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1 Basic scope of document

This document is a guideline for the application of bursting discs and their operation principle.
It shall answer the following questions:

- When is a bursting disc required?
- What alternatives to a bursting disc can be used?
- When a bursting disc is needed to protect a pressure vessel:
  - How many bursting discs are required?
  - Which size of the bursting disc is required?
  - Where must the bursting discs be installed on the vessel?
  - What must be considered for the header / the exhaust line?
  - Which standards are applicable?

Most of these questions are discussed using the example of a shell and tube heat exchanger (refer to TDO 2011219 E01).

2 Background

In case the pressure inside a vessel increases to a pressure level higher than its design pressure, the vessel can be destroyed. Such a failure can cause extensive damage and injure or kill operators or other people near the facility.

A typical example for a pressure vessel in which the inside pressure can suddenly increase during operation is a shell and tube heat exchanger. Typically, the gas is on tube side and the cooling water is on shell side. The gas pressure is often higher than the design pressure of the shell, which will result in a sudden increase of the pressure inside the shell in case of tube rupture. This may occur due to cracks caused by corrosion, vibrations or fatigue.



Figure 1: catastrophic rupture of a shell & tube heat exchanger

As shown in Figure 1, if the heat exchanger is not protected against over-pressurization, a tube rupture can cause a damage at the heat exchanger itself and the environment.

This document provides necessary guidelines to use the BCAG standard specification and to help to deal with client's requirements. This document is not mandatory but shall be used as guideline for the application of bursting discs. Deviations from this document may be required on a case-by-case basis depending on customer specifications and available further data.

2.1 Causes of over-pressure

There are many causes which can lead to an over-pressure and as a result in equipment failure, e.g. heat exchanger tube rupture:

- Corrosion
- Erosion
- Vibration
- Thermal Fatigue

3 When is a protection required?

An overpressure protection is required as soon as a tube failure results in an increasing pressure inside the shell of the heat exchanger, which is higher than the allowable shell design pressure. The max. allowable pressure in the shell is the pressure which the shell can withstand, i.e. the test pressure. (ref. to API 521 June 2022 chapter 4.4.14).
In client specifications, the execution of this code is often described using the so-called 10/13 Rule or 2/3 Rule, which are considered best practice methods.
Those rules refer to the relationship between the test pressure and the design pressure:

- 10/13 Rule: Applied when the test pressure is 1.3 times the design pressure
- 2/3 Rule: Applied when the test pressure is 1.5 times the design pressure

Table 1: Examples to show if a safety measure is required

	Example 1		Example 2	
	Shell	**Tube**	**Shell**	**Tube**
Design pressure [barg]	10	12	10	16
Test pressure [barg]	13	15.6	13	20.8
Overpressure required?	No, because 13 > 12		Yes, because 16 > 13	
Set pressure of bursting disc [barg]	10		10	
Allowable pressure of the shell [barg]	0.9 x 13 = 11.7		0.9 x 13 = 11.7	

Please note that in the following chapters the high-pressure side is related to the pressure in the tubes and the low-pressure side in the shell.
If the higher pressure is on shell side or a pressure relief device direct on the heat exchanger is not possible, please refer to Chapter 8.

4 Pressure relief devices

In the following sections different pressure relief devices are shortly presented. Generally, there are two different types of pressure relief devices:

- Non-reclosing relief devices like bursting discs (see chapter 6) are often used to achieve an instant and unrestricted pressure relief. A calibrated membrane ruptures as soon as the set pressure is achieved and the fluid exhausts through the opened bursting disc. The membrane stays open after activation, resulting in a complete discharge in the downstream installation.
  Bursting disc and bursting disc are the synonyms, but the official BC-terminology is bursting disc.
- Reclosing relief devices like safety pressure valves or pressure relief valves (see section 7) provide opening for relief at a defined set pressure. As soon as the pressure drops below the set pressure, the valve recloses, and the over-pressure is relieved. This is also possible for vacuum applications. Typical applications of reclosing relief devices are pressure safety valves in the gas system after each compression stage or pressure safety valves to compensate thermal expansion of the cooling water system.

Depending on the specific application, a reclosing or non-reclosing relief device can be chosen. As shown in Table 2, they have sometimes complementary properties. However, the focus of this document is on bursting discs and their application. For details to pressure relief devices like spring-loaded pressure relief valves, please refer to the white book “Pressure relief valves”: TDO 2012968.

Table 2: Comparison between reclosing and non-reclosing relief devices

Property	Non-reclosing relief device (e.g. bursting disc)	Reclosing relief device (e.g. relief valve)
Complexity of device	Low	High
Investment cost	Low	High
After activation	Replace	Reset
Protection against over-pressure	Yes	Yes
Protection against vacuum pressure	Yes	No
Mounting position restrictions	None	Vertical only
Installation cost	Low	High
Maintenance cost	Low	High
Requires regular recalibration	None	Yes
Affected by back pressure	Yes	Yes
Operational testing possible	None	Yes
Leak tight	Yes	No
Selection of materials of construction	Large	Limited
Size range	Large	Limited
Change of set pressure	None	Yes
Suitable for gas / liquid / 2-phase	Yes	No
Reaction time	Low	High
Unrestricted opening	Yes	No

5 Sizing of bursting disc and exhausting line

5.1 Tube rupture

The considered base scenario is that one tube breaks and gas enters the shell from both sides(acc. to API521, para 4.4.14.2.2). The most likely breaking points of the tube are the tube sheet connection (ref. to Figure 2), the middle of the tube and the bending of the U-Tube.

