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Safety devices for overpressure protection.

Rupture discs: applications, sizing, and types

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Summary

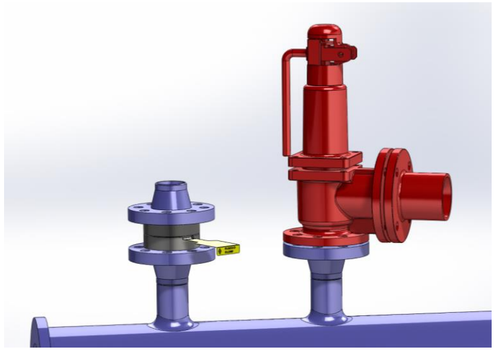
- Devices for overpressure protection
- Pressure Safety Valves and Rupture discs
- Rupture Disc properties and application parameters
- Evolution of rupture disc models and performance
- Evolution of manufacturing technology
- The laser scoring process

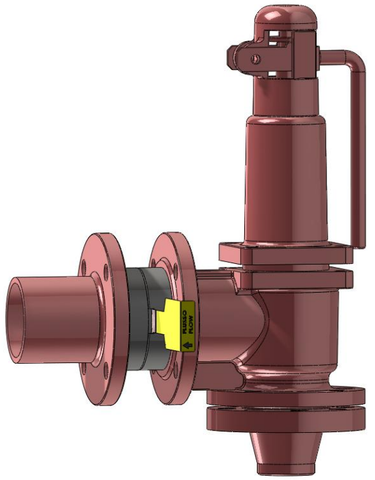
Pressure Safety Valves and Rupture Discs

- Pressure Safety Valves and Rupture Discs are **Pressure Safety Devices** designed to protect plants and equipment from overpressure conditions
- Pressure Safety Valves (PSV) are **reclosing** safety devices
- RD are **non-reclosing** safety devices
- When the overpressure condition that has caused the opening of the device ceases, PSV **recloses**, instead RD **will not reclose**
- Both devices **protect** from overpressure, however PSV is **mechanical** and RD is **simple**
- PSV must be installed in **vertical** position; RD may be installed in **every** position
- These devices may be used as **alternative** or **complement** .

Installation of PSV and RD

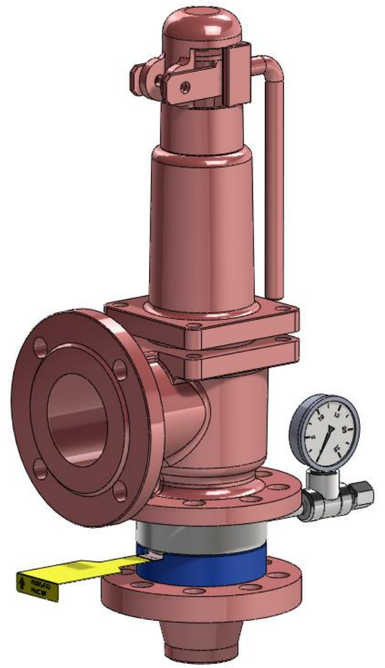
- When used together a PSV, the RD may be installed:
  - In **parallel**, useful for ensuring an additional protection level for the same or different plant failure case (typical application: protection of liquefied gas tanks)
  - **Downstream**, useful for protecting the valve from corrosive fluids that may be present in the discharge piping (typical application: petrochemical plants where all effluents are collected in a common piping leading to the flare)
  - **Upstream**





Main Advantages of RD upstream a PSV

- **Protection** of the valve from corrosive or fouling process fluids
- Reduction of valve **maintenance costs** (cleaning and calibration)
- Reduction of **manufacturing cost** of the valve that may be fabricated with less expensive materials



Total Ownership Cost

- These advantages more than offset the cost of installation of a rupture disc upstream a PSV
- **Leaks** and **maintenance requirements** of PSV, due to corrosion or fouling of the seat (very important for dangerous fluids), are avoided
- This means a reduction of **Total Ownership Cost**

Rupture Disc properties and applications

- RD are **differential** devices: they open when the pressure difference between upstream and downstream is above the set pressure
- RD are **non-reclosing** devices: once the disc has opened, it will not re-close (and all the fluid is discharged)
- Opening (or bursting) is a very **rapid** phenomenon and therefore the RD is able to protect equipment also from a very steep pressure increase.

