filling station tanks, the problem arose that potentially explosive vapors consisting of hydrocarbons and air that form around the tanks and loading equipment could ignite. Given the need for safe handling in dangerous atmospheres, major oil companies advanced the development of protective devices for both industrial and military applications.

Initial successes were achieved with gravel pots that were used on fuel tanks. The entrance of an explosion in the atmosphere into the storage tank or into the connected line was stopped by the gravel, and the flame was extinguished. The tank remained protected. The problem with loose gravel, however, is the non-reproducible flame arresting capability and high pressure losses. In 1929, a new development was patented that replaced the loose gravel with wound corrugated strips of metal (Fig. 1a). Together with the patented shock-absorber, a protective device was developed that stopped detonative combustion processes in the pipe with the lowest possible loss. The PROTEGO® detonation flame arrester – developed by Robert Leinemann – was born (Fig. 1b). It was given its name many years later in 1954 when Robert Leinemann founded his company Braunschweiger Flammenfilter.

As chemical processes developed, the requirements on protective devices became increasingly complex. There were also environmental protection requirements. Vapors from processes needed to be disposed of in an environmentally friendly manner and incinerated in incineration plants according to air pollution control regulations. The continuously, or only occasionally explosive mixture, was sent to an ignition source during operation. These particular hazards had to be countered with special measures. PROTEGO® flame arresters offer reliable protection in plant systems. These flame arresters are always state-of-the-art as a result of continuous research and development.

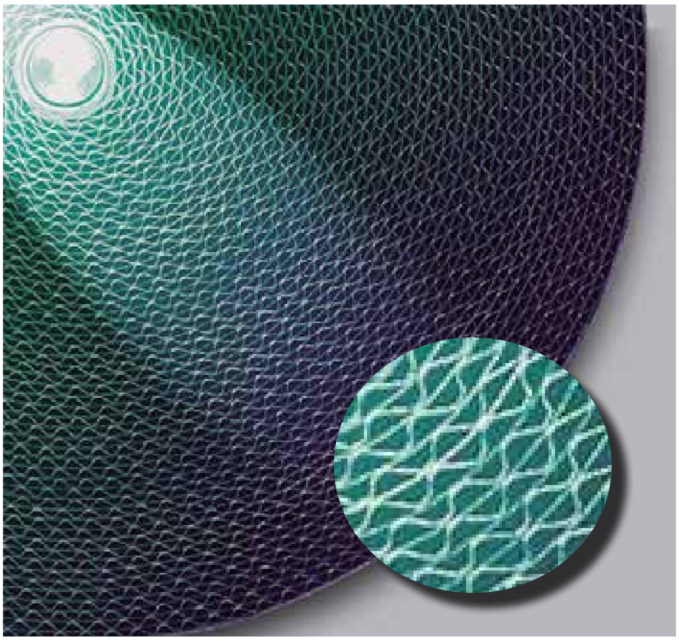

Figure 1a: FLAMEFILTER® wound out of corrugated metal strips

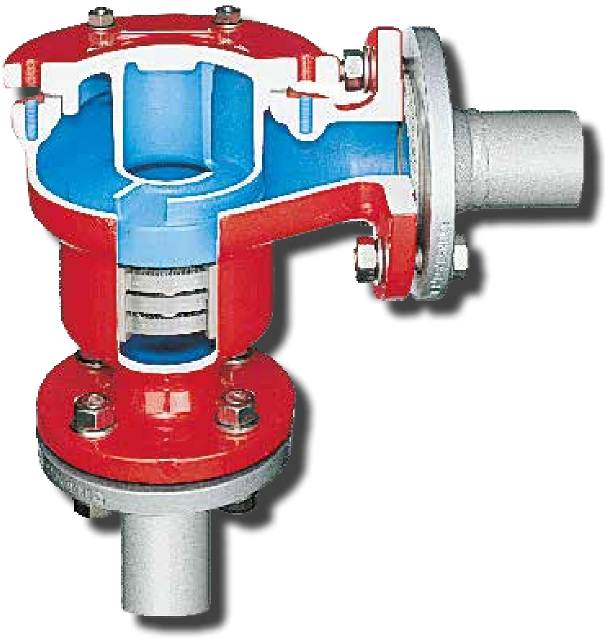

Figure 1b: Detonation Flame Arrester with Shock-Absorber

Combustion Processes

Explosive mixtures can burn in various ways. The following, among other things, can influence the combustion process: the chemical composition of the mixture, possible pressure waves, pre-compression, the geometric shape of the combustion chamber, and the flame propagation speed.

The relevant **combustion processes** for flame arresters are defined by international standards:

Explosion is the generic term for abrupt oxidation or decomposition reaction producing an increase in temperature, pressure, or both simultaneously [also see EN 1127-1].

Deflagration is an explosion that propagates at subsonic velocity [EN 1127-1]. Depending on the geometric shape of the combustion area, a distinction is made between atmospheric deflagration, pre-volume deflagration, and in-line deflagration.

Atmospheric deflagration (Fig. 2) is an explosion that occurs in open air without a noticeable increase in pressure.

Pre-volume deflagration (Fig. 3) is an explosion in a confined space (such as within a vessel) initiated by an internal ignition source.

In-line deflagration (Fig. 5) is an accelerated explosion within a pipe that moves along the axis of the pipe at the flame propagation speed below the speed of sound.

Stabilized burning is the even, steady burning of a flame, stabilized at or close to the flame arrester element. A distinction is made between **short time burning** (stabilized burning for a specific period of time) and **endurance burning** (stabilized burning for an unlimited period of time) (Fig. 4).

Detonation is an explosion propagating at supersonic velocity and is characterized by a shock wave [EN 1127-1]. A distinction is made between **stable detonations** and **unstable detonations** (Fig. 5).

A detonation is **stable** when it progresses through a confined system without a significant variation of velocity and pressure characteristic (for atmospheric conditions, test mixtures, and test procedures typical velocities are between 1,600 and 2,200 meter/second). A detonation is **unstable** during the transition of the combustion process from a deflagration into a stable detonation. The transition occurs in a spatially limited area in which 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 on, among other things, the operating pressure and operating temperature, the pipe diameter, the pipe configuration, the test gas, and the explosion group and must be predetermined by experiments in each case.

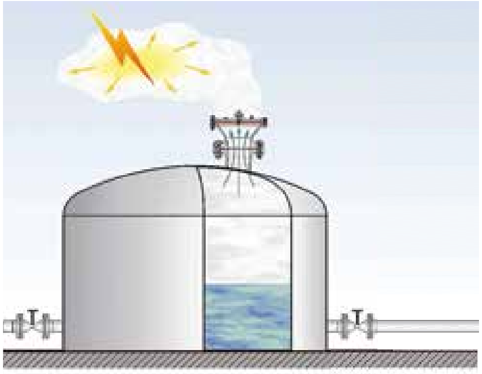

Figure 2: Atmospheric deflagration

Figure 3: Pre-volume deflagration

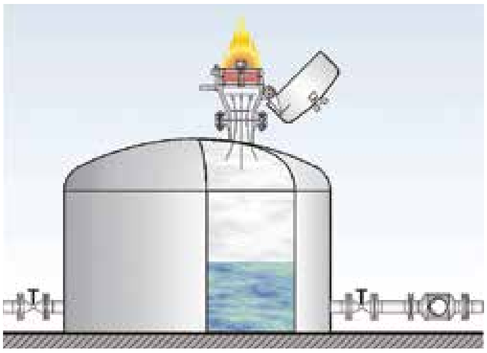

Figure 4: Stabilized burning

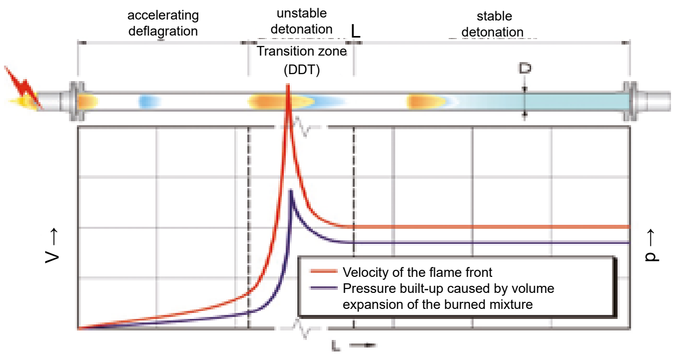

Figure 5: Deflagration – unstable detonation – stable detonation.
L= distance to ignition source
D= diameter of the pipeline
v= velocity of the flame front
p= pressure
DDT = Deflagration to Detonation Transition

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Basic Types

Flame arresters are subdivided into different types according to the combustion process (endurance burning, deflagration, detonation, and the various sub-groups) and by type of installation (in-line, end-of-line, in equipment).

They are categorized as:

a) static dry flame arresters
b) static liquid seal flame arresters
c) dynamic flame arresters

Working functions

a) Static dry flame arresters

Flame arrester elements made of wound, corrugated metal strips can be manufactured with consistently reproducible flame quenching gaps. The gap size can be adjusted according to the flash back capability of the explosive mixture.

The FLAMEFILTER® is made of wound, corrugated metal strips and forms the flame arrester element. The principle of flame quenching in narrow gaps is applied in PROTEGO® end-of-line flame arresters and PROTEGO® in-line flame arresters (Sections 2, 3, 4, and 7).

When a mixture ignites in a gap between two walls, the flame spreads towards the non-combusted mixture. The expansion in volume of the combusted mixture pre-compresses the non-combusted mixture and accelerates the flame.

By heat dissipation in the boundary layer “s”, transferring it to the large surface of the gap length compared to the gap width “D”, and by cooling down the product below its ignition temperature (Fig. 6), the flame is extinguished.

The gap width and the gap length of the flame arrester element determines its extinguishing ability.

The narrower and longer the gap, the greater the extinguishing effectiveness. The wider and shorter the gap, the lower the pressure loss. Experiments can determine the optimum solution between these two conditions.

Original PROTEGO® technology

To protect against all of the previously mentioned combustion processes, PROTEGO® developed static dry flame arresters, optimized their design, and had them undergo national and international certifications in prototype tests (Fig. 7a and b).

All static dry PROTEGO® flame arresters are based on the working principle of the FLAMEFILTER®.

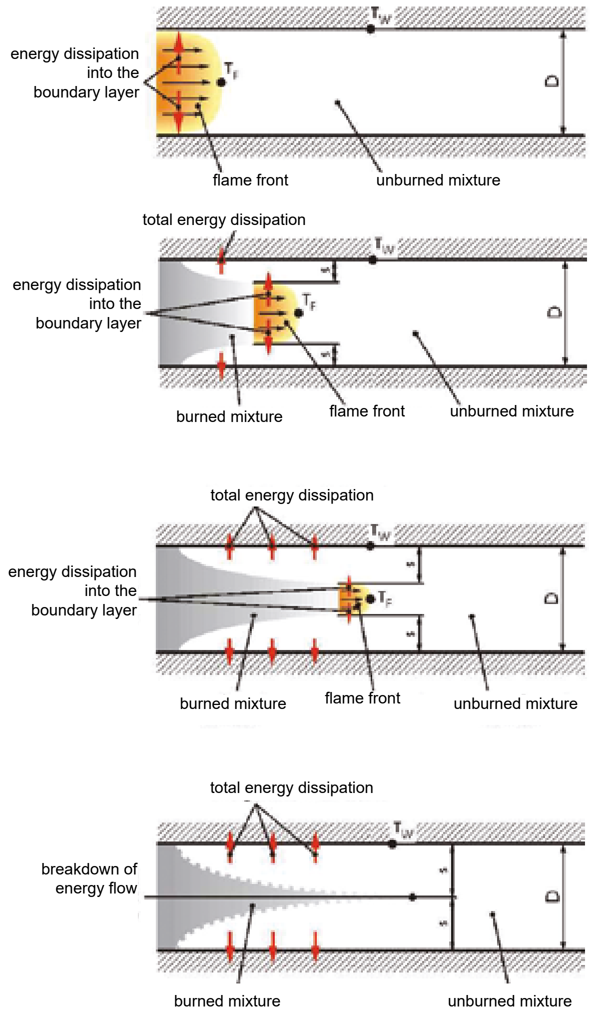

Figure 6:
Extinguishing the flame in the narrow gap (flame quenching) by heat transfer

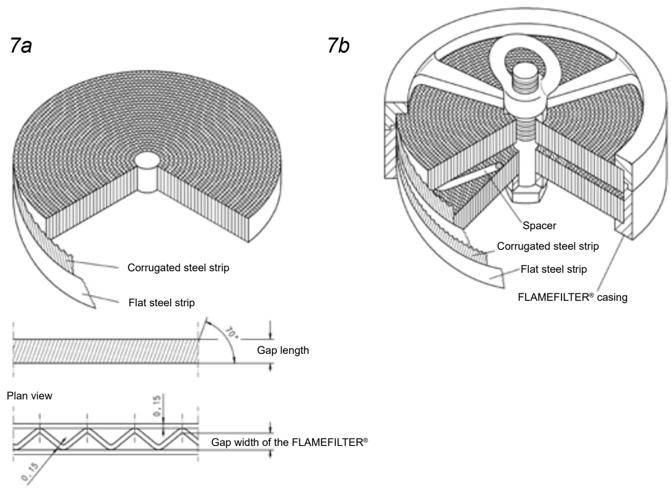

Figure 7:
FLAMEFILTER® (a) with gap widths and gap lengths and PROTEGO® flame arrester unit (b) with FLAMEFILTER®, spacer, and FLAMEFILTER® casing

Definitions

1. **Flame arresters** (Fig. 8a) are devices that are installed at the opening of an enclosure or to the connecting pipe of a system of enclosures. Their intended function is to allow flow but prevent the transmission of flame.

8a

8b

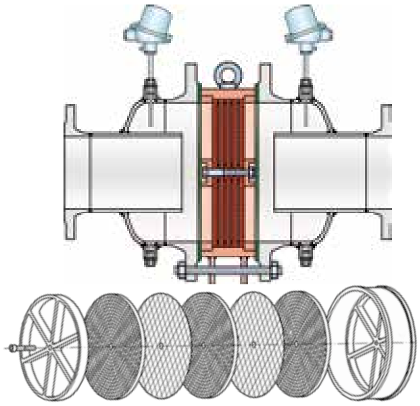

Figure 8: PROTEGO® flame arrester (a) and PROTEGO® flame arrester unit (b - modular design)

2. The PROTEGO® **flame arrester unit** (Fig. 8b and 7b) is the part of a flame arrester with a main task of preventing the transmission of flames.

3. Several **FLAMEFILTER®** components (Fig. 7a) form the PROTEGO® flame arrester unit (Fig. 7b and 8b), together with the spacers and surrounding casing.

4. Either **deflagration flame arresters or detonation flame arresters** are required depending on installation and operating conditions. Depending on the mode of operation, resistance against stabilized burning (short burning, endurance burning) may be necessary.

b) Liquid seal flame arrester

In liquid seal flame arresters, liquid barriers prevent the flames of an incoming deflagration and/or detonation from entering the protected components. Two different types exist:

1. **The liquid product flame arrester:** the liquid product is used to form a liquid seal as a barrier for flame transmission. The PROTEGO® liquid product flame arrester is an in-line or end-of-line detonation flame arrester (Section 4).

2. **The hydraulic flame arrester:** it is designed to break the flow of an explosive mixture into small bubbles flowing through water which act like a liquid barrier. The PROTEGO® hydraulic flame arrester is designed and certified to stop deflagrations, detonations, and endurance burning combustions. It is tailor made to meet the customer's specific requirements (Section 4).

The PROTEGO® hydraulic flame arrester is used both as an in- line flame arrester and as a vent header collection drum and back flow preventer in vapor collecting lines close to the incinerator. Accordingly, important safety measures have to be observed to ensure the required explosion protection.

c) Dynamic flame arresters

High velocity flame arresters are designed to produce flow velocities under operating conditions which exceed the flame velocity of the explosive mixture, and in turn, prevents flame transmission. This principle is applied in PROTEGO® Pressure Relief Diaphragm Valves (Section 7) and in PROTEGO® High Velocity Valves (Section 7) with appropriate high set pressure.

Flame arresters are type-examined **Protective Systems** in accordance with ATEX directive and are marked with CE. They are tested and certified in accordance with EN ISO 16852. Any certification in accordance with other international standards is shown by the appropriate marking.

Explosion groups

Different gases have different flame propagation capacities and are categorized into explosion groups according to their hazard level. The standard for this is the **MESG = M**aximum **E**xperimental **S**afe **G**ap, a characteristic number measured in the laboratory for the flame propagation ability of the product. The MESG, or **standard gap width**, is the largest gap width between the two parts of the inner chamber of a test setup which, when the internal gas mixture is ignited and under specified conditions, prevents ignition of the external gas mixture through a 25 mm long gap, for all concentrations of the tested gas or vapor in the air. The MESG is a property of the respective gas mixture [EN 1127-1]. NOTE: The test setup and methods are specified in EN 60079-20-1. The most explosive composition is close to the stoichiometric mixture of the gas/vapor-air mixture.

Explosion group	Max. Experimental Safe Gap (mm)	NEC	Reference Substances for testing flame arrester
IIA1*	$\geq$ 1,14		Methane
IIA	> 0,90	D	Propane
IIB1	$\geq$ 0,85	C	Ethene
IIB2	$\geq$ 0,75	C	Ethene
IIB3	$\geq$ 0,65	C	Ethene
IIB	$\geq$ 0,5	B	Hydrogen
IIC	< 0,5	B	Hydrogen

* former designation Expl. Gr. I

The above table shows the categorization of substances into the respective explosion group according to their MESG (IEC 79-1, EN ISO 16852).

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Please refer to more specific literature (especially for technical information concerning safety ratings) for the MESG of individual substances, additional ratings, and characteristic substance quantities. This information is provided by PROTEGO® upon request.

As the pressure and temperature increases, the load on the flame arresters generally increases. Flame arresters that have been tested under standard conditions are approved for and can be used at temperatures of up to 60°C (140°F) and 1.1 bar (15.9 psi). If the operating temperature and/or the operating pressure is higher, the flame arrester must undergo a special examination for the higher operating parameters.

PROTEGO® offers flame arresters for the above mentioned explosion groups for higher pressures (>1.1bar abs, 15.9 psi) and higher temperatures (>60°C, 140°F) as required by the operating pressure or temperature.

Location of installation

Depending on the location of installation, the flame arresters must fulfill various protective tasks:

At the opening of a system part to the atmosphere
→ **End-of-line flame arrester**
At the opening of a component on a connecting pipe
→ **Pre-volume flame arrester**
In the pipe
→ **In-line flame arrester**

PROTEGO® End-of-line flame arresters protect against atmospheric deflagrations and stabilized burning — either short-time burning or endurance burning. They can only be connected on one side and cannot be installed in the pipe. PROTEGO® end-of-line flame arresters can, however, be combined with valves (see Section 7: Pressure and Vacuum Relief Valves with PROTEGO® flame arresters).

PROTEGO® Pre-volume flame arresters are flame arresters which prevent flame transmission from the inside of an explosion-proof container to the outside or into a connected pipe.

PROTEGO® In-line flame arresters protect against deflagration and stable or unstable detonations in pipes. Stable detonation flame arresters prevent an explosion transmission of deflagrations and stable detonations. In-line flame arresters, which are tested against unstable detonations, protect from deflagrations and stable and unstable detonations.

The flame arresters must be installed according to their specified use. In the case of in-line deflagration flame arresters, make sure that the allowable L/D (L = distance between the ignition source and the installation location of the flame arrester; D = pipe diameter) is not exceeded. The in-line deflagration flame arresters must not be installed too far from the ignition source so that they are not subject to a detonation due to a long starting distance. The allowable L/D is stated in the manufacturers' manual of the flame arrester.

Selection

The effectiveness of flame arresters must be tested and approved. Flame arresters are categorized according to the combustion process and the installation site.

