PROTEGO® Technology

Volume 1

- **Flame Arresters**
- **Valves**
- **Tank Accessories**

PROTEGO

for safety and environment

How to use this catalogue

The PROTEGO® catalogue has a modular structure.

In Volume 1 the company is introduced and with the "Technical Fundamentals" and the "Safe Systems in Practice" a basic explanation of operation and use of PROTEGO® devices is provided.

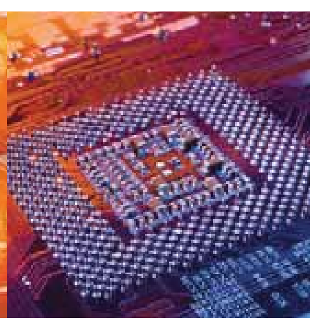
In the following Volumes 2 through 9 the devices are described in detail.










Typical Applications

- Storage Tanks and Loading Facilities
- Vapour-return at Petrol Stations
- Combustion Systems
- Chemical and Pharmaceutical Processing Systems
- Landfill and Biogas Systems
- Wastewater Treatment Systems

Exotic Applications

- Nitrous Oxide Supply in Clinical Applications
- Explosionproof 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
- Vitamine Production
- Production of Tooth Paste and Mouthwash

Contents

PROTEGO
for safety and environment

Corporate Video

Our Vision & Mission

Thinking sustainably - taken by 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 fields of activities are explosion protection as well as environmental conservation through retaining and relieving pressure in the exploration, processing and storage of flammable liquids and gases.

PROTEGO® World Team

Provicing first-class performance

- Dedicated to solutions
- High-quality standard
- Consultative
- Environmentally compatible

PROTEGO® is a world market leader operating with a large global network of subsidiaries and representations. The PROTEGO® Team includes 12 distribution and after-sales service companies as well as 120 representations in 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. The PARCs, being certified service partners, meet the requirements of the PROTEGO® Works Standard in the fields of human resources, organization, workshop equipment, 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 varied and subtly differentiated application issues. They have been trained to consider engineering tasks from a process safety perspective.

Maintenance: We can place at your disposal our field staff for installation and maintenance which have been adequately trained and prepared for their tasks at the manufacturer's; alternatively, you may just resort to our authorized workshops.

In the Company's worldwide largest Research & Development Center

We develop - highly comitted and successfully

In developing our products we closely cooperate with users, technical institutes and notified bodies. To this end, the PROTEGO® Research & Development Center - worldwide the largest of its kind - does not only serve to improve and upgrade our products; it is also available for general research projects and tailor-made dedicated development work. The potential offered 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 satisfying themselves periodically of the high standard seek our support too.

Development

Flame arresters protect systems subject to explosion hazards from the effects of explosions. Ever since methane gas explosions were successfully suppressed in the mining industry in the mid-19th century by the development of the mine shaft lamp with a Davy screen, 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 of explosive vapours arose, consisting of hydrocarbons and air that form around the tanks and loading equipment, which can ignite. Given the need for safe handling in dangerous atmospheres, the large 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 not reproducible flame arresting capability and the 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 at minimum pressure 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. To this the requirements of environmental protection were added. Vapours from processes needed to be disposed in an environmentally friendly manner and supplied to combustion systems according to clean-air 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 always correspond to the state-of-the-art as a result of continuous research and development.

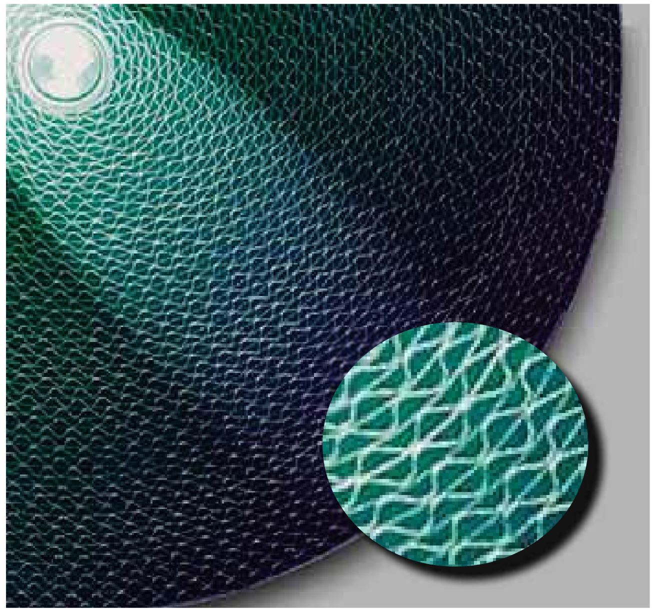


Figure 1a: FLAMEFILTER® wound out of corrugated metal strips

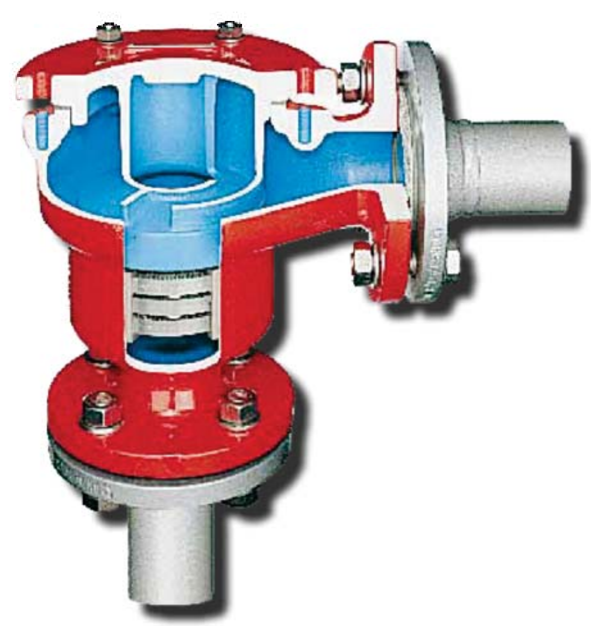


Figure 1b: Detonation Flame Arrester with Shock-Absorber

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 velo-city [EN 1127-1]. Depending on the geometric shape of the combustion area, a distinction is drawn 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 volume (such as within a vessel) initiated by an internal ignition source.

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

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

Detonation is an explosion propagating at supersonic velocity and is characterised by a shock wave [EN 1127-1]. A distinction is drawn 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, among others, on the operating pressure and operating temperature, on the pipe diameter, the pipe configuration, the test gas and the explosion group and must be predetermined by experiments in each case.

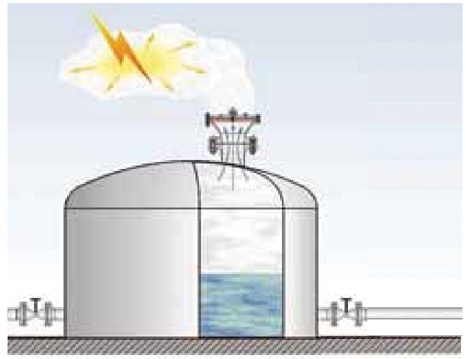


Figure 2: Atmospheric deflagration

Figure 3: Pre-volume deflagration

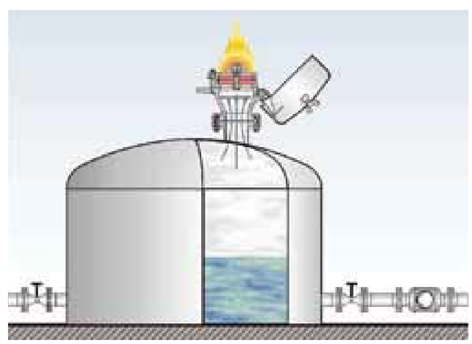


Figure 4: Stabilized burning

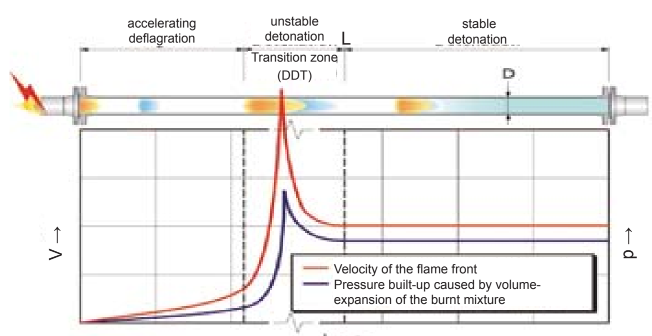


Figure 5: Deflagration – unstable detonation – stable detonation.
L= distance to ignition-source
D= Diameter of the pipeline
v= velocity of the flame front
p= pressure
DDT = Deflagration to Detonation Transition

Master Types

Flame arresters are subdivided into different types depending upon the combustion process (Endurance burning, Deflagration, Detonation and the various sub-groups) and in accordance to the installation (in-line, end-of-line, in equipment).

Master types are

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

Working principle

a) Static dry flame arresters

Flame arrester elements made of wound corrugated metal strips can be manufactured with consistantly reproducible flame quenching gaps. The gap-size can be adjusted in accordance 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 small gaps is applied in PROTEGO® end-of-line flame arresters and PROTEGO® in-line flame arresters (volume 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 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. The optimum solution between the two conditions is determined by experiments.

Original PROTEGO® technology

To protect against all of the previously mentioned combustion processes, PROTEGO® developed static dry flame arresters and 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 FLAMEFILTER®.

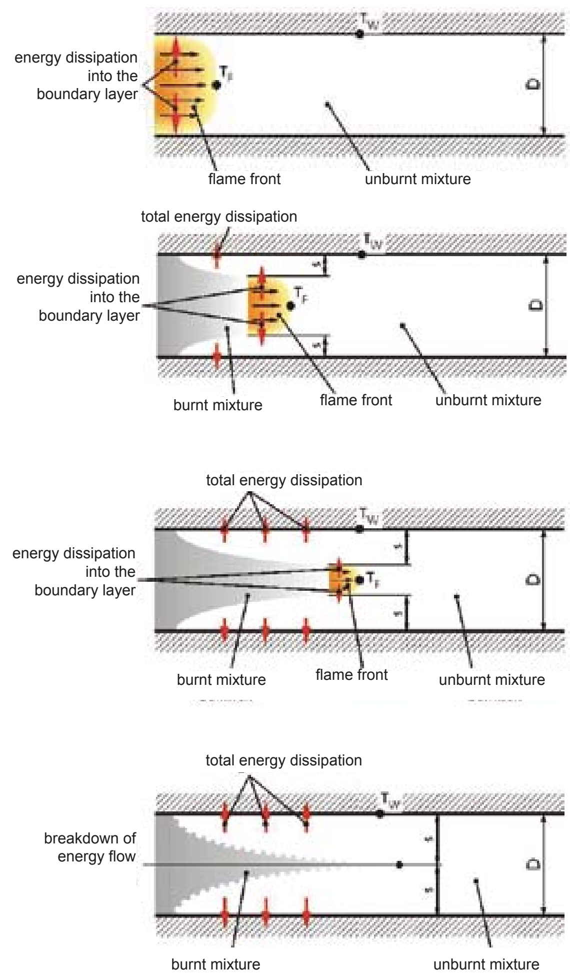


Figure 6:
Extinguishing the flame in the narrow gap (flame quenching) by heat transfer

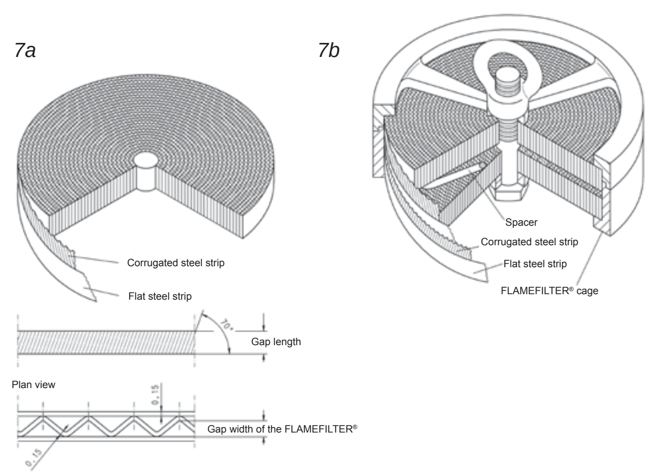


Figure 7:
FLAMEFILTER® (a) with gap widths and gap lengths and PROTEGO® flame arrester unit (b) with FLAMEFILTER®, spacer and FLAMEFILTER® cage

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 and whose intended function is to allow flow but prevent the transmission of flame.

