RESISTANCE OF PEX PIPE AND TUBING TO BREAKAGE WHEN FROZEN (FREEZE-BREAK RESISTANCE)

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Foreword

This technical report was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute (PPI). These members have shown their commitment to developing and improving quality products by assisting standards development organizations in the development of standards, and also by developing design aids and reports to help engineers, code officials, specifying groups, contractors and users.

The purpose of this technical report is to discuss the resistance of crosslinked polyethylene (PEX) pipe and tubing to breakage when frozen (freeze-break resistance), and steps that installers can take to prevent freezing of water and fluids within PEX pipe tubing and the damage that might result.

PPI has prepared this technical report as a service to the industry. The information in this report is offered in good faith and believed to be accurate at the time of its preparation, but is offered "as is" without any express or implied warranty, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Additional information may be needed in some areas, especially with regard to unusual or special applications. Consult the manufacturer or material supplier for more detailed information. A list of member manufacturers is available on the PPI website. PPI does not endorse the proprietary products or processes of any manufacturer and assumes no responsibility for compliance with applicable laws and regulations.

PPI intends to revise this technical note within five years, or sooner if required, from the date of its publication, in response to comments and suggestions from users of the document. Please send suggestions of improvements to the address below. Information on other publications can be obtained by contacting PPI directly or visiting our website.

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RESISTANCE OF PEX PIPE AND TUBING TO BREAKAGE WHEN FROZEN (FREEZE-BREAK RESISTANCE)

1.0 INTRODUCTION

Crosslinked polyethylene (PEX) is a polyethylene material which has undergone a change in molecular structure whereby the majority of polymer chains are chemically linked. This crosslinking of the polymer chains results in improved performance properties such as elevated temperature strength, chemical resistance, environmental stress crack resistance (ESCR), resistance to slow crack growth (SCG), toughness, and abrasion resistance.

These properties are described in great detail in other PPI publications.

The inherent flexibility of crosslinked polyethylene also results in excellent freeze-break resistance properties. This means that if water- or fluid-filled PEX pipe or tubing freezes, the elasticity of the material typically allows it to expand without cracking or splitting, and then to return to its original diameter upon thawing. However, there are installation variables that can cause PEX to fail in certain situations, as described within this Report, and the freezing of fluid within any type of pipe should be prevented for multiple practical reasons.

This Technical Report will explain how proper installation and protection can prevent freezing of water or other fluids inside PEX, how the inherent material properties of PEX can delay freezing of water, and how PEX can resist breaking *if* the fluid inside *does* freeze.

Topics discussed in this document include:

- Section 2.0: PEX material properties
- Section 3.0 Published research
- Section 4.0: Code requirements for piping insulation & protection
- Section 5.0: PPI recommendations
- Section 6.0: Summary

This Technical Report is not an installation guide. Installers, builders, inspectors, engineers, and designers should refer to local regulations to determine the requirements for protecting PEX pipe and tubing against freezing.

Note 1: Although fittings and connections are part of every PEX system, fittings are not specifically addressed within this Report. Various fitting types constructed of materials such as brass and polymer are described within the research reports referenced in Section 3.

2.0 MATERIAL PROPERTIES

The overall material properties of PEX pipe and tubing are specified in numerous publications, including industry standards such as ASTM F876, ASTM F2788, ASTM F3253, and CSA B137.5, as well as several PPI publications.

This Technical Report will focus on the properties of PEX which allow it to resist breakage when water or fluid contained within is frozen, also known as “freeze break resistance”. These properties include: insulating properties which reduce heat transfer through the pipe wall and can delay the freezing of fluids within, the strength and flexibility of PEX, and the cold-weather behavior of PEX which contributes to this flexibility.

2.1. R-Value and Thermal Conductivity of PEX Material

For fluid within a pipe to freeze, first the heat must be transferred out of the fluid through the pipe wall. Although PEX is often used as a heat-transfer pipe (e.g. radiant heating/cooling, snow and ice melting, geothermal ground loops), the relatively low thermal conductivity of PEX material, as compared to metal piping materials, reduces heat transfer through the pipe wall. This can delay the freezing of fluids within PEX pipe or tubing, potentially preventing freeze events.

