7.17 Rupture Discs


Types: Forward Acting and Reverse Acting (see Table 7.17a)

Sizes: 0.18 to 44 in. (4.8 mm to 1.12 m)

Burst Pressure Ranges: 0.25 to 120,000 PSIG (0.017 to 8274 barg)

Maximum Operating Pressure: 50 to 90% of marked burst pressure depending on design

Maximum Operating Temperatures and Materials:

Rupture Tolerance: ±5% for B.P. > 40 PSIG (2.75 barg) and ±2 PSI (1.04 bars) for B.P. < = 40 PSIG (2.75 barg)

Cost: See Figure 7.17c


Carbone Lorraine (www.chem.carbonellorraine.com)
Continental Disc Corp. (www.continentaldisc.com)
Elfab Limited (www.elfab.com)
Fike Corporation (www.fike.com)
Hoke Inc. (www.hoke.com)
OSECO (www.oseco.com)
Parker Hannifin Corp. (www.parker.com)
Rembe (www.rembe.com)
Swagelok (www.swagelok.com)
Zook Enterprises (www.zookdisk.com)

INTRODUCTION

Overpressure may occur due to thermal expansion, equipment or control failure, misoperation, external fire, runaway reaction, or a combination of these. The rupture disc has been recognized for many years as a suitable device for relieving overpressure. The rupture disc in its simplest form is a metallic or graphite membrane that is held between flanges and that is designed and manufactured to burst at some predetermined pressure and corresponding temperature. Rupture discs, which are generally installed on or directly above a pressurized vessel nozzle, can be looked upon as the weak link in the pressure system. They will burst and relieve pressure before other system components fail. Another common use of a rupture disc is as single use, fast acting valve in fire suppression systems, aerospace fuel systems, petroleum well drilling tools, laboratory test apparatus, etc.

DEFINITIONS

Rupture Tolerance—The tolerance range on either side of the marked or rated burst pressure within which the rupture disc is expected to burst. Rupture tolerance may also be represented as a minimum–maximum pressure range. Also referred to as performance tolerance in International Organization for Standardization (ISO) standards.
Manufacturing Range—A range around the specified burst pressure within which the marked or rated burst pressure must fall. Manufacturing range is not used in ISO standards.

Operating Ratio—The ratio of the maximum operating pressure to the marked burst pressure expressed as a percentage (common US definition). The ratio of the maximum operating pressure to the minimum of the performance tolerance expressed as a percentage (common ISO definition).

Nonfragmenting—A rupture disc design that when burst, does not eject fragments that could interfere with the operation of downstream equipment (i.e., relief valves).

**TABLE 7.17a**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Forward Acting</th>
<th>Reverse Acting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prebulged (FAB)</td>
<td>Composite (FAC)</td>
</tr>
<tr>
<td>Max operating ratio</td>
<td>70%</td>
<td>80%</td>
</tr>
<tr>
<td>Life under cyclic conditions @ max operating ratio</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Fragmenting</td>
<td>Yes</td>
<td>Varies</td>
</tr>
<tr>
<td>Vacuum resistant</td>
<td>With support</td>
<td>With support</td>
</tr>
<tr>
<td>Low pressure</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>High pressure</td>
<td>Yes</td>
<td>No</td>
</tr>
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</table>

**TABLE 7.17b**

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>250°F (121°C)</td>
</tr>
<tr>
<td>Graphite</td>
<td>430°F (221°C)</td>
</tr>
<tr>
<td>Hastelloy® C276</td>
<td>900°F (482°C)</td>
</tr>
<tr>
<td>Inconel®/Alloy 600</td>
<td>1000°F (538°C)</td>
</tr>
<tr>
<td>Monel®/Alloy 400</td>
<td>800°F (427°C)</td>
</tr>
<tr>
<td>Nickel 200</td>
<td>750°F (399°C)</td>
</tr>
<tr>
<td>Silver</td>
<td>250°F (121°C)</td>
</tr>
<tr>
<td>Tantalum</td>
<td>500°F (260°C)</td>
</tr>
<tr>
<td>Teflon®</td>
<td>500°F (260°C)</td>
</tr>
<tr>
<td>316 stainless steel</td>
<td>900°F (482°C)</td>
</tr>
</tbody>
</table>

**CODE REQUIREMENTS**

Significant changes in the governing codes and standards regarding rupture discs have occurred since the last edition of this handbook and continue to occur. Compliance with the applicable standards can be complex and is beyond the scope of this work. However, key points relating to the most common standards are summarized. It should also be noted that certain standards have specific testing requirements that are different than or exceed normal commercial practice and can increase the cost.

