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Good Design Eliminates Frozen Storage Tanks

E. Crone Knoy
President
Tank Industry Consultants, Inc.
Speedway, Ind.

One of the worst things that can happen in a distribution system during the winter is having the storage tank freeze. A frozen storage tank creates severe problems that cannot be easily fixed. The first article in this series, which appeared in the January 1991 *Opflow*, discussed why storage tanks freeze and what can be done to thaw them and repair the damage. This article discusses specific causes of freezing and design elements to discourage freezing.

Why Tanks Freeze

Basically, there are three reasons why storage tanks freeze: static water conditions, tank overflows, and improper design.

Static water conditions. Static water conditions, or lack of sufficient water turnover, prevent water in the tank from being warmed by incoming water. Some causes of static water include

- tanks are reserved for fire protection (these should be heated);
- the tank high-water line is lower than the system pressure gradient and is kept static by an altitude valve;
- the tank is located in a low-water-consumption area with high pipe friction between the tank and the pumping facility and between the tank and the high-use area;
- a normally heavy water user suddenly stops, such as when a school closes for the summer or a factory shuts down for several days;
- pumps supplying the system are of variable-output, constant-pressure type and have a capacity equal to the peak demand;
- the water main serving the tank freezes solid;
- the tank is valved off for winter with water in it;
- the controls for the pumps or altitude valve are frozen or damaged by ice; or
- the tank is too large for the present system.

Tank overflows. Freezing may occur when the tank is allowed to overflow at a trickling or slow rate, which will permit freezing in the overflow pipe. In freezing weather, the escaping water will immediately freeze. Causes of overflow include

- improper control specification or adjustment;

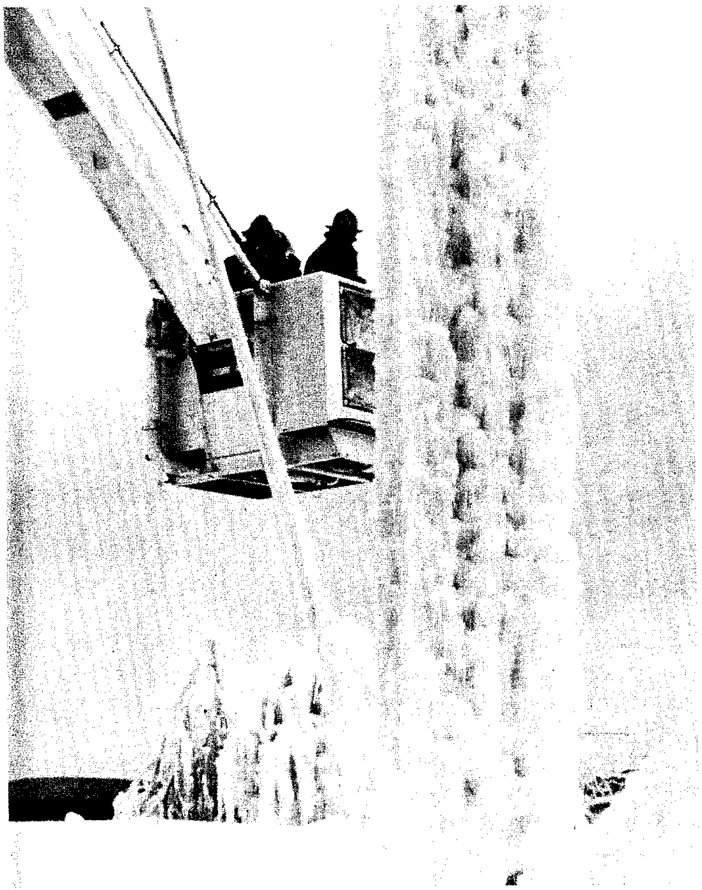

Figure 1 A frozen storage tank endangers lives and disrupts service. Good design can help prevent freezing.

- frozen controls for pumps or altitude valves;
- telemetering conductors damaged by ice or wind;
- leaky valves; or
- tanks designed to "float" on the system with other tanks will occasionally overflow due to pressure variations.

Improper design of the structure. Sometimes, design and specifications can contribute to problems with freezing in tanks. Some troublesome design elements include

- piping arrangement and size;
- vent design;

Tank Structure, External Features Can Cause Freeze Problems

- inadequate freeboard between the overflow and the roof structure;
- structural members, piping, ladders, or other protrusions below the high-water level;
- heat-conducting projections or narrow gratings across riser piping;
- insufficiently insulated piping or riser; or
- static piping projections from the tank.

Good tank design can eliminate many of the problems that lead to freezing or can mitigate the troubles resulting from freezing.

Interior Structure

Tanks located in areas with a lowest one-day mean temperature (LODMT) of –10°F (–23°C) or colder should not be equipped with inside ladders or overflow pipes.

As ice forms and moves up and down, it exerts tons of force on ladders and pipes, tearing them loose from their supports and many times ripping or punching holes in the container.

These holes create a leak at a very bad time. If an inside overflow pipe is broken, the tank will quickly lose all water down to the break. This will create a skating rink down below. If the vent is plugged with ice or snow, the tank roof may collapse when water rapidly drains from the tank.

Tanks may be equipped with interior ladders and overflow pipes if the tank has a high turnover of warm water. Or, a ladder and overflow may be installed at the center of a tank supported by an access tube, such as single-pedestal tanks and very large column-type tanks.