For similar material thickness, PEX is **68 times** less conductive than copper, which will delay heat transfer into or out of the contained fluid.

According to **PPI Technical Report-48** *R-Value and Thermal Conductivity of PEX and PE-RT,* the normalized thermal conductivity (K-factor) for PEX is **2.86 (BTU·in)/(ft^2·hr·°F).** This compares with a thermal conductivity (K-factor) for copper tubing material of **196 (BTU·in)/(ft^2·hr·°F)**, a factor of 68 times.

Another way of expressing the relatively low thermal conductivity of PEX is to covert this to an R-value of **0.38 (ft^2·°F·h/BTU)**, expressed as *per inch of material thickness*. The higher the Resistance value, the slower the rate of heat transfer through the insulating material.

However, the wall thickness of each diameter of PEX tubing varies, based on a standard dimension ratio (SDR) of 9, with the wall getting increasingly and proportionally thicker as diameter increases. In fact, in all diameters, the wall thickness of PEX tubing is higher than that of copper tubing, so a direct comparison of R-values is not linear. See **Table 1** for the R-value of PEX tubing by nominal diameter.

Table 1: R-value of PEX Tubing by Nominal Tubing Size (i.e. diameter)

	Nominal Tubing Size (NTS)						
Property	**3/8**	**1/2**	**3/4**	**1**	**1 ¼**	**1 ½**	**2**
Wall Thickness (in)	0.070-0.080	0.070-0.080	0.097-0.107	0.125-0.138	0.153-0.168	0.181-0.200	0.236-0.260
R-value (ft^2·°F·h/BTU)	0.0277	0.0277	0.0383	0.0494	0.0604	0.0715	0.0932

Note 2: Normalized R-values are based on standardized material thickness of one inch

2.2. Material Strength & Flexibility

One method to quantify strength and flexibility of a material is by measuring the Modulus of Elasticity (i.e. Young's Modulus, E).

For PEX pipe or tubing, the modulus of elasticity varies somewhat, depending on the production method or the density of the raw materials, but it is typically less than 150,000 pounds per square inch (psi) (1,034 MPa). A higher modulus of elasticity means the material is more rigid.

PEX material has both short-term and long-term hydrostatic strength far in excess of the requirements for most applications. For example, the minimum short-term burst strength of SDR 9 PEX tubing, per ASTM Standard Specification F876, is 475 psi (3.27 MPa).

Elasticity has been defined as "a measure of material stiffness or the ability of the material to stretch or deform temporarily under a load". So, while copper tubing is approximately 180 times more rigid than PEX, PEX has elastic properties which allow it to expand somewhat, and then return to its original diameter. Since water expands upon freezing, this elastic property is beneficial during a freeze event, as the pipe can expand with the water.

This elasticity is similar to that of high-density polyethylene (HDPE), which provides the benefit of freeze-break resistance for water mains, protecting them against breakage if frozen, in most situations.

2.3. Cold-weather behavior

Crosslinked polyethylene remains a flexible material even at temperatures well below freezing. In fact, PEX tubing remains flexible and can still be bent at temperatures below -40°F (-40°C). The actual low temperature embrittlement of most polyethylene, the resin material on which PEX compounds are based, is below -180°F (-118°C)[1].

The so-called "glass transition temperature" for PEX materials, which means the temperature below which the material become brittle and can shatter, has been published as below -148°F (-100°C)[2][3].

2.4. PEX with EVOH Oxygen Diffusion Barrier

The addition of a co-extruded barrier layer, commonly using an ethylene vinyl alcohol material (EVOH) applied to PEX tubing for the purpose of resistance to oxygen permeation or diffusion, does not seem to change the freeze-break resistance of PEX tubing. An EVOH barrier layer may delaminate or crack when PEX tubing is frozen and expanded.

3.0 PUBLISHED RESEARCH

The topic of freeze-break resistance of piping materials in general, and of PEX pipe and tubing, in particular, has been studied by several institutions and research centers over the past decades. Some of this research is available online, while other reports have not been widely published, but have been presented at conferences or other events.

This report will share specific excerpts from published research which are relevant to this report.