The American Society of Mechanical Engineers (ASME) Section VIII Division 1 (ASME Code) is the primary pressure vessel code used in North America and is also used in various regions of South America, Asia, and the Middle East. It is also used as a company standard by many multinational companies. In the 1997 addenda of the 1995 edition, significant changes were made to the rupture disc requirements. ASME UD code symbol stamping was added, requiring design verification testing and third-party approval as well as changes to the methods used for sizing rupture disc devices. The 2001 edition incorporated additional changes in certification and sizing by recognizing flow resistance values for rupture discs on liquid applications.

ISO 6718 is used primarily in Europe as well as parts of South America, Asia, and the Middle East. The most significant differences in these rules from the ASME rules are in the area of sizing. The coefficient of discharge is different in some cases, and sizing methods beyond the coefficient of discharge method are offered although not described in detail.

ISO 4126–2 and 4126–6 are new standards that are going through their final approvals as of this writing. These standards are based on ISO 6718 with the objective of meeting the requirements of Directive 97/23/EC (pressure equipment directive [PED]). Marking of the rupture disc device with the CE mark identifies it as meeting the requirements of the PED and available for use within the European Union.

The American Petroleum Institute (API) RP520, an industry standard, has more how-to information and in most cases supports the requirements of ASME Section VIII Division 1. RP520 also goes beyond the ASME Code by providing additional guidance in sizing and applying pressure relief devices.

**RUPTURE DISCS VS. RELIEF VALVES**

Rupture discs and relief valves can be used individually, in series, or in parallel. The greatest difference between relief valves and rupture discs is that relief valves are reclosing devices and rupture discs are not.
As the process pressure starts to build, a relief valve will gradually open and then reseal the process once the pressure drops. The rupture disc will remain sealed tight until its burst pressure is reached. In order to reclose the process, the disc must be replaced. It follows from this that the rupture disc can be used as a tight seal whereas the relief valve cannot. The only time a rupture disc will leak is if it develops pinholes due to corrosion, or if hairline cracks develop due to metal fatigue caused by the stress of pressure cycling.

A second area of difference is in the construction of the two relief devices. Because rupture discs have a relatively simple construction, they are commercially available in an extremely wide variety of materials at reasonable cost and on reasonable delivery schedules. This cannot be said for relief valves, which are generally limited to copper alloy, steel, and stainless steel constructions. They can become very expensive, long-delivery items if special materials are required.

**WHEN TO USE A RUPTURE DISC**

With the code requirements and the comparison between discs and valves in mind, the following rules can be used on where and when to specify rupture discs.

**As a Primary or Sole Relief Device**

As shown in Figure 7.17d, the rupture disc may be used to relieve an inexpensive and inert material to air if the loss of process pressure can be tolerated. At the other extreme, rupture discs may be used to vent highly toxic, poisonous, or corrosive materials into a vent surge or flare header system. The advantage of the rupture disc for this application is that under normal conditions, it will not allow any leakage.

**As a Supplemental Relieving Device**

When a relief valve is the primary relieving device, the rupture discs are set at the higher relieving pressures as permitted by the ASME Code. The relief valve will open on mild overpressures, relieve a small amount of material, and reclose the process. The rupture disc will not function unless a more extreme condition arises (Figure 7.17e). When such a condition arises, the process must commonly be shut down. Therefore, the complete system pressure loss caused by the rupture of the disc is acceptable.
In addition, the causes of more extreme overpressure, such as external fire, generally require a larger venting area. For a given venting area, the rupture disc is less expensive than the relief valve.

### Upstream of a Relief Valve

Being mounted upstream to relief valves is a very useful application for rupture discs (Figure 7.17f). Under normal conditions the rupture disc is sealed tight and protects the relief valve from being contacted by corrosive, plugging, hazardous, freezing, or regulated processes. If the maximum allowable working pressure is exceeded, the disc will break and the relief valve will start to relieve the pressure. As the pressure drops, the valve will shut and reclose the process. Thus, the best characteristics of both devices are utilized.