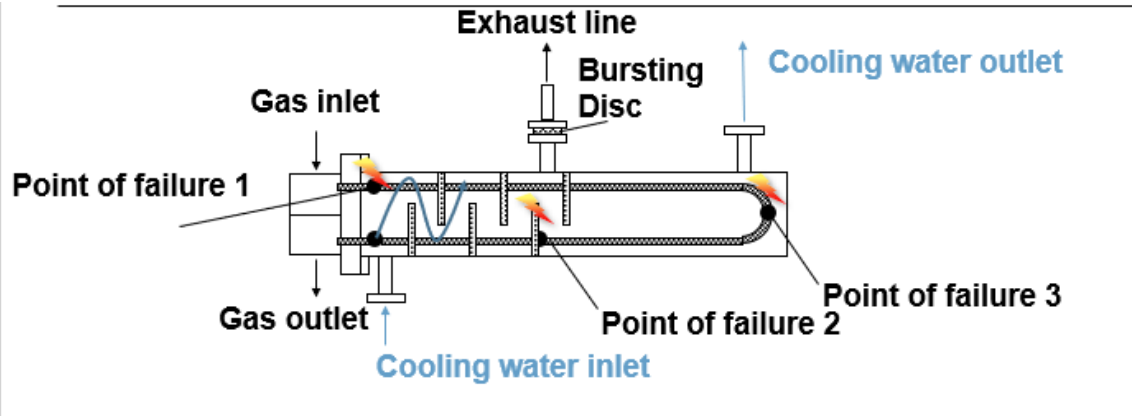


Figure 2: most likely breaking points

Once the tube breaks, the pressure will increase (Phase I), the bursting disc will break, or the relief valve will open. Water will be released (Phase II) as depicted in Figure 3.
BC assumes that the amount of water which must be released is identical to the gas volume entering the shell. Since the water is not compressible and causes a back pressure in the exhausting line, BC designs the Bursting disc in order that the safety device is able to release the water.

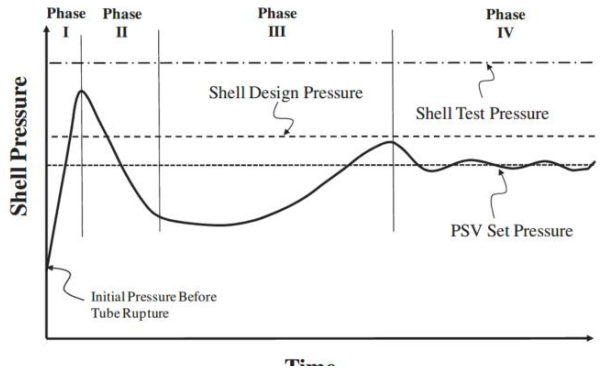
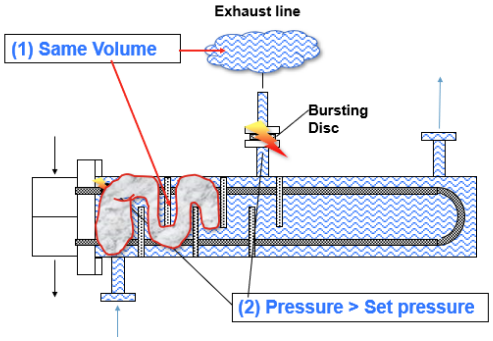


Figure 3 Pressure relief

The pressure inside of the Heat Exchanger (Point of failure) is higher as the set pressure.

5.2 Dimensioning of bursting discs

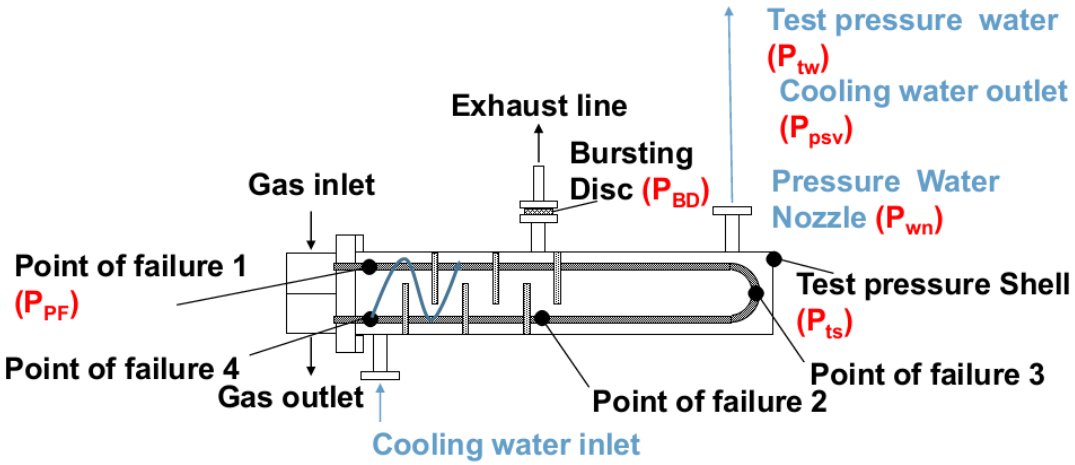
The size of the bursting disc depends on the amount of water to be released without causing back pressure. Therefore, the exhausting pipe must be as big or larger than the bursting disc opening diameter. This amount is strongly influenced by the diameter of the tubes, a rupture of a tube with an OD of 19.05mm would release less gas than a tube with an OD of 25mm.
For the calculation of the entering gas volume, sharp edge flow is assumed.
The number of Discs depends on the amount of water that must be released and on the pressure loss



within the heat exchanger. If the pressure loss within the heat exchanger is high, two bursting disc must be installed. The pressure loss depends on the tube number, pitch, and number of baffles. PEO can give design recommendation regarding disc position or baffle number as soon as the sizing of the cooler has been completed.
Please note that not only the heat exchanger itself must be considered for sizing the bursting disc. The cooling water system must also be considered, for instance the cooling water system design pressure should be higher than the bursting disc set pressure.
Note that PEO has a calculation tool to design the size and numbers of bursting discs.

