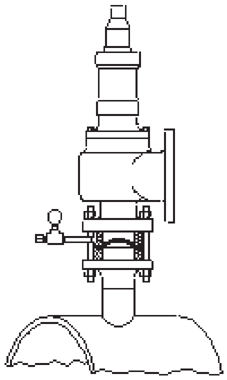
TECHNICAL BULLETIN

BEST PRACTICES FOR RUPTURE DISC (RD) / PRESSURE RELIEF VALVE (PRV) COMBINATIONS

Rupture discs, also known as bursting discs, are commonly used to isolate pressure relief valves from corrosive or otherwise fouling service on the process side and/or the discharge side. This paper will discuss the various code requirements, the practical aspects, and recommended best practices. The basis of most of the discussion comes from ASME Section VIII Division 1; however similar requirements and/or principals are found in API RP520 and EN ISO 4126-3.

RUPTURE DISCS LOCATED UPSTREAM OF A PRESSURE RELIEF VALVE

Why?



The primary reasons for applying rupture discs upstream of pressure relief valves include:
- Prevent plugging of PRV – some RD designs are designed to be less sensitive to product buildup.
- Prevent corrosion of PRV – The RD is used to prevent corrosive materials from contacting the PRV internals during normal operating conditions. Exposure is limited to the duration of an overpressure situation.
- Avoid cost of high alloy PRV – High alloys or exotic alloys for RD construction cost much less that a corresponding relief valve with the same alloy trim.
- Prevent leakage through PRV – Many direct spring valves rely on lapped metal to metal seats for sealing and they rely on the difference of the spring force and the hydrostatic force applied to the valve disk. This results in a situation where the sealing force decreases as the valve approaches set point.

Rupture Disc Requirements

When installing a rupture disc between a pressure vessel and pressure relief valve the following requirements must be met:

Monitoring (tell-tale indicator)

- Since the RD is a differential pressure device, the pressure in the vessel required to burst the disc will increase equally with any pressure that accumulates between the RD and PRV. The space between the RD and PRV must be vented and/or monitored to prevent or detect pressure buildup between the RD and the PRV. The ASME and EN Pressure Vessel Codes require the use of a pressure gauge, a try cock, free vent, or suitable telltale indicator.
  - If the space is otherwise closed then a pressure gauge alone should not be considered suitable. This approach relies on plant personnel to periodically check each gauge to insure that pressure buildup has not occurred. This could easily result in an unsafe situation existing for hours, days or weeks at a time.
  - A pressure switch or transmitter that provides an alarm in the control room is a more appropriate indication method.
  - A pressure gauge along with a pressure switch or transmitter may be an even better choice so not only the control room is notified but the maintenance personnel also have visibility to the elevated pressure condition prior to breaking loose the pipe flanges.
  - In some cases the space is not vented but in others venting to atmosphere, catch tank, or collection header may be desired. It is common in these cases to use an excess flow valve (a type of check valve) on the venting line. At very low flow conditions as in the case of thermal expansion of trapped air the check ball allows the fluid to vent. When the disc ruptures, the excess flow valve closes to prevent fluid loss through the vent.
  - The use of a break wire or other flow sensitive burst indication devices alone are not considered suitable unless they are capable of detecting leakage through the rupture disc.
  - No one configuration is ideal for all applications. The corrosiveness or toxicity of the media is often what drives how this space is monitored and vented.

Fragmentation

The rupture disc used on the inlet side of a PRV must not interfere with the performance of the PRV. It must be of a non-fragmenting design. In other words the disc must not eject material that can impair PRV performance; this includes relief capacity as well as the ability to reclose without leakage. It should be noted that once the disc has burst, corrective measures must be taken to reduce the vessel pressure. Some rupture discs may fragment eventually under sustained or repeated relieving conditions.

Capacity

The rupture disc must be sized to allow at least as much capacity as the PRV. For nozzle-type direct spring PRV's this generally means that the rupture disc has to be the same nominal pipe size as the PRV inlet or larger.

