RUPTURE DISCS FOR PROTECTING PLANTS FROM OVERPRESSURE

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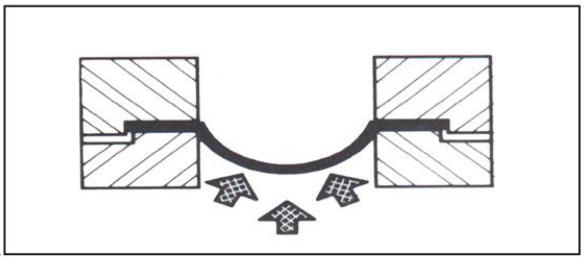
1. INTRODUCTION TO RUPTURE DISCS

Rupture discs are safety devices used to protect pressurised systems and equipment from over pressure and/or vacuum. They are devices that perform the same basic function as safety valves. The main difference however being that they intervene as a result of the differential pressure to which they are subjected but then they cannot be re-closed (in fact, they must be replaced once opened).

Typically, rupture discs are devices composed of an assembly that also includes a special container called holder and, when necessary, other components such as: a vacuum or back pressure support, a reinforcement ring, a rupture detector, etc.



Rupture discs are pressure-tight devices designed to open by means of rupture at a pre-predetermined pressure value.
There are different types of rupture discs manufactured in corrosion resistant metals or in graphite. They can cover a wide range of sizes, rupture pressures and operating temperatures.

Rupture disc have many advantages:

- They are often the more economical solution with respect to other types of pressure relief devices (especially when it is necessary to utilise particularly expensive materials or to ensure high discharge areas).
- They are available in a wide range of sizes, materials and calibration pressures.
- They have a low maintenance cost.
- They have no components in relative motion to each other and therefore guarantee faster intervention times than other pressure relief safety devices.
- They ensure an excellent level of system sealing, thus helping to reduce the risk of fugitive emissions of toxic, dangerous or precious substances.
- They make it possible to isolate the safety valve from contact with corrosive or fouling fluids.

2. COMPARISON WITH SAFETY VALVES

Rupture discs are often thought of as alternatives to safety valves. Both were developed to relieve overpressure, but in fact they have extremely different characteristics, detailed below:

When comparing the main features of these two devices the main differences are:

EQUIPMENT	RUPTURE DISC	SAFETY VALVES
Type of device	Simple	Mechanical
Installation position	All positions	Vertical only
Behaviour when overpressure ceases	Does not re-close: The disc must be replaced	Re-closes
Protects from overpressure	Yes	Yes
Protects from vacuum	Yes	No
Periodic calibration check	Not required	Required
Possible to change calibration	No	Yes
Calibration lower than 0.1 bar	Yes	No
Calibration higher than 500 bar	Yes	No
Availability of diameters	High	Limited
Availability of materials	High	Limited (and expensive)
Operating losses	No	Possible
Maintenance	Minimum	High
Costs	Low	High

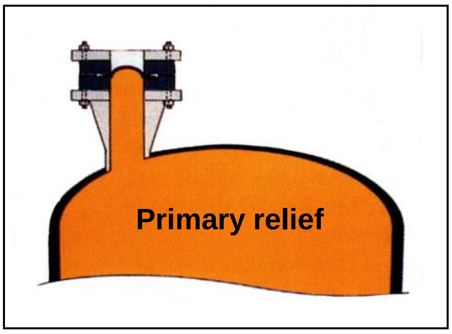
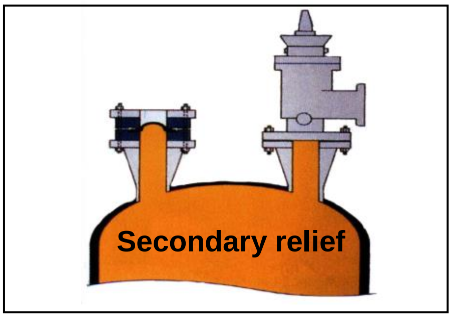
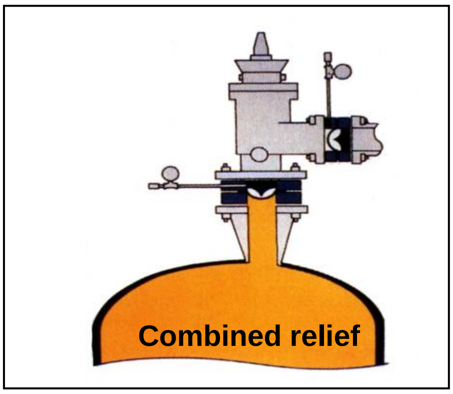
Comparing advantages and disadvantages of the two devices, it is clear that are in fact complementary.