Another important advantage in this type of installation is that the rupture disc may be used as a break point in piping specification. This means that materials of construction for the rupture disc and the inlet flange of the disc must be compatible with the process. However, the downstream flange of the rupture disc, the relief valve, and all downstream piping may be garden-variety materials such as carbon steel. This is permissible because the rupture disc can be relied on to seal the process away from the downstream items. The resultant savings from using lower-grade downstream materials will in many cases more than pay for the rupture disc.

Because the rupture disc is a differential pressure (d/p) device it is important to prevent a buildup of pressure between the disc and the relief valve. This is accomplished by the use of a pressure switch and/or a pressure gauge and excess flow valve (Figure 7.17f).

### Downstream of a Relief Valve

This installation of a rupture disc downstream of a relief valve may be desired when the valve discharges to a vent header that might contain corrosive vapors (Figure 7.17g). A low-pressure rupture disc with a burst indicator can also be used as a means to detect leakage through the relief valve.

Precautions should be taken to prevent the buildup of pressure between the valve and rupture disc due to valve leakage, if conventional relief valves are used. A better option...
is to use bellows sealed or pilot-operated relief valves (Figures 7.16c, 7.16q, and 7.16s), whose set pressure is unaffected by the accumulated pressure between the valve and rupture disc. The rupture disc should also have sufficient opening to permit at least as much flow as the rated capacity of the valve.

**Explosion Relief**

In comparison with relief valves, rupture discs open faster and provide more relief area. Be aware however that the methods for sizing rupture discs (or explosion vents) is quite different than that for traditional pressure relief and the required relieving areas can grow quite large. See the National Fire Protection Association (NFPA) 68 or Verein Deutscher Ingenieure (VDI) 3673 for guidelines regarding explosion relief.

**RUPTURE DISC TYPES AND FEATURES**

Rupture discs can be classified in two general categories: forward acting or reverse acting. Forward acting discs are pressurized on the concave side of the disc such that the material in the dome of the disc is subjected to tensile stresses (Figure 7.17d). Flat discs are also considered to be forward acting. Forward acting rupture discs can be prebulged, composite, scored, flat, and graphite.

Reverse acting discs are pressurized on the convex side of the disc such that the material in the dome of the disc is subjected to compressive stresses. Reverse acting types include those that use knife edges to cut the disc membrane and are scored (Figure 7.17h). The vast majority of recent rupture disc development has been in the area of reverse acting designs.

**Nonfragmenting Discs**

Early rupture discs were prebulged solid metal discs that burst in tension and therefore could release metal fragments. These fragments could prevent relief valves from reseating. The newer rupture disc designs protect against this by either using tension-loaded scored or slotted metal discs (with Teflon seals), reverse-buckling discs with knife-edge cutters, or reverse-buckling discs that are preweakened (scored along lines), so that they burst with full opening without fragmentation (Figure 7.17i).

**Graphite Discs**

Figure 7.17f shows the installation for a metal disc and Figure 7.17j shows the installation for a graphite disc. As can be noted, the graphite disc requires some extra piping to guarantee its successful operation. First of all, it is not good practice to allow a graphite disc to rupture directly into a relief valve.

The reason is that a graphite disc will fragment rather than tear as a metal disc does. Since the graphite fragments can jam or restrict the operation of a relief valve, it is necessary to provide some kind of downstream pocketing to catch the fragments. A further difficulty arises once the relief valve recloses. If the graphite fragments are pocketed directly over the vessel nozzle, they will drop back into the tank. They can then get into the piping and damage pumps and instruments.

For this reason, the entire relief assembly is shown offset from the vessel nozzle, and an additional pocket is shown upstream of the graphite disc flanges. Graphite discs are best suited for corrosive applications, because they resist almost all chemicals. Another consideration is the margin between normal working pressure and burst pressure, which is about 30% in the case of metal discs because of fatigue. In case of graphite discs, which do not fatigue, this margin can be reduced to 20 to 25%.
Some rupture disc models have the capability to withstand vacuum either with or without a vacuum support. A vacuum support typically provides additional strength for the dome of the disc to prevent its collapse. Many models will collapse when exposed to vacuum on the process side so it is important to always check if vacuum could be present during startup and shutdown conditions or under normal operation. Cooling of closed systems is a common cause of developing vacuum and causing rupture disc failure, if this possibility is overlooked when specifying the rupture disc.

