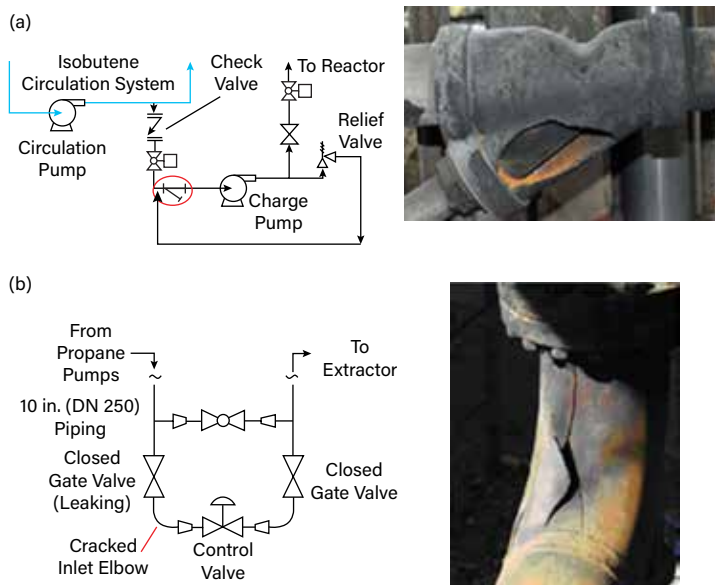


Thermal Expansion Runs Hot and Cold

August 2025



▲ Figure 1. In 2019, (a) overheating in a liquid isobutene system caused a cast-iron strainer to burst, leading to an explosion. The burst section is circled in red. In 2007, (b) water trapped in a propane pipe froze, splitting the pipe wall and leading to a loss of containment incident. These two incidents reveal how damage to processes can be caused by both excessive heat and freezing.

In April 2019, at a facility producing specialty chemicals, a piping section filled with liquid isobutene was closed off (Figure 1a). As its temperature slowly increased, a cast-iron strainer burst, leaving a hand-sized hole. The release was followed by an explosion and fire, injuring 31 people, leading to one fatality, and causing enormous damage. See the May and July 2024 Beacons for more information.

In February 2007, at a refinery, a section of piping cracked and released pressurized propane (Figure 1b). That section had been out of service for 15 years but was still connected to active piping. The resulting fire injured four people and caused huge material losses. One leaking block valve allowed small quantities of water contained in the propane feed to collect in a low part of the seemingly blocked-off section. Cold temperatures caused the water to freeze and split the pipe. When the ice thawed, propane escaped. For more information about this incident, see the October 2008 Process Safety Beacon.

Did You Know?

- Matter normally expands when the temperature rises. This is because the molecules or atoms move more and occupy more space.
- The gas phase of any material has a much larger volume than its solid or liquid phases. A gas can easily be compressed, which reduces the empty space.
- For gases like air, a temperature increase from 32°F to 523°F doubles the volume. If no additional volume is available in the pipe or container, the pressure doubles.
- Liquids and solids have tightly packed molecules and atoms and are difficult to compress even by very high pressures. However, when heated, they expand. Liquids expand much more than solids. Pipelines in hot service have compensating expansion loops. Liquids blocked in without a gas space or relief device can rupture equipment, as shown in Figure 1a.
- Water expands by 9% when it freezes. This effect causes ice to float, water bottles to burst in a freezer, and equipment to rupture, such as the elbow in the propane piping shown in Figure 1b.

What Can You Do?

- When you notice parts of equipment that are not rigidly fixed, it may be to compensate for thermal expansion. Do not try to correct it; point it out to your supervisor.
- Do not block in hoses or pipes that are filled with liquid if they are exposed to sunlight or heat unless there is a relief device. This is easily overlooked during troubleshooting activities. Follow established procedures for isolating and depressurizing.
- If ambient temperatures can drop below 32°F, make sure that the pipe is freeze-proofed in sections that could contain water. The freezing point of other materials may require freeze-proofing at different temperatures.

Too hot or too cold can be a bad “break” for your equipment