8a

8b

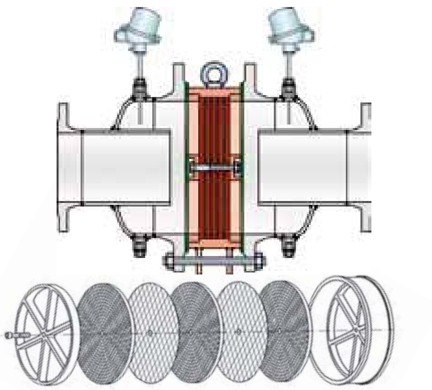


Figure 8: PROTEGO® flame arrester (a) and PROTEGO® flame arrester unit (b - modular design)

2. The PROTEGO® **flame arrester unit** (Fig. 8b and 7b) is that part of a flame arrester whose main task is to prevent the transmission of flames.
3. Several **FLAMEFILTER®** (Fig. 7a) form the PROTEGO® **flame arrester unit** (Fig. 7b and 8b) together with the spacers and enclosing cage.
4. 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 stop the entering deflagration and/or detonation before it reaches 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 (Vol. 4).

2. The hydraulic flame arrester: it is designed to break the flow of an explosive mixture into discrete bubbles flowing through water which acts 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 with regard to the specific customers requirements (Vol. 4).

When installing the PROTEGO® hydraulic flame arrester as in-line flame arrester, as vent header collection drum and back flow preventer in vapour collecting lines close to the incinerator, important safety measures have to be taken into consideration to assure the required explosion safety.

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 thus preventing flame transmission. This principle is applied in PROTEGO® Pressure Relief Diaphragm Valves (Vol. 7) and in PROTEGO® High Velocity Valves (Vol. 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 according to EN ISO 16852. They are certified in accordance with the specific requirements of the standard. Any certification according to other international standards is shown by marking with the appropriate indication.

Explosion groups

Different gases have different flame propagation capacities and are therefore categorized into explosion groups corresponding to their hazard level. The yardstick 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 interior 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 vapour in 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/vapour-air mixture.

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

* former designation Expl. Gr. I

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

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

As the pressure and temperature increase, the load on the flame arresters generally increases. Flame arresters that have been tested under standard conditions are approved and can be used 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 an equipment onto 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 stabilised burning — either short time burning or endurance burning. They can only be connected on one side and can not be installed in the pipe. PROTEGO® end-of-line flame arresters can however be combined with valves (see Volume 7: Pressure and Vacuum Relief Valves with PROTEGO® flame arresters).

PROTEGO® Pre-volume flame arresters are flame arresters which avoid flame transmission from the inside of an explosion-proof vessel to the outside or to a conntected pipe.

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

The flame arresters should be located 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 and that the in-line deflagration flame arresters are not installed too far from the ignition source, so that they are not subject to a detonation because the path is too long. 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 volumes. The different variations and wide range of types arises from the tailored solutions for different applications. PROTEGO® flame arresters are generally 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 and 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	→ Tank, page 35 → Reactor, page 36 → Free venting, page 37			→ Blower → Vacuum pump (p. 40)	→ For vent header, page 35 → Combustion system, page 37 → Vapour return, page 38		
Products	→ Volume 2	→ Volume 2	→ Volume 2	→ Volume 3	→ Volume 3	→ Volume 4	→ Volume 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, Volume 2
- End-of-line flame arresters for atmospheric deflagrations and short time burning: PROTEGO® Deflagration Flame Arresters, short time burning proof, end-of-line, Volume 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, Vol. 2
- Pre-volume flame arresters on equipment: PROTEGO® Deflagration Flame Arrester units on equipment, Volume 3
- In-line flame arresters for deflagrations: PROTEGO® Deflagration Flame Arresters, in-line, Volume 3
- In-line flame arresters for deflagrations and stable detonations: PROTEGO® Detonation Flame Arresters, in-line, Volume 4
- In-line flame arresters for deflagrations as well as stable and unstable detonations: PROTEGO® Detonation Flame Arresters, in-line, Volume 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 has to be compensated for when the tank or vessel is drained so that it does not implode. Unallowable overpressure and negative overpressure will accumulate with loading and unloading procedure, steam cleaning processes, blanketing and 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).

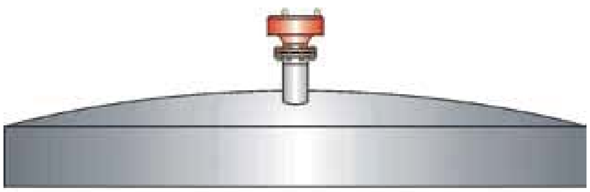


Figure 1: Free venting of the storage tank with PROTEGO® EH/0S

The vented product vapours 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).

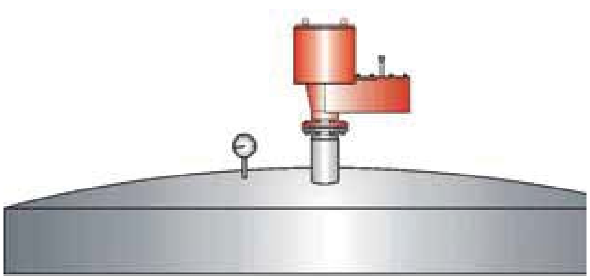


Figure 2: Venting of the storage tank with pressure and vacuum relief valve PROTEGO® VD/SV

These valves need to be simple and robust valves that do not require remote control, are trouble-free and reliably fulfill 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 thereby releases the flow into the atmosphere (Fig. 3a) until the pressure falls below the set pressure. The valve then reseats. 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).

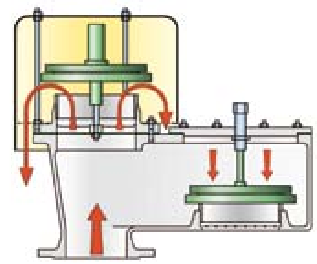


Figure 3a: Operation of the valve under pressure in the tank

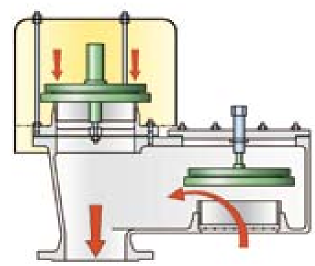


Figure 3b: Operation of the valve under vacuum (negative pressure) in the tank

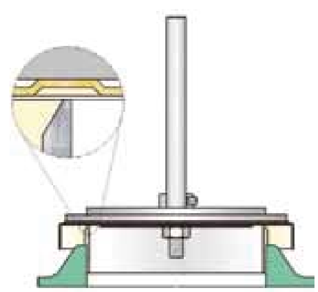


Figure 4: PROTEGO® full-lift pallet with air cushion seal

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 valve pallet and valve seat is provided by an FEP air cushion seal, a metal to metal sealing, or 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 (API2000 resp. EN ISO 28300) and hence meets the stringent demands of emission control regulations.

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

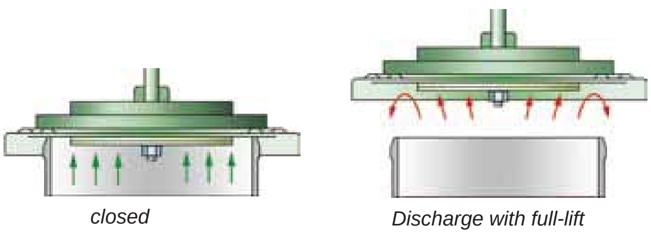


Figure 5a: Discharge with full-lift pallet and air-cushioned seal

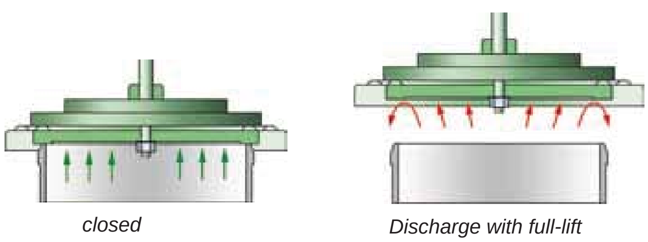


Figure 5b: Discharge with full-lift pallet and metal seal

This is attained by precisely harmonizing 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** discharge the flow within a 40% pressure.

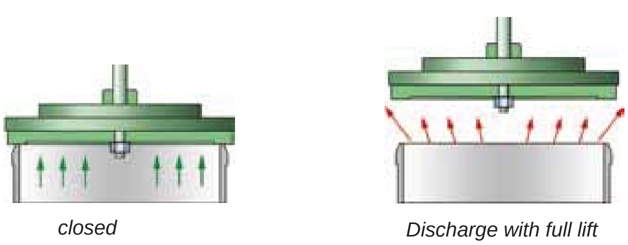


Figure 6: Discharge with normal pallet (flat with metal seal)

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 agreed, 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 vapour emissions

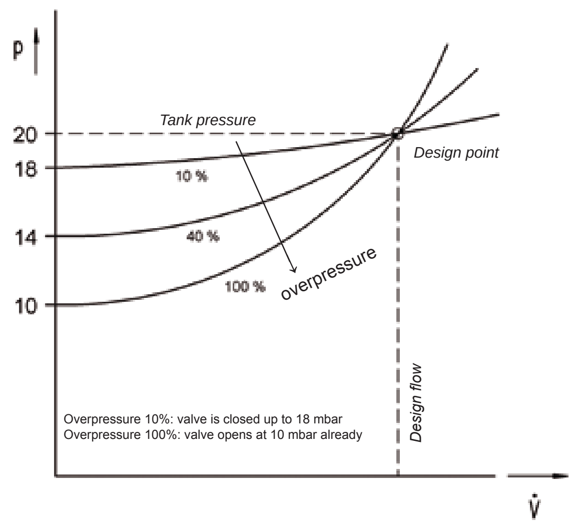


Figure 7: Opening characteristics of valves with different overpressure levels

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 discharge. Due to the flexible diaphragm, these valves are used in weather-related low temperatures and in sticky, polymerizing media. PROTEGO® diaphragm valves are the only valves worldwide which are frost-proof down to temperatures of -40°C (-40°F).

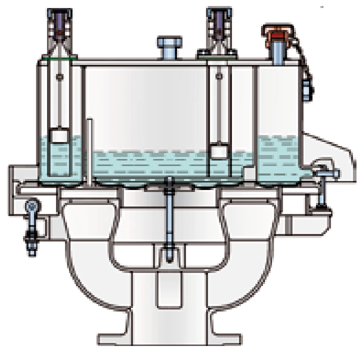


Figure 8: Diaphragm Valve PROTEGO® UB/SF-0

The self-controlled PROTEGO® **pilot operated valve** (Fig. 9) discharges the flow without requiring additional overpressure. Up to the set pressure until the pilot reacts, the valve remains sealed; it immediately opens in a 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 discharged and the pressure falls below the opening pressure, the valve recloses. PROTEGO® pilot valves are generally used as safety relief valves for low-temperature storage tanks or wherever the valve must be very tightly sealed up to the set pressure.

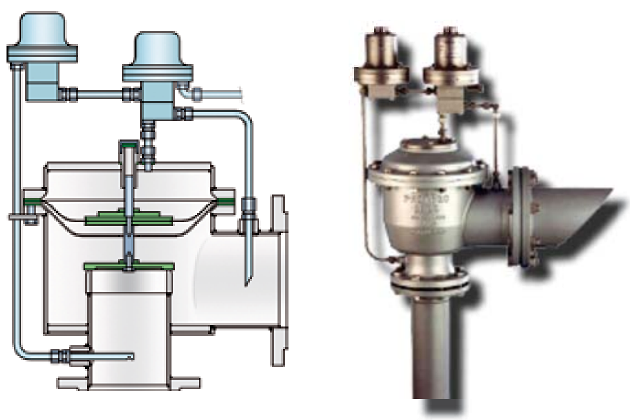


Figure 9: pilot operated pressure relief valve PROTEGO® PM/DS

The operating requirements regarding the amount of outbreathing and inbreathing 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 (vapour conservation)

Process-dependent 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). They need to meet other criteria however: Provide a good seal, be frostproof, trouble-free and easy to maintain. PROTEGO® pressure and vacuum conservation valves meet these requirements while being highly efficient, operate stable and offer safe function even at very low pressures due to the 10% technology. In addition emissions of the products are reduced.

