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Rupture Disc: Usage, Strengths and Weaknesses, Incident Study

What does a rupture disc do aside from rupturing? Rupture discs are emergency relief devices used in industries such as aerospace, petrochemical, chemical, pharmaceutical, and food processing as well as in any processes with potential for pressure build-up. Rupture discs, as the name suggests, rupture; however, more importantly, it ruptures during an overpressure scenario to prevent catastrophic consequences such as shrapnel impacts or release of toxic chemicals which can cause severe harm to personnel and the surrounding environment.

How would I know if I should use rupture discs? Sometimes depicted on the engineering drawings as a Process Safety Element (PSE), a rupture disc contains two main components, a rupture disc and disc holder that provides a pressure boundary and keeps the disc in place. The rupture disc is made of thin metal that is carefully designed to actuate upon a predestined differential pressure across the disc. Once used, the disc must be replaced. Due to the nature of these discs, they cannot be tested prior to application, and they can also be easily damaged during installation/handling or become compromised due to corrosion. Also, rupture discs are not practical for any processes with extreme pressure changes which can lead to frequent disc replacement, downtime for maintenance, and increased likelihood for hazards. In addition, more often than desired, the discs or holder components are installed incorrectly, leading to a blocked discharge port or failure to rupture. We will discuss a specific case study regarding an improperly installed rupture disc in the next section. Aside from rupture discs, there are countless amounts of pressure relief devices, from relief valves, safety valves, explosion doors, explosion vents, and any other types that are available from a large variety of manufacturers. Nevertheless, rupture discs are still one of the most common pressure relief devices used throughout all industries. Some processes would use rupture discs as their primary pressure relief device, while others use the disc in conjunction with pressure relief valve or safety valves. This is because rupture discs come with many benefits.

Figure 1: An example of forward-acting rupture disc.
[Sources: Technical Engineering School]

Rupture discs are fast-acting, which are suitable for any processes that can overpressure very rapidly. Assuming rupture discs are properly installed by an experienced technician, they require much less maintenance compared to other devices serving similar purposes. Rupture discs are also lighter in weight and generally cheaper than other options. So, for any systems that handle benign contents and can afford to lose them, a rupture disc is a good option. The rupture disc may be installed as the primary relief device, as a secondary relief device in parallel with relief valves, or even combined with relief valves, either at the inlet or outlet of the valves. Some benefits of a

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disc installed on the inlet includes ensuring positive seal in case of valve leak, preventing damage to the valve over time due to large solids, protecting valve from corrosion thus reducing maintenance, and allowing relief valve calibration and testing. Discs installed on the outlet protects the valve from atmospheric and downstream fluids that may lead to corrosion in the valves. Rupture discs have proven themselves to be an affordable option not only as a pressure safety element, but also as an asset when combined with pressure relief valves to provide various enhancement for safety and environment protection.

Figure 2: An example of rupture disc installed on the inlet of the pressure relief valve. [Source: Process Technology Online]

Rupture discs, when installed incorrectly, may either have a much higher or much lower activation setpoint. There are two types of rupture discs: forward-acting and reverse-acting. Visually, the only difference between the two types is whether it is concaved or convex on the process side. For that reason, it is easy to accidently instal the reverse-acting discs upside down. When that happens, the upside-down reverse-acting disc would be able to withstand at least 1.5 times more pressure than its intended design, and the system would overpressure before the disc is activated. A brewery at Denmark had a reverse-acting rupture disc installed upside down, which made the disc, originally designed to rupture at <50 kPa, now able to withstand ≥150 kPa. For that reason, when the overpressure scenario occurred at the cylindrical tank at 60 kPa, the tank failed and "rocketed" up, reaching 30 m in height, before crushing a van below. Thankfully, both service technicians were not in the van at the time of the incident. Aside from the causes that led to the tank overpressure, poor inspection, managerial oversight, and even the lack of additional overpressure safeguards were all contributing factors to the accident. If the rupture disc had been correctly installed, it would have been able to relieve vessel pressure before the "rocket" could have taken off.

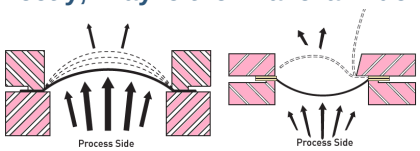

Figure 3: Right – forward-acting; Left – reverse-acting. [Source: Discos de Ruptura]

Conclusion: Rupture discs come in various types/materials and offer a simple and economic method to provide overpressure protection for systems either as the primary relief device, secondary relief device, or combined with pressure relief valves for improved safety and environmental protection when installed correctly.

Resources

1. Rupture discs: when and why to use them? (linkedin.com)
2. Large Steel Tank Fails and Rockets to Height of 30 meters – Rupture Disc Installed Incorrectly - ScienceDirect
3. Common Problems with Rupture Discs (smartmachine.com)
4. Delve Deeper into "Premature Failures" of Rupture Discs | Chemical Processing
5. Advanced Piping Design | ScienceDirect
6. Handbook of Pollution Prevention and Cleaner Production - Best Practices in The Petroleum Industry | ScienceDirect
7. The Safety Relief Valve Handbook | ScienceDirect
8. Rupture Disk Working Principle and Type - Mechanical Engineering Site

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