3.1. Passive Freeze Protection for Passive Solar Thermal DHW Systems
Morgan B. Heater, 2006

This thesis evaluates the freeze tolerance of PEX piping materials as a failsafe in solar water heating systems in the event that the primary freeze protection for the system fails.

Notable conclusions from this research include "**PEX pipe was conclusively shown to be freeze tolerant up to 400+ cycles**" and "…**PEX piping materials are experimentally and analytically shown to be reliable under repeated freezing conditions**…"

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[1] *PPI Handbook of Polyethylene Pipe 2nd Edition*, Chapter 8 *Above-Ground Applications for PE Pipe*, page 307 *Low Temperature Extremes*
[2] https://inis.iaea.org/collection/NCLCollectionStore/_Public/32/068/32068344.pdf
[3] https://omnexus.specialchem.com/polymer-properties/properties/glass-transition-temperature

The basis for this evaluation comes from the testing conducted during the research, including Dynamic Mechanical Analysis (DMA), stress-strain curves, freeze-induced strain analysis of PEX materials, and freeze cycle testing.

Within this document, mathematical equations identified a volume increase of 9.1% for water when changed from liquid to ice. This value was used to calculate a 3.5% hoop strain with a 1.75% axial strain for pressure vessels. This was followed with physical outside diameter measurements of water-filled PEX piping, frozen and unfrozen specimens, that yielded a 3.5% average strain. Development of stress-strain curves for two PEX materials were conducted to evaluate the stress-strain curve; results showed a 3 - 4% elastic range.

Data was collected on a combination of PEX pipe types, fittings, pipe lengths, and insulation thicknesses that were exposed to freeze/thaw cycles. The piping system was insulated with low R-value insulation material on its ends and higher R-value insulation material in the center of the pipe. This experiment was intended to initiate freezing at the pipe ends and drive the freezing event to the center of the pipe section, where pipe failures were created. There were also recorded failures in short pipe lengths, less than 5 inches (12.7 cm), that seemed to correspond with freezing on the ends and driving a pressure increase to the middle.

Note 3: Within this report, Table 11 indicates that connections at one polymer tee and one polymer elbow did fail, the latter after just 23 cycles. The report states, "It's likely that the …elbow failure was caused by installation error. It was replaced with an identical fitting that has since lasted over 350 cycles without failure".

3.2. An Investigation into Freezing and Bursting Water Pipes in Residential Construction, Research Report 96-1[4]
Jeffrey R. Gordon, School of Architecture- Building Research Council, University of Illinois (1996)

The research conducted by Gordon details a two-phase approach, including laboratory and field testing. It identified that a water pipe freezing event can be broken down into four stages:

1. Initial cooling through supercooling
2. Dendritic ice formation
3. Annular ice formation, and
4. Final cooling to ambient temperature.

[4] https://www.ideals.illinois.edu/handle/2142/54757

Within this document is the following statement “This research shows how pipe bursts occur. A commonly held view, that is growth simply pushes against pipe walls, is not correct.

“Pipe bursting occurs when:

1. freezing temperatures create ice blockages in water pipes, then
2. further ice growth applies dangerously high pressures to a confined water volume.

“This understanding of rupture mechanism has been confirmed in two years of laboratory and field studies.”

Temperature data was collected in both phases of testing, identifying the environmental conditions and the timeline associated with each stage. Test data is presented that shows a time delay in the freezing process by reducing the thermal exchange from the water pipe to the environment through the addition of pipe insulation.

3.3. Northward Market Extension for Passive Solar Water Heaters by Using Pipe Freeze Protection with Freeze-Tolerant Piping
J. Burch, NREL and M. Heater, M. Brandemuhl, and M. Krarti, University of Colorado (2006)

This conference paper further highlights the potential use of some PEX piping as a failsafe freeze protection for passive solar water heating systems. This paper identifies both of the previously-defined documents as references, and discusses topics such as the effect of non-uniform freezing of a piping system.

As stated, “As pipes freeze, an annulus of ice attaches on the pipe inner surface and freezes inward toward the pipe axis. However, there is not pressure buildup until two separated “ice blockages” occur because until that occurs water is pushed back into the mains or forward in the downstream house piping system (which has significant expansion capability). Subsequent to blockages, further freezing causes pressure to build up. Pathological cases of non-uniform freezing with a “piston action” can be created by tapering insulation to force the freeze between the blockages to occur non-uniformly from the blockages in, forcing water inward and creating potentially very high pressures and/or strains.”