The selection criteria are described in the appropriate sections. The different variations and wide range of types are a result of tailor-made solutions for different applications. PROTEGO® flame arresters are service-friendly due to the modular design of the flame arrester unit. Special details of the design (patented Shock Wave Guide Tube Effect SWGTE or Shock absorber) enable a superior flow due to the minimum pressure loss.

Location of Installation	End-of-line			On-equipment	In-line		
Combustion process	Atmospheric deflagration	Atmospheric deflagration and short-time burning	Atmospheric deflagration, short-time burning, and endurance burning	Pre-volume deflagration	In-line deflagration	Stable detonation and in-line deflagration	Unstable and Stable detonation and in-line deflagration
Application example	→ see Safe Systems in Practice						
Products	→ Section 2	→ Section 2	→ Section 2	→ Section 3	→ Section 3	→ Section 4	→ Section 4

PROTEGO® has the right flame arrester for all applications

- End-of-line flame arresters for atmospheric deflagrations: PROTEGO® Deflagration Flame Arresters, end-of-line, Sec. 2
- End-of-line flame arresters for atmospheric deflagrations and short time burning: PROTEGO® Deflagration Flame Arresters, short-time burning-proof, end-of-line, Sec. 2
- End-of-line flame arresters for atmospheric deflagrations and short-time and endurance burning: PROTEGO® Deflagration Flame Arresters, endurance burning-proof, end-of-line, Sec. 2
- Pre-volume flame arresters on equipment: PROTEGO® Deflagration Flame Arrester units on equipment, Sec. 3
- In-line flame arresters for deflagrations: PROTEGO® Deflagration Flame Arresters, in-line, Sec. 3
- In-line flame arresters for deflagrations and stable detonations: PROTEGO® Detonation Flame Arresters, in-line, Sec. 4
- In-line flame arresters for deflagrations as well as stable and unstable detonations: PROTEGO® Detonation Flame Arresters, in-line, Sec. 4

Development

Closed vessels or tanks filled with liquid products must have an opening through which the accumulated pressure can be released so that the vessel does not explode. Along the same lines, a vacuum must be compensated for when the tank or vessel is drained so that it does not implode. Unallowable overpressure or underpressure can occur during loading and unloading, steam cleaning processes, or blanketing due to thermal effects. Free openings enable a free exchange with the atmosphere or with connected pipe systems that are uncontrolled and unmonitored. Vent caps are used in this case (Fig. 1).

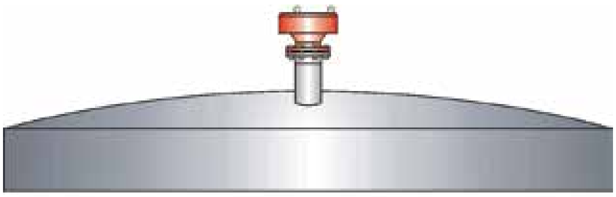


Figure 1: Free venting of the storage tank with PROTEGO® EH/0S

The vented product vapors can be poisonous, odorous, flammable, or simply represent the loss of product. They pollute the atmosphere.

The local concentration of chemical and processing plants and the associated environmental pollution have increased so much over the last 50 years that valves are now to be used, especially in industrially developed countries, to keep the free opening cross-sections closed during operation and only permit emergency venting or relief.

The ventilation devices, which are in the form of pressure and vacuum relief valves, should not be shut off (Fig. 2).

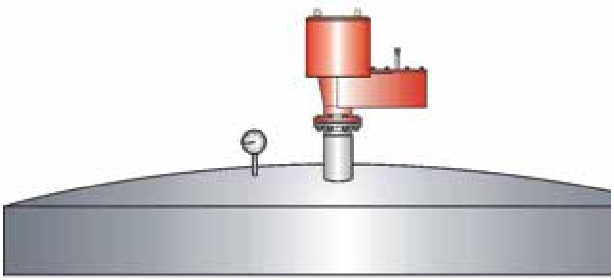


Figure 2: Venting of the storage tank with pressure and vacuum relief valve PROTEGO® VD/SV

These valves need to be simple and robust valves that do not require external control, are trouble-free, and reliably fulfill the expected tasks: maintaining and compensating pressure and vacuum.

Valve Technology

PROTEGO® pressure and vacuum relief valves have weight-loaded or spring-loaded valve pallets. When there is excess pressure in the tank, the pressure valve pallet guided in the housing lifts and releases the flow into the atmosphere (Fig. 3a) until the pressure falls below the set pressure. The valve then re-seats. The vacuum side of the valve is tightly sealed by the additional overpressure load. When there is a vacuum in the tank, the overpressure of the atmosphere lifts the vacuum disc, and the tank is vented (Fig. 3b).

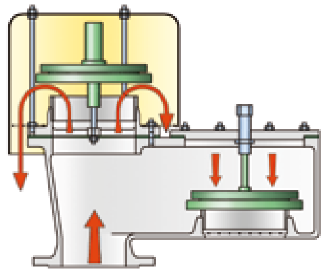


Figure 3a: Operation of the valve under pressure in the tank

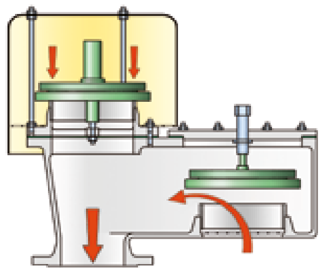


Figure 3b: Operation of the valve under vacuum (negative pressure) in the tank

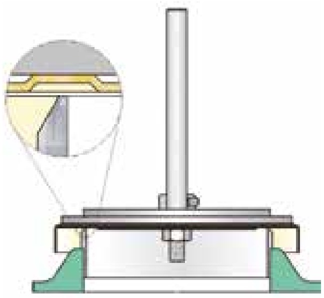


Figure 4: PROTEGO® full-lift pallet with air cushion seal

In principle, the diaphragm valve, which is loaded with liquid (as a weight), and the pilot valve, which is self-controlled, operate in the same manner. The weight-loaded valve pallets have different designs. A distinction is made between the full-lift pallet (Fig. 4 and Fig. 5 a, b) and the normal pallet (Fig. 6).

The sealing between the valve pallet and the valve seat is provided by an FEP air cushion seal, a metal to metal sealing, or a PTFE flat sealing, depending on the set pressure or on the application. The best sealing is obtained with a metal valve disc lapped to be seated on the metal valve seat (metal to metal). When the set pressures are low, an FEP air cushion seal provides a tight seal. The tightness of the PROTEGO® valves is far above the normal standard (API 2000 or EN ISO 28300) and meets the stringent demands of emission control regulations.

PROTEGO® **pressure and vacuum relief valves with full-lift pallet** release the flow within 10% overpressure from the set pressure to a fully opened valve (full-lift).

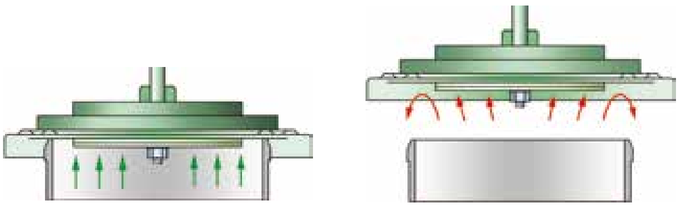


Figure 5a: Discharge with full-lift pallet and air-cushioned seal

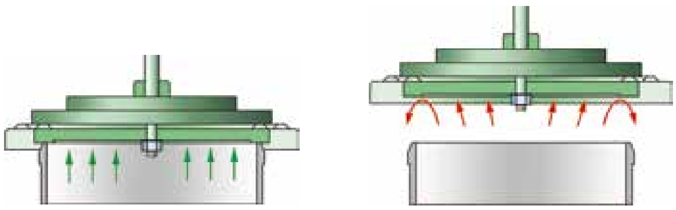


Figure 5b: Discharge with full-lift pallet and metal seal

This is achieved by precisely matching the diameter and height of the valve pallet rim with the adapted machined and lapped valve seat. In addition, the flow-enhancing design reinforces the overall effect on the outflow side. These valve pallets are used in end-of-line and in-line valves.

PROTEGO® **pressure and vacuum relief valves with conventional pallets** release the flow within a 40% pressure (Fig. 6).

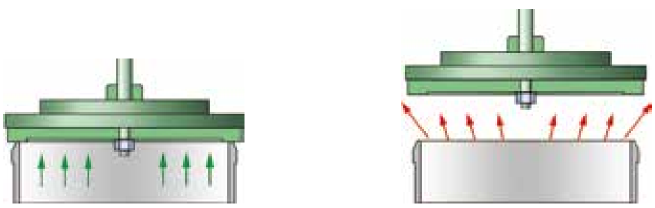


Figure 6: Discharge with normal pallet (flat with metal seal)

After the initial response, the rise in pressure is proportional to the discharged flow up to a full lift. When the back pressure in the connected pipeline is high, or the valve is installed in combination with a pressure control valve, this method provides greater stability for the overall system. However, the overall flow performance is not as good as that of valves with full-lift valve pallets. These valve pallets (Fig. 6) are primarily used in in-line valves when required by operating conditions.

Depending on the design of the valve and the valve pallets, the design pressure and design vacuum (negative gauge pressure) is achieved with different overpressure (Fig. 7). Unless otherwise specified, the standard PROTEGO® valve design is for 10% technology.

Advantages of **PROTEGO® 10% technology**:

- Pressure conservation very close to the maximum allowable tank pressure
- Minimization of product losses
- Reduction of vapor emissions

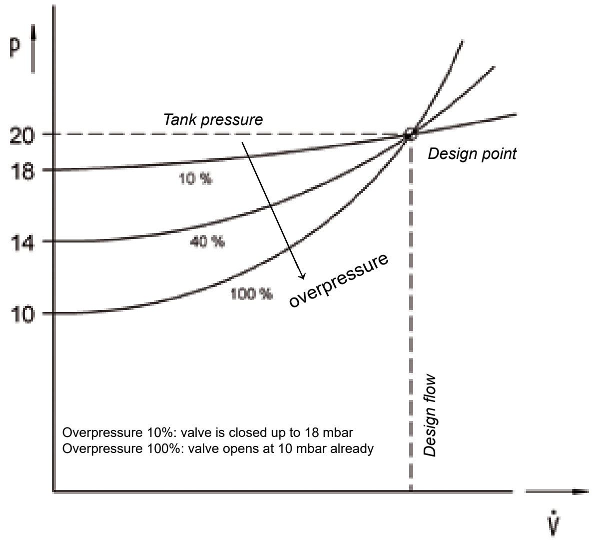


Figure 7: Opening characteristics of valves with different overpressure levels

The PROTEGO® **diaphragm valve** (Fig. 8) has a liquid load above the diaphragm.

The static liquid column is an indication of the set pressure. The flexible liquid-loaded diaphragm adjusts tightly to the metallic valve seat to provide an excellent seal. If the set pressure is exceeded, the diaphragm lifts and releases the cross-section for the flow to release. Due to the flexible diaphragm, these valves are used in weather-related low temperatures and in sticky, polymerizing substances. PROTEGO® diaphragm valves are the only valves worldwide which are frost-proof down to -40°C (-40°F).

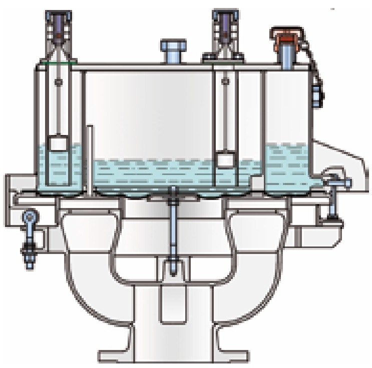


Figure 8: Diaphragm Valve PROTEGO® UB/SF-0

The self-controlled PROTEGO® **pilot operated valve** (Fig. 9) releases the flow without requiring additional overpressure. Up to the set pressure until the pilot reacts, the valve remains sealed. It immediately opens to full-lift after the set pressure is reached without overpressure and releases the cross-section of the valve (set pressure = opening pressure). As the pressure increases, the seal increases up to the set pressure. Once the flow is released and the pressure falls below the opening pressure, the valve recloses. PROTEGO® pilot valves are mainly used as safety relief valves for low-temperature storage tanks or when the valve must be very tightly sealed up to the set pressure.

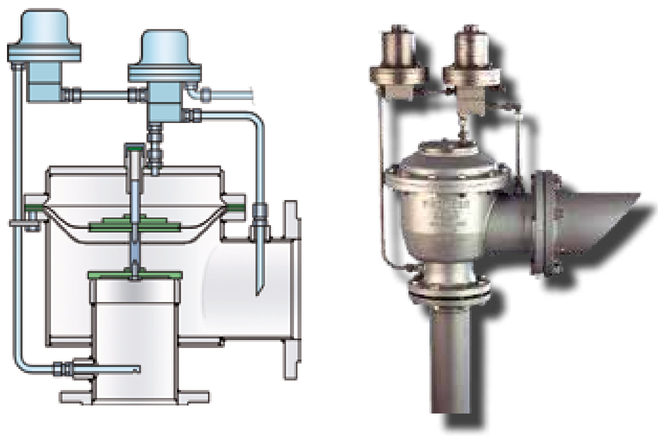


Figure 9: pilot operated pressure relief valve PROTEGO® PM/DS

The operating requirements, regarding the amount of out-breathing and in-breathing capacity, determine whether separate pressure valves and vacuum valves, or combined pressure and vacuum relief valves are used.

Pressure and vacuum relief valves for maintaining pressure (vapor conservation)

Process-related pressure maintenance in systems is ensured by valves that take pressure vessel related parameters into consideration. Conventional safety valves are used for pressures above 0.5 barg (7.25 psig) according to EN-ISO 4126 and Pressure Equipment Directive (PED), API 526 and ASME VIII, Div.1, or other international standards. For pressures below 0.5 barg (7.25 psig), the pressure can be maintained with safety valves that are not subject to the regulations of Pressure Equipment Directive (PED). However, they need to meet other criteria, e.g., provide a good seal, be frost-proof, trouble-free, and easy to maintain. PROTEGO® pressure and vacuum conservation valves meet these requirements with the highest degree of efficiency. And thanks to the 10% technology, they ensure reliable operation and minimum emission losses, even at the lowest setting pressures.

National and international technical regulations for maintaining clean air serve as the basis for calculating savings (such as VDI 3479: “Emission Control - Marketing Installation Tank Farms”, VOC Directive 1999/13/EC and 94/63/EC or API MPMS Chapter 19.1: “API Manual of Petroleum Measurement Standards - Chapter 19, Evaporative Loss Measurement, section 1 - Evaporative Loss from Fixed-Roof Tanks, 3rd Edition”). The design of the tank, the paintwork, the insulation, and the pressure maintenance via the valves have an influence on the emissions reduction.

The effect that pressure maintenance has on the reduction of product (vapor) loss improves as the set pressure of the valve approaches the maximum allowable tank pressure. The flow needs to be reliably released without the tank rupturing. A comparison of product loss at different overpressures clearly shows the advantages of 10% technology compared to 40% overpressure and especially compared to 100% overpressure. The specially developed design yields measurable savings – the required opening pressure differential is lower to the required performance (Fig. 10).

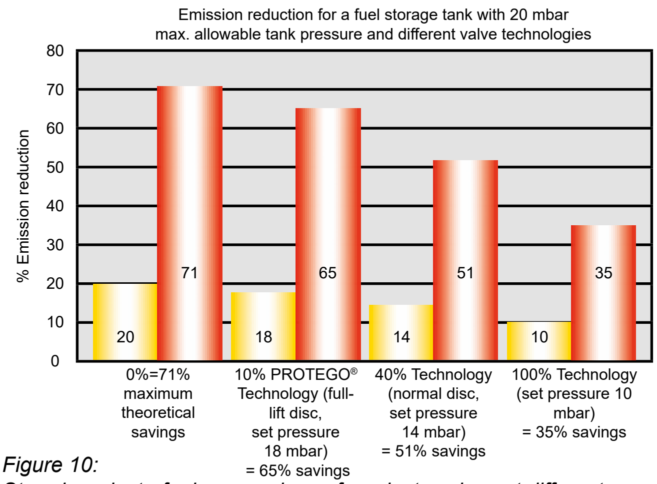


Figure 10:
Stored product - fuel: comparison of product savings at different over-pressure levels versus the free vented storage tank: example of product loss at 20 mbar allowable tank pressure savings in % at different overpressure
0% = up to 20 mbar (8 inch W.C.) the valve is closed (theoretical): more than 70% savings
10% = only at a valve set pressure 18 mbar (7.2 inch W.C.) the valve opens, 65% savings
40% = at a valve set pressure 14 mbar (5.6 inch W.C.) the valve opens, 51% savings,
100% = already at a valve set pressure 10 mbar (4 inch W.C.) the valve opens, only 35% savings.

Pressure and Vacuum Relief Valves for Pressure Relief and Tank Breathing

Outdoor storage tanks and vessels are exposed to weather conditions such as heating up and cooling down (the tank must be able to breathe). These influences must be considered in addition to filling and emptying capacities as well as inert-gas supply. They can be calculated with good approximation (see Venting Requirements of Above-ground Storage Tanks - Sizing and Calculation Formulas). The valve opening pressure must not exceed the maximum allowable tank pressure, which is also called the tank design pressure. The construction and design of the valve determines how this opening pressure is reached. Safety valves with conventional construction designed for pressure vessels with 0.5 bar (7.25 psi) overpressure require an overpressure of 10% above the set pressure to attain the opening pressure. Below 1 bar (14.5 psi) pressure, the maximum overpressure may reach 100 mbar (4 inch W.C.), which is clearly above the 10% level. In contrast, PROTEGO® valves with the relevant technology meet the requirements of conventional safety valves with an overpressure of 10% even at low set pressures down to 0.003 bar (1.2 inch W.C.).

Under normal operating conditions, it must be impossible to block the venting system on the tank. The sizing of the pressure and vacuum relief system must be such that the design pressure, i.e., the pressure and vacuum (negative pressure), in the tank cannot be exceeded under any operating conditions. The **pressure and vacuum relief valve** must be designed for maximum flow arising from the pump capacity, thermal influences, and where the tank is not constructed with a frangible roof. This valve is frequently called the vent valve.

When extremely high venting rates are required due to fire on the outside surface of the tank or malfunctions in special tank equipment (such as tank blanketing gas systems), additional **emergency pressure relief valves** must be used, especially when the tank roof does not have a frangible roof (Fig. 11).

When a blanket gas system fails, large amounts of gas can flow into the tank. The excess gas must be released from the tank through the pressure relief system without exceeding the tank design pressure.

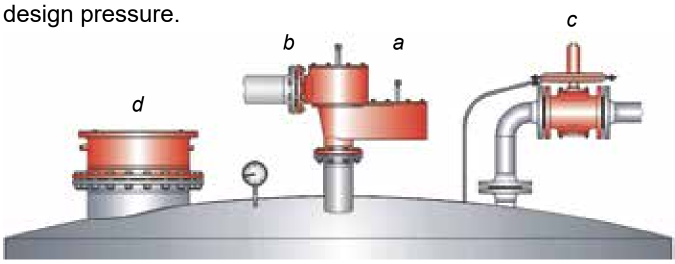


Figure 11: Venting of the storage tank with a pressure and vacuum relief valve PROTEGO® VD/SV-PA (a); piped into the vent header during operation (b); venting during operation via the nitrogen control valve PROTEGO® ZM-R (c); relieving in fire emergency through the emergency pressure relief valve PROTEGO® ER/V (d).

PROTEGO® valves fulfill the above-mentioned functions of maintaining and relieving pressure **as pressure relief valves, vacuum relief valves**, or **combined pressure and vacuum relief valves**.

Location of installation

PROTEGO® end-of-line valves are mainly used for storage tanks, vessels, or for ventilation lines. In pipes, PROTEGO® in-line valves are used for backflow prevention as overflow valves and, occasionally, as control valves. The great advantages are their simple design and large opening cross-sections. These valves operate problem-free. If the flowing products are explosive, in-line valves must have upstream flame arresters to protect the system against accelerated combustions. End-of-line valves must be equipped with an end-of-line flame arrester to protect the system against atmospheric deflagration (see also Section 7).