5.3 Pressure consideration

For the definition of the size, certain pressure must be considered as explained below:



- Set Pressure Bursting Disc (**PBD**) > PSV Water system (**Ppsv**)
  - Water pressure fluctuation
- Pressure Point of Failure (**PPF**) < 90% Test pressure Shell (**Pts**)
- Pressure Water Nozzle (**Pwn**) < 90% Test pressure Water (**Ptw)**
- Pressure Point of Failure (**PPF**) ≠ Set Pressure Bursting Disc (**PRD**)
- = Set Pressure Bursting Disc (**PBD**) + Pressure loss in cooler
- Pressure Water Nozzle (**Pwn**) ≠ Set Pressure Bursting Disc (**PBD**)
- = Set Pressure Bursting Disc (**PBD**) + Pressure loss in cooler

In the 2 examples below the above criteria are fulfilled:

	Shell	Tube
Design pressure barg	10	30
Test pressure barg	15	39
PSV Water system (P_{psv}) barg	8	
Pressure loss P_{pf} to P_{BD} bar	0.5	
Bursting disc Set pressure barg	10	

Shell	Tube
12	250
15.6	325
9	
3.5	
10	

If the design pressure of the shell of the heat exchanger is higher than the design pressure of the cooling water system, the set pressure of the bursting disc shall be adapted to the test pressure of the cooling water system.

Please be aware that a pneumatic test pressure of times 1.1 can cause issue. As example pressure drop within heat exchange is bigger as the different between design pressure and test pressure, the set pressure must be set lower as the design pressure and may conflicts with the water PSV set pressure.

In heat exchangers with a design pressure over 100bar and large tube diameter (e.g. LDPE) a high pressure loss in the cooler can occur. Therefore, it is recommended to set the design pressure for the shell higher than the water system design pressure (between 12-15barg)

5.4 Sizing method acc. to AirLiquide and Linde

AirLiquide and Linde have simplified calculation methods for the released gas mass flow.

The gas flow is considered that one tube breaks and from both side gas enters the Shell. Flow Coefficent are given in the AirLiquide and Linde Formular (For more detail please contact PEO).
Air Liquide and Linde do not consider different breaking points, the release of water or the pressure loss in the shell.
Therefore, BC will only calculate according to those methods if clearly specified by the client and is aware of the simplifications taken. The engineering tool available for PEO to use.

5.5 Additional considerations regarding costs

The sizing of the bursting disc depends on the defined set pressure and on the temperature at which it is supposed burst. Since the opening of a bursting disc is irreversible and functionality must be absolutely ensured, additional discs must be produced and destroyed for testing purposes for every disc ordered. This has a big impact on the price; ordering multiple identical discs at once is much more cost-efficient.

Total number of discs in a production series	Number of discs to be checked
Less than 10	2
10 to 15	3
16 to 30	4
31 to 100	6
101 to 250	4%, but not less than 6
251 to 999	3%, but not less than 10
1000 and more	At least 30

Table 3: Bursting disc test procedure according to DIN-4126

For that reason, it makes sense to oversize bursting discs in certain cases, enabling the purchase of a higher number of identical discs. It is advisable to discuss this topic for the specific case with the supplier of the discs. Further, the additional costs for bigger flanges and sealing rings must be considered. In addition, it is recommended to combine the orders for multiple ships if possible.

6 Bursting discs

6.1 Types of bursting discs

In Figure 4, a typical bursting disc is shown. The conventional design is a pre-bulged membrane (BCAG standard), which fails at a pre-defined differential pressure (positive pressure or vacuum). As soon as the pressure inside the vessel to be protected (point A) exceeds the set pressure of the bursting disc, the disc brakes and the fluid exhausts (point B).
Note that the differential pressure is relevant in the application. The bursting disc stays open after its opening.
Bursting discs are especially applicable for very corrosive environments due to the variety of different materials. They are used to protect vessels in gas service, in liquid service and even with two-phase flow.



Figure 4: Schematic sketch of a bursting disc (on the left); new bursting disc as well as a triggered one (on the right)

There are two main types of bursting discs:

- Tension type bursting discs are installed with the concave side against the flow of the process medium. In the case that the medium pressure exceeds the set pressure of the bursting disc, the bursting disc will rupture due to its maximum tensile strength being exceeded. Figure 5 on the left shows a tension type bursting disc. Typically, tension type bursting discs are used if there are no pressure pulsations and if the ratio between bursting pressure and operating pressure is less than 80%.
- Reverse acting type bursting discs are installed with the convex side against the flow of the process medium. In the case that the medium pressure exceeds the set pressure of the bursting disc, the bursting disc is reversed (the curvature is flipped). In doing so, the bursting disc will rupture due to a pre-defined pattern of notches. The advantage is a non-fragmenting opening for which reason this kind of bursting discs is BCAG standard. Figure 5 on the right shows a reverse bursting disc before and after triggering. This kind of bursting disc is used if there are high pressure pulsations and if the ratio between bursting pressure and operating pressure is higher than 80%. Reverse acting bursting discs do not work if they are in direct contact with water; an air cushioning between the disc and the water is required.