Installation

The most common installation is one where the rupture disc holder is mounted directly upstream of the PRV. This installation is referred to as "close-coupled". This is a good installation approach but care needs to be taken to insure that the holder provides sufficient clearance to allow the rupture disc to open without blocking the nozzle of the PRV. Single petal rupture discs may extend significantly beyond the end of the holder after rupture and have the potential to block the PRV nozzle.

In other cases the rupture disc holder and PRV may be separated by a spacer or length of pipe. Short sections of 1 or 2 pipe diameters in length are preferred. Longer lengths may result in the PRV not opening when the rupture disc opens. Longer pipe sections have been known to cause reflective pressure waves that can cause the rupture disc petals to re-close or even fragment when they ordinarily would not.

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Specified BP and PRV Set Pressure

There is a variety of guidance in industry regarding the relationship between the specified burst pressure of the rupture disc and the set pressure of the PRV.

For applications, ASME UG-127 footnote 52 says: "….result in opening of the valve coincident with the bursting of the rupture disk."

For RD/PRV combination capacity testing, ASME UG-132(a)(4)(a) says: "The marked burst pressure shall be between 90% and 100% of the marked set pressure of the valve."

API RP520 paragraph 2.3.2.2.2 says: "…the specified burst pressure and set pressure should be the same nominal value."

EN ISO4126-3 paragraph 7.2 says: "The maximum limit of bursting pressure…shall not exceed 110% of the…set pressure or a gauge pressure of 0.1 bar, whichever is greater…". and " The minimum limit…should not be less than 90% of the…set pressure."

While all slightly different the basic guidance is the same and keeping the rupture disc specified burst pressure and PRV set pressure at the same nominal value, ignoring tolerances, meets the intent of each of the standards and is relatively easy to implement.

There may be special cases where it is desirable to have these pressures significantly different: in these cases the user should carefully evaluate both the RD and PRV function to insure that there are no adverse effects on performance.

PRESSURE RELIEF VALVE REQUIREMENTS

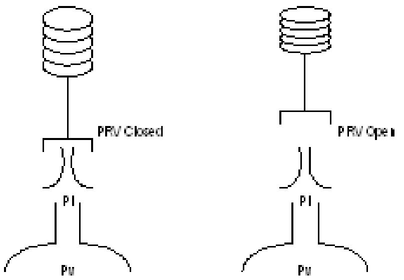
Inlet line loss

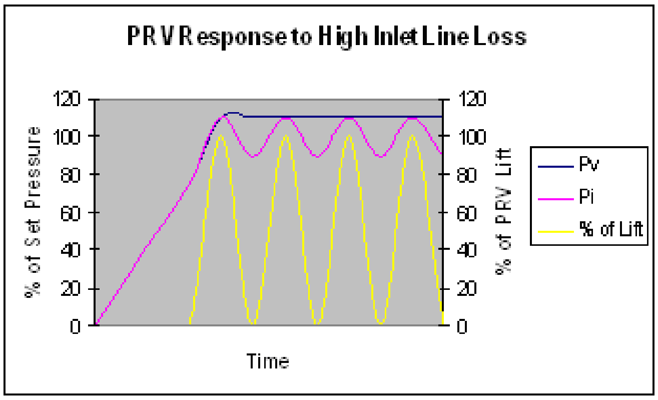
Most pressure relieving codes address the issue of inlet line loss or the non-recoverable losses between the pressure vessel and the inlet of the PRV. ASME, API, and EN/ISO all limit this loss to 3% of the PRV set pressure. For ASME and API this is evaluated at the rated capacity of the PRV, while EN/ISO requires evaluation at the maximum flowing conditions.

Why is inlet line loss important? One of the primary concerns is the concept of relief valve stability during discharge. A direct spring PRV is subject to rapid and sometimes destructive dynamic behavior under certain operating conditions. The graphic shows in simple terms what happens as the valve goes from static non-flow conditions to dynamic flowing conditions. The pressure drop between the vessel and the PRV inlet causes Pv and Pi to become unequal during flowing conditions. If Pi is less than the blowdown pressure (closing pressure) of the PRV then a condition can develop where the PRV opens and closes very rapidly and causes damage to the valve seats, failure of valve components, damage to piping, and/or failure to flow at the rated capacity.

