APPENDIX IV

RUPTURE DISK SELECTION

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It has been a practice in the process industry to fit rupture disks in pressure equipment to provide means of relieving excess pressure. The disk ensures the safety of life and plant equipment in case of overpressure (Fig. IV-1). A rupture disk is a non-reclosing pressure relief device designed to provide overpressure relief in chemical, petrochemical, and sanitary applications. It can also be defined as a thin metal membrane designed to burst at a certain pressure and temperature to prevent overpressurization of the attached vessel. A rupture disk can be scored, machined, or injection molded. Rupture disks are also known as *burst disks*, due to their characteristic way of bursting when relieving pressure buildup [1].

Rupture disks are similar to pressure relief valves due to their function of reducing overpressurization but differ in the sense that while a pressure relief valve will reseat after discharging, a rupture disk remains open after discharging. A rupture disk consists of a thin metal disk held at both ends by specially machined flanges. The disk can be made of aluminum, silver, copper, nickel, or other metal. It is because of the disk material and thickness that it will burst at a predetermined pressure. Since the rupture disk metal is thin, the stresses are high, and noncorrosion allowance is allowed. However, the disk material must be more resistant to corrosion than the metal from which the pressure vessel is constructed. As a preventive alternative, linings, coatings, or other materials can be employed to protect the disk against corrosion.

A rupture disk with accessories consists of selected instruments that work as a unit with the single objective of controlling pressure buildup. A disk's accessories consist of burst checks, burst indicators, clamps, and ferrules [1]. A rupture disk can be actuated thermally or mechanically. Regardless of the disk design, it should be made with a *safety factor*, which means that a rupture disk designed to burst at 80 psi must burst at 80 psi (it must burst within the agreed tolerance) [3].

IV.1 RUPTURE DISK TYPES

Various types of rupture disks are used in the oil and gas, sanitary, and other industries: forward- and reverse-acting rupture disks. The type employed depends on its suitability for the process.

IV.1.1 Forward-Acting Rupture Disk

The forward-acting rupture disk is dome shaped and is oriented into a system with the process medium (phase application) pressure against the concave side of the disc (Fig. IV-2). When there is an increase in the process pressure beyond the designed or allowable operating pressure, the tensile strength of the material is reached and rupture occurs. This type of rupture disk is employed in systems that typically have operating ratios at about 80% or less. They are usually designed to act in tension, somewhat like a balloon. There are different types of forward-acting rupture disks: forward-acting composite disk, forward-acting solid metal disk, forward-acting scored metal disk, and graphite disk. They have the advantage of being cheaper than reverse-acting rupture disks.

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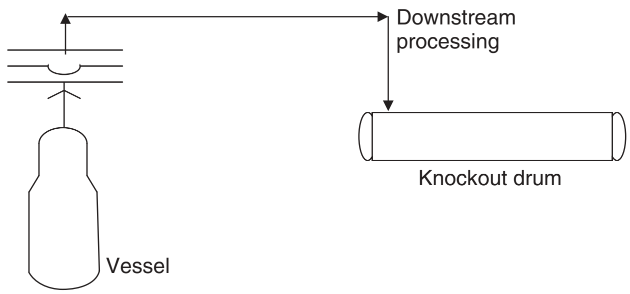

Figure IV-1 Vessel being protected by a rupture disk.

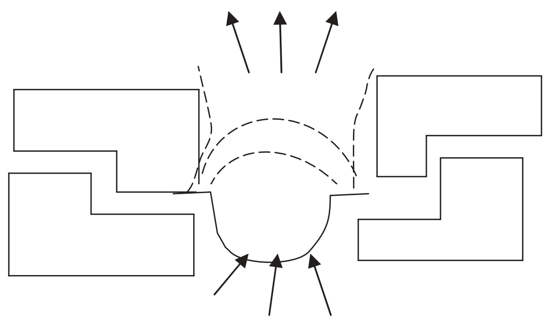

Figure IV-2 Forward-acting rupture disk.

IV.1.2 Reverse-Acting Rupture Disk

The reverse-acting rupture disk is also dome shaped, but is installed with process pressure against the convex side of the disk, thereby placing the rupture disk in compression (Fig. IV-3). It is designed such that as the designed burst pressure of the rupture disk is attained, the compression loading on the disk causes it to reverse back into a forward-acting disk and then burst. This causes the disk to open by a predetermined knife blade or scoring pattern penetration. Reverse-acting rupture disks are employed in systems where operating ratios are as high as 95% or less [4]. They can be used in combination with relief valves, which means that they can be nonfragmenting. Reverse-acting rupture disk can also be used in vacuum or larger backpressure applications without special supports. They have the advantage of controlling burst pressure at close tolerances.

IV.2 OPERATING A RUPTURE DISK

While using a rupture disk, backpressure buildup in the space between the disk and the pressure relief valve should be controlled. The contrary will lead to the disk not bursting at its designed pressure. This backpressure buildup could be caused by leakage, as a result of physical damage or corrosion. Proper inspection for corrosion and physical

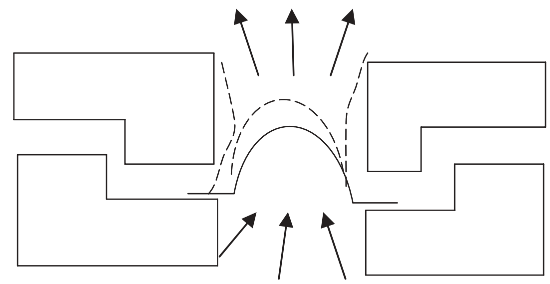

Figure IV-3 Reverse-acting rupture disk.

damage of the rupture disk will give satisfactory service and enhance process safety [2].

