

## Rupture Disks for Process Engineers (From the Process Design Engineer's Perspective) Part 6: Specifying the Rupture Disk

Part 1 of this series on rupture disks for Process Engineers covered *why* you use a rupture disk and *when* you might want to use this device. Part 2 discussed *how to size the rupture disk*. Part 3 discussed *how to set the burst pressure*. Part 4 discussed *how temperature and backpressure affects the rupture disk specification and the relief pressure in the system*. Part 5 discussed *the Relief Valve/Rupture Disk combination*. In this part, I conclude the series with a discussion of the rupture disk specification. I will also touch upon the type of rupture disks you can purchase. Before I begin, let me point out that most of what is included in this series of articles can be found in API RP520<sup>1</sup> and API RP521<sup>2</sup>, and ASME Section VIII, Division 1<sup>3</sup>. Much of what is found in these documents can also be found in vendor literature.

We've answered the two questions required to size a rupture disk, how much flow and how big. Now it's time to specify the rupture disk so that it can be purchased for our process. Although API RP520<sup>1</sup> provides a specification sheet that can be adapted by any company as a standard, there are fifty-three separate items asked for in this specification sheet. Much of what is on this specification sheet is not required by the manufacturer to be able to provide you with the correct disk. Let's look at the basic minimum information you, the Process Design Engineer must provide.

### **MUST HAVES**

#### ***Project Identifier/Company Information/Device identifier/Number of Devices***

The vendor will want to know who you are. It is also *necessary* to "name" the relief device for proper documentation. A unique instrument Tag number should suffice for each device ordered.

#### **Code/Standards Requirements**

Various codes and standards dictate how the rupture disk is to be marked and stamped.

#### **Maximum Operating Conditions**

##### *Pressure*

The maximum operating pressure will be used with the stamped burst pressure to determine the Operating Ratio. The Operating Ratio will help determine the type of disk to purchase.

##### *Temperature*

The maximum operating temperature is used to determine materials compatibility.

#### **Rupture Disk Burst Conditions**

##### *Pressure*

This is the pressure that meets system protection requirements, taking into account the Manufacturing Range. The vendor will stamp this value on the disk. It is also used with the Maximum Operating Pressure to determine the Operating Ratio.

##### *Temperature*

This must be coincident with the bursting pressure and will also be stamped on the disk. You will recall from Part 4 that this parameter is extremely important in making sure the disk will burst at the pressure you need it to burst, not less or greater. Also remember that it is not necessarily the same as the maximum operating temperature of the system.

**Process Media (liquid/gas/2-phase)**

Some rupture disk models are designed according to the media in which they are used. Process media is also used to determine materials compatibility.

**Backpressure/Vacuum**

The manufacturer uses the backpressure to help determine disk type and how it is to be supported in the system. Vacuum service will either require the use of a special support for disk installation or even dictate the type of disk to use. *Note that exposure to vacuum conditions must be considered both upstream and downstream of the disk.*

**Service Conditions (static/cyclic/pulsating)**

This typically refers to the upstream conditions. Cyclic service is considered to be large changes in pressure over a relatively long period of time. Pulsating service is considered to be small changes in pressure but occurring frequently or even rapidly. Both of these can have a major affect on the Operating Ratio. The manufacturer uses the service conditions to help determine disk type and how the disk is to be supported in the system.

**Rupture Disk and Holder Material Requirements**

Many installations require the rupture disk to be mounted inside a holder. The holder is then bolted onto a vessel nozzle or between pipe flanges. Make very certain the materials of construction of both the disk and its holder is totally compatible with the system media and operating conditions.

**Disk Size**

This is the nominal size you determined when answering the question, how big?

**Flange Connection size/class/type at Installation**

These tell the manufacturer how big the holder needs to be (connection size), the pressure rating of the system it will be installed in (class) and the type of connection, e.g. raised or flat faced flanges, sanitary connections, etc.

The pressure rating or class can be a most confusing concept. This refers to the flanges in the piping system. More common flange ratings are 150 and 300 pounds (pressure pounds, not weight) but they can go very much higher. A major difference in these classes is the thickness of material, number of boltholes and the bolthole pattern you would get in the flange.