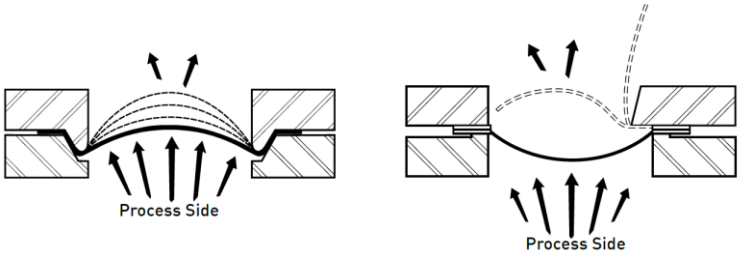


Figure 5: Tension type bursting disc (on the left) and reverse acting type bursting disc (on the right)

Additionally, process parameters like the kind of service (gas or liquid), the operating temperature or pressure as well as material requirements (e.g. corrosion) have to be considered for the correct bursting disc selection.
Bursting discs are available in different materials like

- Metal
- Graphite
- Composite
- Others

The material choice depends on the application and the process gas. In most BCAG applications, the membrane is made of metal. Corrosion of the very thin metal membrane can cause a failure of the disc at lower pressures after short service time. Due to the fact that many factors influence the lifetime, there is never a guarantee on the service lifetime for bursting discs.

6.2 Double-type bursting discs

The functionality of a bursting disc is only given, if the back pressure is known and constant. If this is not the case, a double-disc assembly is applied, where two identical discs are placed in series. This layout has two main advantages: The inner disc is guarded against external influences like pressure fluctuations, changes in gas composition or moisture. In addition, a redundancy is introduced: In case of leakage of one disc, the cooler is still sealed off against the environment. Thus, this setup is used for toxic and/or valuable fluids. To detect possible leakages at the inner disc, an intermediate pressure indicator with a connected shut-down is required. In marine applications, the setup with two serial bursting discs and an intermediate pressure transmitter is the only one that can be certified.

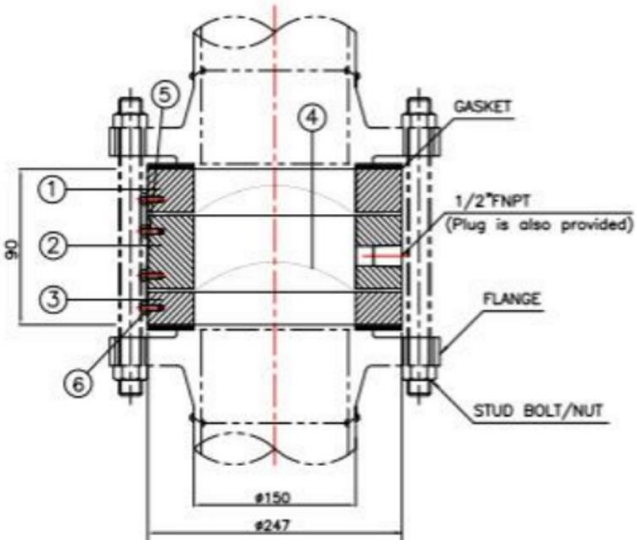


Figure 6: Double-disc assembly

For the pressure transmitter, only a HH-transmitter is required; due to the fast increase in pressure in case of a tube rupture, an H-transmitter would not have any additional vlaue. It is recommended to define the set pressure of the HH-transmitter close to the back pressure, e.g. at 1 barg in case of atmospheric back pressure. This prevents accidental opening due to normal pressure fluctuations or changes in temperature, but still allows a proper reaction of the disc by allowing a longer pressure peak. Thus, an orifice is not required. In case of questions, contact PEO or I&C. A typical setup is shown in the following picture:



Figure 7: Double-type bursting discs, including pressure transmitter, mounted on top of a cooler.

6.3 Installation of bursting discs / bursting disc holders

Typically, bursting discs are installed in a holder, which consists of a base flange (at the inlet) and a hold-down flange (at the outlet) as shown in Figure 8. The holder is designed to:

- align the bursting disc in a defined position
- provide a tight sealing
- prevent fragmentation of the bursting disc
- optimize the flow through the assembly

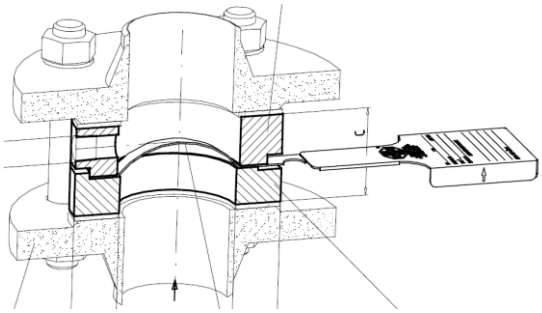


Figure 8: Typical installation of a bursting disc: the bursting disc is clamped in a holder, which is installed between two flanges

The inside of the dome (concave side) is exposed to the pressure. There are different holder types like bolted type (used in most of BCAG applications), screwed type, union type, pre-torqued type or double type (see Figure 9).
If a bursting disc leak detection is required, a double disc assembly consisting of three holder components (an additional mid-flange) can be used.

The bursting discs shall be installed at the top of the vessel, so that there is no risk of contamination and sediments (e.g. dirty cooling water in a heat exchanger). It is advised to place the discs as close as possible to the vessel in order to minimize pressure losses and reduce costs by avoiding additional flanges.