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 paint, the insulation, and pressure maintenance via the valves influence - among others - the reduction of emissions.

The effect that pressure maintenance has on the reduction of product (vapour) loss improves as the set pressure of the valve approaches the maximum allowable tank pressure. The flow needs to be reliably discharged without the tank rupturing. A comparison of product loss at different overpressures clearly reveals the advantages of the 10% technology over the 40% overpressure and especially in contrast to a 100% overpressure: The specially developed design yields measurable savings by decreasing the accumulation up to the required performance (Fig. 10).

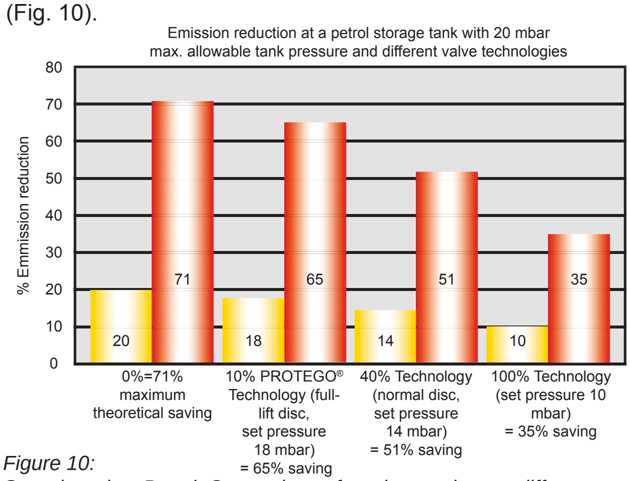


Figure 10:
Stored product Petrol: Comparison of product savings at different overpressure levels versus the free vented storage tank: Example of product loss at 20 mbar allowable tank pressure savings in % at different overpressure
0% = up to 20 mbar (8 inch W.C.) the valve is closed (theoretical): more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

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 breath). 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 Aboveground Storage Tanks - Sizing and Calculation Formulas, Page 26). The valve opening pressure must not exceed the maximum allowable tank pressure which also is 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 off 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, can not be exceeded under any operating conditions. The **pressure and vacuum relief valve** must be designed for maximum flow arising from the pump capacity, thermal and other influences. 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 weak seam (Fig. 11).

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

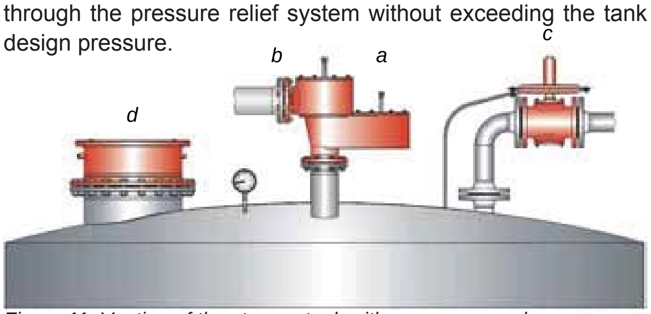


Figure 11: Venting of the storage tank with a pressure and vacuum relief valve PROTEGO® VD/SV-PA (a), piped into the vent header during operation (b), venting during operation via the nitrogen control valve PROTEGO® ZM-R (c), relieving in a fire-case through the emergency pressure relief valve PROTEGO®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

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

Location of installation

In general, PROTEGO® end-of-line valves are used for storage tanks, vessels or for ventilation lines. In pipes, PROTEGO® in-line valves are used as overflow valves, for backflow prevention and occasionally as control valves. The great advantages are their simple design and large opening cross-sections. These valves operate trouble-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 in this case of hazardous application, must be equipped with an end-of-line flame arrester to protect the system against atmospheric deflagration (see also Vol. 7).

Sizing of the Valves

The maximum possible volumetric flow, the maximum permissible 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)

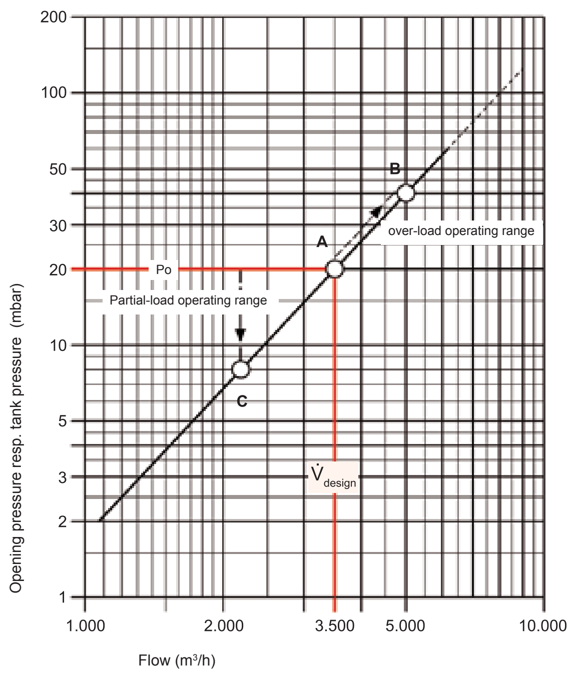
Pressure loss = decrease in pressure within the valve at a given flow

Pressure loss curve (Flow Chart) = performance curve in the flow chart = the characteristics of the valves as the pressure in mbar (inch W.C.) plotted against the 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 an equipment, storage tank or vessel may not be exceeded. The maximum possible flow must be reliably discharged through the valve so that the maximum allowable design pressure of the equipment is not exceeded. Safety factors must be taken into account.

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



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

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, discharges 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 an additional overpressure is required after a full lift to discharge 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 takes possible operating conditions into consideration is therefore 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 guidance.

Selection

The valves are selected using the above selection criteria depending 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	→ Storage tank, page 35				→ Vent header, page 35		
Product	→ Volume 5	→ Volume 5	→ Volume 5	→ Volume 5	→ Volume 6	→ Volume 6	→ Volume 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 (Vol. 5)

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

For venting of tanks storing products at low temperatures and storing critical products

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

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 that the flame arrester units are external and hence easily accessible (Fig. 1 and 2).

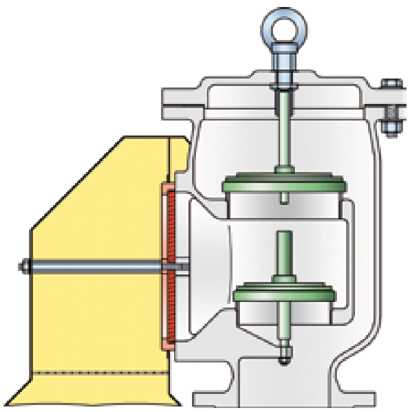


Figure 1:
Deflagration-proof pressure and vacuum relief valve PROTEGO® VD/TS

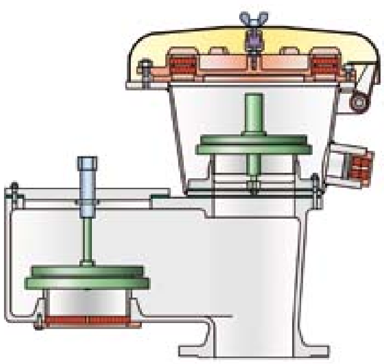


Figure 2:
Pressure and vacuum relief valve protecting against deflagration and endurance burning PROTEGO® VD/SV-HR

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. It must be realized that the downstream flame arrester unit creates a certain back pressure which has no impact on the set pressure but influences the overpressure behaviour. This is considered 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 (vapour conservation), relief pressure** and enable **tank breathing**. For a detailed description, see page 21.

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 media.

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

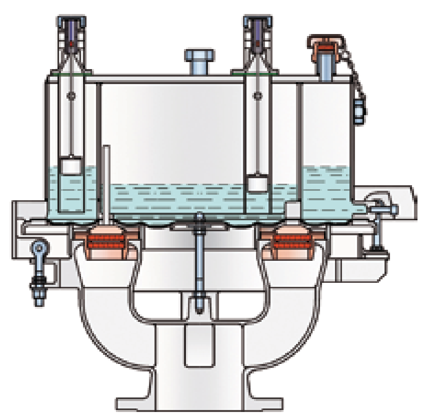


Figure 3: Diaphragm valve PROTEGO® UB/SF protecting against deflagration and endurance burning

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 W.C.). 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 effect a heat accumulation at the flame arrester which finally results 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 states of valves

The sizing and operating states of the pressure and vacuum relief valves are described on pages 22 and 23.

Selection

Since PROTEGO® pressure/vacuum relief valves with flame arrester units are always end-of-line valves, they are selected taking into consideration 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 regarding its flame-transmission protection. When selecting PROTEGO® valves with a flame arrester unit, one must establish 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. The danger of a stabilized burning does not exist for 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	→ Storage tank, Emergency venting / pressure relief, page 35				→ Storage tank, Tank ships, page 38
Products	→ Volume 7	→ Volume 7	→ Volume 7	→ Volume 7	→ Volume 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

PROTEGO
for safety and environment

Pressure Terms and Definitions

Tanks storing flammable and non-flammable liquids are designed and manufactured in accordance to 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 to relief the required massflow.

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 adjusted only 10% below the opening pressure. In accordance to **EN 14015** and **API 650** (**Fig. 1A** and **1B)** the design pressure or **MAWP** = **M**aximum **A**llowable **W**orking **P**ressure of the tank must not be exceeded not even in fire-case or system mal-function. Following **API 620 (Fig. 1C)** the valve must relief the required regular massflow out of thermal influences and pumping at 10% above the design pressure (in general the MAWP) at the latest. For fire-case or emergency an overpressure of 20% is allowable: after exceeding the MAWP by maximum 20% the required emergency massflow must be

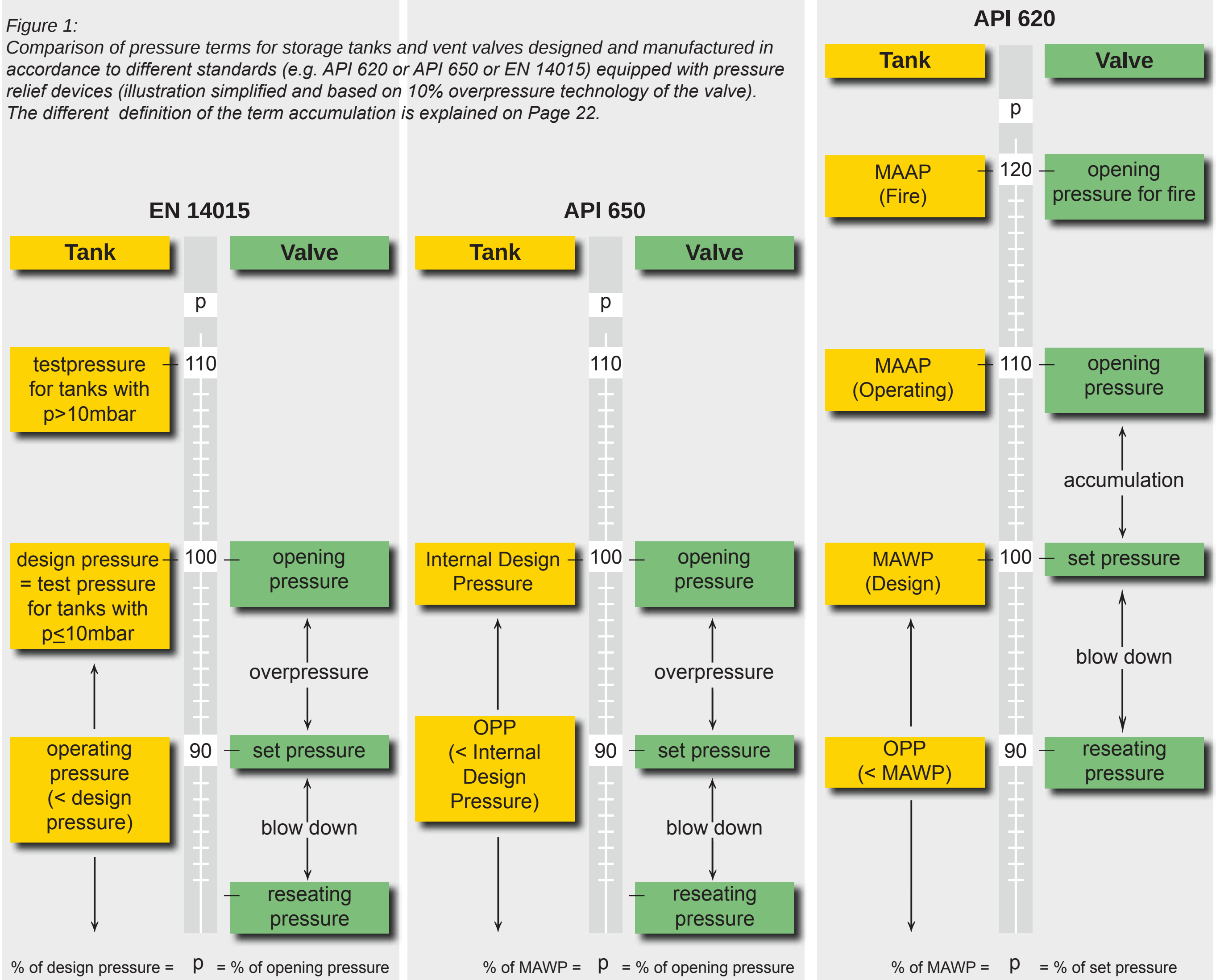


Figure 1:
Comparison of pressure terms for storage tanks and vent valves designed and manufactured in accordance to different standards (e.g. API 620 or API 650 or EN 14015) equipped with pressure relief devices (illustration simplified and based on 10% overpressure technology of the valve).
The different definition of the term accumulation is explained on Page 22.

design pressure
= calculated pressure = Maximum Allowable Working Pressure (MAWP) to be not exceeded at all operating conditions. For fire and emergency conditions weak roof to shell attachment or emergency relief valves to be provided.