**Required Options or Accessories for Rupture Disk (coatings/linings/vacuum support/etc.)**

Options can be added to the basic design. For instance to enhance corrosion protection, coatings or linings can be applied. Some types of rupture disks can withstand upstream vacuum conditions without doing anything special to them others may need special supports.

**Required Options or Accessories for Holder (coatings/linings/etc.)**

Options can be added to the rupture disk holder as well. For instance to enhance corrosion protection, coatings or linings can be applied. Tell-tales may be specified under this header or can be specified under the heading of "Special Considerations".

**Other Special Considerations**

You can specify just about anything under this heading including the need for a tell-tale. You may want to give more specific detail of a particular design item. You can ask for burst detection and alarms, etc., etc. and etc. The best reference source would be your manufacturer and/or their catalog.

Again, the above should be considered just the minimum amount of information the manufacturer needs to provide the proper rupture disk. Of course your particular manufacturer, or even your company standards, may require much more.

Should you stop here, perhaps not? Below is some information that I consider to be "should haves".

## SHOULD HAVES

### **MAWP (or design pressure) of the Vessel or System**

A vendor does not necessarily require this information (they were already told what to stamp the disk for). However a good vendor will actually be your second set of eyes and make sure that this, along with the other information given, is consistent with Code requirements.

### **Manufacturing Range**

One would think that this should fall under the “must haves” but not really. When the burst pressure was specified in the “must haves”, the manufacturing range had to be taken into account. All the vendor needs to know is what to stamp the rupture disk at and will therefore design the disk with the appropriate manufacturing range to accommodate. However, it never hurts to spell it out so there are no misunderstandings.

### **In Combination with a PSV**

With this information, the rupture disk vendor will be able to recommend the proper type of rupture disk to use for this service. They will also be able to recommend proper installation techniques. And again, the vendor is your second set of eyes and may be able to tell whether your specification data is consistent.

### **Calculate and Report the Operating Ratio**

I could never quite figure out why the vendor cannot just do the simple math but I've seen this as requested information on a number of vendor's specification sheets.

What about all the rest of the information usually included in many specification sheets, e.g. required relieving flow, molecular weight, specific heat ratio, specific gravity, compressibility factor, viscosity, etc.? These are definitely important, but really only to the Process Design Engineer. You need this information to answer the two questions, how much flow and how big? The vendor doesn't need these but we all seem to include them on our specification sheets nevertheless!

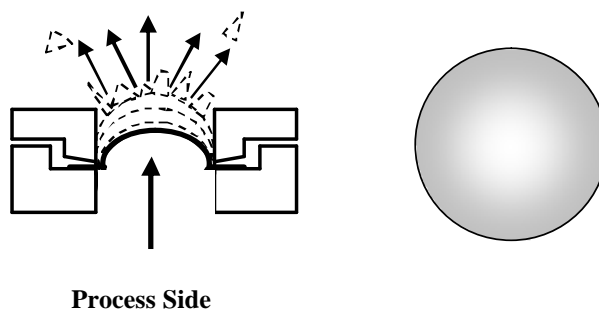
The best suggestion I can make is to talk to the vendor first, find out exactly what they need and provide it. But of course, never violate your own company standards.

## TYPES OF RUPTURE DISKS

The manufacturer can recommend the type of rupture disk that will best suit your application based on the information supplied. However, it doesn't hurt to have some knowledge of the type of rupture disks that can be purchased. There are a multitude of different types and the following only represents the most common types you will most likely come across.

### **Forward Acting Solid Metal**

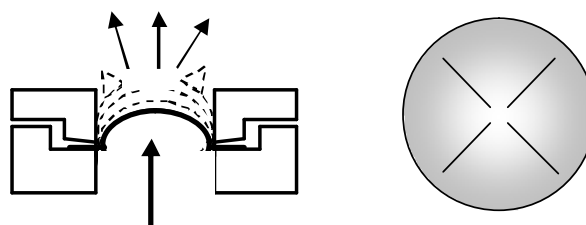
This rupture disk is domed shape and installed such that the media is on the concave side of the disk (Figure 1). It can be used in systems where the Operating Ratio is at about 70% or less. It has a random bursting pattern which means it can be fragmenting (loose material) and thus cannot be used in combination with relief valves. This type of rupture disk can be used in vacuum or larger backpressure services but will require special supports to prevent reverse flexing. Its number one advantage is that it is cheap.