Figure 9: Different bursting disc holders: bolted type (left); pre-torqued type (middle); double type (right)

6.4 Combination of a bursting disc with a pressure relief valve

The combination of a bursting disc with a pressure relief valve is also state of the art (see Figure 10): In this case, the bursting disc gives a positive seal compared to a disc-to-seal design of a spring-operated valve. This is advantageous when handling toxic gas. The spring-operated relief following the bursting disc resets when the pressure drops below the blow-down pressure. So, the discharge of the vessel is stopped. According to ASME, a pressure detection device needs to be placed between bursting disc and spring-operated valve. It has to be considered that the bursting disc has no pinhole because a pin-hole leak increases the pressure on the discharge side of the disc. Therewith, the relief pressure is increased because the differential pressure across the bursting disc is the rupturing mechanism. In case of rupture: The bursting disc needs to maintain its integrity when it is ruptured, so

a non-fragmenting membrane is required which ensures that no pieces of the bursting disc will plug the discharge orifice.

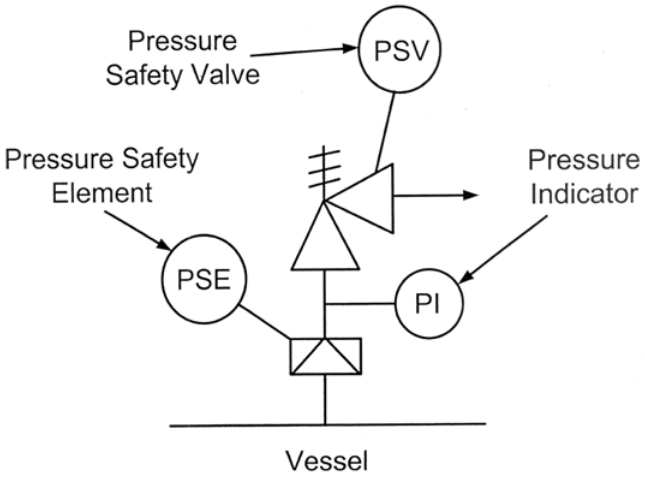
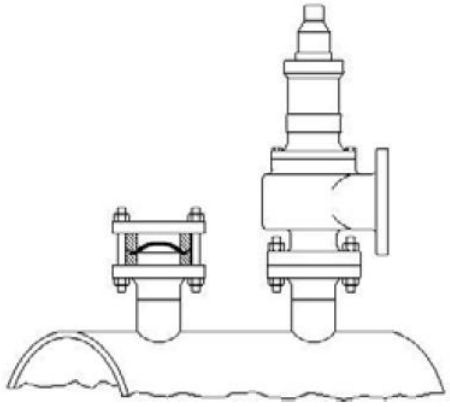
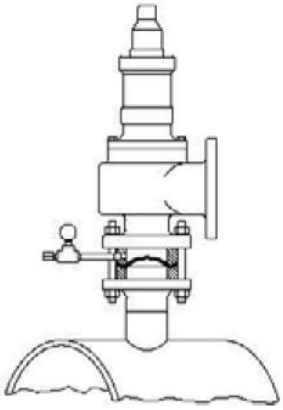
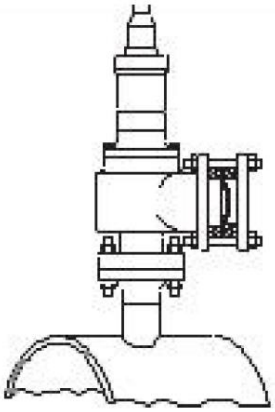


Figure 10: Combination of a bursting disc with a pressure relief valve

Table 4: Comparison of different combinations of bursting disc and relief valve

Bursting disc in parallel with relief valve	Bursting disc in series with relief valve
	Bursting disc upstream of the relief valve:  Bursting disc downstream of the relief valve: 

Relief valve to handle the over-pressure; with bleeding the pressure until acceptable value is achieved. Bursting disc to relief the over-pressure if the over-pressure cannot be effectively relieved by the relief valve → bursting disc provides a secondary (back-up) relief path → higher safety	Installing a bursting disc upstream of the relief valve has following advantages: - Plugging of the relief valve is prevented - Corrosion of the relief valve internals is prevented - Leakage through the relief valve is prevented - Testing of the relief valve on site is possible It must be ensured that in a case of failure (bursting disc opens) no fragmentation of the membrane takes place. The size of the bursting disc shall be the same as the inlet of the relief valve.
	Installing a bursting disc downstream of the relief valve has following advantages: - Corrosion of the relief valve is prevented - Fouling and sticking of the relief valve are prevented - Leakage or opening of the relief valve are detectable - Superimposed back-pressure from the relief valve is prevented This combination of bursting disc and relief valve is relatively unknown. It must be ensured that the set pressure of the bursting disc is low enough so that the performance of the upstream relief valve is not affected by the opening of the bursting disc.
Set pressures of the bursting disc shall be higher than the set pressure of the relief valve (according to ASME section VIII, division 1: the set pressure of the bursting disc shall not exceed 116% of the equipment design pressure; according to European pressure equipment directive 93/23/EC EN 764-7: set pressure of the bursting disc shall not exceed 110% of the equipment design pressure)	Both alignments create higher safety due to the second pressure relief device. Maintenance costs are reduced which → reduced cost of ownership and investment → cost savings

6.5 Specification of bursting discs

PEO will calculate the size of the bursting disc and deliver a table of the required gas/waterflow for the specification.

The strength of materials depends on the temperature, so the burst pressure also depends on the temperature. Therefore, the operating temperature as well as the ambient temperature must be specified. The temperature used for the design by the supplier is mostly the temperature of the disc at which it is expected to burst.