**Back-Pressure**

Similar to vacuum, some rupture disc models have the ability to withstand some back-pressure, while others require special supports to prevent damage or collapse of the dome. Rupture discs that discharge to common headers are often exposed to some low levels of continuous back-pressure and the possibility of periodic increases due to discharges from other sources into the header. Be aware that the presence of back-pressure will cause an equivalent increase in the burst pressure of the rupture disc.

Although not as often as in the past, some users perform in place relief valve testing by pressurizing the cavity between the disc and relief valve until the valve opens. In a spring-loaded relief valve, this test does not give accurate data on the popping pressure or blowdown of the relief valve, but it does confirm that the valve is not frozen shut. When such test is performed, the rupture disc must have the ability to withstand a back-pressure equivalent to the set pressure of the relief valve.

**Margin between Operating and Burst Pressures**

A second commercially available disc construction that may be operated at 75 to 80% of the burst pressure is as shown in Figure 7.17k. This disc consists of a relatively weak disc (seal) plus a heavier metallic backup plate that has been scored or punched so that it will open like orange peels when burst pressure is reached. This construction is less subject to deterioration due to metal fatigue than the plain disc is.

The reverse-buckling rupture disc constructions may be operated to 90% of the rated bursting pressure. Figures 7.17h and 7.17l show the reverse-buckling, knife-edge designs. Rupture discs that are prebulged can be installed with the bulge toward the outside. The reverse-buckling disc is
Safety and Miscellaneous Sensors

installed with the bulge facing into the process. Because of this, the disc is not as sensitive to high pressures and pressure cycling. Once the bursting pressure is reached, the reverse-buckling disc will snap its prebulge to the downstream side. As the bulge passes from the upstream to the downstream side, it is cut into segments by sharp knife edges placed against the disc, allowing the process to vent.

**Dual Discs or Back-Pressure Loading**

There are other disc constructions and methods of installation that allow higher operating to burst ratios. One method is to use two identical discs in series. The idea here is to assume that the first disc will fatigue and fail or leak prematurely because of high normal pressure operation, but the second one will then take over to operate satisfactorily for a period of time. The first disc must, of course, be replaced at the earliest opportunity. A pressure gauge with maximum pointer and an excess flow valve is installed in the pocket between the two discs (Figure 7.17m).

Finally, it is possible to load a back-pressure artificially on the rupture disc. The back-pressure reduces the differential across the rupture disc and allows the normal operating pressure to be any desired percent of the rupture pressure. Back-pressure is unloaded by an external venting system when process overpressure occurs. Here again, this is not a self-contained system; it relies on the proper operation of external components.

**Special Applications**

**Pressure Cycling and Water Hammer** A common cause of rupture disc failure is fatigue failure due to pressure cycling. The fatigue life of the disc is a function of the amplitude, frequency, and peak value of the pressure. When specifying rupture discs, both the operating ratio and the severity of pressure cycling should be considered. In general, reverse acting rupture discs tend to provide the best life in severe pressure cycling environments.

The effects of water-hammer on rupture discs should also be considered in liquid full (hydraulic) systems. The rupture disc is a d/p device and, due to its low mass, it can respond to very high amplitude, short duration pressure spikes such as water-hammer. Discs that have burst due to water-hammer often exhibit only partial opening due to a lack of sustained pressure. To avoid this type of problem, it is important to avoid rapid opening or closing of valves in these systems.

**Two-Way Relief** Rupture discs may be used where two-way relief is required. There are commercially available discs for this purpose. One common installation sketch is shown in Figure 7.17n. The system requirements are as follows. A highly corrosive process is unstable above a certain temperature. Therefore, it is necessary to quench the reaction if the temperature rises above this point. Further, due to its corrosive nature, it is decided to vent the process into a surge system in case of process overpressure (rupture disc as primary relief).

This application calls for a rupture disc to vent overpressure and for a two-way rupture disc to isolate the process away from the quench valve and to prevent quench leakage into the process. The solution is to specify a two-way rupture disc that will burst into the tank if over-temperature occurs, but isolate the valve under other circumstances.