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-case or emergency condition relief at 20% excess 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

relieved. **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 for end-of-line relief valves only without a back-pressure originated by e.g. connected pipe-away-line. If the tank is designed in accordance to 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 to API 620 the opening pressure may exceed the tank design pressure by 10% for regular breathing and 20% for fire-case (Fig. 2B). The set pressure again is the result of the opening pressure minus the valve-characteristic overpressure.

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.

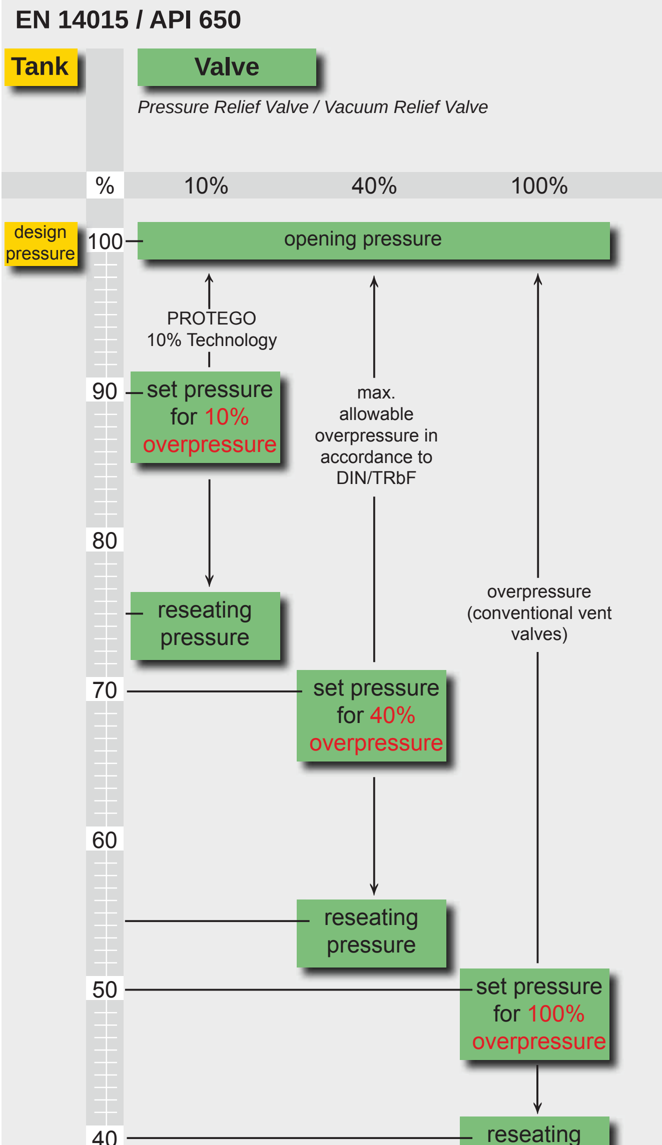


Figure 2A: Design in acc. to EN 14015 or API 650

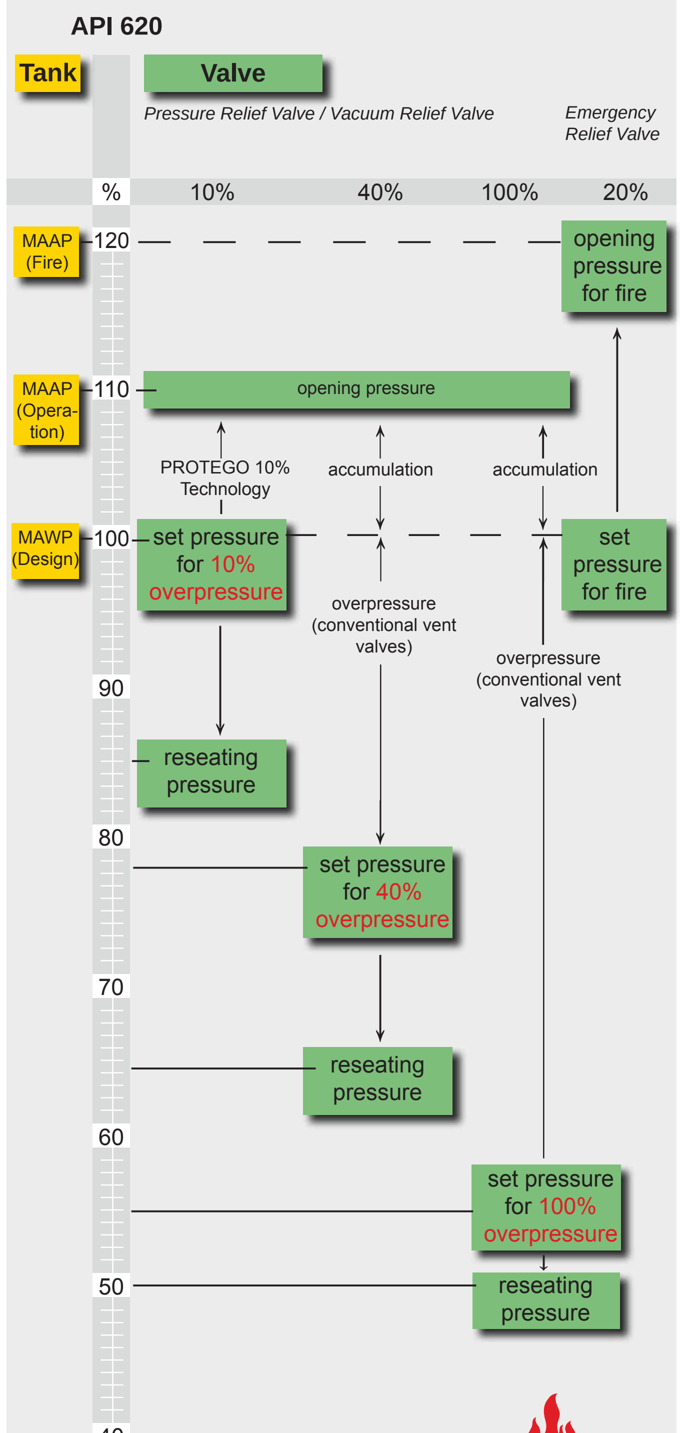


Figure 2B: Design in acc. to API 620

Calculation of the Out- and Inbreathing venting capacity in acc. to ISO 28300/API 2000:

The maximum required venting capacity is the total amount of pump capacity and capacity out of thermal influences:

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

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

The calculation of the maximum required capacity out of the thermal influences is based on ISO 28300 with regard to aboveground storage tanks with or without insulation.

Thermal capacity for heating up $\dot{V}_{thermal\ out}$ in m³/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 m³/h

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

- V_{Tank} is the volume of the tank in m³

  $V_{tank} = 0{,}7854 \cdot D^2 \cdot H$
- R_i is a reduction factor for insulation (see ISO 28300/API 2000)
- $\dot{V}_{pump\ in}$ is the filling rate to calculate the outbreathing capacity out of the maximum pump capacity in m³/h for products stored below 40°C and a vapour pressure p_{vp} < 50 mbar. For products stored at a temperature above 40°C or with a vapour 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 inbreathing capacity of the pump in m³/h.
- C=3 for products with equal vapour pressure as hexane and storage temperature < 25°C
- C=5 for products with vapour pressures higher than hexane and/or storage temperature above 25°C (if vapour pressure not known, then C=5)

The mentioned calculation formulas are valid for latitudes 58° to 42°; other latitudes see ISO 28300/API 2000.

Particular influences to be considered are e.g.:

- 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 inbreathing capacity

Calculation of the Out- and Inbreathing venting capacity in acc. to TRGS 509:

To calculate the out- and inbreathing capacity of storage tanks (e.g. tanks in acc. to DIN 4119 – aboveground storage tanks or DIN 6608 – horizontal underground or buried tanks) the calculation formulas of TRGS 509 (since 1 January 2013 VdTÜV-Merkblatt Tankanlagen 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- and Inbreathing venting capacity in acc. to API 2000 5th edition / ISO 28300 Annex A:

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

If required and when the tanks are specified and designed in accordance to **API 650,** the venting capacity is to be calculated in accordance to **API 2000** for in- and outbreathing as well as for emergency fire cases.

When calculating the required capacities in accordance to 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 flashpoint < 100°F (< 37,8°C) and for liquids with flashpoint ≥ 100°F (≥ 37,8°C). The maximum required venting capacity is the total amount of pump capacity plus capacity out of thermal influences. In contrast, the calculation of the pump capacity must consider a factor for the inbreathing rate and the different flashpoints for the outbreathing rate.

Calculation of the inbreathing 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 to the specified operating rates for emptying.

Calculation of the outbreathing 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 to the specified operating rates for filling.

In case there is no weak roof-to-shell attachment, the venting for fire emergency case is to be realized through an emergency pressure relief valve. The required capacity for fire emergency case $\dot{V}_{Fire}$ is rated in accordance to 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:

$$\dot{V}_{fire} = 208{,}2 \times F \times A^{0{,}82} \text{ for Metric Units in Nm}^3\text{/h}$$

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

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

Requirements of Thermal Venting Capacity (English Units)

Tank Capacity	Tank Capacity	Inbreathing *thermal in*	Outbreathing *thermal Out*	
			Flashpoint ≥ 100°F	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 of API 2000 5th ed.

Figure 2A

Requirements of Thermal Venting Capacity (Metric Units)

Tank Capacity	Inbreathing *thermal in*	Outbreathing *thermal Out*	
		Flashpoint ≥ 37,8°C	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	388,00	647,00
5.000	787,00	472,00	787,00
10.000	1.210,00	726,00	1.210,00
20.000	1.877,00	1.126,00	1.877,00
25.000	2.179,00	1.307,00	2.179,00
30.000	2.495,00	1.497,00	2.495,00

Excerpt of API 2000 5th ed.

Figure 2B

Venting Requirements of Aboveground Storage Tanks - Sizing and Calculation Formulas

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 of 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 of API 2000 5th ed.

Figure 3B

Environmental Factors for nonrefrigerated Aboveground 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 of API 2000 5th ed.

Figure 4A

Environmental Factors for nonrefrigerated Aboveground 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 of 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 conside-ring 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

Indices

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

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

Gas = Actual product

Dia = Related 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 = related to the outlet of the device (p_G back pressure) for operating conditions

PROTEGO
for safety and environment

Safety Proceeding to Protect 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 respectively EN 12874 Flame Arresters

- Deflagration in the atmosphere, in a pre-volume or in a pipeline
- Detonation in a pipeline, stable or unstable
- Endurance burning due to continous flow of vapours/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, vapours and multiple component mixtures

- Liquids: subdividing in flammable, easy flammable and highly flammable due to the flash point of the liquid and verifying the ignition temperature.