Sizing Requirements

The





process of sizing the PRV is exactly the same for a RD/PRV combination as it is for a stand alone PRV except for the addition of the combination capacity factor (CCF). This factor represents the ratio of the capacity of the combination to the capacity of the valve alone. CCF = Capacity PRV/RD / Capacity PRV

The default CCF (Fd for EN/ISO) for most codes is 0.90 or in other words, the combination is assumed to have a capacity equal to 90% of the PRV rated capacity if nothing more is known about the actual capacity. EN ISO 4126-3 adds an additional condition on the use of the default CCF. EN/ISO requires that the petal(s) of the rupture disc be fully contained within the holder after rupture in order to use the default CCF, otherwise a tested or certified value must be used.

CCF values higher than 0.90 may be used in certain cases where specific testing has been done with a particular RD/PRV combination. This is often referred to as a "certified" combination capacity factor (CCCF). The methods for establishing the CCCF vary based on the applicable code and are summarized as follows:

ASME:

- Testing must be done by an authorized testing laboratory and results registered with the National Board of Boiler and Pressure Vessel Inspectors.
- Testing of only one size is required to establish a CCCF for a range of sizes.
- Testing with the smallest size and minimum corresponding pressure covers all higher pressures in that size and all sizes larger.

EN ISO 4126-3:

- No certifying body or laboratory requirements.
- One size method and three size method are accepted.
- One size method applicable to all combinations of the same size and design of RD and PRV equal to or above the tested pressure.
- Three size method applicable to all combinations of the same design of RD and PRV in all sizes equal to or greater than the smallest tested size and pressures equal to or greater than the appropriate minimum pressure for the size.

Marking Requirements

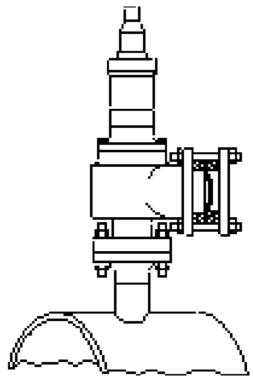
Both ASME and EN/ISO have requirements for establishing nameplate marking to reflect the capacity (or combination capacity factor) of the combination, model and manufacturer of both the RD and PRV, etc. Although these are requirements of both ASME and EN/ISO this nameplate is rarely supplied because the RD and PRV are generally purchased independently with neither manufacturer aware of the other.

RD INSTALLED DOWNSTREAM OF PRV

Why?

The primary reasons for applying rupture discs downstream of pressure relief valves include:

- Prevent corrosion of PRV – The RD is used to prevent corrosive vapors in common headers from contacting PRV internals during normal operating conditions.
- Prevent variable superimposed backpressure in a common header from affecting PRV set pressure – RD's are available that have low burst pressures but can withstand higher backpressures, hence avoiding the need for PRV's equipped with balancing bellows in some cases.
- Detect opening or leakage of PRV – Some rupture disc types have integral burst indication that can signal the control room if the disc has been burst due to PRV opening or leakage.



RD Requirements

The marked burst pressure of the rupture disc plus any downstream backpressure shall not exceed the design pressure of the PRV outlet or the set pressure of the PRV.

The opening through the rupture disc device after rupture is sufficient to flow the rated capacity of the PRV without exceeding the allowable overpressure.

The system design shall consider the adverse effects of any leakage through the PRV or through the rupture disc to ensure performance and reliability.

PRV Requirements

The PRV may not fail to open at the expected opening pressure regardless of any backpressure that may accumulate between the PRV and the RD. The space between the PRV and the RD shall be vented, drained or suitable means shall be provided to ensure that an accumulation of pressure does not affect the proper operation of the PRV. Venting, pressure monitoring, and selection of low RD burst pressures are commonly used to meet these requirements.