Sizing of the Valves

The maximum possible volumetric flow, the maximum allowable pressures, and the operating data (process parameters) must be taken into account when sizing pressure/vacuum relief valves.

Definitions:

Set pressure = the valve starts to open = adjusted set pressure of the valve at 0 bar back pressure

Opening pressure = set pressure plus overpressure

Reseating Pressure = Closing pressure = the valve recloses and is sealed

Overpressure = pressure increase over the set pressure

Accumulation (ISO) = pressure increase over the maximum allowable tank pressure of the vessel allowed during discharge through the pressure relief valve

Accumulation (EN) = differential pressure between the set pressure of the valve and the tank pressure at which the required flow rate is reached, or the set vacuum of the valve and the tank internal negative pressure at which the required flow rate is reached (not used in this catalog)

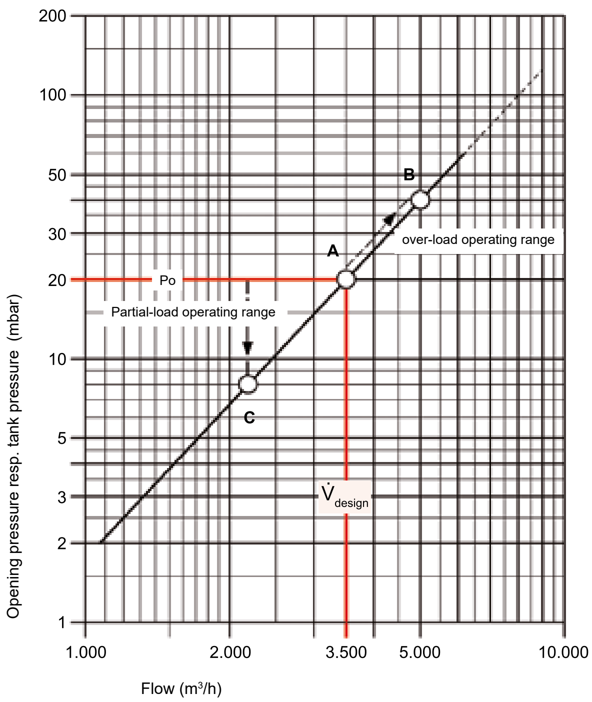
Pressure loss = decrease in pressure within the valve at a given flow

Pressure loss curve (Flow Chart) = pressure loss in mbar as a function of the volume flow in m^3/h (CFH)

Back pressure = pressure in the system that acts against the flow out of the valve and that needs to be included as additional pressure on the valve pallet

The maximum allowable design pressure of equipment, a storage tank, or vessel may not be exceeded. The maximum allowable flow must be safely released through the valve so that the maximum allowable design pressure of the equipment is not exceeded. Safety factors must be considered.

Operating conditions of pressure and vacuum relief valves: The valve is optimally sized when the operating point lies on the performance curve, i.e., when the calculated maximum flow is released with the valve completely open without requiring additional overpressure (with a completely open valve) (full-load operating range A, Fig. 12).



$$\textit{set pressure} = \frac{\textit{opening pressure or tank design pressure}}{1 + \frac{\textit{overpressure \%}}{100\%}}$$

Figure 12: Design and operating points in the flow chart

When the design flow is not being reached during discharge, the valve does not open completely. The valve pallet only lifts briefly, releases the volume, and then recloses when the pressure falls below the set pressure. The reseating pressure depends on the design of the valve pallet and the geometry of the valve. There are partial-load operating ranges in which the full-lift is not reached (over-sized valves) and overload ranges in which additional overpressure is required after a full lift to release the flow (under-sized valves). Within the overload range, the valve is stable; in the partial load range, the valve pallet can flutter due to instability. A proper sizing that considers possible operating conditions into consideration is essential.

Example (Fig. 12):

Valve opening pressure P_o = 20 mbar
Valve set pressure P_{set} = 18 mbar (20 mbar - 10%)

A design flow $\dot{V}_{design}$ = 3.500 m³/h
B over-load $\dot{V} > \dot{V}_{design}$
C partial-load $\dot{V} < \dot{V}_{design}$

For sizing of combined single component devices which have not been flow tested as combined devices (e.g., DR/ES with DV/ZT), a special sizing process needs to be considered. Please contact our sales engineers for specific information.

Selection

The valves are selected using the above selection criteria which depends on the **location of installation** and whether the valve is to **function** as a pressure relief valve, vacuum relief valve, or combined pressure and vacuum relief valve.

Location of Installation	**End-of-line Valves**				**In-line Valves**		
Function	Pressure Relief Valves	Vacuum Relief Valves	Pressure and Vacuum Relief Valves	Pressure Relief and Vacuum Valves, pilot operated	Pressure or Vacuum Relief Valves	Pressure and Vacuum Relief Valves	Blanketing Valves
Example of Use	→ see Safe Systems in Practice						
Product	→ Section 5	→ Section 5	→ Section 5	→ Section 5	→ Section 6	→ Section 6	→ Section 6

PROTEGO® has the right valve for all applications

For venting of storage tanks and vessels
→ PROTEGO® Pressure and Vacuum Relief Valves, end-of-line (Sec. 5)

As overflow valves or backflow preventers
→ PROTEGO® Pressure or Vacuum Relief Valves, in-line (Sec. 6)

For tanks which store critical substances or where frost protection must be guaranteed:

→ PROTEGO® Pressure / Vacuum Relief Diaphragm Valves, end-of-line (Sec. 5)

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Development

When storing flammable products or processing chemical products that can create explosive mixtures, the opening of the storage tank or vessel must be additionally protected with flame arresters. The task was to develop a device that combined the properties of a flame arrester and a valve into one design.

PROTEGO® valves with integrated flame arrester units have the unique advantage in that the flame arrester units are external, making them easily accessible (Fig. 1 and 2).

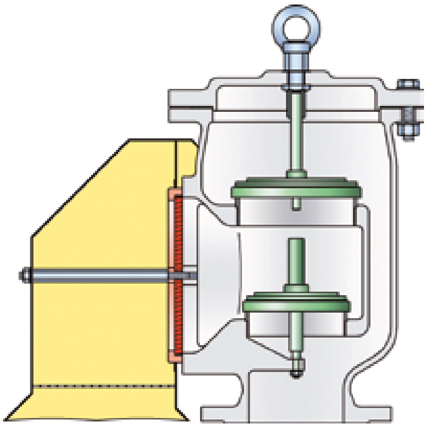

Figure 1:
Deflagration-proof pressure and vacuum relief valve PROTEGO® VD/TS

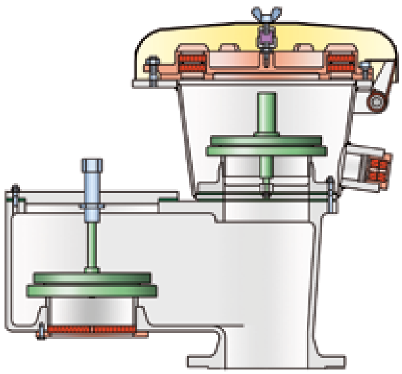

Figure 2:
Pressure and vacuum relief valve protecting against deflagration and endurance burning PROTEGO® VD/SV-HR

The operating conditions must be carefully considered. Depending on the possible combustion processes, protection must be provided against atmospheric deflagration, and/or short-time burning, and/or endurance burning.

Valve Technology

The valve technology and function of the pressure and vacuum valves with integrated flame arrester units are equal to those without flame arrester units, through which the down-stream flame arrester unit creates a certain back pressure which has no impact on the set pressure but influences the overpressure difference. This has been considered and is shown in the flow charts.

Pressure and Vacuum Relief Valves with Flame Arrester

Pressure and vacuum relief valves with integrated flame arrester units have the same tasks and functions as valves without flame arrester. They serve to **maintain pressure (vapor conservation) or for pressure relief** and enable **tank breathing**.

Flame Arrester

The valves also have an **integrated flame arrester unit**. The explosion group of the chemical products to be protected needs to be considered in the flame transmission-proof selection of the valve. The chemical products are categorized into explosion groups according to the maximum experimental safe gap (MESG) of the mixtures. The valve is tested and approved for the explosion group.

The PROTEGO® **diaphragm valve** (Fig. 3) has a liquid load above the diaphragm. The static liquid column is proportional to the set pressure. The flexible liquid-loaded diaphragm adjusts tightly to the metal valve seat to provide an excellent seal. If the set pressure is exceeded, the diaphragm lifts and releases the cross-section for the discharging flow. Due to the flexible diaphragm, these valves are used in weather-related low temperatures and for sticky, polymerizing substances.

The PROTEGO® **diaphragm valve** (Fig. 3a) offers dynamic flame-transmission protection against endurance burning and atmospheric deflagrations.

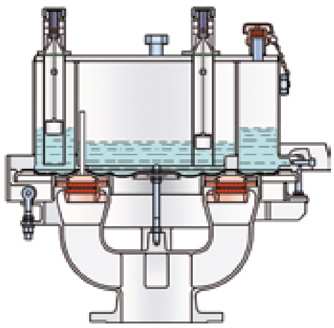

Figure 3: Diaphragm valve PROTEGO® UB/SF protecting against deflagration and endurance burning

Figure 3a: Endurance-burning test with diaphragm valve PROTEGO® UB/SF

The **high velocity valve** (Fig. 4) has special flame transmission protection with a dynamic discharge between the valve cone and valve seat starting at a set pressure of +60 mbar (24 inch WC). The high velocity valve is endurance burning-proof.

Figure 4: Endurance burning-proof high velocity valve PROTEGO® DE/S with a connected deflagration-proof vacuum valve PROTEGO® SV/E-S

Location of installation

Valves with flame arrester units are always end-of-line valves since the heat must be released to the environment with no heat build-up to prevent transmission of flame. Otherwise, the unallowable heat build-up would lead to a heat accumulation at the flame arrester, resulting in a flash-back. They are primarily used for storage tanks and containers in which flammable liquids are stored or processed and for relief openings in process containers in which the occurence of explosive mixtures cannot be excluded.

Design and operating conditions of valves

The sizing and operating conditions of the pressure and vacuum relief valves are described on the previous page.

Selection

Since PROTEGO® pressure/vacuum relief valves with flame arrester units are always end-of-line valves, they are selected according to their function as a pressure valve, vacuum valve, or combined pressure and vacuum relief valve.

After the explosion group of the products and the possible combustion process have been determined, the valve can be selected for its flame transmission protection. When selecting PROTEGO® valves with a flame arrester unit, it must be determined whether flame transmission protection is to be provided against atmospheric deflagrations or endurance burning. Endurance burning flame arresters include protection against atmospheric deflagrations. Flame transmission-proof vacuum relief valves are deflagration-proof. There is no danger of a stabilized burning with vacuum relief valves.

Location of Installation	**End-of-line Valve**				
Function	Pressure Relief Valve with Flame Arrester	Vacuum Relief Valve with Flame Arrester	Pressure and Vacuum Relief Valve with Flame Arrester	Pressure- / Vacuum Relief Diaphragm Valve with Flame Arrester	High Velocity Valve
Example of Use	→ see Safe Systems in Practice				
Products	→ Section 7	→ Section 7	→ Section 7	→ Section 7	→ Section 7

PROTEGO® has the right valve for all applications.

For flame transmission-proof pressure and vacuum relief of storage tanks and containers:
→ PROTEGO® Pressure and Vacuum Relief Valves with Flame Arresters, end-of-line

For frost-proof application, for critical products, and for flame transmission-proof pressure and vacuum relief of tanks and containers:
→ PROTEGO® Pressure-/ Vacuum Relief Diaphragm Valves

For flame transmission-proof pressure and vacuum relief of tank ships:
→ PROTEGO® High Velocity Valves

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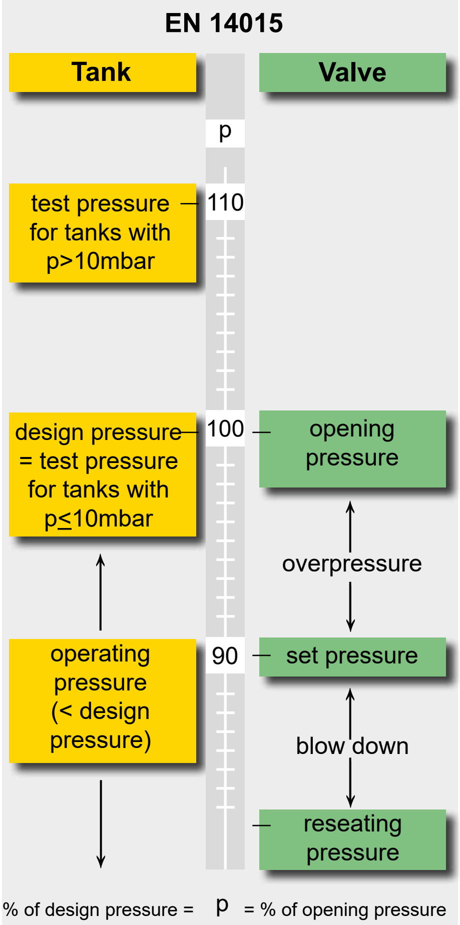
Pressure Terms and Definitions

Tanks storing flammable and non-flammable liquids are designed and manufactured in accordance with different standards: EN 14015, API 620, or API 650 are the most important standards worldwide. Depending on the standard, different maximum tank pressures are allowable where the discharge flow has to be achieved.

Fig. 1 shows the most common terms for tanks and valves. This comparison clarifies the sizing of end-of-line relief valves featuring the 10% overpressure technology with a set pressure of only 10% below the opening pressure. In **EN 14015** and **API 650** (**Fig. 1A** and **1B)** the design pressure (**MAWP** = **M**aximum **A**llowable **W**orking **P**ressure) of the tank must not be exceeded, not even in fire emergencies or system malfunction. According to **API 620 (Fig. 1C),** the valve must release the required regular flow rate 10% above the design pressure of the tank. For fire or other emergency conditions, an overpressure of 20% is allowable, i.e., the required flow rate must be released after exceeding the MAWP by a maximum of 20%.

Figure 1:
Comparison of pressure terms for storage tanks and vent valves designed and manufactured in accordance to different standards (e.g., API 620 or API 650 or EN 14015) equipped with pressure relief devices (illustration simplified and based on 10% overpressure technology of the valve).

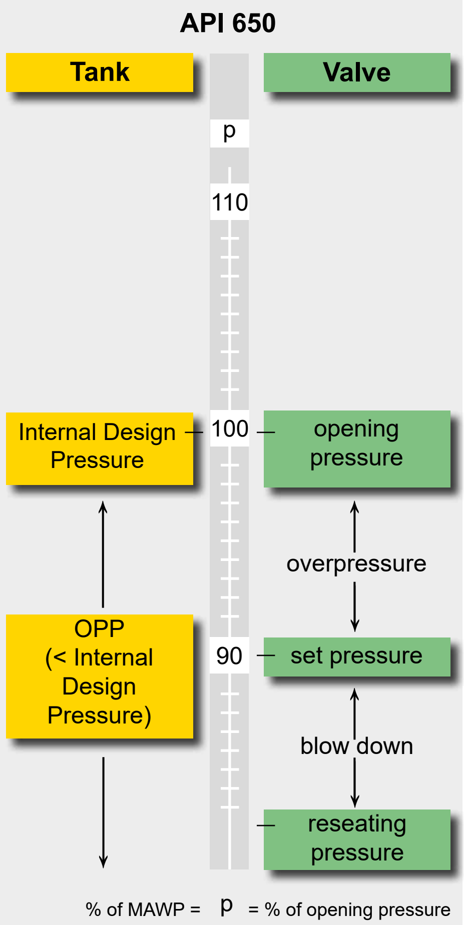


design pressure
= calculated pressure = Maximum Allowable Working Pressure (MAWP) must not be exceeded under any operating conditions. For fire and emergency conditions, a frangible seam or emergency relief valve is required.

opening pressure
≤ design pressure;

set pressure = 0,9 x opening pressure for 10% overpressure technology.

Figure 1A



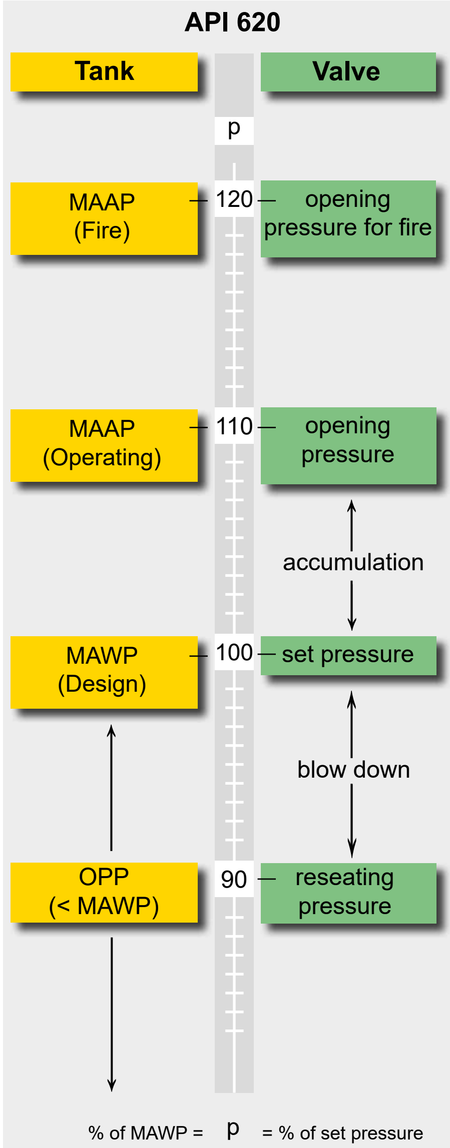
internal design pressure
= max. relieving pressure under operating condition, fire condition or emergency (max. relieving pressure for valve and emergency valve).

OPP = Operating Pressure

opening pressure
≤ internal design pressure

set pressure = 0,9 x opening pressure for 10% overpressure technology.

Figure 1B



MAAP
= Maximum Allowable Acumulated Pressure = max. relieving pressure under operating condition (max. relieving pressure for valve). Relief Pressure for fire and emergency conditions relieve at 20% above overpressure.

Max. allowable set pressure
= MAWP for 10% overpressure technology.
MAWP = Maximum Allowable Working Pressure

Figure 1C

Engineering Service

QuEST - Quick Engineering and Sizing Tool

Fig. 2 shows the procedure to determine the set pressure for valves with different overpressure characteristics by considering the specific tank design pressure. These examples are only for end-of-line relief valves without a back-pressure originated by, e.g., connected pipe-away line. If the tank is designed in accordance with EN 14015 or API 650, the opening pressure must not exceed the design pressure (=MAWP) of the tank (Fig. 2A). The set pressure is a result of the opening pressure minus the overpressure of the valve, which is a characteristic of the specific valve. If the tank is manufactured in accordance with API 620, the opening pressure may exceed the tank design pressure by 10% for regular breathing and 20% for fire emergencies (Fig. 2B). The set pressure is again the result of the opening pressure minus the valve characteristic overpressure. To dertermine the flow rates, the relevant regulations of ISO 28300, TRbF 20, or API 2000 must be applied.

Figure 2:
Selection of the set pressure of the Pressure or Vacuum Relief Valve considering the tank design pressure and the valves characteristic overpressure (e.g. 10%, 40% or 100%). API 620 using the 20% overpressure allowance for fire emergency.