Further, “**We also found that any of the pipes with ‘pathologically tapered’ insulation installed over them would eventually break. Surprisingly, it took 20 - 50 cycles to break the pipes**.” Graphical representation of ice blockages and pressure increase between them is shown in **Figure 1**.

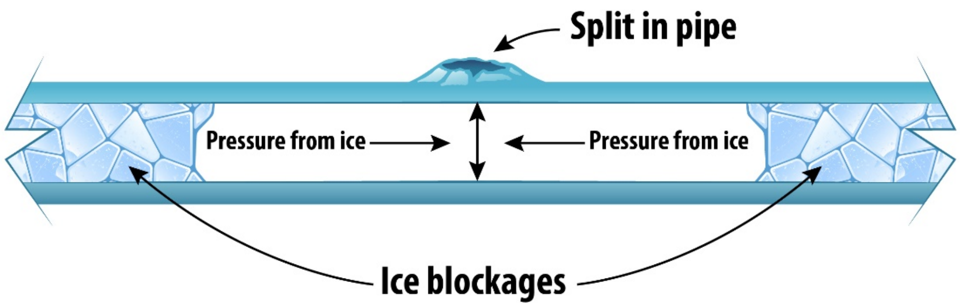

Figure 1: Illustration of ice blockages

Pressure inside the pipe increases as the fluid between the ice blockages continues to freeze, creating a piston effect on the water; this may exceed the elastic limits of the PEX pipe and cause a split.

Note 4: PPI believes that the following errors exist within this report:

- Within Table 1 (page 4), hePEX® Plus is identified as a “silane” PEX, when, in fact, hePEX Plus is a peroxide PEX
- Within Table 1 (page 4), QestPEX® is identified as a “peroxide” PEX, when, in fact, QestPEX is a silane PEX

3.4. <u>Technical Details and Importance of the New Method of Determining “Resistance to Occasional Freeze-Thaw Cycling of PEX” and “Environmental Abuse”</u>
Haemi Pollett, Jacob John, Uponor (2016)

This conference paper reports on a research project which subjected Nominal Tubing Size (NTS) ½ and ¾ PEX specimens with external notches of 10% and 20% of their wall thickness to freeze/thaw cycles while specimens were pressurized to 80 psig (0.55 MPa). Unnotched specimens were also subjected to freeze/thaw cycles. Results showed no leaks in specimens due to freezing.

After five freeze/thaw cycles, each specimen was subjected to burst testing in accordance with ASTM D1599. Both notched and unnotched specimens demonstrated burst pressures of 784 - 791 psig (5.40 to 5.45 MPa), far in excess of the minimum requirement for PEX tubing as published in ASTM Standard Specification F876 of 475 psi (3.27 MPa).

3.5. DESIGN GUIDE – Residential PEX Water Supply Plumbing Systems, 2nd Edition[5]
Home Innovation Research Labs, PPI, PPFA, ICC (2013)

The Design Guide was a joint development project of Home Innovation Research Labs (HIRL), PPI, PPFA, and ICC, intended to provide the information and resources necessary to design and install crosslinked polyethylene (PEX) water supply systems in residential buildings. It includes comprehensive design concepts and installation guidelines to increase the acceptance and proper use of PEX.

It also includes the following statements related to freeze-break resistance:

"PEX pipes are less susceptible to the effects of cold temperatures retaining their flexibility even below freezing. This flexibility means that if water-filled PEX piping freezes, the elasticity of the material allows it to expand without cracking or splitting, and then to return to its original size upon thawing. This applies when PEX pipes have room to expand evenly along their length, as is typical when installed within walls or ceilings. Water-filled PEX pipes, allowed to freeze inside a slab or highly compacted soil, may not be able to expand evenly and may suffer damage."

4.0 CODE REQUIREMENTS FOR PIPING INSULATION & PROTECTION

North American plumbing and mechanical codes address the need for piping insulation and freeze protection in a variety of ways. These codes treat all piping materials the same, with some exceptions.

Note 5: This report is *not* intended to circumvent existing code requirements.