RUPTURE DISC	SAFETY VALVE
Non-reclosing device This has been designed to open a closed and pressurised system once a predetermined pressure value has been exceeded.	**Reclosing device** Designed to open a closed and pressurised system once a predetermined pressure value has been exceeded and to close the same system as soon as pressure falls within the acceptable limits.
Advantages Simple construction, economical, has no moving parts, is airtight, can guarantee full passage without obstructions and smooth surfaces in contact with the process.	**Advantages** There is no permanent opening and it is therefore suitable for continuing operation after intervention.
Disadvantages Once it has intervened, it is not re-closable and must be replaced.	**Disadvantages** Has a relatively complex construction with orifices and shutters that reduce relief and may be potential sources of losses due to leakage.

Since rupture discs are differential pressure devices, avoiding pressure accumulation is essential to ensure correct disc opening at the desired bursting point. Excess flow valves are used when rupture discs are installed together with a safety valve. Excess flow valves close when exposed to the rupture disc discharge flow.

Combined use of rupture discs and safety valves

Safety valves and rupture discs can be used separately as primary safety devices or they can be used together. The possible combinations are:

Primary relief : When the rupture disc is installed as the sole safety component for pressure relief from a closed system or device. Considering that the system or the device on which it is installed remains open after rupture disc intervention, disc use is usually limited to those applications that require pressure relief in emergency limit conditions or when the required relief areas are so large that the use of safety valves is not recommended. In this case, the nominal rupture disc pressure must not exceed the design pressure of the system or device to be protected.	 **Rupture disc: Primary relief**
Secondary relief : When the rupture disc is installed to ensure a second relief output of pressure in parallel use with a safety valve (or with a second rupture disc). A passive device like a rupture disc is installed as additional safety to the safety valve, which is instead the active device. The safety valve will relieve the overpressure, but the disc can ensure further safety in the event of abnormal valve functioning or if the relievable flow rate through it is insufficient.	 **Rupture disc: Secondary relief**
Combined relief : When the rupture disc is installed between the safety valve and the process, thus reducing the normal leakage of fluid through the valve seats and protecting it from corrosion and/or any obstructions due to polymerisation or fouling. The use of a rupture disc in combination with a safety valve combines the typical sealing advantages of discs with those deriving from the possibility of reclosing relief typical of safety valves. A rupture disc can also be installed on safety valve disc discharge to prevent contact with any corrosive fluid present in the discharge manifold.	 **Rupture disc with safety valve**

3. MAIN RUPTURE DISC CHARACTERISTICS

Main information required for correct rupture disc selection, is:

Nominal size or nominal flow rate:

Depends on the amount of fluid to be discharged in the unit of time and varies according to the risk considered (external fire, manoeuvring error, uncontrolled reaction, deflagration or other) and of the design code adopted.

Nominal rupture or burst pressure:

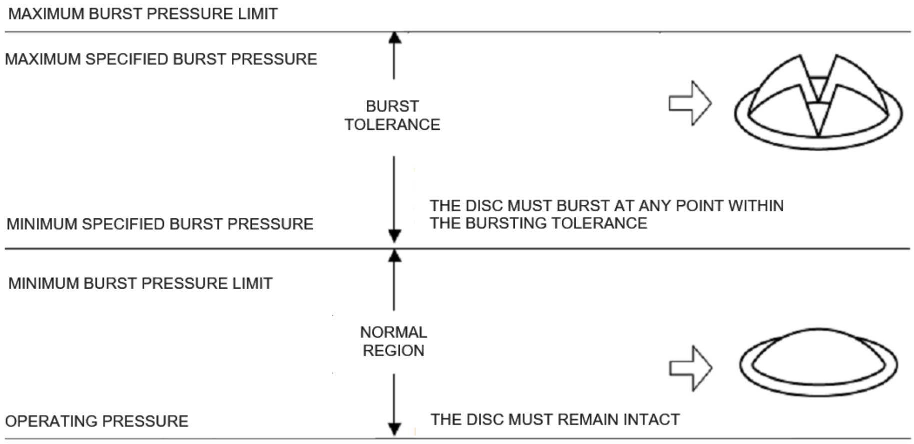
Depends on the design pressure of the system to be protected which, except in special cases, takes on the nominal rupture pressure of the disc = design pressure of the system to be protected.