The lifetime of a bursting disc is mainly influenced by

- Pressure cycles
- Temperature cycles
- Duration of the cycles
- Installation
- Corrosion

6.6 Maintenance

It is recommended by API 510 to inspect pressure vessels periodically. An inside inspection is quite difficult because the vessel has to be taken out of service. External inspections are made more frequently and consist of visual and non-destructive testing like radiographic tests, ultrasonic tests, or eddy-current tests. For bursting discs, especially the corrosion and the thinning of the membrane has to be monitored.
During operation, large temperature differences between the outside and the inside of the vessel have to be avoided to reduce stress inside the material.

6.7 Alert sensors / bursting disc indicators

Burst indicators are used to monitor the condition of the disc (see **Error! Reference source not found.**). Depending on the device selected, an alarm, a bell or a remote annunciator can be activated to start with appropriate follow-up safety procedures.
Burst indicators operate in a 'normally closed' electrical circuit, so it can be detected if the disc is closed (normal condition) or if it is opened (after disc rupture due to over-pressure). The electrical circuit is supported by a polymer (Polyimide or PTFE) membrane, which provides electrical insulation.
If conducting fluids can relief through the bursting disc, the burst indicator technology has to be checked with the supplier.



Figure 11: Bursting disc with burst indicator (on the left) and a single burst indicator (on the right)

7 Spring-loaded pressure relief valves

- Safety valves for gases and vapours
- Relief valves for liquids
- Safety relief valves for liquids and / or gases

As soon as the pressure inside the vessel to be protected (see **Error! Reference source not found.**, point A) exceeds the pressure created by the spring, the valve opens and the fluid exhausts (see **Error! Reference source not found.**, point B). The valve opens at the set pressure which is normally at or below the maximum allowable working pressure.

For more information refer to TDO 2012968

8 No bursting disc on cooler

For larger heat exchangers (nozzle size larger than 6") as used for LDPE, bursting disc are relatively easy to implement. However, for smaller high pressure coolers, the use of bursting discs can be impractical. The bursting disc can be bigger as the nozzle itself and may not be installed on the cooler or/and the cost will increase due adaption of the cooler. Therefore, some alternatives are possible.

8.1 Bursting disc on CW pipe

A relive valve/bursting disc can be installed on the cooling waterpipe. The pressure drop in system and heat exchanger must be considered and designed; accordingly, may the shell pressure must be increased. The pressure relive valve must be design in with the same philosophy as above so that the water can be released.

8.2 Increasing the design pressure of the shell

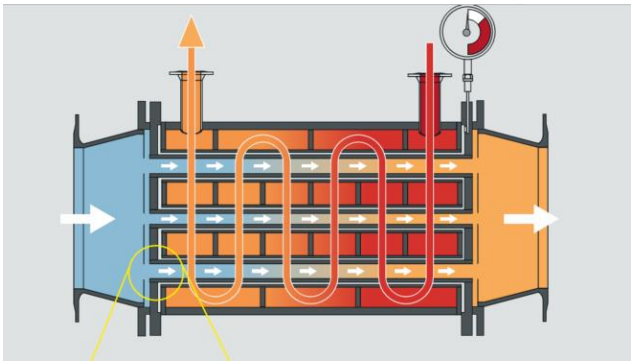
In order to avoid a bursting disc, the shell pressure shall be increased until the rule as explained in Chapter 3 is satisfied. This is a valid approach for limited use cases. For instance:

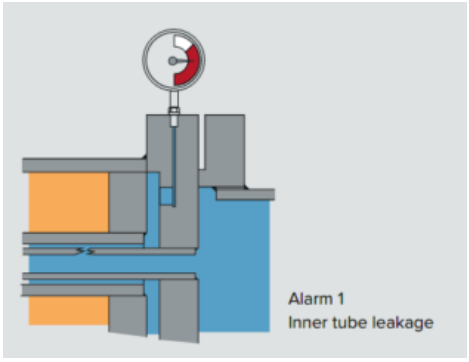
- The open water system of the client must be able to push the water out without creating a too high back pressure (e.g. P-0370).
- For a closed water system, the water system must have the same design pressure as the shell and will be only economic at low pressure, typically < ~20bar.

8.3 Double safety tube

Unlike a standard shell & tube heat exchanger with a single wall design, the tubes in double tube safety models have two walls, consisting of an inner and outer tube. They also have two tube sheets at each end. If a tube wall is damaged, the product flows through leakage channels arranged between the double tubes into a leakage collection space and triggers an alarm in the leak detection device. Because the second tube wall remains undamaged, the media are kept separate. Double tube safety heat exchangers play a role in applications where the prevention of media mixing in the event of a leak is a hard requirement. So far BC does not have experience with this kind heat exchanger.

[Source: Kelvion]





8.4 Printed Circuit Heat Exchangers (PCHE)

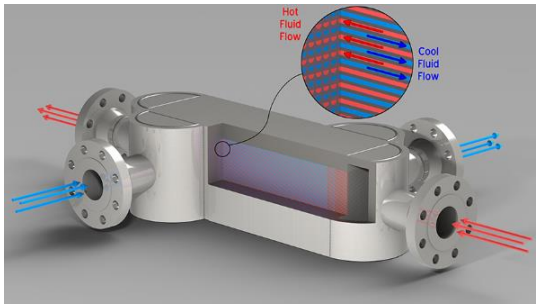
The Printed Circuit Heat Exchangers (PCHE) has micro-channels in stainless steel material. The diameter of the tubes lays in the typical range of 1-2 mm. They are typically suitable for high pressure or/and high temperature applications.
For more info DOCPROPERTY SAPto TDO 2011219 E03.