The most relevant excerpts from US and Canadian model codes follow:

4.1. 2021 IAPMO Uniform Plumbing Code (UPC) [unchanged since 2015]

312.6 Freezing Protection. "No water, soil, or waste pipe shall be installed or permitted outside of a building, in attics or crawl spaces, or in an exterior wall unless, where necessary, adequate provision is made to protect such pipe from freezing."

[5] *DESIGN GUIDE Residential PEX Water Supply Plumbing Systems, Second Edition* available at www.plasticpipe.org

4.2. 2021 IAPMO Uniform Mechanical Code (UMC) [unchanged since 2015]

1210.1 Piping, Tubing, and Fittings. "Hydronic pipe and tubing shall comply with the applicable standards referenced in Table 1210.1 and shall be approved for use based on the intended purpose. Materials shall be rated for the operating temperature and pressure of the system and shall be compatible with the type of heat transfer fluid. Pipe fittings and valves shall be approved for the specific installation with the piping, materials to be installed and shall comply with the applicable Standards referenced in Table 1210.1. **Where required, exterior piping shall be protected against freezing,** UV radiation, corrosion and degradation. Embedded pipe or tubing shall comply with Section 1221.2."

1215.3 Freeze Protection. "Hydronic systems and components shall be designed, installed and protected from freezing."

1220.4 Snow and Ice Melt Controls. "An automatic thermostatically operating control device that controls the supply hydronic solution temperature to the snow and ice melt area shall be installed in the system. **Snow and ice melt systems shall be protected from freezing** with a mixture of propylene glycol or ethylene glycol, and water or other approved fluid. Automotive antifreeze shall not be used."

4.3. 2018 IAPMO Uniform Solar, Hydronics and Geothermal Code (USHGC)

401.8 Freeze Protection. "Hydronic systems and components shall be designed, installed, and protected from freezing."

408.1 Pipe, Tube, Tubing, and Fittings. "Hydronic pipe and tubing shall comply with the applicable standards referenced in Table 408.1 and shall be approved for use based on the intended purpose. Materials shall be rated for the operating temperature and pressure of the system and shall be compatible with the type of heat transfer fluid. Pipe fittings and valves shall be approved for the installation with the piping, materials to be installed and shall comply with the applicable standards referenced in Table 408.1. **Where required, exterior piping shall be protected against freezing**, UV radiation, corrosion and degradation. Embedded pipe or tubing shall comply with Section 417.2."

416.1 Snow and Ice Melt Controls. "An automatic operating control device that controls the supply hydronic fluid temperature to the snow and ice melt area shall be installed in the system. A means shall be provided to prevent low return hydronic solution temperature in accordance with Section 410.4. **Snow and ice melt systems shall be protected from freezing** with a mixture of propylene glycol and water, or other approved fluid."

501.12 Freeze Protection. "Unless designed for such conditions, solar thermal systems and components that contain liquid as the heat transfer medium **shall be protected from freezing** where the ambient temperature is less than 46°F (8°C) by means of fail-safe in accordance with Section 501.12.1 through Section 501.12.5."

4.4. <u>2021 ICC International Plumbing Code (IPC) [unchanged since 2015]</u>

305.4 Freezing. "Water, soil and waste pipes shall not be installed outside of a building, in attics or crawl spaces, concealed in outside walls**, or in any other place subjected to freezing temperatures** unless adequate provision is made to protect such pipes from freezing by insulation or heat or both. Exterior water supply system piping shall be installed not less than 6 inches (152 mm) below the frost line and not less than 12 inches (305 mm) below grade."

1301.8 Freeze protection. "Where sustained freezing temperatures occur, provisions shall be made to keep storage tanks and the related piping from freezing."

4.5. <u>2021 ICC International Mechanical Code (IMC) [unchanged since 2015]</u>

1402.4 Protection from freezing. "**System components shall be protected from damage by freezing** of heat transfer liquids at the lowest ambient temperatures that will be encountered during the operation of the system. Freeze protection shall be provided in accordance with ICC 900/SRCC 300. Drain-back systems shall be installed in compliance with Section 1402.4.1 and systems utilizing freeze-protection valves shall comply with Section 1402.4.2."