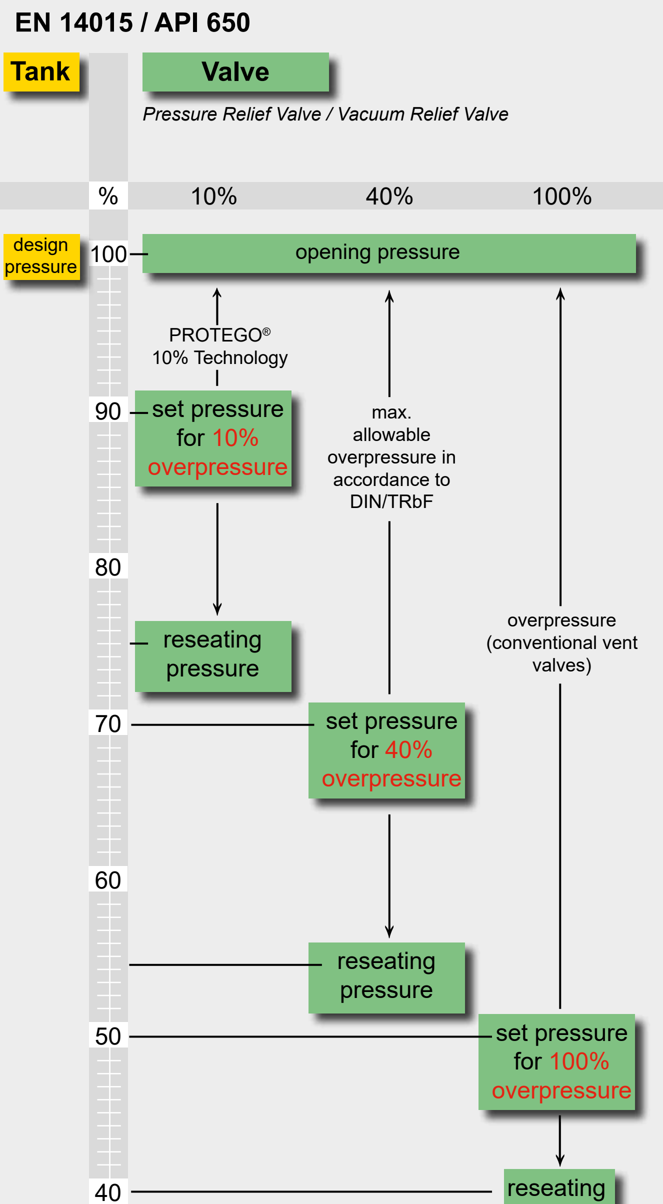


Figure 2A: Design in acc. with EN 14015 or API 650

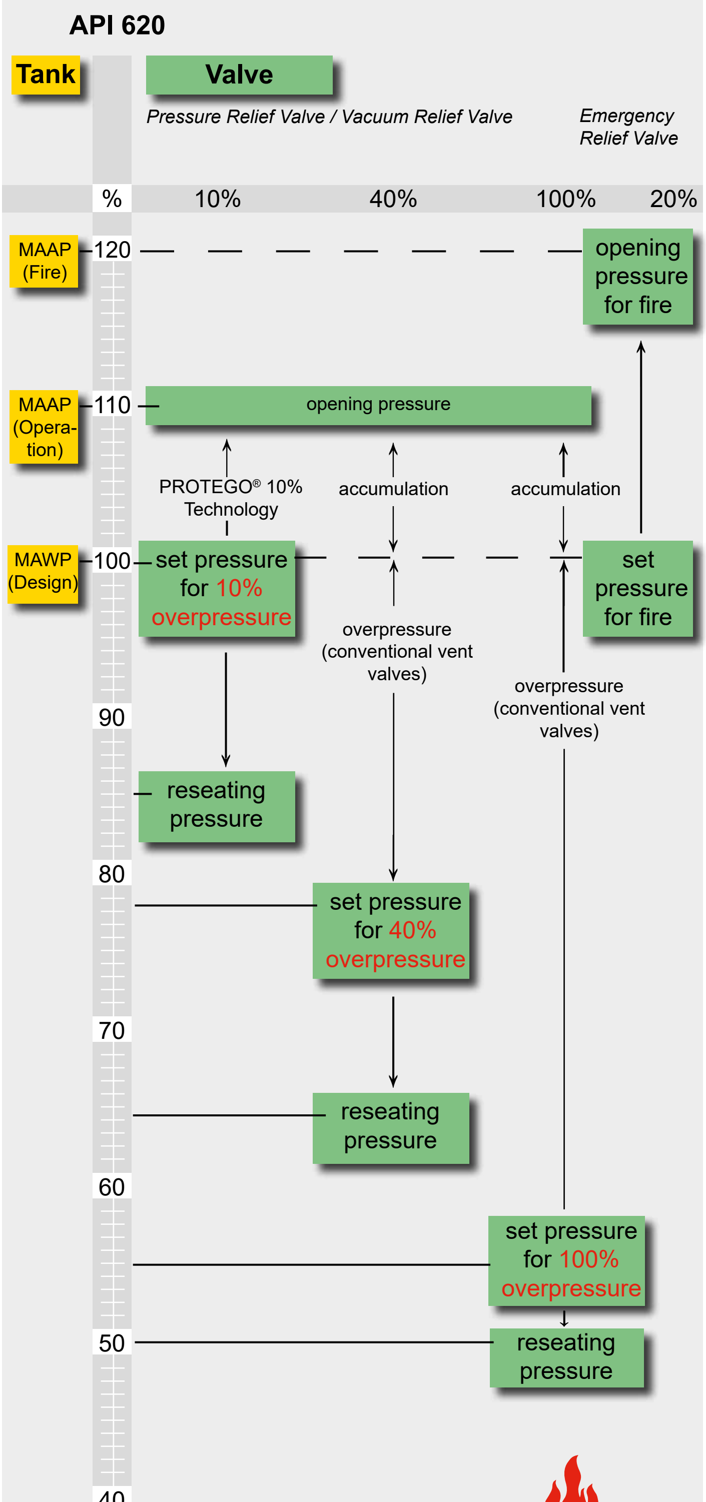


Figure 2B: Design in acc. with API 620

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Calculation of the Out-breathing and In-breathing venting capacity in acc. with ISO 28300/API 2000:

The maximum required venting capacity is the total amount of pump capacity and thermal capacity due to weather related conditions:

$$\dot{V}_{out} = \dot{V}_{thermal\ out} + \dot{V}_{pump\ in}$$

$$\dot{V}_{in} = \dot{V}_{thermal\ in} + \dot{V}_{pump\ out}$$

The calculation of the maximum required capacity from weather related conditions is based on ISO 28300 with regard to above-ground storage tanks with or without insulation.

Thermal capacity for heating up $\dot{V}_{thermal\ out}$ in m^3/h

$$\dot{V}_{thermal\ out} = 0{,}25 \cdot V_{tank}^{0.9} \cdot R_i$$

Thermal capacity for cooling down $\dot{V}_{thermal\ in}$ in m^3/h

$$\dot{V}_{thermal\ in} = C \cdot V_{tank}^{0.7} \cdot R_i$$

- V_{tank} is the volume of the tank in m^3

  $V_{tank} = 0{,}7854 \cdot D^2 \cdot H$
- R_i is a reduction factor for insulation (see ISO 28300/API 2000)
- $\dot{V}_{pump\ in}$ is the filling rate to calculate the out-breathing capacity out of the maximum pump capacity in m^3/h for products stored below 40°C and a vapor pressure p_{vp} < 50 mbar. For products stored at a temperature above 40°C or with a vapor pressure p_{vp} > 50 mbar, the out-breathing rate must be increased by the evaporation rate.
- $\dot{V}_{pump\ out}$ is the emptying rate to calculate the in-breathing capacity of the pump in m^3/h.
- C=3 for products with equal vapor pressure as hexane and storage temperature < 25°C
- C=5 for products with vapor pressures higher than hexane and/or storage temperature above 25°C (if vapor pressure not known, then C=5)

The mentioned calculation formulas apply to latitudes of 58° to 42°. For other latitudes, see ISO 28300/API 2000.

Particular influences to be considered are:

- Failure of the nitrogen blanketing valve – Installation of an additional emergency relief valve to vent the non calculated flow which was not foreseen under operation
- Filling the empty hot tank with cold liquid product – Considering the additional flow due to the sudden cooling down when calculating the necessary vacuum capacity
- Exceeding the maximum given pump out capacity – Considering a safety factor when calculating the required in-breathing capacity

Calculation of the Out-breathing and In-breathing venting capacity in acc. with TRGS 509:

To calculate the out-breathing and in-breathing capacity of storage tanks (e.g., tanks in acc. with DIN 4119 for above-ground, flat-bottom storage tanks, or DIN 6608 for underground or underground horizontal tanks), the calculation formulas of TRGS 509 (as of 1 January 2013, VdTÜV-Merkblatt Tank-anlagen 967) are to be applied.

Calculation of the required capacity due to thermal influences:

Heating up	$\dot{V}_E = 0{,}17 \times \left(\frac{H}{D}\right)^{-0{,}52} \times V_{tank}^{0{,}89}$
Cooling down	$\dot{V}_A = 4{,}8 \times V_{tank}^{0{,}71}$

H = Height of the Tank in m; D = Diameter in m

Calculation of Out-breathing and In-breathing venting capacity in acc. with API 2000, 5th Edition / ISO 28300 Annex A:

The out-breathing and in-breathing capacity of petroleum storage tanks can be calculated in acc. with ISO 28300 Annex A (approximately equivalent to API 2000 5th Edition) if specific boundary conditions are fulfilled (see ISO 28300).

If specified and if the tanks are designed and manufactured in accordance with **API 650,** the venting capacity for in-breathing and out-breathing, as well as for fire emergencies, is to be calculated in accordance with **API 2000**.

When calculating the required capacities in accordance with API 2000, 5th Edition / ISO 28300 Annex A, the flammable liquids must be verified with regard to their flashpoint. Different formulas must be applied for liquids with a flashpoint < 100°F (< 37,8°C) and for liquids with a flashpoint ≥ 100°F (≥ 37,8°C). The maximum required venting capacity is the total amount of pump capacity plus thermal capacity of weather-related conditions. In contrast, the calculation of the pump capacity must consider a factor for the in-breathing rate and the different flashpoints for the out-breathing rate.

Calculation of the in-breathing capacity:

$$\dot{V}_{in} = \dot{V}_{pump\ out} \times 0{,}94 + \dot{V}_{thermal\ in}$$

The thermal capacity thermal$_{In}$ is rated in API 2000, 5th Ed. **(Fig. 2A,** English units and **2B,** Metric units) depending on the tank volume. The maximum pumping capacity $\dot{V}_{pump\ out}$ is rated in accordance with the specified operating rates for draining.

Calculation of the out-breathing capacity:

For liquids with flashpoint <100°F (<37,8°C)

$$\dot{V}_{out} = \dot{V}_{pumping\ in} \times 2{,}02 + \dot{V}_{thermal\ out}$$

For liquids with flashpoint ≥100°F (≥37,8°C)

$$\dot{V}_{out} = \dot{V}_{pumping\ in} \times 1{,}01 + \dot{V}_{thermal\ out}$$

The thermal capacity $\dot{V}_{thermal\ out}$ is rated in API 2000, 5th Ed. (**Fig. 2A,** English units **and 2B,** Metric units) depending on the tank-volume and the flashpoint. The maximum pumping capacity $\dot{V}_{pump\ in}$ is rated in accordance with the specified operating rates for filling.

In case there is no frangible seam, emergency venting for fire emergencies is to be carried out through an emergency pressure relief valve. The required capacity for fire emergencies $\dot{V}_{Fire}$ is rated in accordance with API 2000 **(Fig. 3A**, English units and **Fig. 3B,** Metric units) depending on the wetted surface area of the tank.

Simplified formula for estimating calculation:

$\dot{V}_{fire}$ = 208,2 x F x $A^{0,82}$ for Metric units in Nm³/h

$\dot{V}_{fire}$ = 1107 x F x $A^{0,82}$ for English units in SCFH

Insulation is considered with a factor F in API 2000 **(Fig. 4A,** English units and **4B**, Metric units).

Requirements for Thermal Venting Capacity (English Units)

Tank Capacity	Tank Capacity	In-breathing *thermal $_{in}$*	Out-breathing *thermal $_{Out}$* Flashpoint ≥ 100°F	Out-breathing *thermal $_{Out}$* Flashpoint < 100°F
Barrels	Gallons	SCFH Air	SCFH Air	SCFH Air
100	4.200	100	60	100
500	21.000	500	300	500
1.000	42.000	1.000	600	1.000
2.000	84.000	2.000	1.200	2.000
4.000	168.000	4.000	2.400	4.000
5.000	210.000	5.000	3.000	5.000
10.000	420.000	10.000	6.000	10.000
20.000	840.000	20.000	12.000	20.000
30.000	1.260.000	28.000	17.000	28.000
40.000	1.680.000	34.000	21.000	34.000
50.000	2.100.000	40.000	24.000	40.000
100.000	4.200.000	60.000	36.000	60.000
140.000	5.880.000	75.000	45.000	75.000
160.000	6.720.000	82.000	50.000	82.000
180.000	7.560.000	90.000	54.000	90.000

Excerpt from API 2000, 5th Ed.

Figure 2A

Requirements for Thermal Venting Capacity (Metric Units)

Tank Capacity	In-breathing *thermal $_{in}$*	Out-breathing *thermal $_{Out}$* Flashpoint ≥ 37,8°C	Out-breathing *thermal $_{Out}$* Flashpoint < 37,8°C
m³	Nm³/h	Nm³/h	Nm³/h
10	1,69	1,01	1,69
20	3,37	2,02	3,37
100	16,90	10,10	16,90
200	33,70	20,20	33,70
300	50,60	30,30	50,60
500	84,30	50,60	84,30
1.000	169,00	101,00	169,00
2.000	337,00	202,00	337,00
3.000	506,00	303,00	506,00
4.000	647,00	472,00	647,00
5.000	787,00	537,00	787,00
10.000	1.210,00	807,00	1.210,00
20.000	1.877,00	1.307,00	1.877,00
25.000	2.179,00	1.378,00	2.179,00
30.000	2.495,00	1.497,00	2.495,00

Excerpt from API 2000, 5th Ed.

Figure 2B

Emergency Venting required for Fire Exposure Versus Wetted Surface Area (English Units)

Wetted Area A square feet	Venting Requirement $\dot{V}$ SCFH
20	21.100
40	42.100
60	63.200
80	84.200
100	105.000
140	147.000
180	190.000
250	239.000
350	288.000
500	354.000
700	428.000
1400	587.000
2800	742.000

Excerpt from API 2000, 5th Ed.

Figure 3A

Emergency Venting required for Fire Exposure Versus Wetted Surface Area (Metric Units)

Wetted Area A m^2	Venting Requirement $\dot{V}$ Nm^3/h
2	608
4	1.217
6	1.825
8	2.434
15	4.563
25	6.684
30	7.411
35	8.086
45	9.322
60	10.971
80	12.911
150	16.532
260	19.910

Excerpt from API 2000, 5th Ed.

Figure 3B

Environmental Factors for non-refrigerated Above-ground Tanks (English Units)

Tank-configuration	Insulation Thickness inch	F - Factor
Bare metal tank	0	1.0
insulated tank	1	0.3
insulated tank	2	0.15
insulated tank	4	0.075
insulated tank	6	0.05
underground storage		0
earth covered storage		0.03
impoundment away from tank		0.5

Excerpt from API 2000, 5th Ed.

Figure 4A

Environmental Factors for non-refrigerated Above-ground Tanks (Metric Units)

Tank-configuration	Insulation Thickness cm	F - Factor
Bare metal tank	0	1,0
insulated tank	2,5	0,3
insulated tank	5	0,15
insulated tank	10	0,075
insulated tank	15	0,05
underground storage		0
earth covered storage		0,03
impoundment away from tank		0,5

Excerpt from API 2000, 5th Ed.

Figure 4B

Conversion of operational flow into equivalent diagram flow for use of flow charts

To use the flow charts (pressure vs. flow diagram) by considering the operational and product data, it is necessary to convert the given operational flow $\dot{V}_{B,Gas}$ into the equivalent diagram flow $\dot{V}_{Dia}$. This $\dot{V}_{Dia}$ then creates the same pressure loss as the actual operational flow.

1) Conversion of the operational flow $\dot{V}_{B,Gas}$ into the standard flow $\dot{V}_{N,Gas}$:

$$\dot{V}_{N,\,Gas} = \dot{V}_{B,\,Gas} * \frac{T_N * p_B}{T_B * p_N} = \dot{V}_{B,\,Gas} * \frac{p_B * 273{,}15K}{T_B * 1{,}013\ bar_{abs.}}$$

2) Conversion of the standard flow $\dot{V}_{N,Gas}$ into the equivalent diagram flow $\dot{V}_{Dia}$:

$$\dot{V}_{Dia} = \dot{V}_{N,\,Gas} * \sqrt{\frac{\rho_{N,\,Gas} * p_N * T_B}{\rho_{Dia} * p_G * T_N}}$$

$$= \dot{V}_{N,\,Gas} * \sqrt{\frac{\rho_{N,\,Gas} * T_B * 1{,}013\ bar_{abs.}}{p_G * 1{,}2\,\frac{kg}{m^3} * 273{,}15\ K}}$$

3) Calculation of the average density $\rho_{N,Gas}$ of a gas-mixture

$$\rho_{N,\,Gas} = (v_1 * \rho_{N,\,Gas\,1} + v_2 * \rho_{N,\,Gas\,2} + ... + v_x * \rho_{N,\,Gas\,x})$$

Terms

$\dot{V}$ = Flow m³/h (CFH)

p = Pressure bar abs (psi abs)

T = Temperature K

ρ = Specific density kg/m³ (lb / cu ft)

v = Volume fraction

Indexes

N = Standard condition (at 1,013 bar abs and 273,15 K)

B = Operational condition (pressure and temperature acc. to operation)

Gas = Actual product

Dia = Refers to the diagram when using the flow chart for sizing (ρ_{Dia}=1,189 kg/m³ related density of air at 20 °C and 1 bar abs.)

G = Refers to the outlet of the device (p_G back pressure) for operating conditions

Safety Procedures for Protecting Hazardous Explosive Areas in Third Party audited processing plants

Step 1

Assessment of the possible combustion process based on Standards, e.g., EN 1127-1 General Explosion Protection Methods and EN ISO 16852, or EN 12874 Flame Arresters

- Deflagration in the atmosphere, in the pre-volume or in a pipeline
- Detonation in a pipeline, stable or unstable
- Endurance burning due to continous flow of vapors/gases in the pipeline or at the opening of a tank

Step 2

Classification of the products based on literature and international standards EN ISO 16852, VbF, NFPA, British Standard for liquids, gases, vapors and multiple component mixtures

- Liquids: subdivided into flammable, highly flammable, and extremely flammable due to the flash point of the liquid and verifying the ignition temperature.

The classification is following the VbF (previous) and the Ordinance on Hazardous Substances (Gef. Stoff VO - current):

Non-water soluble		
previous	current	
(A I FP< 21 °C)	FP < 0 °C (32°F)	Extremely flammable
	FP < 21 °C (70°F)	Highly flammable
(A II FP 21–55 °C)	FP 21-55°C (70-131°F)	Flammable
(A III FP 55–100 °C)		-

Water soluble		
previous	current	
(B < FP 21 °C)	FP < 0 °C (32°F)	Extremely flammable
	FP < 21 °C (70°F)	Highly flammable
	FP 21–55 °C (70-131°F)	Flammable

FP = Flashpoint

Products with a flashpoint FP>55°C (>131°F) become flammable when being heated close to the flashpoint (ΔT = 5 degree safety margin as a rule of thumb for hydrocarbons and 15 degrees for mixtures).

Vapors: classification of the gas/vapor-air-mixtures according to the MESG of the substances or the mixture into the Explosion Groups IIA1, IIA, IIB1, IIB2, IIB3, IIB, and IIC (NEC Group D, C, and B).

Step 3

Consideration of the operational process parameters of the unburned mixtures and the impact on the combustion behavior:

- OperatingTemperature
  ≤ 60°C (≤ 140°F) Standard, no particular requirements
  > 60°C (> 140°F) Special approvals necessary
- Operating pressure
  ≤ 1,1 bar abs (≤ 15.95 psi) Standard, no particular requirements
  > 1,1 bar abs (> 15.95 psi) Special approvals necessary

Step 4

Assessment of the overall system and classification into hazardous zones according to frequency and duration of explosive atmosphere based on national and international regulations, e.g., TRBS, IEC, or NFPA/NEC.

- Zone 0

  Constant or frequent explosive atmosphere.
- Zone 1

  Occasional explosive atmosphere.
- Zone 2

  No or rare explosive atmosphere.