Being part of a solid core structure in stainless steel material (see below figure) the channels cannot experience a rupture, but cracks might happen (as a results of fatigue or/and corrosion). The amount of gas released in such failure case is little, hence the leakage rate from the high-pressure side to the low-pressure side or to the atmosphere is low.
Plate, PCHE and Heat exchanger cracks are described in API 521 4.4.14.4.

It is not necessary to include a bursting disc to protect these types of heat exchanger. In order to further reduce the risk of leakage over a long time due to a crack, it is recommended to install leak detection device. As further protection measure, PSV in the cooling (i.e. water) system side can be installed. This must be evaluated on a case-by-case project basis. See as well 8.5 Leak before Break.

As per 2025 BC has limited experience with PCHE but has been already installed for H2 application.

[Source: VPE]





8.5 Leak before Break

As explained in previous sections, one tube will most likely leak before it breaks. This concept can be considered where no code requirements apply to comply with a full tube rupture (as example PCHE Exchanger). This concept is to be agreed with client.

The leak needs to be detected after a reasonable time, to prevent further crack growth which can lead to a more severe until catastrophic failure.

Depending on the gas, a gas detector in the water can be installed. There are other measuring methods to detect gas leaks in water, for instance level monitoring or pressure measurement on the highest Point Example:

- Henry Standard E-0029 (PEO08020)
- P -0450

Alternative solutions via pH, infrared or conductivity measurement are also possible; but have not yet been implemented. After building more experience it can be described m

Note that the cooling system needs to be designed to handle the estimated leakage. Closed water systems with bladder have a small expansion volume, therefore if a small leakage occurs the pressure in the system will rise immediately. As example in P-0450 a simulation showed that the pressure in the water system rises within 2 sec in case of a 1g/s. The sizing of the PRV must consider this leakage for the overall volume displacement.

With closed cooling system with open tank the pressure rise is much slower than with the bladder design. In this case the tank design and the hazard to atmosphere leak must be checked.

By open cooling water system (direct Client connection), it may be acceptable to handle the volume displacement (example P-0370); this must be carefully checked on a case-by-case basis with client.

8.5.1 Leaks estimation / calculation

The methods and assumptions how to calculate the amount of leak is under consideration; this chapter will be completed later after gaining more project experience.

Some considerations can be found in API 521 4.4.14.2.2

9 Exhaust line

The outlet connection of the pressure relief device is connected to an exhaust pipe which blows off the fluid, normally to safe location with atmospheric pressure. Depending on the fluid to be exhausted the exhaust line ends in:

- atmosphere, which is possible if the exhausted fluid is innoxious and if regulations allow that procedure.
- vessels which are designed to withstand all over-pressure scenarios, e.g. sufficient high design pressure.
- effluent system, e.g. knock-out drum, quench tank, catch tank, cyclone separator or flare (see **Error! Reference source not found.**).

It must be considered that the pipe to the header shall be as straight as possible due to the extensive forces which might act during relieving the over-pressure.

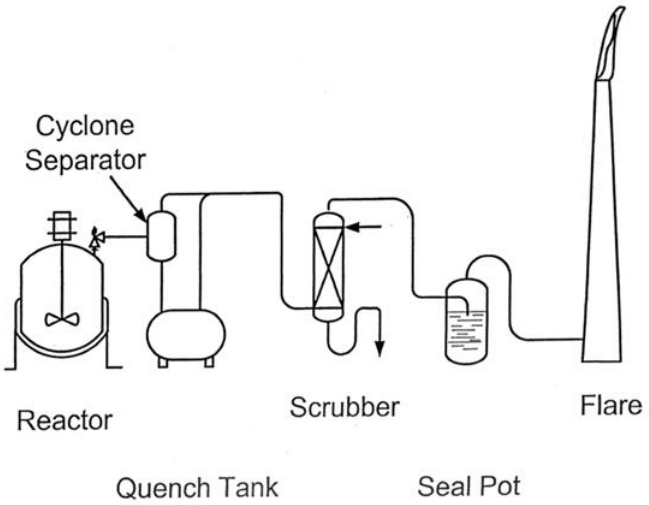


Figure 12: Effluent system consisting of different components

10 Best practice

Here is listed a collection of best practice recommendations based on previous project experience by PEO.

- It is recommended to install bursting discs on the top of the heat exchanger to avoid plugging and blinding of the bursting disc due to dirty cooling water.
- Design pressure of the shell shall be higher than the design pressure of the cooling water system, e.g. equal to the PSV pressure of the cooling water system.
- Safety pressure of the bursting disc shall be higher than the safety valve pressure of the cooling system.
- Design pressure of the shell depends on the design pressure of the tube, usually it is 10 to 20 barg
- Depended on the fluid pressure on tube side, only one bursting disc may be sufficient (< 50 bar g); to be checked PEO.
- The pipe to the header and the header sizing shall be as straight as possible due to high forces in a case a failure; to be checked with CAD.
- Including spares, three to five bursting discs per size shall be ordered.
- F-type of shell with tube OD 25.4 mm calculating bursting disc is difficult with the current excel tool due to higher mass flow through tube. When in such case try to reduce the tube OD if possible or check with PEO for initial discussion. DOCPROPERTY SAPe.g. P-0437
- For Heat exchanger with light molecular weights such as H2, the tube failure approach must be checked carefully. In most of the cases the shell of the heat exchanger is too small to place a bursting disc. Either the bursting disc can be placed on the CW pipe or the leak before break can be considered.