4.6. <u>2018 National Standard Plumbing Code (NSPC)</u>

2.16 FREEZING OR OVERHEATING a. "The plumbing system shall be protected from freezing or overheating. The following conditions shall be met"

5. "In areas with seasonal freezing outdoor temperatures, all drain piping and water piping installed in exterior walls, attics, and other areas exposed to outdoor temperatures shall be protected from freezing. In heated spaces, the piping shall be installed on the heated side of the building insulation."

4.7. 2015 National Plumbing Code of Canada (NPC)

Clause 2.3.5.4 Protection Against Freezing: "Where piping may be exposed to freezing conditions, it shall be protected from the effects of freezing."

5.0 PPI RECOMMENDATIONS

The resistance of PEX tubing to break when fluids contained within are frozen (i.e. freeze-break resistance of PEX tubing) has been proven through decades of real-world installation experience around the world, as well as through empirical testing as noted in Section 3. Several factors are important to note.

PEX tubing does not *prevent* water from freezing in the tubing, but its lower thermal conductivity than metal pipes (i.e. higher insulating value) can *delay* freezing of water or other fluids within the pipes. In other words, it may take longer for fluid within PEX tubing to freeze, as compared with copper or steel pipes. This can prevent freezing events that could happen if metal pipes were used.

PEX tubing is less susceptible to the effects of cold temperatures, retaining flexibility even below freezing, to temperatures below -40°F (-40°C). This flexibility means that if water-filled PEX tubing freezes, the elasticity of the material typically allows it to expand without cracking or splitting, and then to return to its original diameter upon thawing.

This applies when PEX pipes have room to expand evenly along their length, as is typical when installed within walls or ceilings, or lightly compacted earth. This material characteristic is beneficial for applications such as plumbing, water service, fire protection, hydronics, and geothermal ground loops.

Fluid-filled PEX pipes that freeze inside a concrete slab or highly compacted soil may not be able to expand evenly and may suffer damage, such as splitting. This must be prevented to avoid leaks and potential property damage.

The freezing of water or other fluids within PEX tubing should be prevented because a piping system with frozen fluid cannot perform as expected. For example, a frozen plumbing system will not deliver water; a frozen fire protection system will not activate to extinguish a blaze; and a frozen heating or snow melting system will not deliver heat to the intended areas, and will leave them uncleared and unsafe.

CAUTION: PEX tubing systems should not be intentionally subjected to freezing.

Below are recommendations for protecting specific PEX systems against freezing:

5.1. Plumbing and Fire Protection

In plumbing distribution installations, PEX tubing should be installed within heated spaces such as interior walls, floors, or ceilings. If installed within exterior walls, floors, or ceilings, the tubing should be insulated sufficiently to prevent freezing of the water within. The amount of insulation required to achieve this protection varies for every climate zone and location around the world. Local building codes and regulations should apply.

5.2. Water Service

In water service applications, care should be taken to ensure that PEX tubing is buried below the frost line to prevent freezing and to avoid interrupting the water supply.

5.3. Hydronic Radiant Heating and Cooling

In hydronic radiant heating and radiant cooling installations, PEX tubing should be installed within heated spaces such as interior walls, floors, or ceilings. If installed above an unheated crawl space, there should be adequate insulation below the tubing to prevent freezing of the water within, even when the heating system is deactivated. The amount of insulation or use of antifreeze, if selected, required to achieve this protection varies for every climate zone and location around the world. Local building codes and regulations should apply.

5.4. Snow and Ice Melting

In outdoor snow and ice melting installations, PEX tubing should be filled with an antifreeze solution, typically propylene glycol and water, to prevent freezing of the fluid in the coldest expected outdoor temperatures. If fluid is allowed to freeze within tubing embedded in outdoor concrete, the tubing may expand and break the concrete and burst in random locations.

Even if the fluid does not freeze solid within outdoor tubing, it must have sufficient antifreeze to prevent crystallization of the fluid mixture, otherwise it will not be circulated by a circulation pump when the system activates to melt snow or ice. The amount of antifreeze required to achieve this protection varies for every climate zone and location. Local building codes and regulations should apply.