The bonnet of a balanced bellows-type PRV shall be vented to prevent accumulation of pressure in the bonnet and affecting PRV set pressure.

ASME SECTION VIII, DIVISION 1 VS EN ISO 4126-3

Compare and contrast the various requirements within the two major standards on the subject. Note the requirements of API RP520 are taken directly from ASME Section VIII, Division 1.

Requirement	ASME Sect. VIII, Div. 1 (API)	EN ISO 4126-3	Comments
Definition of a RD/PRV combination	None	Rupture disc is within 5 pipe diameters of the inlet of the PRV.	If the RD is not within 5 pipe diameters then a combination capacity factor is not applicable.
3% rule	Pressure drop between the vessel and PRV inlet including the effect of the rupture disc shall not exceed 3% of the valve set pressure at valve nameplate flowing conditions.	Pressure drop between the vessel and PRV inlet including the effect of the rupture disc shall not exceed 3% of the set pressure of the valve at maximum flowing conditions.	The difference between flowing at nameplate capacity or some other maximum could be significant. i.e. what if the PRV is set well below the MAWP but sized to prevent exceeding 110% of MAWP. It may be impossible to meet the ISO requirements in this situation.
Certified Combination Capacity Factor	One size method applicable to all sizes equal to and larger than the tested combination.	One size method for a single size or three size method to be applied to a family.	Pursuit of the ISO 3 size combination capacity factors is cumbersome due to the cost and logistics. With a default of 0.9 the pay-back on 3 size testing is minimal.
Protrusion of petals into valve	No specific requirement.	Petals shall not protrude into the PRV inlet unless the influence of the petals on the capacity and performance of the PRV has been assessed and proven to meet the requirements of Clause 7. (Combination Performance).	Both codes use language prohibiting the RD to impair the performance of the PRV. The ISO document seems to take a firm stand on the petal protrusion issue but points to Clause 7 which allows a default CCF (Fd) of 0.9.
Documentation of the combination	Nameplate marking for the combination provided by the User, PRV mfr, RD mfr, or vessel mfr.	Supplier of the combination shall provide the nameplate, certification, assy & installation instructions…taking into account the results of a hazards analysis.	In both codes there are gaps in these requirements. In practice these requirements are rarely followed.

FAQ'S

Q1 Can a composite rupture disc with a Teflon (or other elastomer) seal or a scored rupture disc with a Teflon liner be used under a PRV?

A1 When a disc with a Teflon seal or liner bursts the Teflon does break apart and discharge out of the PRV. The problem is whether you always know that it will actually discharge or get hung up in the valve disk and blowdown ring. There is a chance that the Teflon will hang up and then get trapped in the valve seat when it re-closes, resulting in a leak. Since re-closing is often a very important part of the PRV performance the conservative answer is no. If leak-tight re-closing is not important for the application then this type of RD may acceptable.

Q2 I am using the default combination capacity factor of 0.90 to determine the capacity of my RD/PRV combination. Do I have to also worry about the PRV inlet line loss calculation? It seems like I'm being penalized twice for using the rupture disc.

A2 Yes, ASME Code Interpretation VIII-1-98-43 requires that the rupture disc be considered when calculating the inlet line loss.

Q3 How do I manage the difference in rupture disc burst pressure and the relief valve set pressure given the manufacturing range, rupture tolerance, and set pressure tolerance?

A3 The easiest way is to specify the rupture disc and pressure relief valve at the same nominal pressure and order the rupture disc with zero manufacturing range. The resulting differences in set pressure tolerances are insignificant.

Q4 The certified combination capacity factor that I want to use was based on a 1" @ 45 psig test series but my application is for a 4" @ 25 psig. Can I still use this CCCF even though it is at a lower pressure than what was tested?

A4 No. The minimum set pressure tested during certification tests is the minimum pressure that may be used for all sizes equal to and larger than the size tested. The established CCCF cannot be used for pressures lower than tested in the same size and the CCCF cannot be used for any sizes smaller than the test series size regardless of pressure.

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