For risk assessment, the possible ignition sources must be evaluated under normal operating conditions as well as under special operating conditions, such as cleaning and maintenance work (see EN 1127-1):

Effective ignition source:

- Steady and continuous under normal operation
- Solely as a result of malfunctions
- Solely as a result of rare malfunctions

Effective ignition sources are chemical reactions, flames and hot gases, hot surfaces, mechanical generated sparks, static electricity, lightning, electromagnetic waves, ultrasonic sparks, adiabatic compression, shock waves, etc.

Effectiveness of the ignition source must be compared with the flammability of the flammable substance.

Step 5

Selection, number and location of the suitable equipment, protective system, and component must follow the requirements of national and international regulations (ATEX Directive).

For equipment (blowers, agitators, containers, etc.)

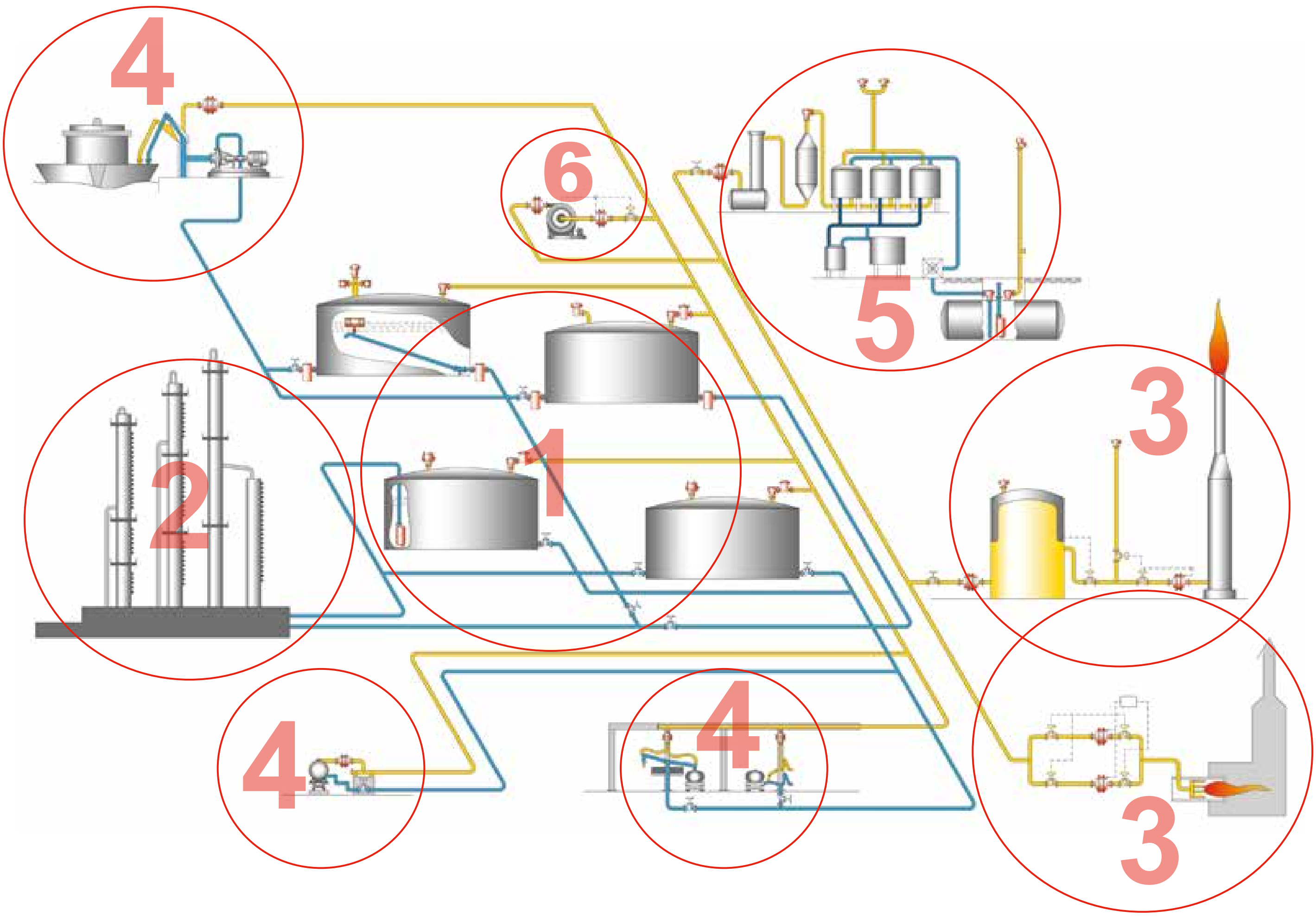
- In Zone 0 equipment categorized in group II, cat. 1
- In Zone 1 equipment categorized in group II, cat. 2
- In Zone 2 equipment categorized in group II, cat. 3

Flame arresters tested in accordance with EN ISO 16852 or EN 12874 fullfil the health and safety requirements of current ATEX regulations.

Flame arresters are protective systems and are not categorized. They must be type examination tested and approved by a Notified Body. They can be installed in all zones (zone 0, 1, or 2) and are marked with CE to show conformity with all applicable requirements.

The procedure and the results of the risk assessment must be verified in the “Explosion Protection Document“. The plant operator (employer) must confirm that equipment has the latest technology and that the equipment, protective systems, and components for intended operation in potentially explosive atmospheres are in compliance with ATEX or other international regulations. Process engineering, plant-layout, material data, zoning, risk assessment, etc. are part of the protection document, as well as oganizational measures and the definition of responsibilities.

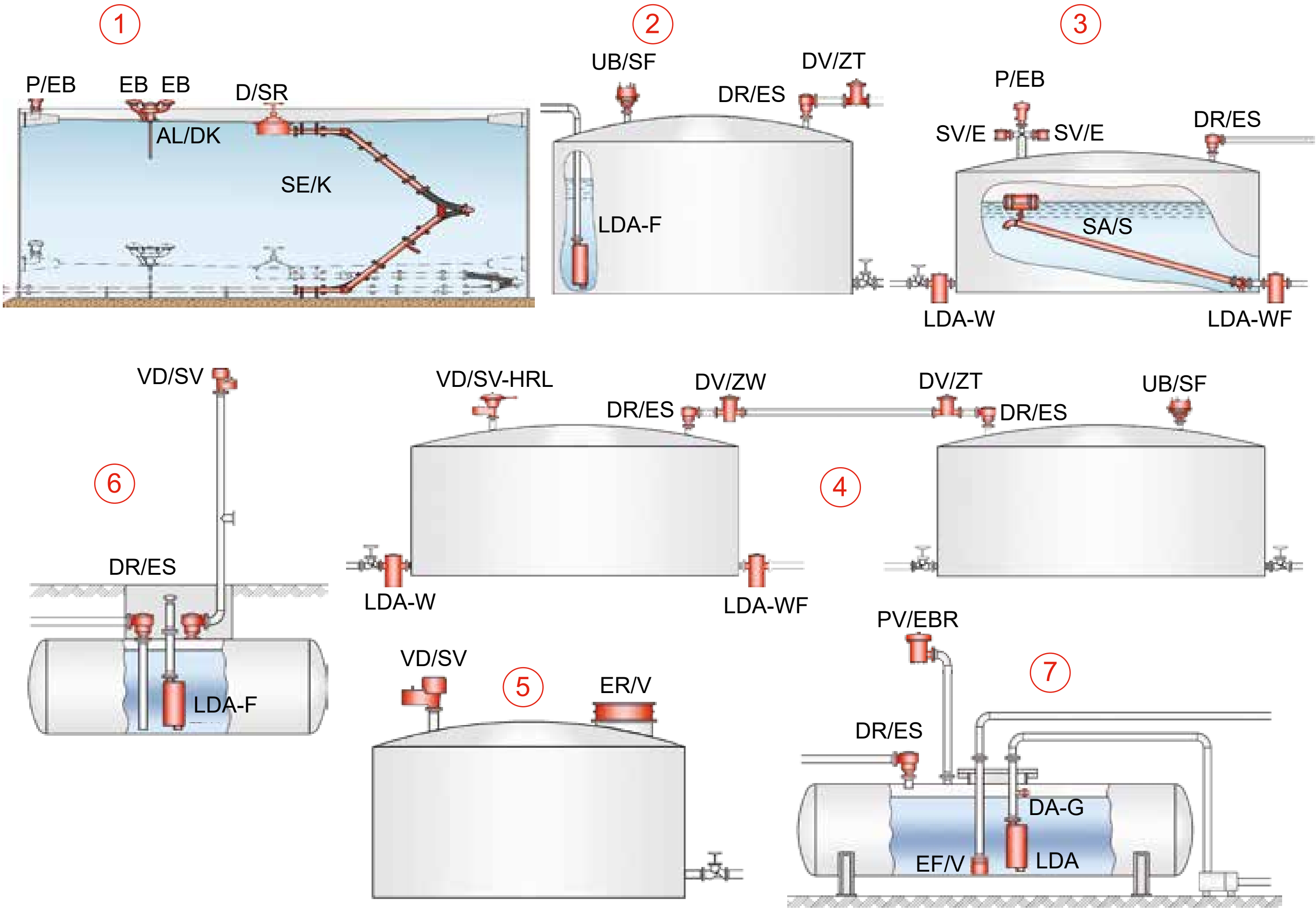
PROTEGO® safety devices are used in a wide range of industrial applications. A safe process requires reliable protection for every conceivable operating parameter. Practical examples show how systems can be made safe and how PROTEGO® devices can be incorporated into control loops. Engineers are responsible for the proper organization of the overall system.



PROTEGO® devices offer safety and environmental protection

1. In Storage Tank Farms for Refineries and Chemical Plants
2. In Processing Systems for Chemical and Pharmaceutical Industries
3. In Vapor Combustion Systems and Flares
4. In Ship Building and Loading Systems
5. In Vapor Recovery Units
6. As integrated Component of Equipment, Machines, and Vessels

Applications of PROTEGO® devices are used in other areas such as in biogas and landfill gas systems, medical technology, food processing, aircraft construction, automotive engineering, IT clean room technology, thin-film technology, etc.



1. Floating roof storage tank with floating-roof drainage system SE/K (→ Sec. 8), roof valve D/SR (→ Sec. 8) stem-actuated valve AL/DK (→ Sec. 8) with deflagration flame arresters EB (→ Sec. 2)

2. Fixed roof storage tank for flammable liquids with pressure and vacuum diaphragm valve UB/SF (→ Sec. 7), liquid detonation flame arrester LDA-F (→ Sec. 4), in the protective gas blanket line DR/ES (→ Sec. 4) with DV/ZT (→ Sec. 6)

3. Fixed roof storage tank for flammable liquids with pressure safety relief valve P/EB (→ Sec. 7) and vacuum safety relief valve SV/E (→ Sec. 7), liquid detonation flame arrester LDA-W (→ Sec. 4) and/or LDA-W-F (→ Sec. 4) in the filling and emptying line, float-controlled swing pipe system SA/S (→ Sec. 8), detonation-proof gas displacement connection DR/ES (→ Sec. 4)

4. Fixed roof storage tank for flammable liquids with pressure and vacuum relief valve VD/SV-HRL (→ Sec. 7), pressure and vacuum relief diaphragm valve UB/SF (→ Sec. 7), connection to gas vent header system with detonation flame arrester DR/ES (→ Sec. 4) and in-line pressure and vacuum safety relief valve DV/ZT or DV/ZW (→ Sec. 6), liquid detonation arrester in the filling line LDA-W and emptying line LDA-WF (→ Sec. 4)

5. Fixed roof storage tank for non-flammable liquids with pressure and vacuum conservation valve VD/SV (→ Sec. 5) and emergency pressure relief valve ER/V (→ Sec. 5) instead of frangible seam.

6. Underground storage tank with safety devices in the filling line LDA-F (→ Sec. 4), detonation flame arrester in the drain line DR/ES (→ Sec. 4), and in the vent line DR/ES (→ Sec. 4) and VD/SV (→ Sec. 5)

7. Aboveground tank for flammable liquids with pressure and vacuum safety relief valve PV/EBR (→ Sec. 7), liquid detonation flame arrester LDA (→ Sec. 4) in the filling line and an additional detonation flame arrester DA-G (→ Sec. 4) ensures that the tank is not emptied, detonation-proof foot valve for drain line EF/V (→ Sec. 4), detonation flame arrester DR/ES (→ Sec. 4) in vapor return pipeline.

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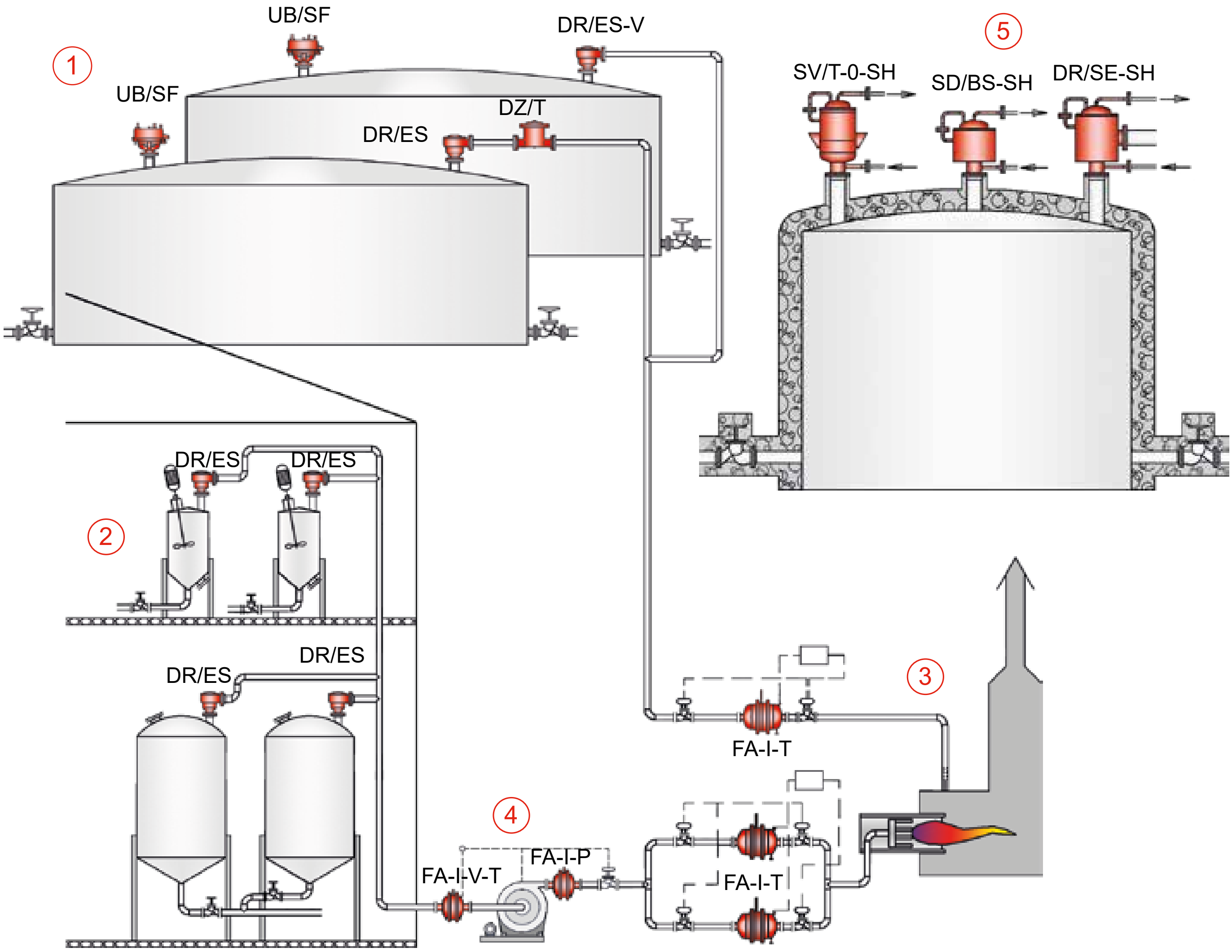


(1) Tank farms for flammable liquids with pressure and vacuum relief diaphragm valve UB/SF (→ Sec. 7), connection to gas vent header system with detonation flame arrester DR/ES-V or DR/ES (→ Sec. 4), and pressure or vacuum relief valve DZ/T (→ Sec. 6).

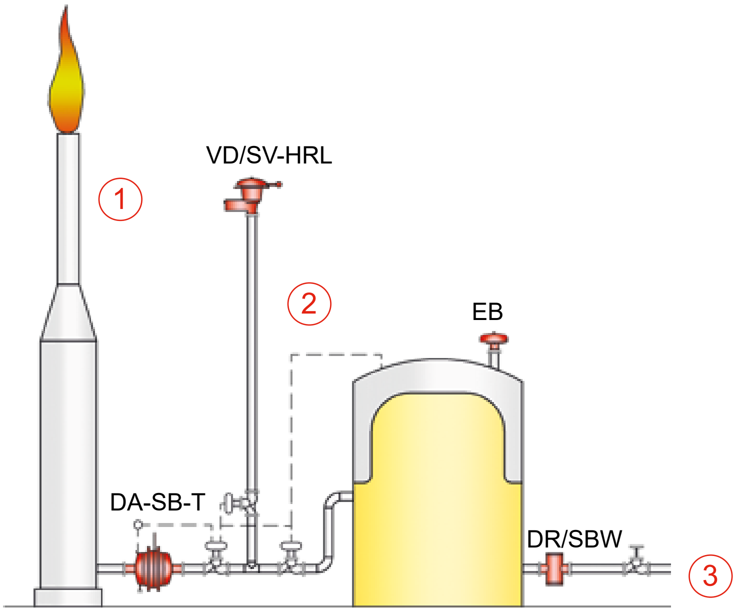
(2) Ventilation of industrial mixers and process vessels in a common vapor vent header via detonation flame arresters DR/ES (→ Sec. 4).

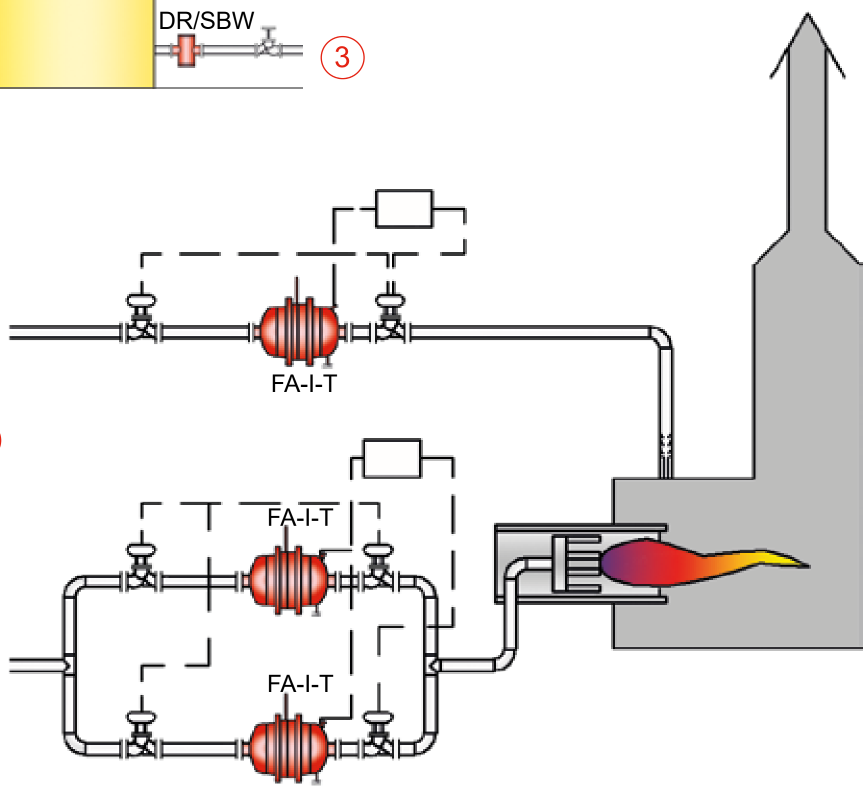
(3) Temperature monitored deflagration flame arresters FA-I-T (→ Sec. 3) in the inlet line for vapor combustion at the maximum allowable distance from the ignition source and installation location of the flame arrester (L/D ratio) an in parallel for the availability of maintenance or emergency switchover in case of an endurance burning on the arrester. Vapor pipeline from plant to vapor combustion unit with deflagration flame arrester FA-I-T (→ Sec. 3) to protect the vent header collection line and the operating locations in the plant.