RD application parameters

- **Specified rupture pressure** is the bursting pressure quoted (with a coincident temperature) when defining the bursting disc requirements

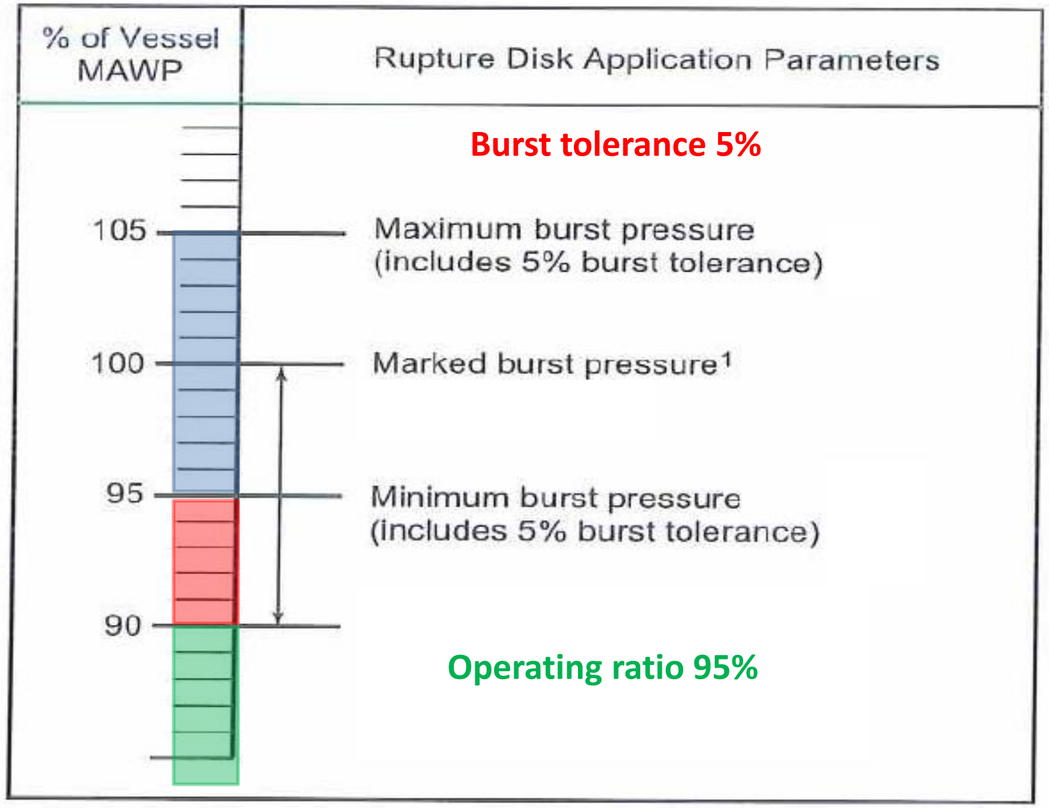
Application parameters 2

- **Tolerance** is the range of pressure between the specified minimum and maximum bursting pressure, it is expressed in percentage or absolute values

Application parameters 3

- **Operating ratio** is the maximum recommended ratio between operating pressure and minimum bursting pressure

Set Pressure, Tolerance and Operating Ratio



Maximum burst pressure = 105 bar g

Marked burst pressure = 100 bar g

Minimum burst pressure = 95 bar g

Maximum recommended operating pressure =
100 x 0,95 x 0,95 = 90,25 bar g

Application parameters 4

- **Vent area**: cross-section area available for discharge of fluid
- Key parameter for sizing the vent area:
  - mass flow rate
  - molecular weight
  - rupture pressure
  - discharge coefficient

Rupture disc materials

- First choice is metal.
  - The rupture disc is thin and therefore expensive materials are frequently used.
  - Common choices are cold rolled coils of: Stainless Steel (316) or high performing alloys like Inconel, Hastelloy, Monel, but also Nickel, Titanium, and Tantalum.
- Graphite is also used in many cases, especially when the disc is used in contact with highly corrosive fluids

A) Base model – solid disc

- These discs are flat or domed in the direction of the bursting pressure and are formed by a single layer of metal or graphite

Calibration

- Rupture pressure depends from 3 factors
  - Active diameter
  - Material thickness
  - Material properties

Performance and applications

- Main drawbacks are:
  - Burst in a non-predictable geometry
  - Fragment
- Generally used for small diameter, low cost and mass applications (e.g. airbags)