**Self-Cleaning and Corrosive Services** Many specialized rupture disc and holder designs are available for unique applications and circumstances. Bidirectional designs are used to provide overpressure protection as well as vacuum protection for low pressure storage vessels (Figure 7.17n).

There are several variations of rupture discs available for use in processes where product buildup and plugging of the inlet pipe is a concern. Some designs use the process flow to keep the disc surface free of buildup (Figure 7.17o). Other devices are designed to minimize the space for product buildup by mounting the rupture disc flush with the vessel or pipe wall such as in plastic extrusion equipment (Figure 7.17p).

Double disc assemblies (Figure 7.17m) are also often specified for highly corrosive applications. The space between the discs is monitored and, when leakage due to
corrosion is detected, the process can be brought down. By manipulating the pressure between the two discs, a double disc assembly can also be used as a fast acting valve. In all double disc applications consult the rupture disc manufacturer to ensure proper specification for the intended use.

**Explosive Actuated Vents** Another technique is to use explosive-actuated rupture discs that do not rupture due to the pressure forces alone. The explosion is ignited by a pressure switch that senses process overpressure and closes an electric circuit to ignite the explosive charge. This is not a self-contained unit and its successful operation is dependent on several outside components plus a reliable power source (Figure 7.17q).

**Selection and Specification**

The selection and specification of rupture discs can be a daunting task due to the wide range of safety, operational, and cost considerations and the availability of a large variety of products with varying characteristics. The selection process is an iterative one, especially when it comes to specifying a disc model. Each rupture disc design has characteristics that make it more or less suitable for a particular application.
As to disc characteristics, Table 7.17a provides some general guidelines and Figure 7.17r illustrates one systematic method of using basic application information to narrow down the choice of suitable rupture discs. Certainly there are exceptions and the manufacturer’s data sheets should be carefully examined prior to specifying a particular model. If in doubt about rupture disc selection or specification, contact a manufacturer for assistance.

**Material Selection**

Temperature and corrosion are the two primary considerations when selecting the rupture disc material. From a temperature perspective, the material is selected based on the expected temperature when it is expected to burst and also taking into consideration the normal operating temperature. Since metals lose strength as they are heated, the disc material should be selected to withstand the highest expected process temperature with some margin to spare (Table 7.17b). High-temperature applications will also accelerate metal fatigue and creep. Thus temperature becomes a factor where high normal pressures or pressure cycling is encountered.

Rupture discs are readily available in a variety of corrosion resistant alloys (Table 7.17b). Other materials that have been used successfully include niobium, Hastelloy® B, and Hastelloy C22. Graphite can be a good answer to some corrosion problems because it resists almost all chemicals, but keep in mind that the resin binder is typically the limiting factor in regard to temperature or corrosion.

In addition to the option of using solid materials, it is also possible to get the discs plated; coated; or lined with Teflon®, tantalum, gold, Kel-F®, polyethylene, urethane, etc. Coatings should not be heavily relied upon to prevent corrosion of the rupture disc as thermal cycling and damage due to handling often compromise the corrosion-resistant boundary. Consider coatings to provide only a level of protection.

**Burst Pressure and Manufacturing Range**

Most rupture discs are not marked at the specified burst pressure but are sold with a manufacturing range. This is a tolerance applied to the specified burst pressure within which the rated or marked pressure will fall. The purpose of the manufacturing range is to minimize the amount of time it takes to produce the rupture disc, resulting in a reduced manufacturing cost. The smaller the manufacturing range, the higher is the cost of manufacturing.

Most rupture disc products introduced since 1990 use three manufacturing ranges: +0/−10%, +0/−5%, and 0%. Since the positive side of the range is always zero, the specified burst pressure can be the maximum allowable working pressure (MAWP) or any other burst pressure that is selected.

Many rupture disc models have manufacturing ranges such as +6/−3%. In these cases the user should realize and should be warned that if the specified burst pressure is at the MAWP, it is very possible that the rupture disc received will be marked above the MAWP.
**Operating Ratio** Another aspect of manufacturing range is its relationship to operating ratio. Once the specified burst pressure and the manufacturing range has been selected, it has to be checked against the operating pressure to insure that the recommended operating ratio has not been exceeded. For example:

A reverse acting rupture disc has a 90% operating ratio
If the specified burst pressure = 100 PSIG @ 72°F
The manufacturing range = +0/−10%
The maximum operating pressure = 85 PSIG
The calculated minimum marked burst pressure = 100 × 0.9 = 90 PSIG
And therefore the calculated operating ratio of 85/90 = 94% exceeds the recommended 90%

A solution for this case is to specify a reduced manufacturing range such as +0/−5%.
In that case, the calculated minimum marked burst pressure = 100 × 0.95 = 95 PSIG, and the calculated operating ratio = 85/95 = 89%, which is within the recommended 90%.