(4) Protection of pressure-resistant radial blowers as type-approved zone-0 blowers with integrated PROTEGO® flame arresters FA-I-V-T and FA-I-P (→ Sec. 3).

(5) Protection of storage tanks for substances that can only be pumped with assistance of heating systems. These applications, e.g., bitumen storage, need continually heated devices, such as the pressure relief valve SD / BS - H (→ Sec. 5), vacuum relief valve SV / T - 0 - H (→ Sec. 5), and heated detonation flame arrester DR / SE – SH for venting up to 320 ° C at 6 bar.

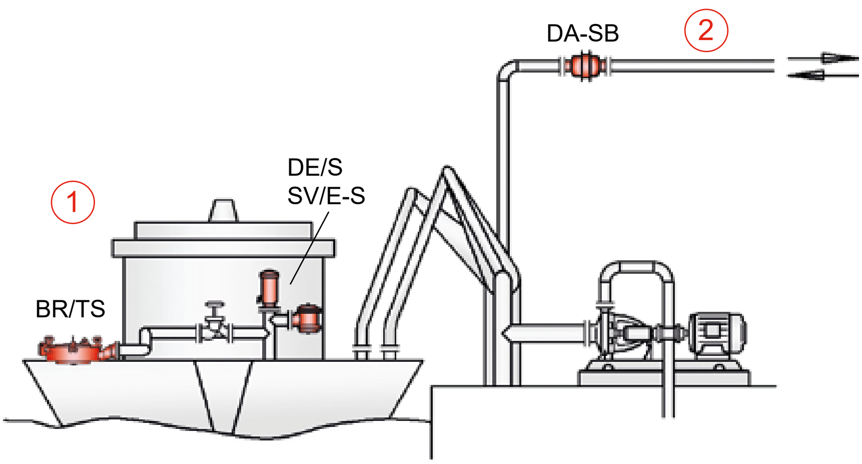
Vapor Combustion Systems and Flares

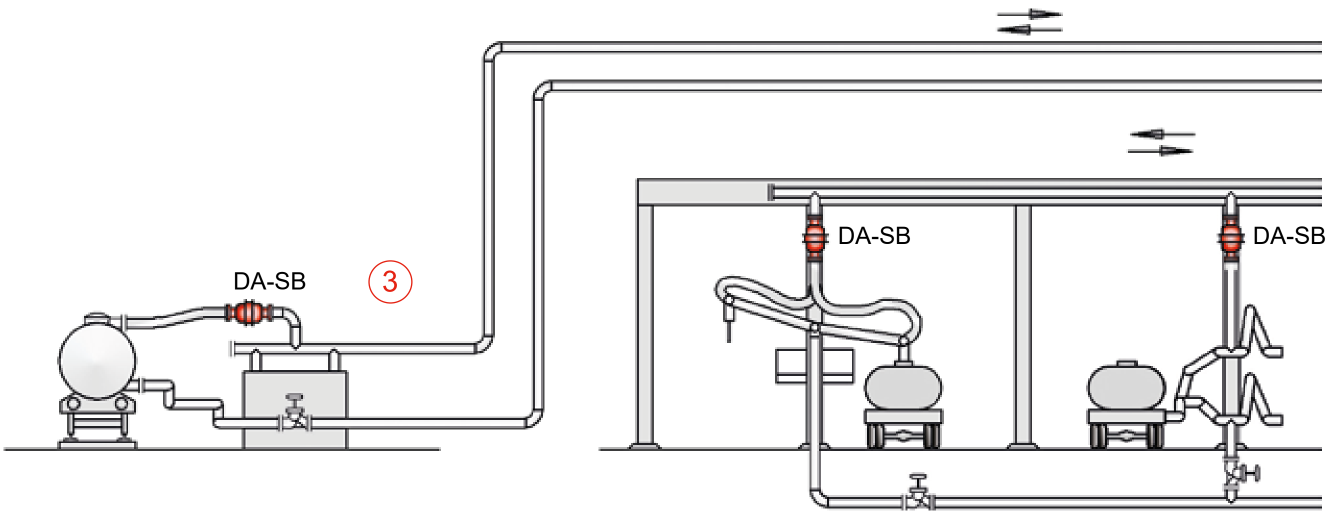




1. Flare pipes or ground flares with detonation flame arresters DA-SB-T (→ Sec. 4).
2. Emergency pressure relief stack with endurance burning-proof pressure and vacuum relief valve VD/SV-HRL (→ Sec. 7).
3. Protection of the gasometers with detonation flame arrester DR/SBW (→ Sec. 4) in the gas supply and end-of-line deflagration flame arrester EB (→ Sec. 2), which protects against endurance burning above the diaphragm.
4. Temperature-monitored deflagration flame arresters FA-I-T (→ Sec. 3) in the inlet line for vapor combustion, arranged without falling below the maximum allowable distance from the ignition source and installation location of the flame arrester (L/D ratio), and in parallel for the availability of maintenance or emergency switchover in case of an endurance burning on the arrester.

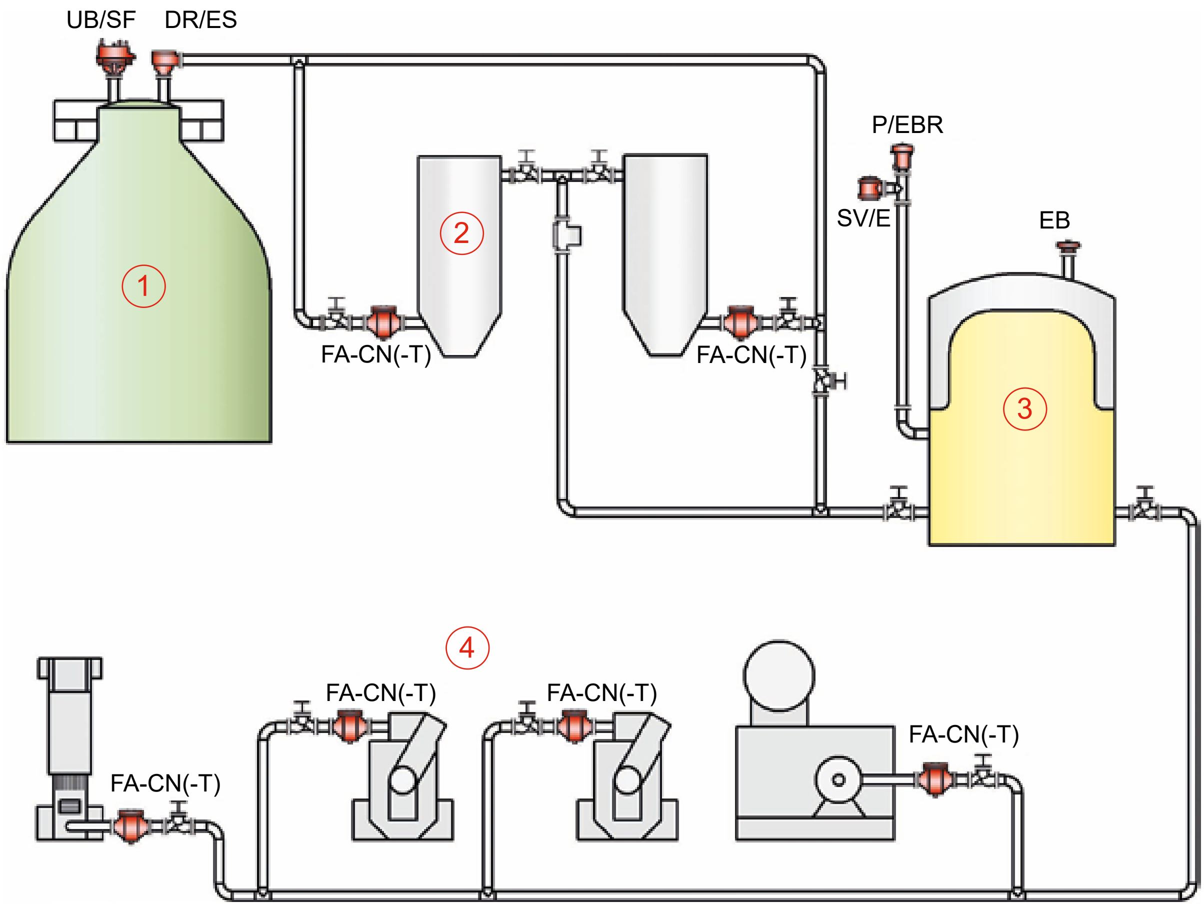
Vapor pipeline from plant to vapour combustion unit with deflagration flame arrester FA-I-T (→ Sec. 3) to protect the vent header collection line and the operating locations in the plant.





1. Tankers for flammable products/chemical tankers with detonation flame arresters BR/TS (→ Sec. 4) on the individual tank, endurance burning-proof high-velocity vent valves DE/S (→ Sec. 7), and explosion-proof vacuum flame arrester SV/E-S (→ Sec. 7).
2. Detonation-proof connection of the gas return line at the loading terminal for flammable liquids with a detonation flame arrester DA-SB (→ Sec. 4).
3. Detonation flame arresters DA-SB (→ Sec. 4) in the gas displacement/gas return line from the loading stations for tank wagons and tank trucks.

Not shown: Offshore platforms/drilling platforms with detonation flame arresters DA-SB (→ Sec. 4) and deflagration flame arresters FA-CN (→ Sec. 3), FPSOs (Floating Production Storage and Offloading) with IMO-approved detonation flame arresters DA-SB (→ Sec. 4) and pressure and vacuum relief valves VD/TS (→ Sec. 7), hydraulic control boxes with deflagration flame arresters BE-AD (→ Sec. 2).



1 Protection of the sewage tower and storage tank with a frost-proof pressure and vacuum relief valve UB/SF (→ Sec. 7) and with detonation flame arresters DR/ES (→ Sec. 4) in the gas collection line.

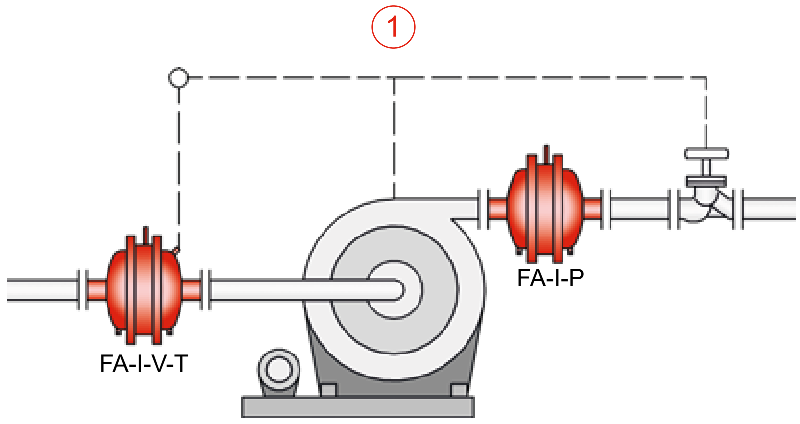
2 Protection of desulfurizers for increased temperature and pressure with suitable deflagration flame arresters FA-CN, FA-CN-T, or FA-E (→ Sec. 3).

3 Protection of the intermediate gasometer in the pressure and vacuum relief line with endurance burning-proof deflagration flame arrester, end-of-line EB (→ Sec. 2), emergency venting with deflagration and endurance burning-proof pressure relief valve P/EBR (→ Sec. 7) and deflagration-proof vacuum relief valve SV/E (→ Sec. 7).

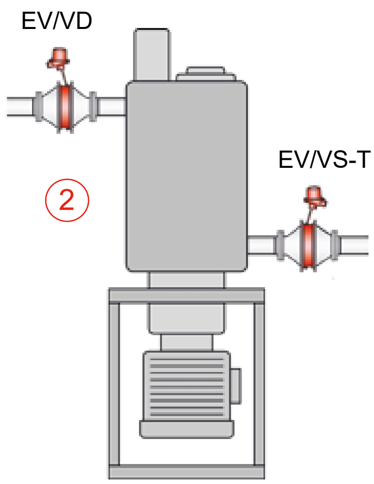
4 Ground flares, block-type thermal power stations, and diesel engine units are potential sources of ignition for biogas (methane) air mixture. Suitable flame arresters, that consider temperature and pressure, must be installed in the pipe toward the system. Either temperature monitored deflagration flame arresters FA-CN-T or FA-E-T (→ Sec. 3) or detonation flame arresters DA-SB or DR/ES (→ Sec. 4) must be used if there is a large distance to the potential ignition source.

Safe Systems in Practice

Flame Arresters as integrated Equipment Components (examples)



Blower



dry running vacuum pump

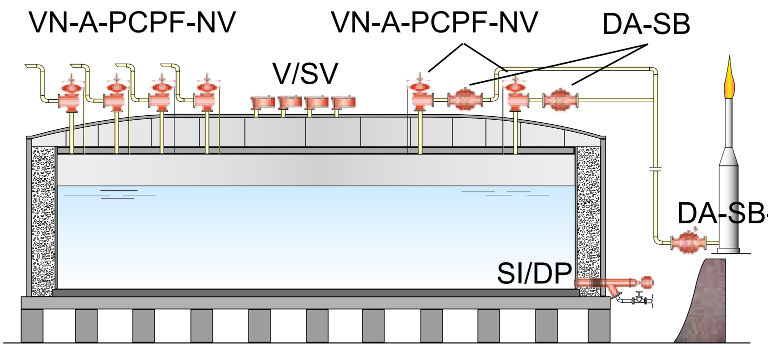
FLAMEFILTER®, or PROTEGO® flame arresters as OEM components, are product varieties that are integrated by equipment manufacturers in their brand-name products.

1 Protection of pressure-resistant radial blowers as type-examined zone-0 blowers with integrated PROTEGO® flame arresters FA-I-V-T and FA-I-P (→ Sec. 3).

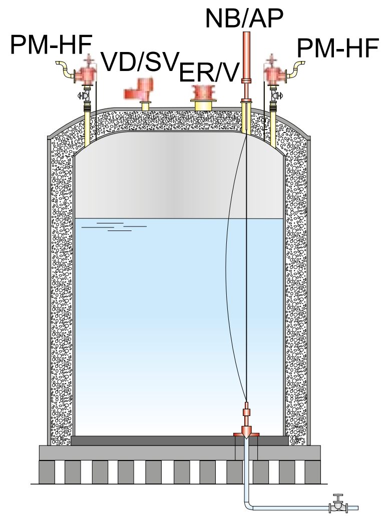
2 Protection of dry-running vacuum pumps with PROTEGO® flame arresters EV/VS-T and EV/VD (→ Sec. 3) at both the inlet and outlet which are tested and certified together with the vacuum pump. Other forms of protection with DR/ES and DR/ES-T (→ Sec. 4) are possible.

Not shown: FLAMEFILTER® used in gas analyzers to protect the explosive environment from explosions arising in the device from the ignition of the gases or vapors to be measured or analyzed. PROTEGO® flame arresters are installed in the pressure and vacuum relief openings of airplane fuel tanks to protect from external explosions.

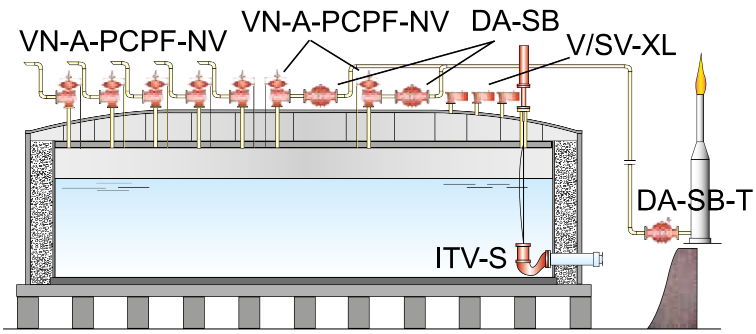
Cryogenic Tanks



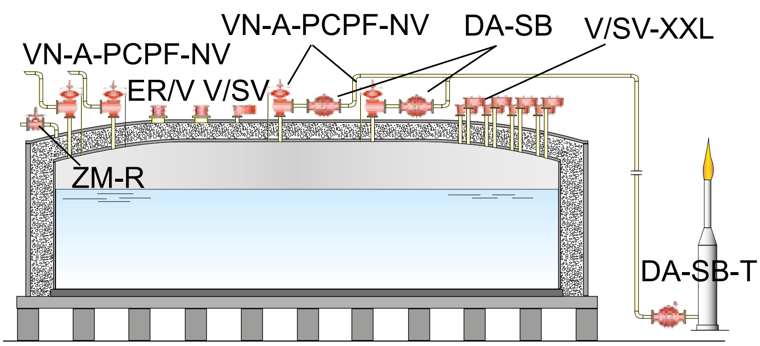
Ammonia Storage Tank



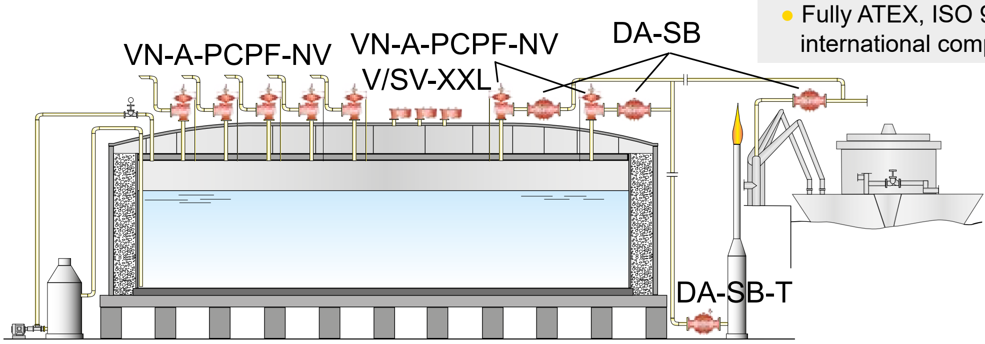
LIN-LOX-LAR Storage Tank



Ethylene Storage Tank



Propylene Storage Tank



LNG Storage Tank

- Pilot operated valves that solve instability problems, such as fluttering and chattering, during operation
- Cleaning for oxygen service available upon request
- Cryogenic functional test available upon request
- Low pressure and vacuum conservation vents
  - Full lift technology available (fully open with only 10% overpressure/pressure accumulation)
  - Weight-loaded or spring-loaded
- Extremely low leakage rates on breather valves (much lower than ISO 28300 and API 2000, 7th Ed.)
- Low pressure reducing valves

- Quick-release bottom outlet valve with pneumatic actuator, in-tank valves
- Internal safety valves with pneumatic and manual actuator

- ATEX approved Flame Arresters
  - End-of-line applications
    - Deflagration Flame Arresters
    - Endurance burning-proof Flame Arresters
  - In-line applications
    - Deflagration Flame Arresters
    - Detonation Flame Arresters

- Sold globally, serviced locally (PARC)
- Fully ATEX, ISO 9001, and ISO 14001 certified international company

Products

VN-A-PCPF-NV, V/SV, ITV-S (→)
NB/AP, SI/DP, PM-HF (→ Sec. 9)
V/SV-XL, V/SV-XXL (→ Sec. 9)
DA-SB, DA-SB-T (→ Sec. 4)
VD/SV, ER/V (→ Sec. 5)
ZM-R (→ Sec. 6)

PROTEGO
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Catalog

Flame Arresters

Deflagration flame arresters, deflagration-proof, short time burning-proof, endurance burning-proof

Vent caps without flame arresters

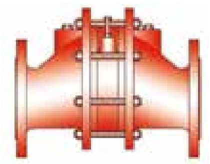
Explosion groups: IIA1, IIA, IIB1, IIB2, IIB3, IIB, IIC

Nominal sizes: 15 to 800 mm (½“ to 32“)

Materials: carbon steel, stainless steel, Hastelloy, ECTFE coated

Special designs according to customer specifications

Service and spare parts



Deflagration flame arresters, in-line deflagration flame arrester units on equipment

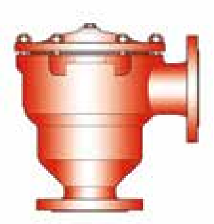
Explosion groups: IIA1, IIA, IIB1, IIB2, IIB3, IIB, IIC

Nominal sizes: 10 to 1000 mm (¼“ to 40“)

Materials: carbon steel, stainless steel, Hastelloy, ECTFE coated

Special designs according to customer specifications

Service and spare parts



Detonation flame arresters for stable and unstable detonations

Explosion groups: IIA1, IIA, IIB1, IIB2, IIB3, IIB, IIC

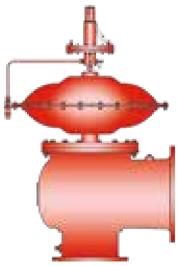
Nominal sizes: 15 to 800 mm (½“ to 32“)

Materials: carbon steel, stainless steel, Hastelloy, ECTFE coated

Special designs according to customer specifications

Service and spare parts

Equipment for Cryogenic Storage Tanks



Pressure and Vacuum Relief Valves – pilot-operated, Vacuum Relief Valves, Change-Over Valve, In-Tank Valves

Pressure settings: 10 to 1034 mbar (4 to 415.1 inch W.C.)