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

Non water soluble		
previous	actual	
(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	actual	
(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) get flammable when being heated close to the flashpoint (ΔT = 5 degree safety margin as a rule of thumb for hydrocarbons as well as 15 degree for mixtures).

Vapours: classification of the gas/vapour-air-mixtures in accordance to the MESG of the products or the mixture into the Explosion Groups IIA1, IIA, IIB1, IIB2, IIB3, IIB and IIC (page 17) (NEC Group D, C and B).

Step 3

Consideration of the operational process parameters of the unburnt mixtures with regard to the impact on the combustion behaviour:

- 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 in accordance to frequency and duration of explosive atmosphere based on national and international regulations e.g. TRBS, IEC or NFPA/NEC.

- Zone 0

  A place in which an explosive atmosphere consisting of a mixture of air with flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.

- Zone 1

  A place in which an explosive atmosphere consisting of a mixture of air with flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.

- Zone 2

  A place in which an explosive atmosphere consisting of a mixture of air with flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

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

effective ignition source:

- Steady and continuously 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, ultrasonics, adiabatic compression, shock waves etc.

Effectiveness of the ignition source is to be compared to 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

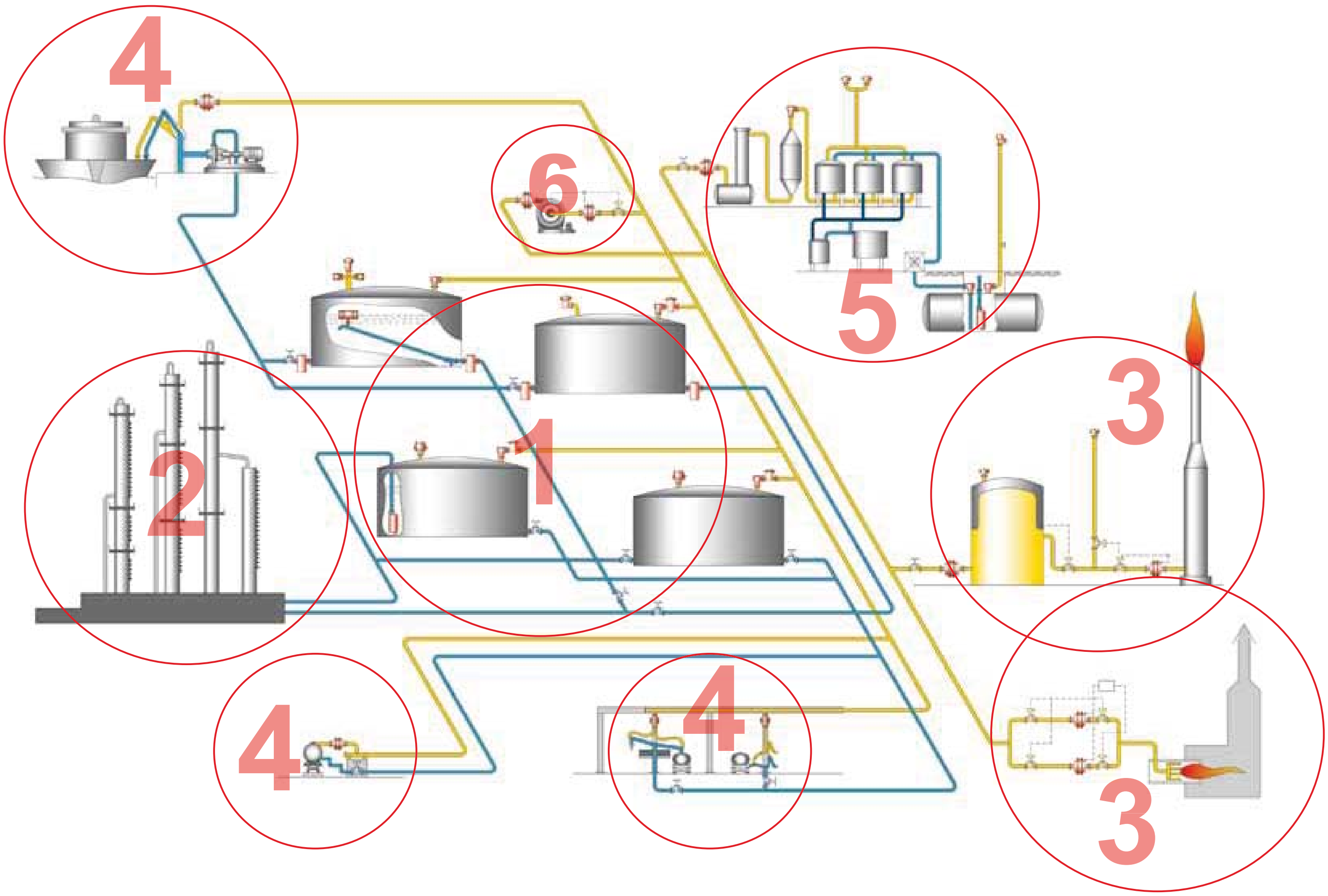
Flame arresters tested accordingly to EN ISO 16852 resp. EN 12874 fullfil the health and safety requirements of current ATEX directive.

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 state the 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) has to confirm that Equipment, Protective Systems and Components are in accordance with the law and are in compliance with the actual state-of-the-art. Process engineering, plant-layout, substances, zoning, risk assessment etc. are part of the protection concept and are determined in connection with the corresponding responsibilities.

Overview

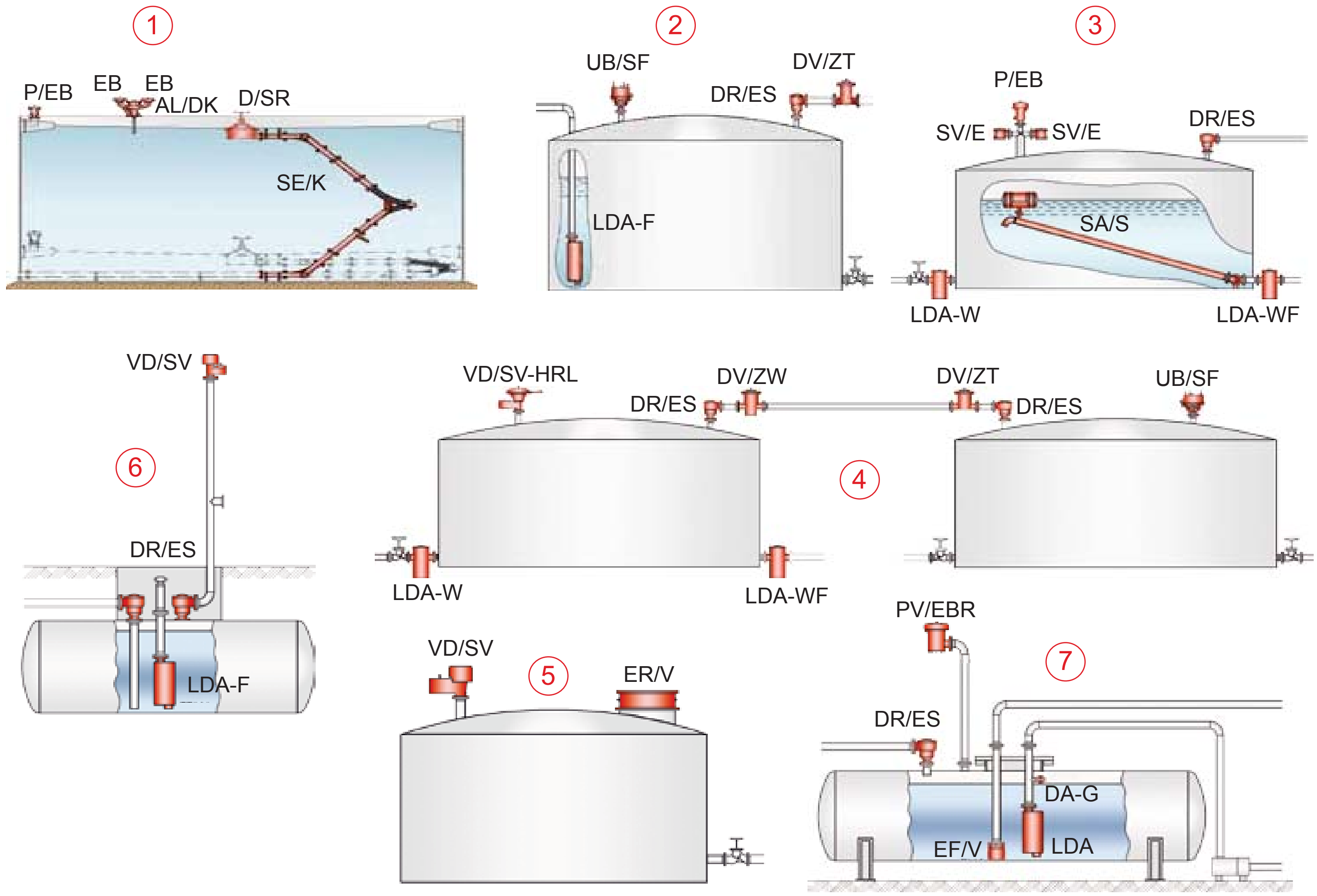
PROTEGO® safety devices are used in a wide range of industrial applications. A safe process requires reliable protection for every conceivable operating parameter. Practical examples show how systems can be made safe and how PROTEGO® devices can be incorporated into control loops. Engineers are responsible for properly harmonizing 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 Vapour Combustion Systems and Flares
4. In Ship Building and Loading Systems
5. In Vapour 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, airplane construction, automobile construction, IT clean-rooms, thin-layer manufacturing, etc.



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

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

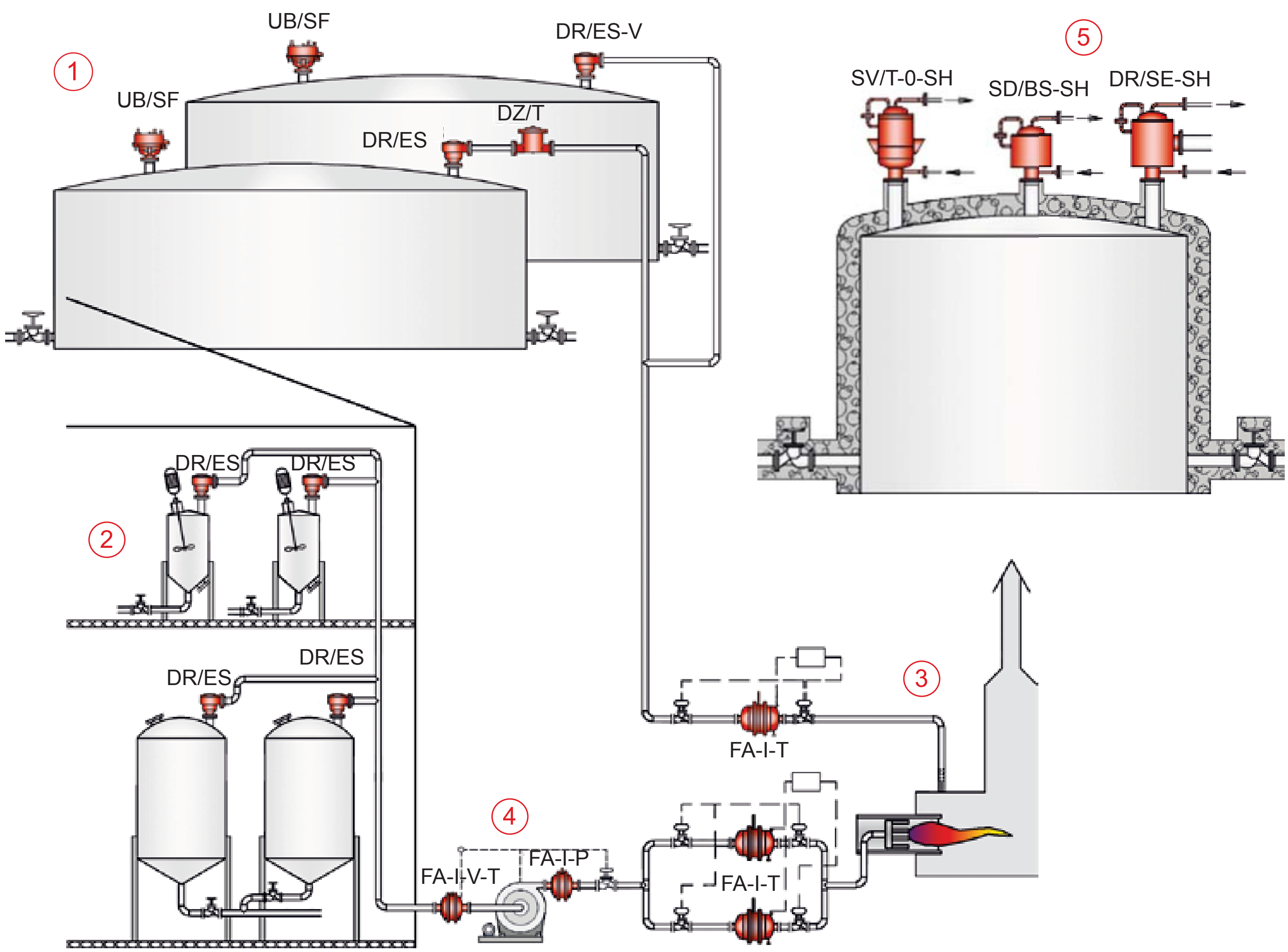
(3) Fixed-roof storage tank for flammable liquids with pressure safety relief valve P/EB (→ Volume 7) and vacuum safety relief valve SV/E (→ Volume 7), liquid detonation flame arrester LDA-W (→ Volume 4) and/or LDA-W-F (→ Volume 4) in the filling and emptying line, float-controlled swing pipe system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