B) Composite discs

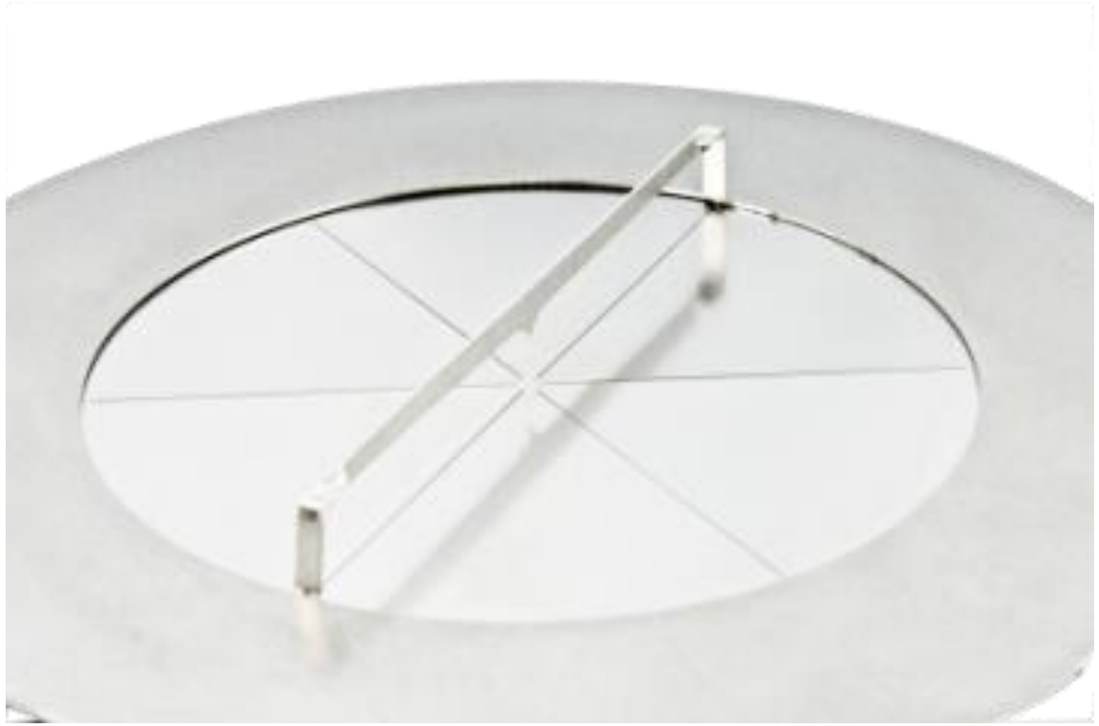
- They are made of at least two layers:
  - One metal layer with calibration slits (or through cuts)
  - One continuous layer that ensures gas tightness, normally a film of PTFE or other suitable polymer

Performance and applications

- Burst tolerance and operating ratio are generally better than in solid discs
- The calibrated part of the disc will not fragment; the membrane will fragment (but if it is a thin PTFE film, fragmentation is going to have little or no impact)

Performance and applications

- The composite disc design allows the manufacturing of RD with **low and very low burst pressure**
- **DonadonSDD** has manufactured discs bursting at **5 millibar**
- This disc model is especially suited for protection of **tanks** both in **pressure** and in **vacuum** and for **biogas digesters**



C) Scored forward acting (tension loaded)

- These discs are made with a single metal layer and are flat or domed in the direction of the bursting pressure.

Calibration

- Calibration is obtained by scoring (non-through cuts)
- Rupture pressure depends from design and depth of the scores

Performance and applications

- Scored discs have lower tolerance than solid and composite discs and better operative ratio
- They do not fragment
- Frequently used in the process and chemical industry

D) Reverse acting discs (compression loaded)

- Scored reverse acting discs are made with a single layer of metal **domed against the direction of the bursting pressure**
- When the pressure differential between upstream and downstream is above the **resistance to compression** of the dome, this will reverse.
- The disc is **scored** and after reversal will **tear along the scores**

Calibration

- Calibration is obtained by controlling the **height** of the dome
- **Defects** may be introduced in the dome in order to lower its resistance and to improve the reversal process

Score design 1

- There are two main designs:
  - The common design is with the score along the **circumference** (perimeter)
  - The disc will open with **one petal** retained by a non-scored sector and, eventually, by a dampener

Score design 2

- Also **cross scored** design is possible.
- Rupture discs with this design have good resistance to fragmentation and large discharge area

Performance and applications

- The reverse / compression loaded design allows very tight **tolerance** and very good **operating ratio**
- Resistance to **repeated pressure cycles** is also extremely good.
- They do not fragment
- They are adequate for gas and liquids, however **full liquid** applications require special care because of possible pressure drop during the reversal / opening phase
- Standard model in oil and gas, chemical and petrochemical and other process industry applications

Manufacturing technology

- The scores are generally made by stamping the disc with a die in a press
- This technology is able to produce high quality rupture discs but requires high capital costs and careful tool maintenance

Laser scoring technology

- **DonadonSDD** has developed and implemented during the last 10 years an innovative technology based on **laser scoring**
- This technology may be used for manufacturing both reverse and forward acting scored discs
- It is very flexible both in score design and in manufacturing planning

Score design

- Laser scoring allows to control and optimize
  - score line design,
  - score depth and
  - score profile
- We can score without defects even very thin (20 micron) metal sheets

Cross scored discs with 6 petals

- DonadonSDD has introduced commercially the **cross scored discs with 6 or more petals** (standard model has 4 petals)
- Key advantages of these models are:
  - Large opening area
  - Resistance to fragmentation even at high burst pressure

Performance and applications

- The **DonadonSDD SCR** model (reverse cross scored with 6 petals) has a discharge area superior to that calculated for the inscripted hexagon and a certified flow resistance coefficient ($K_{Rg)}$) of 0,48.
- This means that head loss through the RD is less than that caused by a pipe length of half diameter)

Laser scoring

- No mechanical tool that may wear with time is required
- Production planning is very flexible because set-up is fast and inexpensive and therefore small lots of rupture discs are economically viable, fast deliveries are possible and rush orders can be handled

Patent coverage

- Donadon SDD has filed many patent applications (some already granted) covering different aspects of the laser scoring process

Additional information

- Additional information is available from

- Internet site : www.donadonsdd.com
- Or direct enquiry

Thank you for your attention

Questions ?