Tolerance on the nominal rupture pressure value:

The tolerance allowed on the nominal rupture pressure value essentially depends on the normal operating pressure of the system and on the overpressure allowed by the design code adopted and is normally +/- 5%.

Operative margin:

One of the first parameters to be considered to prevent premature failure due to disc fatigue. Basically represents the ratio exiting between the operating pressure and the calibration pressure. The operative margin or ratio varies depending on the type of disc utilised.



Temperature:

Since the disc consists of one or more membranes which must rupture, it is easy to understand how the process temperature has a direct influence on its nominal rupture value. For this reason, the following temperature values must be known in order to select discs:

- the temperature coinciding with the rupture pressure at which discs should be calibrated
- the min/max operating temperatures to verify material compatibility

Fragmentation:

In some specific applications, such as for example sanitary or safety valve isolation, it is necessary to select discs that do not release fragments during the rupture phase.

Vacuum resistance:

In cases in which the rupture disc must operate under vacuum during normal system operation, an appropriate type must be selected or a special support must be interposed under the disc, paying attention to the fact that some vacuum support types reduce heavily the effective passage section of the disc.

Type of fluid to discharge:

Special attention must also be paid to the state of the fluid to be discharged because not all types of discs are suitable for discharging non-compressible fluids.

Marking:

All the essential data of both the manufacturer and the protective device are indelibly marked on the rupture disc or on a metal plate welded to the disc.

4. MAIN TYPES OF RUPTURE DISCS

A classification of the main rupture discs can be made by considering the three characteristic factors analysed below:

Materials:

There are two types of materials used rupture disc construction:

- Metal materials (the most common are stainless steel AISI 316, special alloys such as Hastelloy, Monel, Inconel, or Nickel, Titanium and Tantalum in particularly critical cases)
- Impregnated graphite

Type of seal:

The type of seal is determined by the type of insertion in the pressurised system utilised for the rupture disc, which can be carried out in two ways:

Installing the disc in a special container commonly identified by the term "disc holder" and consisting of two or more metal sections which, once tightened, guarantee a "metal-on-metal" seal.

Installing the disc directly on the pressurised system flanges, eventually interposing a sealing element (normally only possible for low pressure discs or some impregnated graphite discs called "monoblock").

Disc profile/design:

In the absence of a complete unification of the rupture discs, manufacturers of this kind of devices have developed various types of discs for different uses:

Conventional (or direct) domed discs (usually to be installed with a disc holder): The principle adopted to assign a predetermined burst pressure is simply the failure of a metal membrane subjected to a load in its concave part.

Solid conventional discs are composed of a single domed metal membrane with an extremely simple design but also with limited application possibilities. This type of disc causes fragmentation of parts as a function of the pressure increase gradient. **Type Ex:** *STD discs*

Conventional composite discs are formed of three parts: a carved, perforated metal section, a seal membrane (usually in PTFE) and a protective bottom. **Type Ex:** *DCD discs*

Conventional scored disc consisting of a single metal layer with radial incision lines whose task is to predetermine the rupture point and avoid part fragmentation. **Ex:** *SCD discs*

Reverse-acting or compression discs (to be installed with a disc holder):

The principle adopted to assign a predetermined burst pressure is the failure of a metal membrane subjected instead to a load in its convex part.

These discs resist absolute vacuum without the need to interpose any supports and, at the same operating conditions, they have a longer life cycle than conventional discs.

Ex: *SCR / KRD / Y90 discs*

Flat metal discs (to be installed directly between flanges):

Generally manufactured for low or very low calibration pressures. The principle adopted to assign to these discs a predetermined burst pressure is always the failure of a metal membrane subjected to a load exercised by pressure. The peculiarity of this type of disc is that it can be installed directly between the flanges simply with the interposition of a seal.