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

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

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

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



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

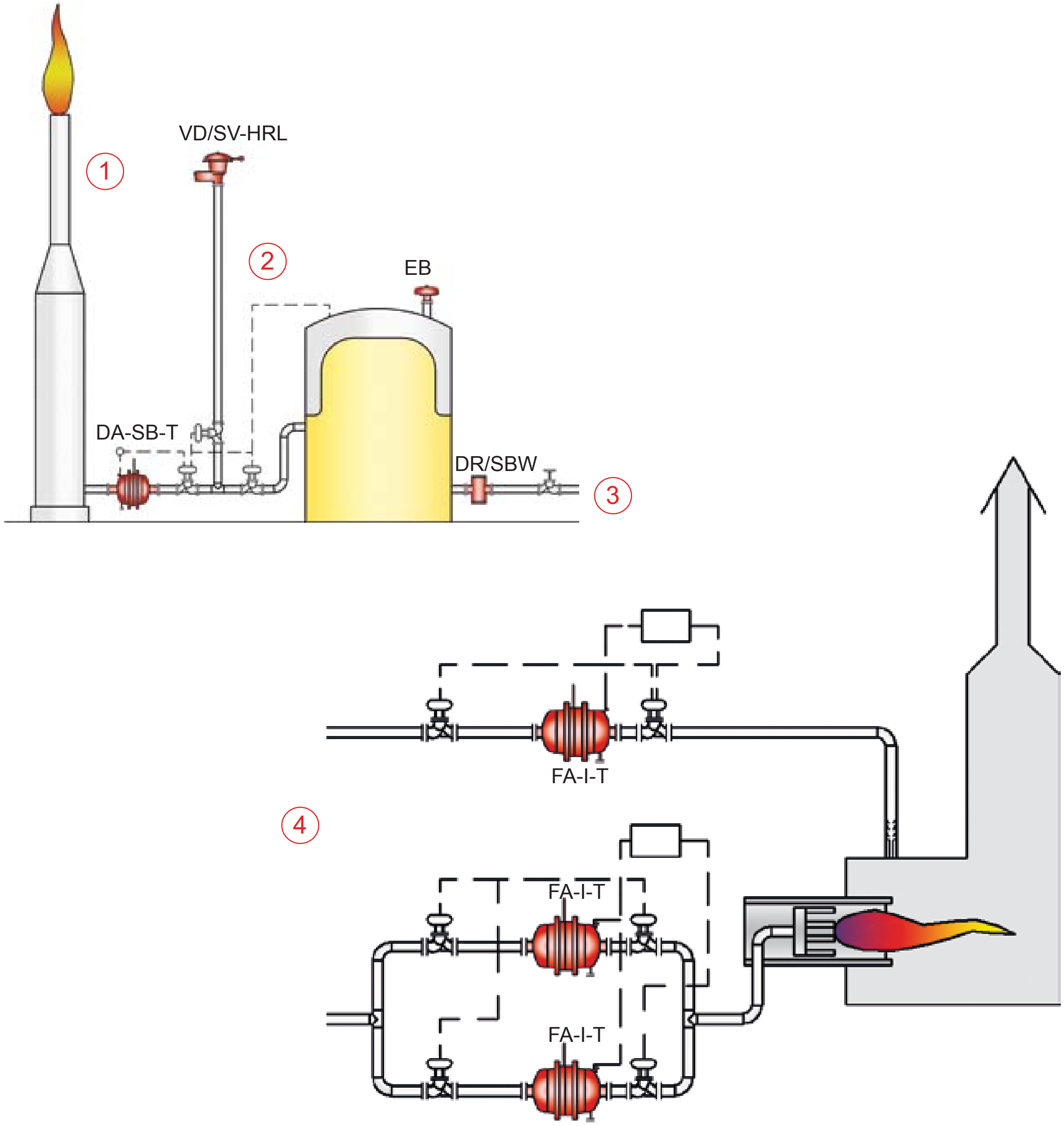
(2) Ventilation of industrial mixers and process vessels in a common vapour vent header via detonation flame arresters DR/ES (→ Volume 4)

(3) Temperature-monitored deflagration flame arresters FA-I-T (→ Volume 3) in the feed line for vapour combustion at the maximum allowable distance from the ignition source and in parallel for the sake of availability for servicing or emergency switching in case of an endurance burning on the arrester. Vapour pipeline from plant to vapour combustion unit with deflagration flame arrester FA-I-T (→ Volume 3) to protect the vent header collection line and the operating locations in the plant.

(4) Protecting pressure-resistant radial blowers as type-examined zone-0 blowers with integrated PROTEGO® flame arresters FA-I-V-T and FA-I-P (→ Volume 3)

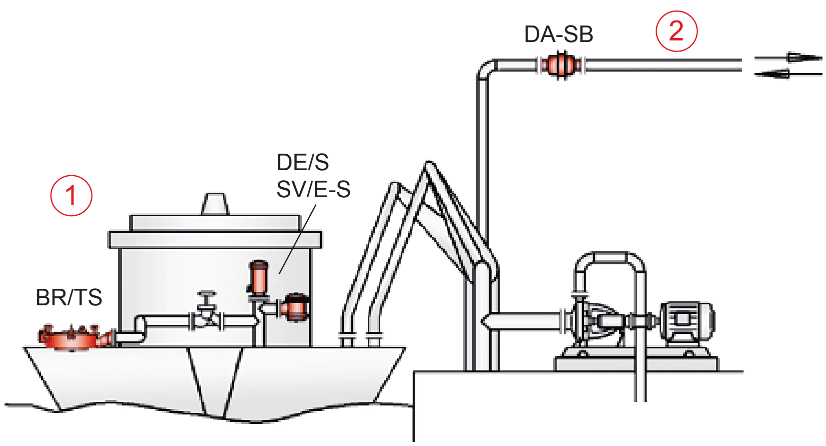
(5) Protection of storage tanks for media that can only be pumped with assistance of heating systems. These applications, e.g. bitumen storage, need fully heated devices such as the pressure relief valve SD / BS - H (→ Volume 5), vacuum relief valve SV / T - 0 - H (→ Volume 5) and heated detonation flame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

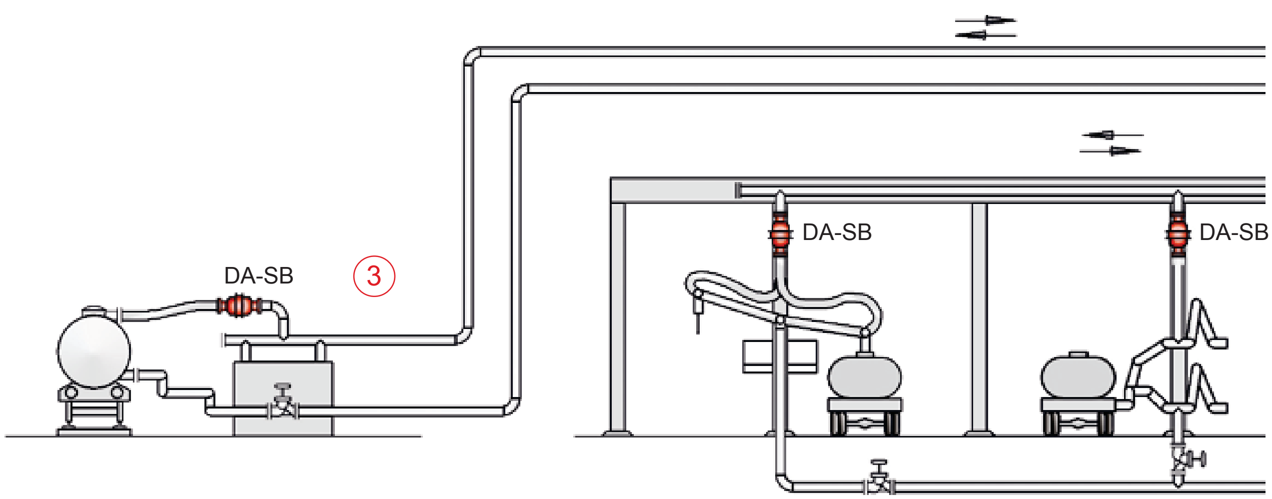
Vapour Combustion Systems and Flares



1. Flare pipes or ground flares with detonation flame arresters DA-SB-T (→ Volume 4)
2. Emergency pressure relief stack with endurance-burning-proof pressure and vacuum relief valve VD/SV-HRL (→ Volume 7)
3. Gasholder with detonation flame arrester DR/SBW (→ Volume 4) in the gas supply and end-of-line deflagration flame arrester EB (→ Volume 2), which protects against endurance burning, above the diaphragm
4. Temperature-monitored deflagration flame arresters FA-I-T (→ Volume 3) in the feed line for vapour combustion at the maximum allowable distance from the ignition source and in parallel for the sake of availability for servicing or emergency switching in case of an endurance burning on the arrester

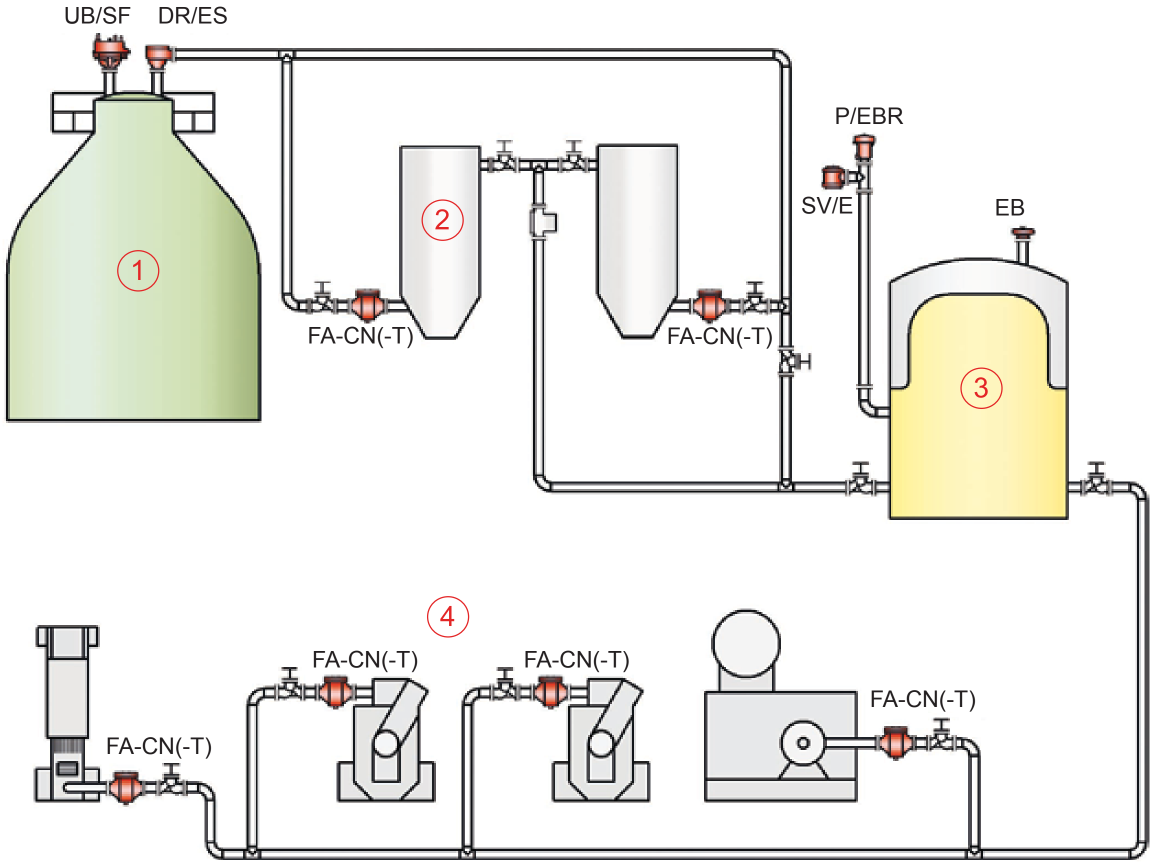
Vapour pipeline from plant to vapour combustion unit with deflagration flame arrester FA-I-T (→ Volume 3) to protect the vent header collection line and the operating locations in the plant.





