

Pressure Vessel

Common Failure Modes and Preventive Actions



A pressure vessel is a container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. Failure of a pressure vessel can have catastrophic consequences, so it's crucial to understand the potential failure modes and take steps to prevent them. Pressure vessels can fail in several ways, and preventing these failures involves careful design, materials selection, inspection, and maintenance. Here are some common failure modes and preventive measures:



1. Overpressure Failure:

- **Description:** This occurs when the pressure inside the vessel exceeds its design limits, causing it to rupture or burst.
- **Prevention:** Design the vessel with a sufficient margin of safety, incorporate pressure relief devices (e.g., relief valves), and regularly inspect and calibrate these devices. Implement a pressure monitoring and control system to prevent overpressure situations.

2. Fatigue Failure:

- **Description:** Repeated cyclic loading and unloading of the vessel can lead to the development of cracks and ultimately failure.
- **Prevention:** Use materials with high fatigue resistance, control stress levels through proper design, and implement inspection and maintenance routines to detect and address fatigue-related damage early.

3. Corrosion Failure:

- **Description:** Corrosion, a chemical reaction between the vessel material and the fluid it contains, can weaken the vessel walls.
- **Prevention:** Select materials with excellent corrosion resistance for the vessel's operating environment, apply protective coatings, and regularly inspect the vessel for signs of corrosion. Implement corrosion monitoring systems.

4. Brittle Fracture:

- **Description:** Certain materials can become brittle at low temperatures, leading to sudden, catastrophic failure.
- **Prevention:** Avoid using materials susceptible to brittle fracture in low-temperature applications. Implement temperature monitoring and insulation to prevent excessively low temperatures.

5. Creep Failure:

- **Description:** Creep is the slow, time-dependent deformation of a material under constant load or stress at elevated temperatures.
- **Prevention:** Select materials that resist creep, monitor and control operating temperatures, and ensure that the vessel is not subjected to prolonged high stress levels.

6. Welding Defects:

- **Description:** Welding imperfections, such as cracks or incomplete penetration, can lead to structural weaknesses in the vessel.
- **Prevention:** Use qualified welders and welding procedures, perform non-destructive testing (e.g., ultrasonic or radiographic inspection) to detect welding defects, and maintain high welding quality standards.

7. Hydrogen Embrittlement:

- **Description:** Hydrogen can diffuse into the material and cause embrittlement, reducing the vessel's ductility.
- **Prevention:** Implement measures to minimize hydrogen exposure, such as using materials less susceptible to hydrogen embrittlement and conducting hydrogen exclusion tests.

8. Crevice Corrosion:

- **Description:** Crevice corrosion can occur in areas with restricted oxygen access, leading to localized corrosion.
- **Prevention:** Design vessels to minimize crevices, use corrosion-resistant materials, and maintain proper water chemistry.

9. Stress Corrosion Cracking (SCC):

- **Description:** SCC occurs due to the combined effects of stress and corrosion.
- **Prevention:** Use materials resistant to SCC, control stress levels, and maintain good water chemistry and environmental conditions.

Preventing pressure vessel failures requires a combination of proper design, material selection, regular inspection, and maintenance. Additionally, adhering to industry standards and regulations is essential to ensure the safe operation of pressure vessels. Regular inspections and testing help identify potential issues before they become critical and potentially catastrophic.