5.5. Thawing Frozen PEX Tubing

Thawing of frozen PEX tubing can be performed using available hot water injection equipment, which uses hot water sprayed forward by a nozzle installed into an open end of the pipe to melt ice inside the pipe. This is usually performed at moderately warm water temperatures. The maximum water temperature allowed for thawing is 180°F (82°C). After thawing, PEX can immediately be put back into service.

Thawing can also be performed by attaching heat trace cable, also referred to as heating cable or heat tape, onto PEX tubing, as long as the cable is self-regulating and self-limiting, and recommended for use on plastic pipe. In some cases, heat trace cable may be left attached to PEX tubing to prevent freeing. Check with the PEX tubing manufacturer for specific approvals on the use of heat trace cable.

Thawing can also be performed by applying hot air to the outside of PEX tubing, using a hot air gun to heat frozen areas of the pipe. Ensure that the temperature of the pipe does not exceed 180°F; ice should thaw long before this temperature is reached. As an alternative, a hair dryer or a warm rag may be use to thaw ice inside the pipe.

Follow the manufacturer's published guidelines and recommendations.

Note 6: If water or other fluid does freeze inside PEX pipe or tubing, do not use an open flame, excessive heat, or an electric resistance pipe thawing device (e.g. HotShot™) to thaw PEX, as this could result in property damage and loss of water pressure. **See Figure 2.**

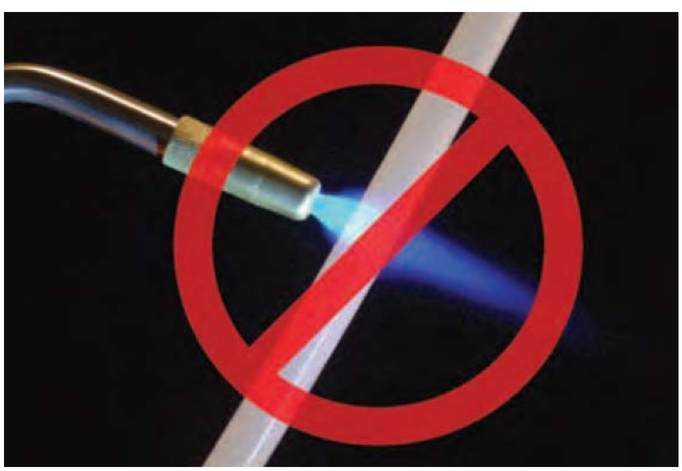

Figure 2: Do not use open flame to thaw frozen PEX pipe or tubing

CAUTION: PEX pipe or tubing that is thawed using an open flame, excessive heat or an electric resistance thawing device may not show any visible damage, but the integrity of the pipe or tubing may have been altered enough to cause premature failure. Any PEX that is thawed incorrectly should be replaced as soon as possible.

6.0 SUMMARY

Based upon the information provided in this Technical Report, the installation of plumbing and other pressure piping systems in unconditioned spaces have provisions within all major building codes that require the piping system be protected from freezing. PEX piping systems are not excluded from these requirements; however, it has been shown in the referenced studies that PEX tubing demonstrates a resistance to rupture from unintended exposure to a freeze event (i.e. freeze-break resistance).

The material properties of PEX pipe and tubing provide it with an inherent benefit when subjected to freezing conditions. PEX materials have a lower thermal conductivity than metallic piping materials, which reduces the thermal exchange rate, which can extend the time required to freeze the fluid within the system. If freezing of fluid within PEX *does* occur, the elastic nature of PEX materials, at temperatures even below -40°F (-40°C), enable for circumferential and axial expansion that correlates to the increase in volume of the fluid during a freezing event.

The flexibility of PEX materials allow the piping to be installed with fewer fittings than other rigid materials, reducing the potential for ice blockage events at transition locations, thus allowing the increased pressure that can build up in a freezing piping system to be distributed throughout the piping system.
It has been demonstrated in the referenced research reports (Section 3) that the fluid within a piping system can freeze when the system is exposed to freezing conditions, and that the freezing condition can vary based upon piping materials, system design, installation and environmental conditions.

There are situations where freezing fluid can damage or burst PEX tubing, and this should be prevented through proper planning and installation of PEX systems. If an unintended freeze event *does* occur, then the properties of PEX tubing are such that, in many instances, the tubing will not burst when the fluid inside is frozen.