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

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



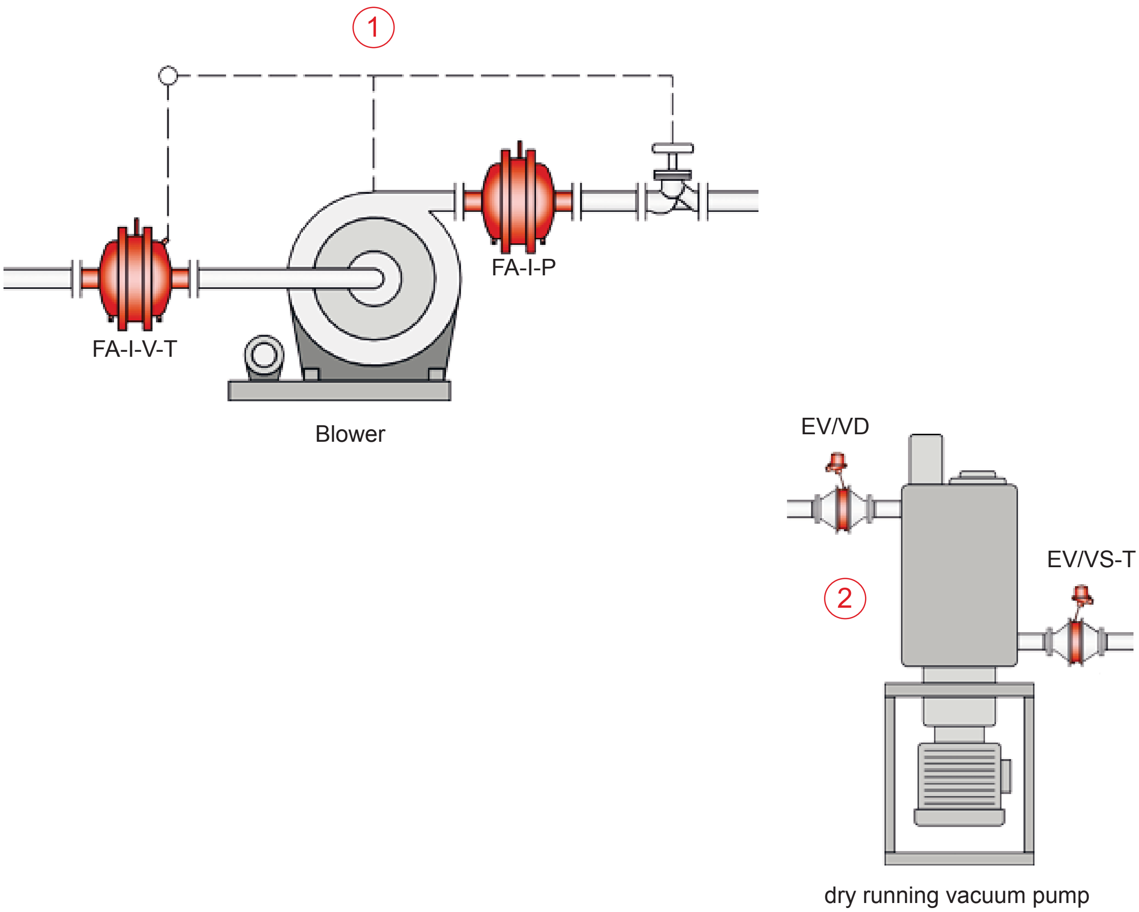
(1) Protecting the sewage tower and storage tank with a frost-proof pressure and vacuum relief valve UB/SF (→ Volume 7) and with detonation flame arresters DR/ES (→ Volume 4) in the gas collection line

(2) Protecting the desulphurization system with deflagration flame arresters suitable for temperature and pressure FA-CN, FA-CN-T alternatively FA-E (→ Volume 3)

(3) Protecting the intermediate gasholder in the pressure and vacuum relief line with endurance burning proof deflagration flame arrester, end-of-line EB (→ Volume 2), equipping the emergency vent stack with deflagration and endurance burning proof pressure relief valve P/EBR (→ Volume 7) and deflagration proof vacuum relief valve SV/E (→ Volume 7)

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

Flame Arresters as integrated Equipment Components (exemplary)

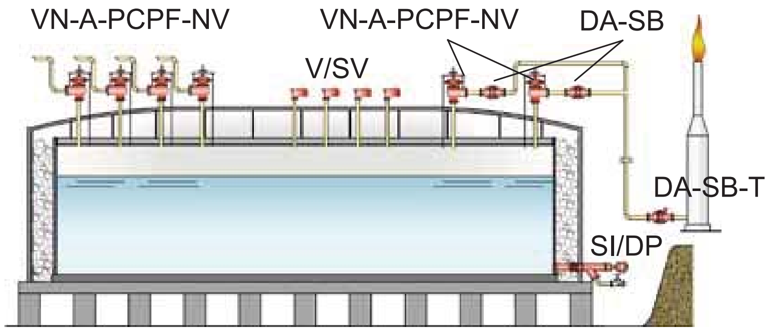


FLAMEFILTER® or PROTEGO® flame arresters as OEM components are product varieties, that are integrated by equipment manufacturers in their brand-name products.

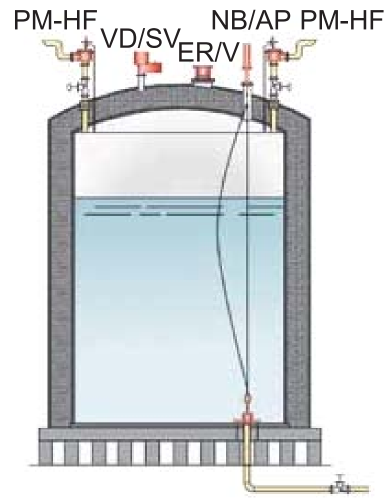
① Protecting pressure-resistant radial blowers as type-examined zone-0 blowers with integrated PROTEGO® flame arresters FA-I-V-T and FA-I-P (→ Volume 3)

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

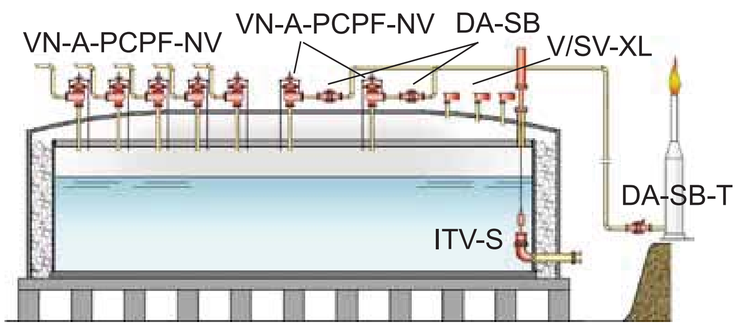
Not shown: FLAMEFILTER® are used in gas analyzers to protect the explosive environment from explosions arising in the device from the ignition of the gases or vapours to be measured or analyzed. PROTEGO® flame arresters are installed in the pressure and vacuum relief openings of air-plane fuel tanks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



Ammonia Storage Tank

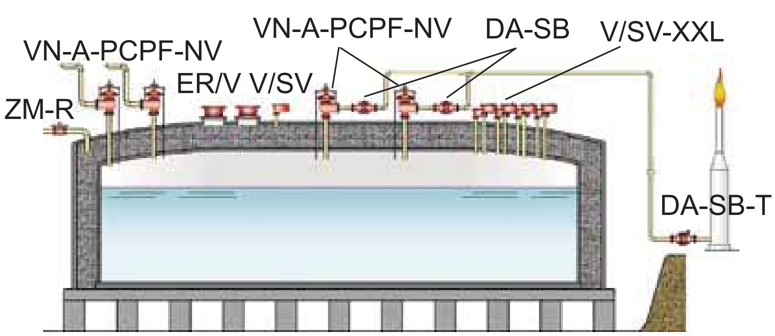


LIN-LOX-LAR Storage Tank



Ethylene Storage Tank

- Pilot Operated Valves that solve instability problems during operation such as fluttering and chattering.
- Cleaning for oxygen service available on request.
- Cryogenic Functional Test available on request.
- Low Pressure and Vacuum Conservation Vents.
  - Full lift technology available (fully open with only 10% overpressure/pressure accumulation)
  - Deadweight or spring loaded
- Extremely low leakage rates on Breather Valves (much lower than ISO 28300 and API 2000 7th ed.)
- Low Pressure Reducing Valves

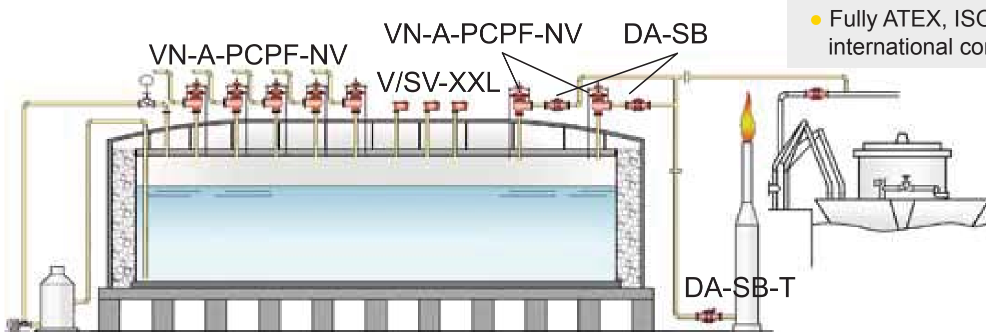


Propylene Storage Tank

- Pneumatic driven fast In-Tank valves.
- Pneumatic and Manual driven Internal Safety Valves.

- 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.



LNG Storage Tank

Products

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

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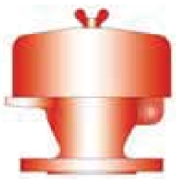
Catalogue

Flame Arresters



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

Vent caps without flame arresters

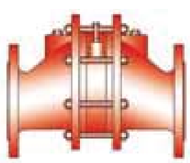
Explosion groups: IIA1, IIA, IIB1, IIB2, IIB3, IIB, IIC

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

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

Special designs according to customer specifications

Services 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

Services and spare parts

Detonation flame arresters for stable detonations, for unstable detonations

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

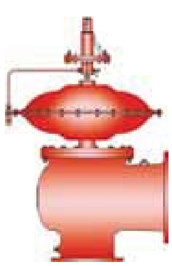
Nominal sizes: 15 to 800 mm (½“ to 32“)

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

Special designs according to customer specifications

Services 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 413.6 inch W.C.)

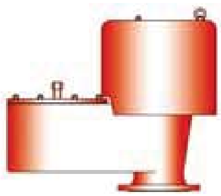
Nominal sizes: 40 (1 ½“) to 300 (12“)

Materials: carbon steel, stainless steel, aluminum

Special designs according to customer specifications

Services and spare parts

Valves



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

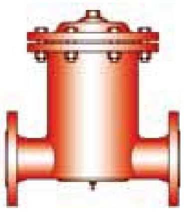
Pressure settings: 2 to 200 mbar (0.08 to 8 inch W.C.)