**Minimum Burst Pressure** Sometimes it is not possible to obtain the conventional rupture disc construction that will burst at the required low pressures. For example, a 2 in. (50 mm) conventional stainless steel disc has a minimum bursting pressure of approximately 160 PSIG (1.1 MPa) (see Table 7.17s). If the corrosion resistance must equal that of stainless steel, but the set pressure must be lower, it is necessary to use a different disc. Some options include:

1. Select a reverse-buckling scored disc (Figure 7.17i), which can be set at less than 10 PSIG in the 2-in. size.
2. Specify some kind of laminated construction such as a Teflon-faced aluminum disc.
3. Utilize the sealed low-pressure design (shown on Figure 7.17k).
4. Specify a larger diameter stainless steel disc.

### TABLE 7.17s

<table>
<thead>
<tr>
<th>Size Inch (mm)</th>
<th>Aluminum</th>
<th>Lead Lined</th>
<th>Copper</th>
<th>Lead Lined</th>
<th>Silver</th>
<th>Platinum</th>
<th>Nickel</th>
<th>Monel</th>
<th>Inconel</th>
<th>316 Stainless</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4 (6.2)</td>
<td>310</td>
<td>405</td>
<td>500</td>
<td>650</td>
<td>485</td>
<td>500</td>
<td>950</td>
<td>1085</td>
<td>1550</td>
<td>1600</td>
</tr>
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<td>250</td>
<td>450</td>
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<td>775</td>
<td>820</td>
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<td>230</td>
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<td>1 1/2 (38)</td>
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<td>120</td>
<td>85</td>
<td>120</td>
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<td>95</td>
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<td>8 (200)</td>
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<td>17</td>
<td>35</td>
<td>35</td>
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<td>—</td>
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<td>12 (300)</td>
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<td>—</td>
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<td>—</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>270</td>
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<td>215</td>
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<td>24 (600)</td>
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<td>—</td>
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<td>—</td>
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<td>250</td>
<td>250</td>
<td>600</td>
<td>750</td>
<td>800</td>
<td>900</td>
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</tr>
<tr>
<td>Temperature, °F (°C)</td>
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<td>(121)</td>
<td>(121)</td>
<td>(121)</td>
<td>(121)</td>
<td>(315)</td>
<td>(399)</td>
<td>(427)</td>
<td>(482)</td>
<td>(315)</td>
</tr>
</tbody>
</table>

*In PSIG (14.5 PSIG = 1.0 barg).
**This data applies to forward acting prebulged discs only. Reverse acting disk designs are not limited by the values listed.
Safety and Miscellaneous Sensors

Accessories

Several accessories are available with rupture disc flanges that may be specified as required.

Studs and nuts are used to apply the necessary load to grip and seal the rupture disc. The studs will be longer than required for a standard bolted joint and is dependent on the height of the rupture disc assembly.

Jack screws are used to jack the rupture disc joint apart so that the disc can be replaced, and they should be considered on all installations of 2 in. (50 mm) and above.

Pressure taps are often specified in the outlet holder flange for a pressure switch or excess flow valve and pressure gauge installation as required in disc/valve combination or double disc applications.

Eyebolts are specified when size, weight, or location require lifting devices to aid in installation.

Burst indicators typically consist of some type of breakwire configuration. The circuit is a thin or fragile, normally closed conductive circuit that is broken due either to mechanical contact from the rupture disc or the initial pressure wave released from the opening disc. Other pressure, temperature, and flow sensing devices (see Figure 7.5d) are also used to detect disc leakage and/or rupture.