Nominal sizes: 40 (1 ½“) to 300 (12“)

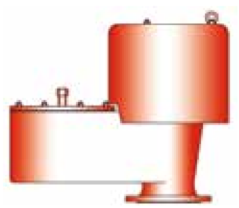
Materials: carbon steel, stainless steel, aluminum

Special designs according to customer specifications

Service and spare parts

Valves

Pressure and Vacuum Relief Valves, end-of-line ....Section 5



Pressure relief valves, vacuum relief valves, pressure and vacuum relief valves, pressure relief and vacuum valves

Pressure settings: 2 to 200 mbar (0.08 to 8 inch W.C.)

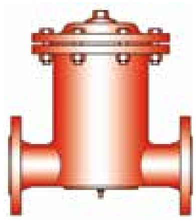
Nominal sizes: 50 to 700 mm (2“ to 28“)

Materials: carbon steel, stainless steel, Hastelloy, aluminum, PP, PE, PVDF, PTFE, ECTFE coated

Special designs according to customer specifications

Service and spare parts

Pressure and Vacuum Relief Valves, in-line..Section 6



Pressure or vacuum relief valves, pressure and vacuum relief valves, blanketing valves

Pressure settings: 2 to 500 mbar (0.08 to 20 inch W.C.)

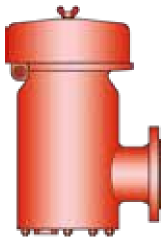
Nominal sizes: 25 to 300 mm (1“ to 12“)

Materials: carbon steel, stainless steel, Hastelloy, PP, PE, PVDF, ECTFE coated

Special designs according to customer specifications

Service and spare parts

Pressure and Vacuum Relief Valves with Flame Arresters, end-of-line..Section 7



Pressure relief valves, vacuum relief valves, pressure and vacuum relief valves, pressure-/vacuum relief diaphragm valves, pressure relief valves, high velocity valves

Deflagration-proof and endurance burning-proof or deflagration-proof only

Explosion groups: IIA1, IIA, IIB1, IIB2, IIB3, IIB, IIC

Pressure settings: 2 to 200 mbar (0.08 to 8 inch W.C.)

Nominal sizes: 50 to 300 mm (2“ to 12“)

Materials: carbon steel, stainless steel, Hastelloy, ECTFE coated

Special designs according to customer specifications

Service and spare parts

Tank Accessories and Special Equipment

Level-gauging and sampling equipment..**Section 8**

Floating suction unit, floating roof drainage system

Floating roof vacuum relief valves, skimming system

Air drying aggregates, sampling and draining valves

Service and spare parts

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Regulations and Laws

2014/34/EU Directive of the European Parliament and the Council of February 21, 2014 on the approximate of the laws of the Member States concerning equipment and Protective Systems intended for use in potentially explosive atmospheres (replaces 94/9/EC since April 20, 2016)

94/9/EC Directive of the European Parliament and the Council of March 23, 1994, on the approximate of the laws of the Member States concerning equipment and Protective Systems intended for use in potentially explosive atmospheres (replaced by 2014/34/EU)

1999/92/EC Directive of the Council on minimum requirements for improving the safety and health of workers potentially at risk from explosive atmospheres (individual directive according to article 16 of Directive 89/391/EEC)

1999/13/EC Directive on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations (replaced by Directive 2010/75/EU) 2010/75/EU Directive of the European Parliament and of the Council of 24. November 2010 on industrial emissions (integrated pollution prevention and control)

97/23/EC Pressure equipment directive of the European Parliament and the European Council (replaced by Directive 2014/68/EU)

2014/68/EU (PED) Pressure equipment directive of the EuropeanParliament and the European Council (replaces 97/23/EC since 17.7.2015 with transitional regulation until 18.7.2016)

2006/42/EC Directive on machinery of 17 May 2006

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EN ISO 28300: Petroleum, petrochemical and natural gas industries - Venting of atmospheric and low-pressure storage tanks, 2008

EN 14015 Specification for the Design and Manufacture of Site-Built, Above-Ground, Vertical, Cylindrical, and Welded Flat-Bottomed, Steel Tanks for the Storage of Liquids at Ambient Temperature and Above,
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EN ISO 16852 Flame Arresters - Performance requirements, test methods and limits for use, 2016

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EN 1127-1 Explosive Atmospheres. Explosion Prevention and Protection.
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EN 1012-2 Compressors and Vacuum Pumps. Part 2: Vacuum pumps, 2011

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EN 12255-10 Wastewater Treatment Plants - Part 10: Safety and Construction Principles, 2001

EN 13463-1 Non-Electrical Equipment Intended for Use in Potentially Explosive Atmospheres - Part 1: Basic Methods and Requirements, 2009 (replaced by EN ISO 80079-36)

EN 13463-5 Non-electrical equipment intended for use in potentially explosive atmospheres - Part 5: Protection by constructional safety ‘c’, 2012 (replaced by EN ISO 80079-37)

EN ISO/IEC 80079-34 Explosive atmospheres - Part 34: Application of quality systems for equipment manufacture, 2012

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EN ISO 80079-37:2016 Explosive atmospheres - Part 37: Non-electrical type of protection constructional safety „c“, control of ignition sources „b“, liquid immersion „k“ (ISO 80079-37: 2016) (Endorsed by AENOR in September of 2016)

EN IEC 60079-0 Explosive atmospheres - Part 0: Equipment - General requirements, 2018

EN IEC 60079-10-1 Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres, 2021

33 CFR Part 154 Facilities Transferring Oil or Hazardous Material in Bulk (USCG-Rule)

API STD 2000 7th Ed. Venting Atmospheric and Low-Pressure Storage Tanks, 2014

API Publ. 2210 3rd Ed. Flame Arresters for Vents of Tanks Storing Petroleum Products, 2000 (2015)

API Publ. 2028 3rd Ed. Flame Arresters in Piping, 2002 (2015)

UL 525 Ed. 8, Flame Arresters, 2023

ASTM F1273-21 Standard Specification for Tank Vent Flame Arresters, 2021
NFPA 30 Flammable and Combustible Liquids Code, 2021
NFPA 36 Standard for Solvent Extraction Plants, 2021
NFPA 59A Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG), 2023

NFPA 67 Guide on Explosion Protection for Gaseous Mixtures in Pipe Systems, 2019

NFPA 68 Standard on Explosion Protection by Deflagration Venting, 2023

NFPA 69 Standard on Explosion Prevention Systems, 2019

NFPA 497 Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas, 2021

HSG176 The Storage of Flammable Liquids in Tanks, 2015
EN 60079-20-1 Explosive atmospheres - Part 20-1: Material characteristics for gas and vapour classification - Test methods and data (IEC 60079-20-1), 2010

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TRGS 723 Gefährliche explosionsfähige Gemische – Vermeidung der Entzündung gefährlicher explosionsfähiger Gemische, 2020

TRBS 3151/TRGS 751 Vermeidung von Brand-, Explosions- und Druckgefährdungen an Tankstellen und Füllanlagen zur Befüllung von Landfahrzeugen, 2022

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Term	Description	Source
accumulation	pressure increase over the MAWP of the vessel allowed during discharge through the pressure-relief device	ISO 28300
adjusted set pressure	inlet static pressure at which a pressure-relief valve is adjusted to open on the test stand	ISO 28300-3.2
ambient air	normal atmosphere surrounding the equipment and protection system	EN 13237 - 3.1
ambient temperature	temperature of the air or other medium where the equipment is to be used (IEV 826-01-04) (IEC 60204-32:1998) Note: For the application of the Directive 94/9/EC, only air is considered	EN 13237 - 3.2
atmospheric conditions	atmospheric conditions are pressures from 80 kPa till 110 kPa and temperatures from -20°C up to +60°C	ISO 16852 - 3.25
atmospheric discharge	release of vapors from pressure-relieving and depressuring devices to the atmosphere	ISO 23251 – 3.4
back pressure	pressure that exists at the outlet of a safety valve as a result of pressure in the discharge system	ISO 4126-3.11
bi-directional flame arrester	a flame arrester which prevents flame transmission from both sides	ISO 16852 - 3.13
blow down	difference between set pressure and reseating pressures; normally stated as a percentage of set pressure except for pressures of less then 3 bar when the blowdown is expressed in bar	ISO 4126 – 3.15
check valve	valve that prevents backflow against flow direction	-
coating	protective painting with defined layer-thickness	-
coefficient of discharge	value of actual flowing capacity divided by theoretical flowing capacity (from calculation)	ISO 4126-3.20
component	a component that is required for the safe operation of equipment and protective systems without performing an autonomous function itself	EN 13237-A.7
condensate drain screw	screw to drain the condensate	-
conventional pressure-relief valve	spring-loaded pressure-relief valve whose operational characteristics are directly affected by changes in the back pressure	ISO 23251 - 3.20
deflagration	explosion propagating at subsonic velocity (EN 1127-1:1997)	EN 13237 - 3.6
deflagration flame arrester	flame arrester designed to prevent the transmission of a deflagration. It can be an end-of-line flame arrester or an in-line flame arrester	ISO 16852 - 3.14
design pressure (tank)	max. permissible over-pressure of a tank in the space above the stored liquid	DIN EN 14015
design pressure / design temperature (general design)	pressure, together with the design temperature, used to determine the minimum permissible thickness or physical characteristic of each vessel component, as determined by the vessel design rules	ISO 23251 - 3.23
design vacuum (negative gauge pressure)	max. permissible vacuum (negative gauge pressure) in the space above the stored liquid	-
detonation	explosion propagating at supersonic velocity and characterized by a shock wave (EN 1127-1: 1997)	EN 13237 - 3.8
detonation flame arrester	flame arrester designed to prevent the transmission of a detonation. It can be an end-of-line flame arrester or an in-line flame arrester	ISO 16852 3.15

Term	Description	Source
diaphragm valve	valve where the moving valve part consists of a diaphragm	-
emergency venting	venting required when an abnormal condition, such as ruptured internal heating coils or an external fire, exists either inside or outside a tank	ISO 28300 - 3.4
emergency venting valves	pressure relief valves for emergency venting	-
empty lift safety device	safety device which prevents the emptying of a liquid detonation safety device up to a maximum suction power	-
end-of-line flame arrester	flame arrester that is fitted with one pipe connection only	ISO 16852 - 3.21
endurance burning	stabilized burning for an unlimited time	ISO 16852 - 3.6
endurance burning flame arrester	flame arrester that prevents flame transmission during and after endurance burning	ISO 16852 - 3.16
equipment	machines, appliances, fixed or mobile devices, control parts and accessories, and warning and prevention systems, whether separate or combined, intended for the generation, transfer, storage, measurement, control, and conversion of energy, and for the processing of materials, which have their own potential source of ignition and may cause an explosion	EN 13237 - 3.13
equipment category	within an equipment group, a category is the classification according to the required level of protection	EN 13237 – 3.26
explosion	abrupt oxidation or decomposition reaction producing an increase in temperature, pressure, or in both simultaneously	ISO 16852 - 3.7
explosion limits	limits of explosion range	EN 13237 - 3.19
explosive atmosphere	a mixture of air and flammable substance in the form of gases, vapors, mists or dusts under atmospheric conditions in which, after ignition, spreads to the entire unburned mixture	EN 13237 - 3.28
explosion pressure resistant	characteristic of vessels and equipment designed to withstand the expected explosion pressure without permanent deformation	EN 13237 - 3.23.1
explosion shock proof	characteristic of vessels and equipment designed to withstand the expected explosion pressure without bursting, but which may sustain permanent deformation	EN 13237 - 3.23.2
flame arrester	device fitted to the opening of an enclosure, or to the connecting pipe work of a system of enclosures, and whose intended function is to allow flow but prevent the transmission flame	ISO 16852 - 3.1
flame arrester housing	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	ISO 16852 - 3.2
flame arrester unit	flame arrester casing with FLAMEFILTER® set	-
flame transmission-proof	characteristic of a device to avoid flashback	-
FLAMEFILTER®	internationally registered trademark of Braunschweiger Flammenfilter GmbH for flame arrester element made of crimped ribbon	-
FLAMEFILTER® casing	enclosure for FLAMEFILTER® including insert rings	-
FLAMEFILTER® gap width	the triangular height of a FLAMEFILTER®	-

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Glossary

Term	Description	Source
FLAMEFILTER® set	combination of FLAMEFILTER® with spacers	-
flammable gas or vapor	gas or vapor which, when mixed with air in certain proportions, will form an explosive gas atmosphere (EN 60079-10:1996)	EN 13237 - 3.36.1
flammable liquid	liquid capable of producing a flammable vapor under any foreseeable operating condition (EN 60079-10:1996)	EN 13237-3.36.2
flammable material	material which is flammable of itself, or is capable of producing a flammable gas, vapor or mist (EN 60079-10-3.20)	EN 13237 - 3.37
flammable substances	substance in the form of gas, vapor, liquid, solid, or mixtures of these, able to undergo an exothermic reaction with air when ignited (EN 1127-1:1997)	EN 13237 - 3.37
flashback	phenomenon occurring in a flammable mixture of air and gas when the local velocity of the combustible mixture becomes less than the flame velocity, causing the flame to travel back to the point of mixture	ISO 23251 - 3.34
flashpoint	lowest temperature at which, under certain standardized conditions, vapors develop from the liquid in such quantity that they are capable of forming a flammable vapor/air mixture	EN 13237 - 3.38
floating cover	structure which floats on the surface of a liquid inside a fixed roof tank, primarily to reduce vapor loss	EN 14015 - 3.1.22
floating exhaust system	movable pipeline, with or without float gauge, within a storage tank for filling and emptying	-
floating roof	metallic structure which floats on the surface of a liquid inside an open top tank shell, and in complete contact with this surface	EN 14015 - 3.1.21
floating suction devices	mechanical device, sometimes articulated, installed in some tanks, which floats on the liquid surface and only permits product to be withdrawn from this point; commonly adopted for aviation fuel storage tanks	EN 14015 - 3.1.28
foot valve flame arrester	flame arrester designed to use the liquid product combined with a non-return valve to form a barrier to flame transmission	ISO 16852 - 3.19.2
free vents	open vents	EN 14015 - 3.1.40
gauging and sampling device	equipment for stating the liquid level within storage tanks as well as for sampling from any height within the stored substance	-
gauging nozzle	opening at a storage tank for gauging or sampling	-
gauging pipe	pipe within the storage tank for determining the liquid level and for sampling - in flashback-proof or regular design	-
gauging probe	device for determining the liquid levels in storage tanks	-
guide pipe	pipe for guiding the guide spindle of a valve pallet	-
guide rod	component (rod) for guiding the valve pallet	-
guide sleeve	component for guiding, e.g., the guide spindle of a valve pallet	-
guide spindle	orthogonal to valve pallet section, centrically arranged pipe for guiding the valve pallet	-
hazardous area	atmosphere which may become explosive due to local and operational conditions	EN 13237 - 3.28.2
hazardous explosive atmosphere	explosive atmosphere which, in the event of an explosion, causes damage	EN 13237 – 3.28.1

Term	Description	Source
heat release	total heat liberated by combustion of the relief gases based on the lower heating value	ISO 23251 - 3.36
heating jacket	enclosed space for heating a device which encloses all or part of the device	-
high velocity vent valve (dynamic flame arrester)	pressure relief valve designed to have nominal flow velocities that exceed the flame velocity of the explosive mixture, resulting in prevention of flame transmission	ISO 16852 - 3.18
housing	enclosure of a product or component	-
hydraulic flame arrester	flame arrester designed to break the flow of an explosive mixture into discrete bubbles in a water column, thus preventing flame transmission	ISO 16852 - 3.20
ignition source	any source with enough energy to initiate combustion	-
ignition temperature (of a combustible gas or of a combustible liquid)	the lowest temperature (a hot surface) at which, under specified test conditions, ignition of a combustible gas or vapor occurs in a mixture with air or air/inert gas	EN 13237 - 3.45
inert gas	non-flammable gas which will not support combustion and does not react to produce a flammable gas	EN 13237 - 3.46
inerting	replacing atmospheric oxygen in a plant with a non-reactive, non-flammable gas to prevent flame propagation in the atmosphere of a plant	EN 13237 - 3.47
in-line flame arrester	flame arrester that is fitted with two pipe connections, one on each side of the flame arrester	ISO 16852 - 3.22
in-tank valve	emergency valve in the tank bottom which closes immediately in case of downstream piping rupture	-
integrated temperature sensor	temperature sensor integrated into the flame arrester, as specified by the manufacturer of the flame arrester, in order to provide a signal suitable to activate counter measures	ISO 16852 - 3.24
leak rate	measure of the amount of substance (liter per second) flowing through a leak in the fitting	-
left-wound	orientation (angle) of gaps of crimped ribbon element	-
lift	actual travel of the valve disc away from the closed position	ISO 4126 - 3.16
limiting oxygen concentration (LOC)	maximum oxygen concentration in a mixture of a flammable substance with air and inert gas in which an explosion does not occur, determined under specified test conditions	EN 13237 - 3.49
lining	protective plastic lining with a defined minimum/maximum thickness to protect against aggressive mixtures (e.g., acid)	-
liquid seal flame arrester	flame arrester designed to use the liquid product to form a barrier to flame transmission	ISO 16852 - 3.19.1
liquid seal (water seal)	device that directs the flow of relief gases through a liquid (normally water) on the path to the flare burner, used to protect the flare header from air infiltration or flashback, to divert flow, or to create back pressure for the flare header	ISO 23251-3.43
lower explosion limit (LEL)	the lowest limit in the explosion range at which an explosion can occur	EN 132237 – 3.19.2