**Figure 1: Forward Acting Solid Metal Rupture Disk**

### Forward Acting Scored Metal

This rupture disk is similar to its solid metal cousin (Figure 1) except that the disk is scored (Figure 2). Unlike the ill-defined bursting pattern of the solid metal design, this rupture disk has scored lines that will force the disk to burst along a fixed pattern. This design is a little more expensive but increases the useful Operating Ratio to about 85 to 90%. It also eliminates fragmenting, which means it can be used in combination with a relief valve. Also, there are many designs that allow this type of disk to be installed in vacuum environments without requiring special supports; it will still need special supports in high backpressure service to prevent reverse flexing.



Process Side

Figure 2: Forward Acting Scored Rupture Disk

### Forward Acting Composite

This rupture disk can be flat or domed and is comprised of a top section preceded by a bottom seal (Figure 3). The burst pressure is a function of these two sections. It is not uncommon for the bottom section to be of a totally different material of construction from that of the top section, even non-metallic. The domed disk design will burst due to pressure applied to the concave side whereas the flat disk design may be designed to burst in either direction!

Slits and tabs in the top section control burst pressure and the bursting pattern. The flat construction can be used for the protection of low-pressure systems. Operating ratios are typically around 80% for the dome construction and 50% for the flat construction. This disk may require special supports to be used in vacuum or high backpressure conditions. Some designs are non-fragmenting, which means they can be used in relief valve combination.

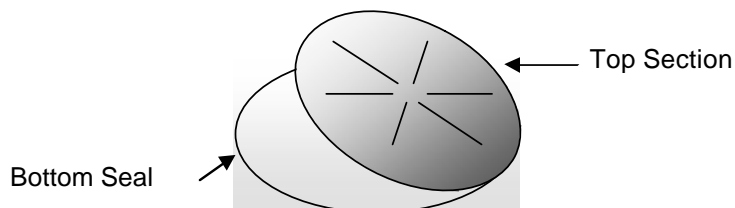
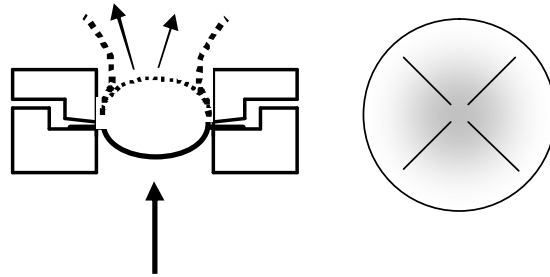


Figure 3: Forward Acting Composite Rupture Disk

### Reverse Acting

This rupture disk is domed shape and installed such that the media is on the convex side of the disk (Figure 4). It is designed such that pressure pushes against the disk causing it to flex back into a forwarding acting disk and then burst. This rupture disk can be used in systems where the Operating Ratio is at about 90% or less. It can be, and very often is, manufactured to be non-fragmenting and thus is a good choice for use in combination with relief valves. This type of rupture disk can be used in vacuum or larger backpressure services without special supports.



Process Side  
Figure 4: Reverse Acting Scored Rupture Disk

### Final Thoughts

#### Liquids

Liquids are treated the same way as gases/vapors in all aspects of determining those two questions, how much and how big. However, do not forget to take the hydraulic pressure into account. Pressure in the system will not be equal throughout. If the rupture disk is installed on a nozzle or in a pipe at the top of a liquid filled vessel, the pressure at the rupture disk will be *less* than all points below it. If the rupture disk is installed on a nozzle at the bottom of a liquid filled vessel, the pressure at the rupture disk will be *greater* than all points above it.

What are the implications of this? If the rupture disk is located at the top of the vessel, the vessel pressure will be greater than the bursting pressure so specify the burst pressure to be *less than* the vessel's MAWP or design pressure. If the rupture disk is at the bottom of the vessel, the vessel pressure will be *less than* the bursting pressure. However, the rupture disk cannot be specified at a pressure higher than MAWP or design. Therefore, realize that the disk will burst even though the pressure at the top of the vessel will be less than design or MAWP.

