FROZEN PIPE WATER LOSSES: MECHANISMS AND CHARACTERISTICS

Author: Brian James, P.Eng, NAFI-CFEI, NAFI-CVFI, Technical Lead, Envista Forensics

Frozen pipes are a leading cause of water losses during the winter months and represent major financial losses. A burst frozen water pipe can damage a single-family dwelling or multiple floors within a condominium or apartment complex, leading to thousands of dollars in remediation. In some cases, even a small pipe fracture can leak hundreds or thousands of gallons of water in just one day, damaging property as well as the contents within. Beyond damaging property and contents, water leaks also lead to mould and flooding when water damage goes unnoticed for an extended time. This is particularly a problem in vacation homes that are left unattended during the winter months.

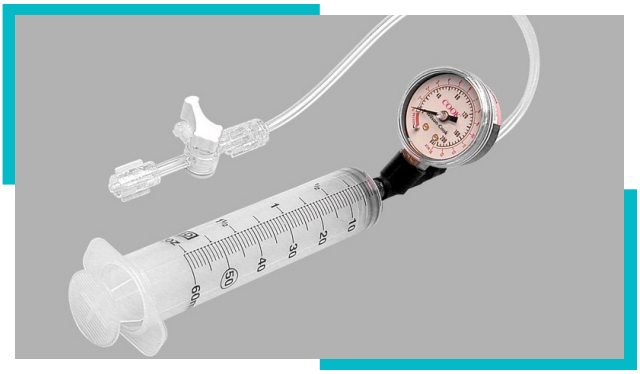
Highlights

- Freeze failure characteristics
- Failure mechanisms
- Cause and origin

Failure Mechanism

At the root of the matter, frozen pipes fail due to excessive pressure buildup within the piping network. One reason for this is because water expands when it is frozen. This buildup of excessive pressure can result in multiple failure locations within a given pipe network, and this pressure is one key factor. However, to build pressure, the fluid (typically water) must be pressurized or encapsulated in the given volume of a piping network.

Here, the working mechanism is effectively an "ice plug" which occurs within a piping section. As this ice plug grows (from continued freezing and water expansion), the pressure of the unfrozen water in the piping network increases. Like a water-filled syringe, if you hold your finger over the opening and block the water from coming out and then push the plunger down, the water pressure eventually exceeds the pressure you can apply with your finger and leak at the blocked location. This is precisely the same mechanism that occurs within freezing pipes.



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G27113_P_001.jpg (800×600) (cookmedical.com) Internet Image

The critical thing to keep in mind is that the piping network failure location will not necessarily correspond exactly to the piping network freezing location. The failure location results from excessive pressure buildup created by the ice plug, where this excessive pressure can not be absorbed within the piping network (the system).

This also means that all piping materials can be susceptible to freezing incidences resulting in their failure and fracture and, ultimately, a water leak. While there are different arrangements of multiple materials consisting of metal and plastic components, they are all susceptible to freezing damage in the right conditions. This highlights the need to understand the failure mechanism and how the failure location fits into the piping network/system.

Typical Failure Locations

As stated above, the failure location is not necessarily representative of the freezing location. The failure locations are typically represented in elbows (such as in cooling fan units) and T-connectors. One of the mechanisms at work is the manufacturing methods used to form these components. Some components have thinner walls, which ultimately represents the "weakest link" in the piping network, to handle the increased and ultimately excessive pressure.

Underground Plumbing Connections

Frozen Pipe Investigations

Residential Properties

The root cause of freezing conditions within a residential or vacation property may be a heat source failure, which in most cases is a central forced-air furnace. Typically, city properties are equipped with natural gas forced-air furnaces, and if there's a component failure or malfunction, depending on the failed component, the furnace attempts a restart. If there is no confirmation that a flame was established, the furnace controller goes into an error mode, which may cause a homeowner to make a call to a furnace service company stating they are without heat. However, if this situation occurs while there is no one home, the building temperature can fall below a freezing temperature. This can become readily apparent on piping components located in exterior walls.

Absence of Heat

Vacation properties can also experience the same absence of heat. Since many vacation properties have an oil-fired furnace as their heat source, one of the main items analyzed is fuel remaining within the fuel oil storage tank. Another essential consideration is the fuel delivery contracts that exist with local suppliers. Are they on-call, on-demand or a scheduled top-up service?

Vacation properties may also have greater periods of homeowner absence between visits. Consequently, if there is no heat combined with cold ambient temperatures, this can create a significant water loss, resulting in water flowing for several days before discovering the freezing event.

