Understanding the Hazard

Boiler and Pressure Vessel Overpressure

Equipment

Boilers and pressure vessels are designed to contain limited pressure. If pressure exceeds the maximum allowable working pressure (MAWP), catastrophic failure may result. Providing and maintaining an adequate overpressure protection device can mitigate this hazard. Boiler or pressure vessel overpressure can disrupt operations, generate repair costs, and interrupt business.

UTH topic categories:

- Construction
- **Equipment**
- Fire Protection
- Human Element
- Natural Hazards
- Process Hazards

This series of publications is designed to help you understand the everyday hazards present at your company's facilities. For more information on how you can better understand the risks your business and operations face every day, contact FM Global.

The Hazard

Overpressure occurs in a boiler or pressure vessel when normal devices fail to maintain heat or pressure input below the maximum allowable working pressure (MAWP) of the boiler or pressure vessel. Boiler and pressure vessel construction and jurisdictional codes require a means to prevent pressure from exceeding MAWP. For boilers, a safety-relief valve is the device most often used. For pressure vessels, alternatives include a relief valve, a rupture disk or, in unusual cases, a safety control system that limits input. Pressure-relief devices are always directly attached to boilers, and they may be either directly attached to pressure vessels or attached to the inlet piping of the vessel.

When operating controls fail, or in the event of operator error, pressure might exceed the strength of the boiler or vessel. Without properly installed and maintained overpressure protection, catastrophic failure can result. Pressure-relief devices are the last line of defense against overpressure.

Important Note: Guidance provided in this brochure is primarily intended for boilers using water and pressure vessels not involved in chemical reactions. Vessels used in process industries, such as pharmaceuticals and petrochemicals, require specialized analysis.

Science of the Hazard

Depending on conditions, a tremendous amount of energy can be released upon failure from overpressure. For boilers, the energy is not only present in the pressurized steam, but also in the superheated water remaining in the boiler. This superheated water will instantaneously convert to steam when the boiler erupts, and begin to expand toward 1,700 times its original volume. This "steam explosion" can physically launch parts of the boiler in all directions. Similar explosions can occur with a pressure vessel, depending on its contents.

If properly installed and maintained overpressure protection is provided, the pressure-relief devices will begin to relieve at slightly less than the MAWP, and will fully open slightly above the MAWP. Relief devices that are not properly installed and maintained may not provide the venting capacity necessary, or may not operate at all. Overpressure protection devices guard against relatively slow pressure increases. These devices are not capable of responding to rapid pressure changes, such as runaway exothermic reactions or pressure waves from fluid traveling at high velocity (water hammer).

What you can do at your facility

Now:

- Verify that all boilers and pressure vessels have some overpressure protection.
- Lift test safety and relief valves to confirm freedom to operate.
- Check overpressure devices for signs of leakage.
- Visually inspect safety and relief valves for sealing wire (assuring valve setting has not been altered).

Soon:

- Start an overpressure protection device inspection program.
- Confirm relieving capacity is ample for the volume of vapor or fluid generated or supplied.
- Have safety or relief valves tested by an authorized repair agency.
- Replace rupture disks that have deteriorated from exposure to process fluid.
- Verify that overpressure device vent pipes and drain pipes are adequately sized, unobstructed and properly supported.

Loss Experience

From 1992 through 2000 (the most recent period for which data is publicly available), the National Board of Boiler and Pressure Vessel Inspectors recorded nearly 19,000 incidents involving boilers and more than 2,300 incidents involving pressure vessels. This data shows 180 overpressure incidents involving boilers and 113 overpressure incidents related to pressure vessels for an average of 33 overpressure incidents each year. While the number of overpressure incidents is a relatively small part of the total, the effects can be severe, resulting in peripheral damage and extended downtime.

The potential for considerable property damage should not be underestimated. As a single example, in 1999, a power failure led to rupture of one vessel of many experiencing overpressure in a process facility. After the incident, overpressure relief devices were found to be isolated from the vessels, and relief piping was obstructed by corrosion. News reports at the time estimated the combined property and business loss in excess of US$80 million.

As a Rule of Thumb…

- All reclosing-type overpressure devices should be tested at least annually to ensure they are operating freely.
- Conduct quarterly lift tests of safety valves on boilers operating at 400 psi (27.5 bar) or less.
- Relief valves on hazardous or flammable fluid systems should not be field-tested. Depending on the fluid, these valves should be removed and tested at one- to three-year intervals.

But What About…

…broken seals—do they need to be fixed? I am confident in my boiler safety valves. If the seals are broken, the valves are still set where they are supposed to be.

Without the seals, there is no assurance the settings have not been altered. Perhaps someone on a back shift took a shortcut to stop weeping of the valve. These devices are too important for taking such a chance. Operating with an unsealed safety valve creates an unknown and potentially dangerous operating condition. The prudent action is prompt replacement of unsealed valves with valves sealed by the manufacturer or an authorized valve-repair agency.