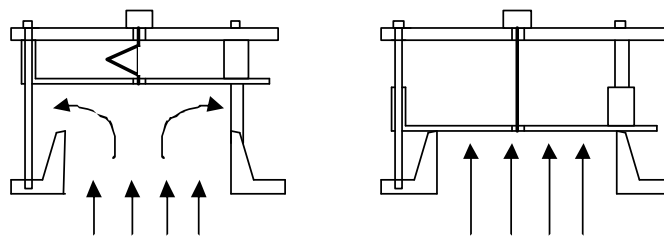
Also note that normal variations in level will cause normal variations in the pressure, i.e. the rupture disk will experience pressure cycling or pulsing. Unlike gases/vapors where normal system pressure cycling or pulsing is usually minimal, it may be significant in liquid filled systems.

#### One More Option to Consider

Ask your manufacturer if they provide a "Fail Safe" design. This design will provide pressure relief at or *below* the certified burst pressure even if the disk is damaged or installed improperly. It will function in this capacity equally well in gas/vapor or liquid service. The major drawback is that it is only available in forward acting non-composite rupture disks.

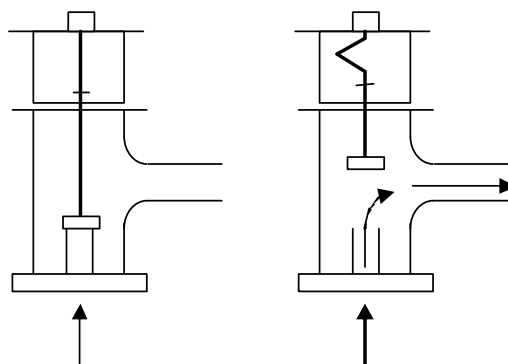
*Other Non-closing Relief Devices*

There are other options to consider for non-closing relief devices other than rupture disks. Although details are beyond the scope of this article, there is one particular device I wish to bring to your attention and which is gaining in popularity, the Rupture Pin<sup>6, 7</sup>. Although ASME will not allow what is called a Breaking Pin device to be used as a primary relief device, as of May 1990, it will allow the use of the Rupture Pin device. The two are similar but for the Breaking Pin device to work, the pin must completely break but for the Rupture Pin device to work, the pin only needs to bend or buckle. Another name for this device is the Buckling Pin. Figures 5A and 5B show two types of rupture pin devices. Device “A” might be used directly on a vessel and will relieve to atmosphere. Device “B” might relieve into a piping header.



Process Side

**Figure 5A: Rupture Pin Relief Device  
End of Pipe with Atmospheric Discharge**



Process Side

**Figure 5B: Rupture Pin Relief Device  
Discharge to Header**

The rupture pin device usually consists of a piston or plunger on a seat, kept in position by a slender, usually cylindrical pin. At set point, axial forces caused by system pressure acting on the piston or plunger area causes the pin to buckle. The unrestrained pin length, the pin diameter and the modulus of elasticity of the pin material determine the buckling point of the pin.

There is virtually no device size limitation. They have been manufactured as small as 1/8” and as large as 48”. There are virtually no pressure or vacuum limits either. They can be designed for a set pressure as low as 2” of water to as high as 35,000 psi and vacuums to as low as 1 psi. Unlike rupture disks, which are solely differential devices, the rupture pin can be designed to sense system pressure only, or differential pressure.

*And Finally*

You are now ready to sit through one of those manufacturer’s presentations and hopefully understand what he is talking about!

**Summary**

- API RP520 provides a specification sheet that can be adapted by any company as a standard
- Not all of the information asked for in the API specification sheet is actually required by the manufacturer in order to design the correct rupture disk. This information can be broken down into “must haves”, “should haves” and “what is needed to size the disk”.
- The manufacturer will always be provided with the “must haves”.
- The manufacturer should also be given the “should haves” as this is a way to utilize them as a second pair of eyes and for a consistency check of the sizing.
- There are many different types of rupture disks on the market. Before selecting the correct rupture disk for your particular application, always discuss this with the manufacturer.
- Liquid service has its own set of potential problems for rupture disk design. It is highly recommended that you discuss liquid service with your manufacturer.
- There are other “non-closing” relief devices that can be considered for use. Some can only be used as secondary relief devices. However the one that can be used as a primary relief device and is gaining in popularity is the Rupture Pin.

**References:**

1. **API** ([www.api.org](http://www.api.org)) **Recommended Practice 520**, "Sizing, Selection, and Installation of Pressure-Relieving Device in Refineries, Part 1-Sizing and Selection", 7<sup>th</sup> Edition (January 2000)
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