Type Ex: *DIF / LPD / TCD discs*

Graphite discs:

Obtained from blocks or sheets of graphite impregnated with resins (generally phenolic) to make it impermeable. In the event of rupture, they always give rise to part fragmentation.

They are available in two basic versions:

- **Monoblock graphite type disc** (to be installed directly between flanges):

Obtained from a single block of graphite for installation directly between flanges with interposition of a seal. Given the extreme fragility of this solution, the disc can be reinforced on its outer rim with a metal ring whose purpose is to support the load resulting in the tightening torque and any imperfections in the alignment of the flange planes. **Type Ex:** *GM / GA discs*

- **Replaceable graphite type disc** (to be installed with a disc holder) :

Obtained from a slab of graphite for installation on a specific graphite or metal disc holder.

Type Ex: *GR discs*

Rupture discs for sanitary connections (tri-clamp):

Applications in the pharmaceutic, food and biotechnological sectors require the use of rupture discs capable of ensuring the respect of all the strict hygienical norms which are intrinsic to this kind of industrial process. Discs can be provided with a perfectly smooth surface, which can be easily subject to procedures including C.I.P. and S.I.P. Rupture discs can be inserted in Clamp or Tri-Clamp connectors, thanks to their PTFE gaskets.

Type Ex: *SCD / SCR / Y90 / KRD discs for clamp application*

Rupture discs in sealed units ready for assembly

These are small rupture discs welded to a fitting or inserted in special threaded and sealed containers, ready to be very easily installed even in the most critical positions, without the need for particular specialisations

Type Ex: *SUM / SUT sealed unit*

5. RUPTURE DISC ACCESSORIES

Some accessories are normally available to extend the field of rupture disc application, including the following:

Vacuum supports:

Metal or graphite supports able to help rupture discs operating under a vacuum or with imposed or accidental back pressures withstand (for example installations of several discs whose relief is conveyed into a single manifold).

Surface coatings:

Plastic coatings (vinyl, Teflon, etc.) or metal (gold or Tantalum foil) can be used to improve the resistance to corrosion or to increase the level of cleaning/non-adhesion.
These coatings can be applied by means of added layers (lining) or using a surface coating.

Rupture Indicators:

Devices capable of detecting the rupture of discs and opening/closing an electrical circuit which, when properly powered, can make the start of any signalling and intervention sequences possible.

As an alternative to normal instrumentation, rupture disc manufacturers have developed simple and compact devices basically consisting of an element similar to a flat rupture disc to be installed between the disc holder and the counter-flange on the relief side:
This element incorporates a film made of conductive material that tears off when fluid passes, consequently rupturing the disc and therefore, if properly powered, can open the electrical circuit in which it has been inserted.

Other instruments:

Often the designer decides to install other instruments able to detect the variation of any atmospheric parameters downstream of the rupture disc, such as for example:

- Pressure by means of a pressure switch
- Temperature by means of a thermostat

In other cases, the designer may resort to the use of more specific systems such as flow sensors, photocells, etc.

6. RUPTURE DISC SELECTION CRITERIA

Tables shows the main characteristics and typical applications of the various rupture discs treated, by way of example, for quick selection in various process applications.

DISC TYPE	CHARACTERISTICS	APPLICATIONS
Solid conventional	Possible fragmentation	General uses
Cambered composite	No fragmentation	General uses also with safety valves
Reverse-acting	No fragmentation	Uses with safety valves
Flat	Installed directly on flanges	Low pressure vessels
Graphite	Fragmentation	Corrosive fluid vessels
Sealed units	Installed by the manufacturer	Used at high pressure
Sanitary connections	Sterilisable	pharmaceutical or food industries

PRESSURE RANGE	DISC TYPE
Very low	LPD
Low	DIF
Low - Medium	DCD / TCD
Low - Medium	Y90
Medium	SCR & KRD
Medium - High	SCD
Medium - High	SU/M
High – Very high	SU/T

MATERIAL	MAX TEMPERATURE
PTFE	260 °C
Titanium	316 °C
Nikel 201	400 °C
Monel 400	425 °C
Stainless Steel	454 °C
Inconel 600	475 °C
Hastelloy C276	575 °C
Inconel 625	600 °C