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

Services and spare parts



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

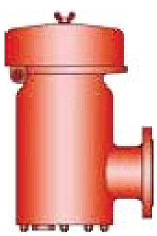
Pressure settings: 2 to 500 mbar (0.08 to 20 inch W.C.)

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

Services and spare parts



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

Services and spare parts

Tank Accessories and Special Equipment

Floating suction unit, floating-roof drainage system

Floating-roof vacuum relief valves, skimming system

Air-drying aggregates, sampling and draining valves

Services and spare parts

PROTEGO
for safety and environment

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 (recast, replace 94/9/EC after 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)

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Term	Description	Source
accumulation	pressure increase over the maximum allowable working pressure of the vessel allowed during discharge through the pressure-relief device	ISO 23251 - 3.1
actual flow capacity	actual flow capacity is the flowing capacity determined by measurement	DIN 3320-75
adjusted set pressure	vacuum or gauge pressure at which under test stand conditions (atmospheric back pressure) valves commence to lift	-
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
annular flame arresting unit	flame arresting unit consisting of annular crimped ribbons	-
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 and gases from pressure-relieving and depressurizing devices to the atmosphere	ISO 23251 - 3.4
back pressure	the back pressure is the gauge pressure existing at the outlet side during blowing ($p_a = p_{ae} + p_{af}$)	DIN 3320-58
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	-
bottom drain valve	emergency valve at the tank bottom to shut immediately in case of downstream piping rupture	-
check valve	valve, that prevents backflow against flow direction	-
coating	protective painting with defined layer-thickness	
combustion air	air required to combust the flare gases	ISO 23251 - 3.19
component	„component“ means any item essential to the safe functioning of Equipment and Protective System but with no autonomous function	EN 1127 - 3.2
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 - 3.15
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 pressure of a tank in the space above the stored liquid	-

design pressure / design temperature (general design)	pressure, together with the design temperature, used to determine the minimum permissible thickness or physical characteristic of each component, as determined by the design rules of the pressure-design code	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 stock wave (EN 1127-1: 1997)	EN 13237 - 3.18
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
detonation proof by-pass	dry-type detonation proof by-pass to keep a minimum liquid for safety reasons	-
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 - 3.23
emergency venting valves	pressure relief valves for emergency venting	-
end-of-line flame arrester	flame arrester that is fitted with one pipe connection only	ISO 16852 - 3.23
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	„equipment“ means machines, apparatus, fixed or mobile devices, control components and instrumentation thereof and detection and prevention systems which, separately or jointly, are intended for the generation, transfer, storage, measurement, control and conversion of energy, for the processing of material, and which are capable of causing an explosion through their own potential sources of ignition	EN 1127 - 3.5
equipment category	within an equipment group, a category is the classification according to the required level of protection. The categories are defined as given in A.6.	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 1127-1:1997)	EN 13237 - 3.29
explosive atmosphere	mixture with air, under atmospheric conditions, of flammable substances in the form of gases, vapors, mists or dusts, in which, after ignition has occurred, combustion spreads to the entire unburned mixture	EN 1127 - 3.17
flame arrester	a device fitted to the opening of an enclosure or to the connecting pipework of a system of enclosures and whose intended function is to allow flow but prevent the transmission of flame	ISO 16852 - 3.1
flame arrester cage	enclosure for the flame arrester element including spider rings	-
flame arrester element	crimped ribbon element	-

flame arrester element gap	flame arrester elements have profiles, which are more or less triangular. The flame arrester element gap is the triangular height of the flame arrester element	-
flame arrester housing	that portion of a flame arrester whose principal function is to provide a suitable enclosure for the flame arrester element and allow mechanical connections to other systems	ISO 16852 - 3.2
flame arrester set	combination of flame arrester elements with spacers	-
flame arrester unit	flame arrester cage with flame arrester elements and spacers	-
flame transmission proof	characteristic of a device to avoid flashback	-
FLAMEFILTER®	international trademarks by Braunschweiger Flammenfilter GmbH for flame arrester element made of crimped ribbon	-
FLAMEFILTER® cage	enclosure for FLAMEFILTER® including spider rings	-
FLAMEFILTER® gap	flame arrester element gap of a crimped ribbon element type FLAMEFILTER®	-
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 - 3.44
flammable liquid	liquid capable of producing a flammable vapor under any foreseeable operating condition (EN 60079-10:1996)	EN 13237 - 3.45
flammable material	material which is flammable of itself, or is capable of producing a flammable gas, vapor or mist (EN 60079-10:1996)	EN 13237 - 3.46
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 - 3.48
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, corrected to a barometric pressure of 101,3 kPa, at which application of a test flame causes the vapor of the test portion to ignite under the specified conditions of test (ISO 13736:1997)	EN 13237 - 3.49
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 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 unit	mechanical device, sometimes articulated, installed in some tanks, which floats on the liquid surface and only permits product to be withdrawn from this point	EN 14015 - 3.1.28
foot valve flame arrester	a 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

fusible link	component which melts at a defined temperature and which actuates another function (opening of hood, closing of valve)	-
gauging and sampling device	equipment for stating the liquid level within storage tanks as well as for sampling from any height within the stored medium	-
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 bushing	component for guiding e.g. the guide spindle of a valve pallet	-
guide rod	component (rod) for guidance of valve pallet	-
guide spindle	orthogonal to valve pallet section, central pipe for guiding the valve pallet	-
guide pipe	pipe for guiding the guide spindle of a valve pallet	-
hazardous area	area in which an explosive atmosphere is present, or may be expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment	EN 13237 - 3.55
hazardous explosive atmosphere	explosive atmosphere which, if it explodes, causes damage	EN 1127 - 3.19
heat release	total heat liberated by combustion of the relief gases based on the lower heating value	ISO 23251 - 3.36
heating jacket	closed room for heating of a device, which encloses the device fully or partly	-
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, thus preventing 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 sufficient energy to initiate combustion (EN ISO 13702:1999)	EN 13237 - 3.62
ignition temperature (of a combustible gas or of a combustible liquid)	the lowest temperature of a heated wall as determined under specified test conditions, at which the ignition of a combustible substance in the form of gas or vapor mixture with air will occur	EN 1127 - 3.31
inert gas	non-flammable gas which will not support combustion and does not react to produce a flammable gas	EN 13237 - 3.68
inerting	addition of inert substances to prevent explosive atmospheres	EN 1127 - 3.21
in-line flame arrester	flame arrester that is fitted with two pipe connections, one each side of the flame arrester	ISO 16852 - 3.22
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	leakage of a device in volume per time (liter per second)	-
left-hand wound	orientation (angle) of gaps of crimped ribbon element	-
lift	actual travel of the valve disc away from the closed position	ISO 4126 - 3.3
limiting oxygen concentration (LOC)	maximum oxygen concentration in a mixture of a flammable substance and air and an inert gas, in which an explosion will not occur, determined under specified test conditions (EN 1127-1:1997)	EN 13237 - 3.64
lining	protective cladding with defined minimum/maximum thickness to protect against aggressive mixtures (e.g. acid)	-
liquid product detonation flame arrester	flame arrester in which the liquid product is used to form a liquid seal as a flame arrester medium, in order to prevent flame transmission of a detonation. There are two types of liquid product detonation flame arrester for use in liquid product lines: liquid seals and foot valves	ISO 16852 - 3.19
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 lower limit of the explosion range	EN 1127 - 3.8
maintenance	combination of all technical and administrative actions, including supervision actions, intended to retain an item in, or restore it to, a state in which it can perform a required function	EN 13237 - 3.78
malfunction	the equipment, protective system and components do not perform the intended function	EN 1127 - 3.25
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	calculated maximum explosion pressure which the equipment will withstand	EN 14460 - 3.7
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 of the joint between the two parts of the interior chamber of the test apparatus which, when the internal gas mixture is ignited and under specified conditions, prevents ignition of the external gas mixture through a 25 mm long joint, for all concentrations of the tested gas or 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 apparatus and the test method	-
maximum operating temperature	maximum temperature reached when equipment or protective system is operating at its intended operating conditions	-

measurable type (static flame arrester)	a flame arrester where the quenching gaps of the flame arrester element can be technically drawn, measured and controlled	ISO 16852 - 3.17.1
most easily ignitable explosive atmosphere	explosive atmosphere with a concentration of flammable substances which under specified conditions, requires the lowest energy for its ignition	EN 13237 - 3.87
nominal size, nominal diameter	(DN) a numerical size designation used for all components of a piping system, for which the external diameter or the size of thread is not indicated. The figure is rounded and has only an approximate relation to the machined dimensions	-
non-measurable type (static flame arrester)	a flame arrester where the quenching gaps of the flame arrester element cannot be technically drawn, measured or controlled (e.g. random such knitted mesh, sintered metal 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 inbreating)	EN 14015 - 3.1.36
normal venting	venting required because of operational requirements or atmosheric changes	ISO 28300 – 3.7
opening pressure	the opening pressure is the vacuum resp. gauge pressure at which the lift is sufficient to discharge the predetermined mass flow; it is equal to the set pressure plus overpressure	DIN 3320 - 54
operating pressure	pressure in the process system experiences during normal operation, including normal variations	ISO 23251 - 3.49
operating temperature	temperature reached when the apparatus is operating at its rating	-
overpressure	pressure increase over the set pressure, at which the safety valve attains the lift specified by the manufacturer, usually expressed as a percentage of the set pressure	ISO 4126 - 3.2.3
pallet guidance	element of valve providing guidance of valve pallet	-
pallet type valve (disc valve)	valve with discoidal 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 actuated 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	pressure unit used in this standard is the bar (1 bar = 10000 Pa), quoted as gauge (relative to atmospheric pressure) or absolute as appropriate	ISO 4126 - 3.2
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	ISO 23251 - 3.11

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	term product covers equipment, protective systems, devices, components and their combinations as well as software as defined in 3.4.2 of EN ISO 9000:2000 (EN 13980.2002)	EN 13237 - 3.95
protective screen	component, which provides free flow, but prevents entrance of foreign matter, for example animals	-
protective system	„protective system“ means design units which are intended to halt incipient explosions immediately and/or to limit the effective range of explosion flames and explosion pressures. Protective systems may be integrated into equipment or separately placed on the market for use as autonomous systems	EN 1127 - 3.36
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 (closing 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 - 3.2.4
right-hand wound	orientation (angle) of gaps of crimped ribbon element	-
safety shut-off valve	a safety shut-off valve is a valve which closes automatically to prevent a predetermined gauge pressure 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 further flow of fluid after normal pressure conditions of service have been restored	ISO 4126 - 3.1
sampling and air bleed valve	flashbackproof and non flashbackproof taps or valves out- and inbreathing of parts of plant	-
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	-
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, which lies on and between the crimped ribbon elements of a flame arrester unit	-
sparge pipe	pipe leading into the dip liquid of an 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	a 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 storage 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
swing pipe unit	flexible pipeline with or without float within a storage tank for filling and emptying	-
swivel joint	part of a swing pipe system	-
temperature class	classification of equipment, protective system or component for explosive atmospheres based on its maximum surface temperature	EN 13237 - 3.111
temperature sensor	temperature sensor for monitoring the temperature	-
test pressure	pressure to test the mechanical stability of devices and or to test devices for leak	-
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 vapours 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 an 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)	the upper limit of the explosion range	EN 1127 - 3.9
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- and inbreathing 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 connected to pipe away valves	EN 14015 - 3.1.45
venting system	system, which consists of pipeline and devices for free out- and inbreathing of parts of plants	-
venting system with flame arresting capability	free vents or pressure and/or vacuum valves combined with a flame arrester or with integrated flame arresting elements	DIN EN 14015 - 3.1.42

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vessel	container or structural envelope in which materials are processed, treated or stored	ISO 23251 - 3.80
zone 0	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	EN 13237 - 3.119-1
zone 1	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	EN 13237 - 3.119-2
zone 2	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	EN 13237 - 3.119-3
zones for gases/vapours	hazardous areas are classified into zones based upon the frequency of the occurrence and the duration of an explosive gas atmosphere, the definitions are only applicable to equipment group II	EN 13237 - 3.119

Notes:

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 to 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	= polyvinylidene fluoride
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 chlorotrifluoro etylene
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/Vapour-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 seperate sheet

Fill in and ☐ tick off, if applicable, delete unit, if not applicable

signed: date: approved: released:

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