SIZING

Rupture discs may be sized in accordance with the following formulas:

For vapor:

\[
d = \sqrt[4]{\frac{W}{146 \cdot P}} \cdot \frac{T}{M_w} \tag{7.17(1)}
\]

For steam, if dry and saturated:

\[
d = 0.205 \cdot \frac{W}{P} \tag{7.17(2)}
\]

For liquids:

\[
d = 0.236 \cdot \frac{\sqrt[4]{Q \cdot SG}}{P_1} \tag{7.17(5)}
\]

where:

- \(d\) = minimum rupture disc diameter in.
- \(M_w\) = molecular weight
- \(P\) = relieving pressure (PSIA), including allowable accumulation (10% in normal conditions, 20% in fire conditions)
- \(P_1\) = relieving pressure (PSIG), including allowable accumulation
- \(Q\) = relieving rate, gal/min
- \(SG\) = liquid specific gravity where water = 1.0
- \(T\) = relieving temperature, °R (460 + °F)
- \(T_s\) = degrees of superheat, °F
- \(W\) = relieving rate, lbm/hr
- \(y\) = percent moisture (100 steam quality)

Note: Where rupture discs are installed upstream of a relief valve, the rupture disc should be the same size as or larger than the relief valve inlet nozzle.

Differences in Assumptions and Standards

Due to differences in the assumptions of the various design standards, it is recommended that one should use Equations 7.17(1) to 7.17(5) only if they match the equations in the applicable standard.

Flashing or reactive multiphase venting or high rate pressure transient methods are beyond the scope of this reference. However, the Design Institute for Emergency Relief Systems (DIERS, www.aiche.org/diers) is a good source of information for complex sizing cases, and API RP520 provides guidance for certain cases of flashing flows. The following will describe the three general methodologies employed in sizing rupture discs.

Coefficient of Discharge Method

When this method is used, the coefficient of discharge \((K_d)\) is applied to the theoretical capacity to arrive at the rated flow rate:

\[
W_{\text{rated}} = K_d \cdot W_{\text{theoretical}} \tag{7.17(6)}
\]
The coefficient of discharge method should be used when sizing simple relief systems. A system is considered simple, if the following are true:

1. There are no more than 8 pipe diameters of piping upstream of the rupture disc device.
2. There are no more than 5 pipe diameters of piping downstream of the rupture disc device.
3. The rupture disc device is equal to or greater than the inlet and discharge piping.
4. The piping discharges to atmosphere.

When these criteria are met, the sizing calculations apply to the entire system of inlet piping, rupture disc device, and discharge piping. Note that for ASME and API calculations, the coefficient of discharge is 0.62. For the ISO standards, the coefficient depends on the shape of the vessel nozzle leading to the rupture disc.

**Resistance Method** The resistance to flow method is a relief system sizing method in which the rupture disc device is treated as any other piping component and is represented in the calculations as a resistance value or velocity head loss ($K_r$). The capacity of the system is a function of the sum of all of the resistance values of the piping and piping components (including the rupture disc device). Use this method to size the relief system when the rupture disc is not used in combination with a pressure relief valve and when the conditions of the coefficient of discharge method cannot be met. For ASME and API applications, the capacity of the system calculated using the resistance to flow method must be derated by a factor of 0.90 to account for inaccuracies in the method. Due to the complexity and iterative nature of the calculations, this method is best performed using computer programs. API RP520, API RP521, and Crane TP410 are good sources for additional information regarding this method.

**Combination Capacity Method** When a rupture disc is used at the inlet of a pressure relief valve, the valve is sized first and then the rupture disc is selected using the same nominal size as the inlet of the relief valve. The capacity of the disc/valve combination is the valve capacity times the combination capacity factor (CCF).

$$W_{\text{combination}} = W_{\text{valve rated}} \times \text{CCF}$$ 7.17(7)

The default combination capacity factor is 0.90, but some disc/valve combinations have certified test values that are higher.

In some cases the rupture disc and inlet piping size will be increased one size larger than the inlet of the relief valve in order to minimize the inlet line losses between the pressure vessel and the valve. The $K_r$ value of the rupture disc can be used in calculation of the inlet line losses to the pressure regulating valve. However, if both the $K_r$ value and the CCF factor are relatively high, it is evidenced by some rupture discs that a rupture disc mounted directly upstream of the valve has little effect on inlet line pressure drop. This may be due to the rupture disc conditioning the flow into the valve nozzle, the opened rupture disc being outside a boundary layer, or some combination of both.

**Bibliography**