External Temperatures

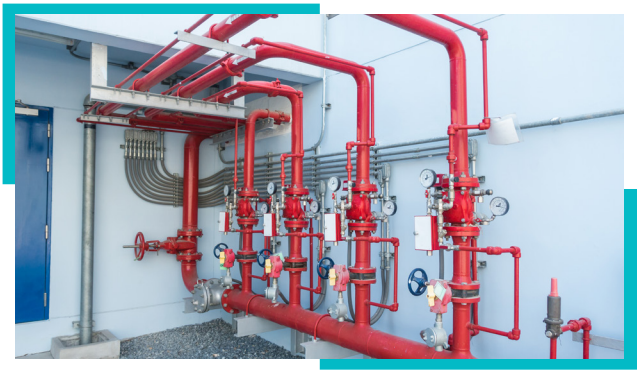
Even with a furnace operating and heating the living space, it is entirely possible that if the ambient temperature is too cold (e.g. cold snap, or change of use/occupancy), it may end up freezing a pipe within a wall cavity and result in a corresponding water leak. Even with the homeowner present during this water leak discovery, it will still significantly damage the building and its contents.

Commercial Properties

Commercial properties are in no way exempt from water losses. In fact, they can represent a much greater loss value since some of the piping network systems have a much larger diameter and corresponding water volume. A failed water pipe or cooling fan unit within a multi-floor condominium or apartment can severely affect multiple units in a water loss.

Electrical Power Outages

Electrical power outages may prevent equipment from automatically restarting, such as pumps or motor drives, and the building maintenance staff would need to reset these manually. Furthermore, significant power outages lasting multiple days may expose components not designed for such temperatures within mechanical rooms to freezing conditions. Many components are equipped with supplementary electrical heaters or rely on heat produced within the facility from operating various mechanical components.



Fire Suppression Sprinkler System

Sprinkler System Freezes

Commercial properties are also commonly equipped with sprinkler systems, which come in two varieties: a wet sprinkler system or a dry pipe sprinkler system.

A wet sprinkler system, as the name implies, is always filled with water. When a sprinkler head activates through temperature, it starts a water flow to suppress the fire within the spreading capacity of the sprinkler head. This water flow also trips a flow sensor, generally monitored by the building management and fire alarm systems. Exposing a wet sprinkler system component to freezing results can form an ice plug, which can fracture the sprinkler piping distribution network. The freezing of a wet sprinkler system section may also prevent its operation, resulting in a large fire that could have been contained.

A dry pipe sprinkler system is for areas normally exposed to freezing conditions, such as vestibules, overhangs and attic spaces. These dry pipe sprinkler systems are not exempt from freezing failures. A dry pipe sprinkler system maintains pressurized air within the dry piping sections exposed to potential freezing. This air is supplemented, and the pressure is maintained with an air compressor, typically located in the mechanical room. Compressing the air (to fill the dry pipes) also includes the moisture level within the compressed air. That moisture is then distributed through the dry pipe section of the sprinkler system. There are maintenance factors regarding a dry pipe sprinkler system, including the regular draining of drip legs positioned at strategic locations within the dry pipe sprinkler system network. This encourages the collection of moisture to keep the system dry, and helps avoid system failure in the event of freezing.

In addition, as the dry pipe name implies, the majority of the piping network exposed to freezing conditions does not contain water; however, if there is a trip event causing water to flow, to restore the system, service personnel have to flush out the water contained within the system to prevent freezing of the residual water within the dry piping network.

Pipe Failure Complexities

A frozen pipe failure is not as straightforward as one would think. Frozen pipe failure investigations rely on a strong understanding of the entire piping network, components related to the system, failure location and potential freezing locations. It's important to understand the relationship between these components to differentiate a freezing event from what may potentially be an installation issue, material failure, or a component failure of an isolated element within the piping network.

If you believe you have a frozen pipe water-loss incident, our team of experts have extensive experience in dealing with these types of losses. Contact Envista Forensics at www.envistaforensics.com for a quick and comprehensive solution.

About the Author

Brian James, P.Eng, NAFI-CFEI, NAFI-CVFI is a Senior Technical Consultant with over 27 years of experience in mechanical valuation of equipment including electrical and hydraulically-driven machinery, components, sub-components, electrical components, appliances, and other devices for assessment of failure modes and evaluation for compliance to applicable codes and standards or suitability of design and operation. He has conducted over 1,000 engineering investigations. In addition, he has conducted origin and cause evaluations of vehicle fires, heavy equipment fires, machinery and equipment fires, and residential and commercial structure fires. Mr. James is also qualified as an expert witness in civil court and Superior Court in the province of Ontario.