Term	Description	Source
maintenance	combination of all technical and administrative actions, including supervision actions, intended to maintain or restore a unit in working order	EN 13237 - 3.78
malfunction	devices, protective system, and components do not fulfill their intended function	EN 13237 - 3.50
manifold	piping system for the collection and/or distribution of a fluid to or from multiple flow paths	ISO 23251 - 3.45
maximum allowable explosion pressure	maximum explosion pressure measured during the explosion pressure test when the proportion of combustible substances in the mixture is varied	EN 13237 - 3.21.1
maximum allowable pressure (pressure equipment)	maximum pressure for which the equipment is designed as specified by the manufacturer	97/23/EC (PED)
maximum allowable temperature (pressure equipment)	maximum temperature for which the equipment is designed as specified by the manufacturer	97/23/EC (PED)
maximum allowable working pressure (MAWP)	maximum gauge pressure permissible at the top of a completed vessel in its normal operating position at the designated coincident temperature specified for that pressure	ISO 23251 - 3.47
maximum experimental safe gap (MESG)	the maximum gap width between the two parts of the interior chamber of the test equipment 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 vapor in air. The MESG is a property of the respective gas mixture (EN 1127-1: 1997) Note: IEC 60079-1 A standardizes the test equipment and the test method	-
maximum operating temperature	maximum temperature reached when a piece of equipment or protective system is operating under its intended operating conditions	-
measurable type (static flame arrester)	flame arrester where the quenching gaps of the flame arrester element can be technically drawn, measured and controlled	ISO 16852 - 3.17.1
melting element	component which melts at a defined temperature and triggers an action (opening of hood, closing of valve)	-
most inflammable explosive atmosphere	explosive atmosphere with a concentration of flammable substances which, under specified conditions, requires the smallest amount of energy to ignite	-
nominal size	(DN) alphanumeric designation of size that is common for components used in a piping system, used for reference purposes, compromising the letters DN followed by a dimensionless number having an indirect correspondence to the physical size of the bore or outside diameter of the component end connection	ISO 4126-1.3.22
non-measurable type (static flame arrester)	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 materials and gravel beds)	ISO 16852 - 3.17.2
normal pressure venting	outbreathing under normal operating conditions (pumping product into the tank and thermal outbreathing)	EN 14015 - 3.1.35
normal vacuum venting	inbreathing under normal operating conditions (pumping product out of the tank and thermal in-breathing)	EN 14015 - 3.1.36

Term	Description	Source
normal venting	venting required because of operational requirements or atmospheric changes	ISO 28300 – 3.7
opening pressure	the vacuum or gauge pressure at which the valve reaches the distance required for mass flow to be released; it is equal to the set pressure plus overpressure	DIN 3320 - 54
operating pressure	pressure existing at normal operating conditions within the system being protected	ISO 4126-2:2003(E) - 3.16
operating temperature	temperature reached when the equipment is operating under design conditions	-
overpressure	pressure increase over the set pressure. Overpressure is usually expressed as a percentage of the set pressure	ISO 4126 - 3.7
pallet type valve (disc valve)	valve with disc-shaped seal and axial guide	-
pilot-operated pressure relief valve	pressure relief valve in which the major relieving device or main valve is combined with and controlled by a self-actuated auxiliary pressure-relief valve (pilot)	ISO 23251 - 3.52
pilot-operated valve	valve controlled by a control device (pilot)	-
pipe away valve	pressure or vacuum valve to which a vent pipe may be connected	EN 14015 - 3.1.44
pressure (gauge pressure)	Pressure for which the value is equal to the algebraic difference between the absolute pressure and the atmospheric pressure	ISO 21013-2:2007
pressure-relief valve	valve designed to open and relieve excess pressure and to reclose and prevent the further flow of fluid after normal conditions have been restored	ISO 23251 - 3.56
pressure/vacuum valve (PV valve)	weight-loaded, pilot-operated, or spring-loaded valve used to relieve excess pressure and/or vacuum that has developed in a tank	EN 14015 - 3.1.41
pre-volume flame arrester	flame arrester that, after ignition by an internal ignition source, prevents flame transmission from inside an explosion-pressure-resistant containment (e.g. a vessel or closed pipe work) to the outside, or into the connecting pipe work	ISO 16852 - 3.23
product	includes equipment, protective systems, devices, components and combinations of these	-
protective screen	component which allows free flow but prevents the passage of foreign matter, e.g., animals	-
protective system	all devices, with the exception of components (see A.6) of the equipment, intended to immediately stop explosions and/or to limit the area affected by an explosion and separately placed on the market as autonomous systems	EN 13237 – A.5
quenching	cooling of a fluid by mixing it with another fluid of a lower temperature	ISO 23251 - 3.59
relieving pressure	pressure at the inlet of a relief device when the fluid is flowing at the required relieving capacity	ISO 28300 - 3.15
reseating pressure	value of the inlet static pressure at which the disc re-establishes contact with the seat or at which the lift becomes zero	ISO 4126 - 3.8
right-wound	orientation (angle) of gaps of crimped ribbon element	-

Glossary

Term	Description	Source
ring-shaped flame arresting unit	flame arrester consisting of ring-shaped crimped ribbons	-
safety shut-off valve	a safety shut-off valve is a valve which closes automatically to prevent a predetermined gauge pressure from being exceeded	DIN 3320-2
safety valve	valve which automatically, without the assistance of any energy other than that of the fluid concerned, discharges a quantity of the fluid so as to prevent a predetermined safe pressure being exceeded, and which is designed to re-close and prevent further flow of fluid after normal pressure conditions of service have been restored	ISO 4126 - 3.1
sampling and air bleed valve	flashback-proof and non-flashback-proof taps or valves for out-breathing and in-breathing plant components	-
set pressure	gauge pressure at the device inlet at which the relief device is set to start opening under service conditions	ISO 28300 - 3.19
set vacuum	internal negative gauge pressure at which a vacuum valve first opens	EN 14015 – 3.1.4
shock absorber	component to reduce the kinetic energy of a detonation	-
Shock-Wave-Guide-Tube (SWGT)	component for decoupling of shock wave and flame front: PROTEGO® patent	-
short time burning	stabilized burning for a specific time	ISO 16852 - 3.5
spacer	component that is installed on and between the crimped ribbon elements of a flame arrester	-
sparge pipe	inlet pipe into the stored substances of a hydraulic flame arrester	-
stabilized burning	steady burning of a flame stabilized at, or close to the flame arrester element	ISO 16852 - 3.4
stable detonation	a detonation is stable when it progresses through a confined system without significant variation of velocity and pressure characteristics	ISO 16852 - 3.10
static electricity	build-up of an electrical difference of potential or charge, through friction of dissimilar materials or substances e.g. product flow through a pipe	EN 14015 - 3.1.18
static flame arrester	flame arrester designed to prevent flame transmission by quenching gaps	ISO 16852 - 3.17
stoichiometric air	chemically correct ratio of fuel to air capable of perfect combustion with no infused fuel or air	ISO 23251 - 3.73
storage tank/vessel	fixed tank or vessel that is not part of the processing unit in petrochemical facilities, refineries, gas plants, oil and gas production facilities, and other facilities	ISO 23251 - 3.74
swivel joint	part of a swing pipe system	-
temperature class	classification of equipment, protective systems, or components for explosive atmospheres based on their maximum surface temperature, or to classify flammable gases and vapors according to their ignition temperature	EN 13237 - 3.63
temperature sensor	temperature sensor for monitoring the temperature	-
test pressure	pressure to test the static strength and/or tightness of a device	-
theoretical discharge capacity	calculated capacity expressed in mass or volumetric units of a theoretically perfect nozzle having a cross-sectional flow area equal to the flow area of a safety valve	ISO 4126-1:3.19

Term	Description	Source
thermal inbreathing	movement of air or blanketing gas into a tank, when vapours in the tank contract or condense as a result of weather changes (e.g. decrease in atmospheric temperature)	ISO 28300 - 3.20
thermal outbreathing	movement of air or blanketing gas out of a tank, when vapors in the tank expand and liquid in the tank vapourizes as a result of weather changes (e.g. increase in atmospheric temperature)	ISO 28300 - 3.21
unstable detonation	detonation 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	ISO 16852 - 3.11
upper explosion limit (UEL)	highest concentration limit in the explosion range with which an explosion can occur	EN 13237-3.19.2
valve disc guide	valve element for guiding a valve pallet	-
valve lift	actual travel of the valve pallet away from the closed position when a valve is relieving	-
valve pallet gasket	sealing element between valve pallet and valve seat	-
vent cap	end-of-line device for free out-breathing and in-breathing of plant components. This device can be flame transmission-proof	-
vent header	piping system that collects and delivers the relief gases to the vent stack	ISO 23251 - 3.78
vent pipes	pipes for valves with pipeline connection	EN 14015 - 3.1.45
venting system	system which consists of pipeline and devices for free out-breathing and in-breathing of plant components	-
venting system with flame arresting capability	vent and vent hood or pressure/vacuum valves combined with a flame arrester or with integrated flame arresting elements	DIN EN 14015 - 3.1.42
vessel	container or structural envelope in which materials are processed, treated or stored	ISO 23251 - 3.80
zone 0	a place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapor or mist is present continuously or for long periods or frequently	1999/92/EC – appx. 1
zone 1	a place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapor or mist is likely to occur in normal operation occasionally	1999/92/EC – appx. 1
zone 2	a place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapor or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only	1999/92/EC – appx. 1
zones for gases/vapors	hazardous areas are classified into zones based on the frequency and duration of the occurrence of an explosive gas atmosphere; the definitions are only applicable to equipment group II	1999/92/EC – appx. 1

Materials, Terms, and Conversion Tables

Pressure

1 bar	= 14.504 psi	1 lb/ft^2	=	47,88 N/m^2
	= 29.530 inch Hg		=	0,4788 mbar
	= 0.987 atm		=	4,882 mm WC
	= 401.46 inch W.C.			
1 mbar	= 0.0145 psi	1 inch W.C.	=	249,09 N/m^2
	= 0.0295 inch Hg		=	2,4909 mbar
	= 0.4015 inch W.C.		=	25,4 mm WC
	= 2.089 lb/ft^2	1 inch Hg	=	33,864 mbar
1 kPa	= 10 mbar	1 psi	=	68,94757 mbar
1 inch H_2O	= 2,49089 mbar	1 inch Hg	=	33,8639 mbar
1 Pa	= 1 N/m^2	1 psi	=	1 lb/in^2

Temperature

To convert ºC in ºF use	T_F	=	$32 + 1,8\ T_C$
	0ºC	=	32ºF
	100ºC	=	212ºF
To convert ºF in ºC use	T_C	=	$^5/_9\ (T_F - 32)$
	0ºF	=	-17,8ºC
	100ºF	=	37,8ºC

Material

DIN Material Number	DIN-Material	ASTM-Material	
0.6020	GG 20	A 278-30	C.I.
0.7040	GGG 40	A 536-77	C.I.
1.0619	GS-C 25	A 216 Gr. WCB	C.S.
1.4301	X5 CrNi 18 10	A 240 Gr. 304	S.S.
1.4408	G-X6 CrNiMo 18 10	A 351 Gr. CF 8 M	S.S.
1.0425	P 265 GH	A 515 Gr. 60	C.S.
1.4541	X6 CrNiTi 18 10	A 240 Gr. 321	S.S.
1.4571	X10 CrNiMoTi 18 10	A 240 Gr. 316 Ti	S.S.
3.2581	AC 44200	A 413	Alu
Ta	Tantal	UNS R05200	
2.4610	NiMo 16 Cr 16 Ti	UNS N06455	C-4
2.4686	G-NiMo 17 Cr	UNS N30107	Casting
2.4602	NiCr 21 Mo 14 W	UNS N06022	C-22
2.4819	NiMo 16 Cr 15 W	UNS N10276	C-276

The applicable materials are specified in the quotation or the order acknowledgement:
In general the following means
CS (Carbon steel) = 1.0619 or 1.0425
SS (Stainless steel) = 1.4408 or 1.4571
Hastelloy = 2.4686 or 2.4602

Important differences: US decimals in accordance with SI-System

e.g.	1 m	= 100 cm	= 100,00 cm	(UK/US: 100.00 cm)
	1 km	= 1.000 m	= 1.000,00 m	(UK/US: 1,000.00 m)

Sealings and Coatings

PTFE	=	polytetrafluoroethylene
PVDF	=	polyvinylidenfluoride
PFA	=	perfluoralkoxy polymer
FPM 70	=	fluoropolimer elastomer
WS 3822	=	aramide and anorganic fibers as well as mineral reinforcement materials bonded with NBR rubber
ECTFE	=	ethylene chlorotrifluorethylene
FEP	=	perfluoroethylene propylene

DN	10	15	20	25	32	40	50	65	80	100
Size	1/4	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4

DN	125	150	200	250	300	350	400	450	500	600
Size	5	6	8	10	12	14	16	18	20	24

DN	700	800	900	1000	1200	1400	1600	1800	2000
Size	28	32	36	40	48	56	64	72	80

Length

1 cm	= 0.3937	inch	1 inch		=	25,4 mm
1 m	= 3.2808	ft	1 ft	= 12 inch	=	0,3048 m
	= 1.0936	yards	1 yard	= 3 ft	=	0,9144 m
1 km	= 0.621	miles	1 mile		=	1,609 km

Area

1cm^2	= 0.1550	sq inch	1 sq inch	=	6,4516 cm^2
1 m^2	= 10.7639	sq ft	1 sq ft	=	0,0929 m^2
	= 1.196	sq yards	1 sq yard	=	0,836 m^2
1km^2	= 100	hectares			
	= 0.3861	sq miles			
	= 247	acres			

Volume

1 cm^3	= 0.06102	cu inch	1 cu inch	=	16,3870 cm^3
1 liter	= 0.03531	cu ft	1 cu ft	=	28,317 liter
	= 0.21997	gal (UK)	1 gal (UK)	=	4,5461 liter
	= 0.26417	gal (US)	1 gal (US)	=	3,785 liter
1 m^3	= 35.315	cu ft	1 cu ft	=	0,028317 m^3
	= 6.290	petr. barrels	1 petr. barrel	=	0,15899 m^3

Mass

1 g	= 0.03527 oz	1 oz	=	28,35 g
1 kg	= 2.2046 lb	1 lb	=	16 oz
			=	0,4536 kg

Velocity and Volume Flow

1 m/s	= 196.85	ft/min	1 ft/min	=	0,508 cm/s
1 km/h	= 0.6214	mph	1 mph	=	1,60934 km/h
1 m^3/h	= 4.403	gal/min (US)	1 gal/min (US)	=	0,227 m^3/h
	= 3.666	gal/min (UK)	1 gal/min (UK)	=	0,273 m^3/h
	= 0.5886	cu ft/min	1 cu ft/min	=	28,317 liter/min
1 kg/h	= 0.0367	lb/min	1 lb/min	=	27,216 kg/h
			1 cu ft/h	=	0,028317 m^3/h

Torsion

1 Nm	= 0.738 lb ft	1 lb ft	= 1,36 Nm

Density

1 kg/dm^3	= 62.43 lb/cu ft	1 lb/cu ft	= 0,016 kg/dm^3

Project Data Sheet

Quotation-No.	**Order-No.**
Project-No.	**Project Reference**
Valve / Flame Arrester Tag No.	**Tank / Vessel No.**

Storage Tank / Vessel

□ aboveground		diameter	m/ft	design pressure	mbar/inch W.C.
□ underground		height	m/ft	design vacuum	mbar/inch W.C.
□ insulated		wall height	m/ft	pumping-in-rate	m³/h cu ft/min
ins. thickness	mm / inch	blanketing level	m/ft	pumping-out-rate	m³/h cu ft/min
□ inert gas		inert gas	blanketing level	tank design standard	

Stored Product   Offgas/Vapor-Composition

Components Name	Formula	Vol.%	Flashpoint °C/°F	CAS	MESG mm/inch	Ex.-Group

Processing Plant

design temperature	°C/°F	design pressure	bar/psi		
operating temperature	°C/°F	operating pressure	bar/psi	back pressure	mbar/inch W.C.

Installation

□ in-line	□ horizontal	distance to source of ignition	m/ft
□ end-of-line	□ vertical		

Function

□ pressure	□ endurance burning proof	□ temperature monitored on side
□ vacuum	□ short-time burning proof	□ temperature monitored both side
□ pressure/vacuum combined	□ deflagration proof	□ pressure monitored
	□ detonation proof	□ bidirectional flame arrester

Valve and Flame Arrester Data

size nominal DN		flow $\dot{V}$	m³/h cu ft/min	density	kg/m³ lb/cu ft
pressure nominal PN		inlet flange	DN	PN	form
set pressure	mbar/inch W.C.	outlet flange	DN	PN	form
set vacuum	mbar/inch W.C.	pressure drop Δp	mbar/inch W.C.		

Material

pressure carrying parts	internals	lining

Inspection/Documentation

material certificate	works certificate	performance certificate

Piping Flow Diagram (excerpt) / Additional Remarks / Miscellaneous → refer to separate sheet

Fill in and □ check, if applicable

signed: date: approved: released:

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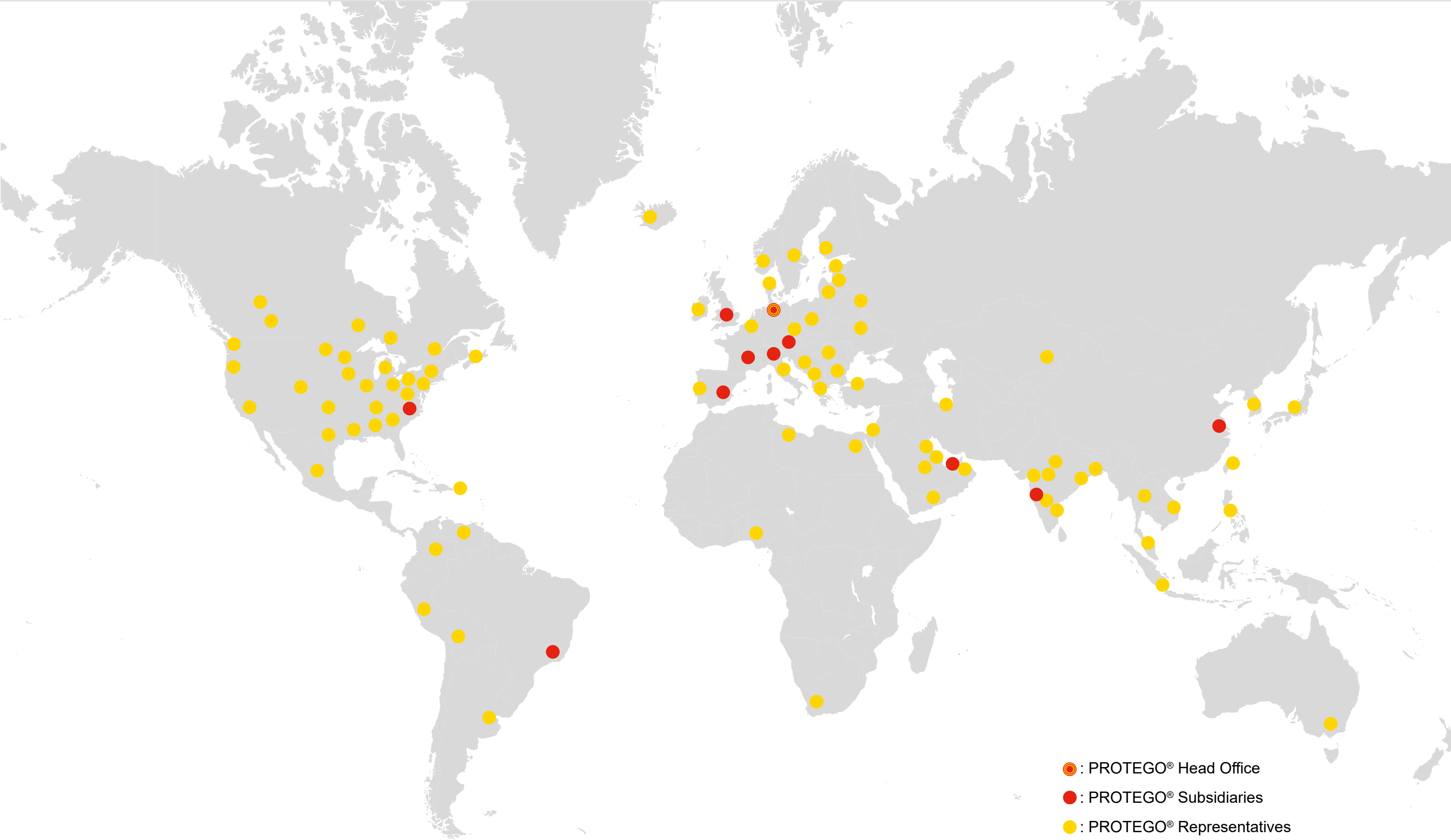

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