It is a bad idea to position interior girders, roof bracing, painter's rails, or any other protrusion below the high-water line or in areas of the tank affected by floating or suspended ice. This is especially important for tanks in locations where temperatures get to be –20°F (–29°C) LODMT or colder.

Again, local conditions or tank-use patterns may create severe icing problems in warmer areas.

External Features

Roof-opening location. Risers or inlet pipes should be directly below roof vents or manholes, or an auxiliary opening should be provided. This will help you thaw the tank if that becomes necessary.

Figure 2 After the thaw, tears in the tank become visible. There are several methods to prevent freezing.

The pipe openings should not have a protective discharge cap where they enter the container. Grates over pipes should be open enough to allow you to lower thawing lines through the grates. Keep in mind that grates conduct heat and promote freezing.

Static water projections. Pipes extending from the tank or piping should not contain static water unless the piping is heated and insulated.

For example, drain valves extending on nipples will freeze easily. Drain valves should be of the double-seating, internal-closing type.

Additional outlets. The tank design may include side outlets on the riser pipe. Steam or warm-water lines can be attached to the side outlets to thaw the riser. The outlets should be plugged to eliminate an unheated projection.

Frostproof vents. Vents should be designed so they won't freeze over. Some tank manufacturers have proprietary designs for this.

Dark color. If a dark color is aesthetically agreeable and will not keep the water too warm in the summer, consider using one on the tank exterior to absorb radiant heat from the sun.

Riser pipes. Riser pipes should be properly sized and/or insulated. Locations where temperatures fall to –20°F (–29°C) usually have small (less than 12 in. [0.3 m]) risers insulated with at least 4 in. (0.1 m) polyurethane foam.

In the past large steel plate risers (36 in. [0.9 m] or larger) have relied on ice for insulation, but this is no longer recommended. Large risers, 48 in. (1.2 m) and 60 in. (1.5 m), have been successfully used in areas that get down to –20°F (–29°C).

Preventing Freezing

Heating. It is usually too expensive to heat a community water supply tank. Industrial sprinkler tanks for fire protection have been heated for many years. New insurance rate structures and better community water supply systems have allowed many factories either to dismantle the tank or stop heating it.

Air bubblers. Air bubblers have been used successfully in ground storage tanks and in elevated tanks with large risers. The compressor should be high volume with just enough pressure to overcome air-line friction, orifice friction, and the hydrostatic head due to the water depth. There must also be an influx of warmer water because the

Insulating Riser Pipes Is Common Precaution for Tanks

bubbling actions tends to remove all the heat from a confined volume of water.

Circulating pumps. Circulating pumps that do not heat the water have been successful on tanks with small (6 in. to 12 in. [152 mm to 305 mm]) riser pipes in Iowa, Minnesota, and the Dakotas.

A relatively small (1.5 hp [1.1 kW]) pump draws water from the base elbow, pulling water down the insulated riser or from the connecting pipe. The pump discharges water into a 1-in. (25-mm) line entering the riser at the base of the tank and discharging into the tank container. This creates circulation in the riser.

Insulation. Insulating riser pipes is common. Many ground-storage tanks, and a few elevated tanks, have been sprayed with urethane foam to insulate them. This creates a rough appearance, and sometimes it is difficult to make the foam stick to the steel.

It is important to remember that, no matter how thick the insulation, with no heat input to the water stored, it will freeze given enough time. ♦

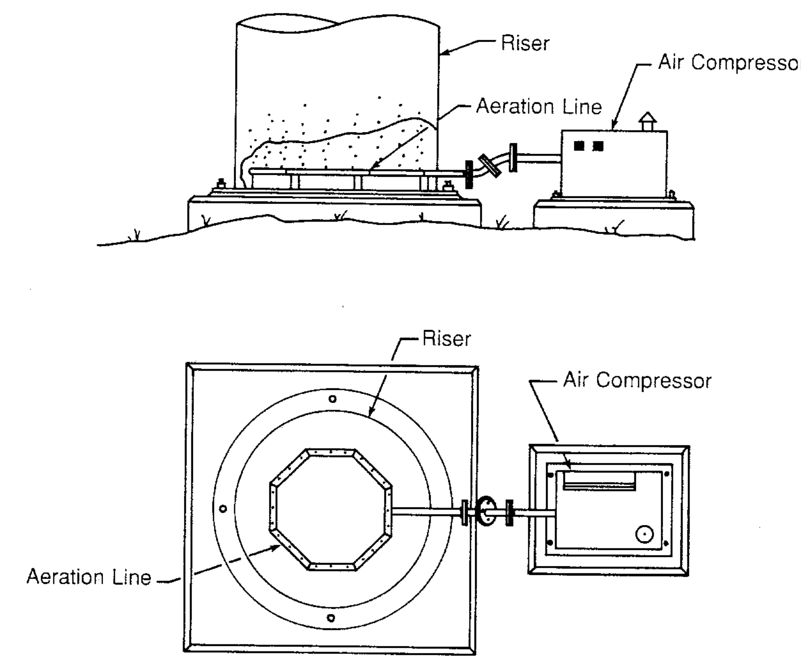

Figure 3 An air bubbler directs compressed air into the riser.