Protection Devices:

Examples

- Safety and safety-relief valves are generally intended for service on boilers and water heaters. Safety relief valves are appropriate for hot water and high-temperature water boilers. These valves are designed to "pop" open very near the set pressure and snap closed at a pressure slightly below the set pressure. This feature rapidly reduces excessive pressure while minimizing unnecessary loss of steam or hot water.
- Relief valves are intended for pressure vessel service. These valves begin to open at the set pressure and open proportionally with pressure increase until fully open at no more than 10 percent above the set pressure. These valves may be used for steam, air, water, flammable gas and other fluid. When used on vessels containing hazardous or flammable fluid, no manual test lever is provided. This safeguard is designed to prevent unintentional release of the material. Depending on design and service, these valves may close at a pressure significantly below the set pressure, or may require manual re-closing.
- Rupture disks are constructed from a variety of material and configurations for specific applications. Care must be taken to match the rupture disk material with the fluid to assure intended protection. Rupture disks are single-use devices, and the process or vessel must be isolated to replace the disk after it operates.

…bench testing steam safety valves with water or air?

The results will not be accurate. The opening pressure of a valve at operating temperature, when the pressure is from steam, differs considerably from the ambient temperature of the valve when water or air pressure exists. Valve-set pressure verification should be contracted with an agency that has a current valve-repair-authorization (VR) stamp from the National Board. An authorized repair agency can perform set pressure testing in shop or on your boiler.

…the possibility that manually lifting my boiler safety valves will cause them to leak?

The central question is, will they open when needed? Often, and over time, chemicals build up on the seat-disk interface and effectively weld the valve shut. During idle periods, condensation may collect in the valve body, corroding the moving parts and locking them in place. The only way to assure free movement of the valve mechanism is to periodically lift the valve, either by increasing the pressure on the boiler or by lifting the valve manually. Before lifting by hand, make sure the boiler pressure is no less than 75 percent of the lift pressure before hand-lifting. This precaution will prevent the valve stem from bending and assure the valve will snap closed when released.

…piping to the fluid-system relief valve or rupture disk — should that be inspected?

Yes, some fluids solidify at reduced temperatures. Carbonaceous or other solids may be formed from overheating of other fluid. The overpressure protective device must be removed periodically to assure the connection to the protected vessel or system remains fully open.

…the rupture disk? Why does that need to be replaced?

Rupture disks may look fine, but the material characteristics change with exposure to process fluid and temperature. These material changes will generally reduce the burst pressure; therefore, replacement at an interval recommended by the disk manufacturer can prevent unnecessary shutdown to replace a disk.

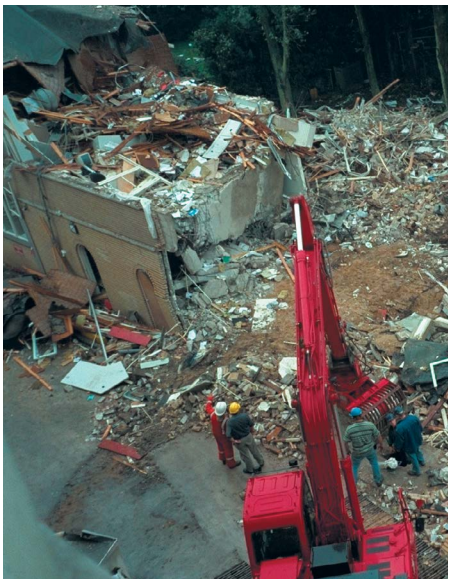
…our ammonia system and propane tank relief valves. Why must they be removed for testing?

For safety reasons, relief valves on hazardous or flammable gas systems cannot be tested while installed. Relief valves are mechanical devices and, over time, the parts may corrode or stick for other reasons. Also, the spring may lose strength. The only safe way to confirm proper functioning of these relief valves is to remove them and have them tested by an authorized repair agency.

Need more information?

Ask your FM Global engineer or client service team about the following:

- *Equipment Hazard Playing Cards* (P0682)
- FM Global Property Loss Prevention Data Sheet 12-43, *Pressure Relief Devices*
- *Pocket Guide to Boiler Care and Operation* (P0273)
- *Safe Boiler Operation* online client training



Don't Let This Happen to You

One of two firetube boilers was required to supply process and heating steam for this facility. The boiler involved had been in service 24 years, produced 5,000 lbs./hr. (2,268 kg/hr.) steam, was 13 feet (4m) long, operated at 115 psi (8 bar) and had 175 psi (12 bar) MAWP. The boiler was running at operating pressure when the longitudinal seam in the shell failed, permitting the high temperature water in the boiler to instantaneously expand to nearly 1,700 times its original volume.

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