11 Applicable codes and regulations

11.1 Overview

- American Society of Mechanical Engineers (ASME): Boiler and pressure vessel code, section VIII, division 1
- American Petroleum Institute (API): API standard 520: Sizing, selection and installation of pressure-relieving devices

- Safety devices installed in countries of the European Community are to be designed, manufactured and tested acc. to the “Pressurized Equipment Directives 97/23/EC” (PED). They are to be classified in “Category IV”, fluid group 1 or 2, depending on the handled fluid. It is not of importance whether the valves are sized acc. to AD 2000 or ASME / API
- ISO 4126-2:2003: Safety devices for protection against excessive pressure – Part 2: Bursting disc safety devices
- ISO 4126-3:2006: Safety devices for protection against excessive pressure – Part 3: Safety valves and bursting disc safety devices in combination
- ISO 4126-6:2014: Safety devices for protection against excessive pressure – Part 6: Application, selection and installation of bursting disc safety devices

11.2 ASME UG 150

According to ASME, bursting discs shall rupture within a tolerance of ±5 % if the specified set pressure is higher than 40 psi (2.76 bar).
Sizing according to ASME:

- Coefficient of discharge method (K_D):
  The coefficient of discharge, K_D, is applied to the theoretical flow rate to determine the rated flow rate. This method is suitable for simple systems when the discharge side of the bursting disc is connected directly to atmosphere and of the 8/5 rule is fulfilled (the bursting disc is installed within 8 x pipe diameter of the vessel and the exhaust pipe after the bursting disc does not exceed 5 x pipe diameter).
- Resistance to flow method (K_R):
  This method is used when the 8/5 rule cannot be fulfilled, e.g. if the bursting disc is installed in combination with a pressure relief valve or if the flow is turbulent. K_R is a coefficient which represents the velocity head loss due to a bursting disc. This method is based on analyzing the flow capacity of the complete relief piping, which enables to determine the size of the bursting disc.
- Combination capacity method:
  This method describes the sizing if a bursting disc is combined with a relief valve. Details are described in the technical bulletin TB8101 from FIKE.

11.3 ISO 4126

In ISO 4126 series two different approaches to size bursting discs are presented: a simplified method, which neglects pressure drops in the upstream and downstream piping and a more extensive method which considers the pressure drops in the relief system.
ASME defines different test methods to check if the bursting discs are manufactured correctly (rupture at the specified set pressure). The most common test is to use two bursting discs of the manufactured lot for testing. Therefore, it is recommended to order at least 3 to 5 bursting discs.

11.4 API Code

API 521 June 2020 Chapter 4
describes the causes of overpressure and the philosophy resp. determination of individual relieving rates.

API 618 5th Chapter 7.8.1.2

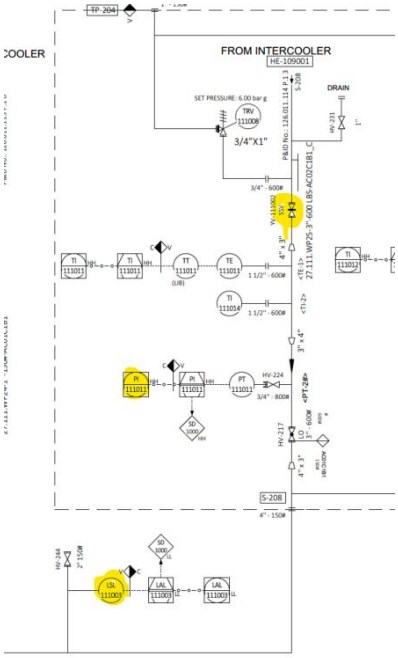
—the use of shell side rupture discs, relief valves or similar devices;

API 614 6th Chapter 7.6.8
API521 Pressure-relieving and de-pressuring System

7.6.8 Rupture disks on the shell side of fixed tube sheet heat exchangers (to protect the shell in case of tube failures) shall be used only if specifically approved by the purchaser.

12 Lesson learned

12.1 P-0450



For P-0450_Storage Etzel 01, Tube rupture scenario was not considered at the time of pre-bid, meaning no specific safeguards were considered. The closed CW system, including a bladder accumulator, lacked an expansion of Cooling water to handle a tube rupture.
First it was intended to rate the whole water system at the Desing pressure of the Water system, which is not possible for a Bladder system.
Second proposal from BC was a Tuning fork-type level switch, pressure transmitters, and bursting disc.

However, the customer argued that gas leakage would occur too rapidly, potentially compromising system safety before the level switch could activate the trip. Their simulation results showed that gas could pressurize the CW system beyond design limits within approx two seconds.:
they insist on implementing their own solution, which consists of automated shut-off valves and high-integrity differential pressure transmitters. However, as per BC experience, the proposed solution is not sufficient to safeguard the system in event of a tube rupture in gas coolers. If gas pressurizes the system within two seconds, an automated isolation valve requiring up to 10 seconds to close, would not effectively safeguard the CW system.
Finaly installed has been a level Switch in the Cooling System, PE/PT in the Cooling System and Shut off Valve.

13 Reference documents / Standards

TDO 2012968	Pressure Relief Valve (PRV) White book
TDO 2011219	Tubular exchanger White book

14 Revision index

Rev 03	8.4 Printed Circuit Heat Exchangers (PCHE) 8.5 Leak before Break Review of document
REV 04	12. Lesson learned
Rev 00, 16.03.2026	5.5 Additional considerations regarding costs 6.2 Double-type bursting discs Minor corrections of typos, sentence structures