Rupture disks are used on vessels, piping, and pressure relief valves, where the pressure buildup is formed as a result of unavoidable mechanical malfunctions and runaway chemical reactions. They are also used to protect heat exchangers and large equipment such as compressors and pumps. Rupture disks can be termed "nonreturn" when the relief is discharged to the atmosphere, and can be termed "return" when they discharge to some downstream collection and treatment systems, such as the knockout drums (Fig. IV-1).

IV.3 RUPTURE DISK SELECTION CRITERIA

Process industry professionals claim that over 60% of rupture disks installed do not perform satisfactorily, and improper selection strategy accounts for over 80% of these problems. Proper selection of a rupture disk is more than performing sizing calculations to make sure that it is adequately sized for the emergency event. Failure to select the correct rupture disk for an application can result in significant plant downtime due to "nuisance failures." In a worst case, an improperly specified disk can fail to open during an overpressure event, resulting in a catastrophic failure.

There are five basic selection criteria to consider to improve rupture disks operating efficiency and service life:

1. *Phase application*. In selecting a particular rupture disk for installation, its phase application must be considered. This implies that gas-only disks should be used under gas-only conditions, because a disk may not open at all under liquid conditions. For example, many reverse-buckling disks are applied under gas conditions; its opening is actuated by the energy stored in the compressed gas; and since liquids are incompressible, stored energy due to compression is not available [1]. Therefore, all liquid-only disks are eliminated in this stage if the application is gas.

2. *Rupture disk operating ratio*. The rupture disk operating ratio indicates the pressure at which the disk can be operated with a prolonged service life. The operating ratio is gotten by dividing the maximum operating pressure by the rupture disk burst pressure. Rupture disk selection with a higher-than-required operating ratio will be a waste of revenue and failure, but selecting a rupture disk with a lower operating ratio than required will cause reduced production and frequent change-outs. Rupture disks have a recommended maximum operating ratio of about 50 to 95%, depending on the construction method and materials. They should not be selected for applications where the disk will be subjected to conditions above the specified maximum operating ratio. Therefore, any rupture disk that does not meet the required operating ratio requirements must not be considered.

3. *Does the rupture disk withstand full vacuum*? Rupture disks are required to be vacuum resistant. In some cases, a rupture disk needs an additional vacuum support, whereas in others they withstand the full vacuum as its standard condition. There are forward- and reverse-acting rupture disk that don't need optional vacuum supports and at the same time don't withstand full vacuum. Such disks are not considered when the need for vacuum resistance exists [2].

4. *Does the rupture disk require being nonfragmenting?* Rupture disks used upstream of a pressure relief valve are normally specified to be the nonfragmenting type. This is because when a disk fragment lodges in the relief valve, it obstructs the valve from closing properly [4]. In some applications it is advisable not to contaminate the process with pieces of rupture disks. This is the case in sanitary applications. If fragmentation is not required for the application, all fragmenting rupture disks should be eliminated.

5. *The soft criterion*. Once the final selection list is established, this criterion is used to evaluate the final suitability of a rupture disk design for a given application. The most important point is that time-intensive evaluation is carried out on a smaller set of rupture disks suited for the application. At this stage, the expertise of the rupture disk manufacturer does not really affect the final decision on the type of disk design to use in the application [3]. Such a soft criterion is previous plant history with the rupture disk design in the same or similar applications (e.g., interchangeability, ease of maintenance, cycle life).

IV.4 TROUBLESHOOTING

Understanding the causes that make a rupture disk fail will help ensure that they don't fail. When the cause of a rupture disk failure is unknown, it is imperative that the disk manufacturer be consulted for further analysis. To prolong the service life and high accuracy of rupture disks, the causes of its problems should be determined. The first step in troubleshooting a rupture disk problem is to make sure that it is selected and installed properly. Table IV-1 provides guidance on troubleshooting four common problems.

TABLE IV-1 Common Rupture Disk Problems and Remedies [1]

Possible Problems	Remedies
Disk is not discharging	
Is scale lodged in the disk?	Clean the disk.
Is the disk applied in the wrong phase media?	If so, check for adequate rupture disk for the particular phase medium: gas or liquid.
Is the disk scored or machined to the vessel properly?	Check coupling.
Is the pressure gauge functioning?	Replace a faulty gauge.
Is the rupture disk small?	Install a properly sized disk.
Disc is experiencing excess pressure	
Is valve opening and/or closing too quickly?	Install slow-closing valves upstream of the rupture disk.
Is the pressure meter installed far from the disk?	Check for proper disk and pressure meter distance.
Is there a hammer effect along the line leading to the disk?	If so, install air-filled dampers to the line.
Disk leaks	
Is the rupture disk installed incorrectly?	Check the manufacturer's manual.
Is the rupture disk assembly worn out?	Replace the rupture disk assembly.
Is there residual porosity in the disk?	Refer the disk for impermeability test.
Disk is not installed correctly	
Is the disk installed with the wrong holder?	Specify the proper disc holder.
Is a damaged disk installed?	If so, replace the disk, and refer for maintenance.
Are the installation instructions complied with?	Maintain design conditions.

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