

Ultraviolet (UV) Resistance of PEX Tubing



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The Plastics Pipe Institute

PPI Represents All Sectors of the Plastic Pipe Industry

- PPI was formed in 1950 to develop test methods for plastic pressure pipes
- Today: Non-profit trade association serving North America

PPI Mission: To advance the acceptance and use of plastic pipe systems through research, education, technical expertise and advocacy

Members: PPI members share a common interest in broadening awareness and creating opportunities that expand market share and extend the use of plastics pipe in all of its many applications

2020: Over 170 members firms involved with the plastic pipe industry around the world

Website: www.plasticpipe.org

The Plastics Pipe Institute

PPI Represents All Sectors of the Plastic Pipe Industry

- PPI's five divisions focus on solutions for multiple applications:
 - **Building & Construction Division (BCD)**
 - Drainage
 - Energy Piping Systems
 - Municipal & Industrial
 - Power & Communications

BCD Materials: PEX, CPVC, PE-RT, PEX-AL-PEX, PP, HDPE (Geothermal)



Ultraviolet (UV) Resistance of PEX Tubing

Outline

1. Introduction to PEX tubing systems for plumbing - Current status
2. Industry standards for PEX tubing and systems - Overview
3. Effects of UV on PEX tubing – Achieving UV Resistance
4. ASTM Test Method F2657 - PEX UV Ratings
5. PPI PEX Labeling Guidelines for UV



1. Introduction to PEX Tubing

Overview

- PEX was introduced for radiant heating in Europe in the early **1970s**
- Introduced to USA and Canada in **1984** for heating and plumbing
- PEX is a high-temperature flexible pressure piping system
- PEX tubing systems are used for water service lines, hot- and cold-water distribution, radiant heating *and* cooling, outdoor snow and ice melting, residential fire protection, geothermal ground loops and other demanding applications



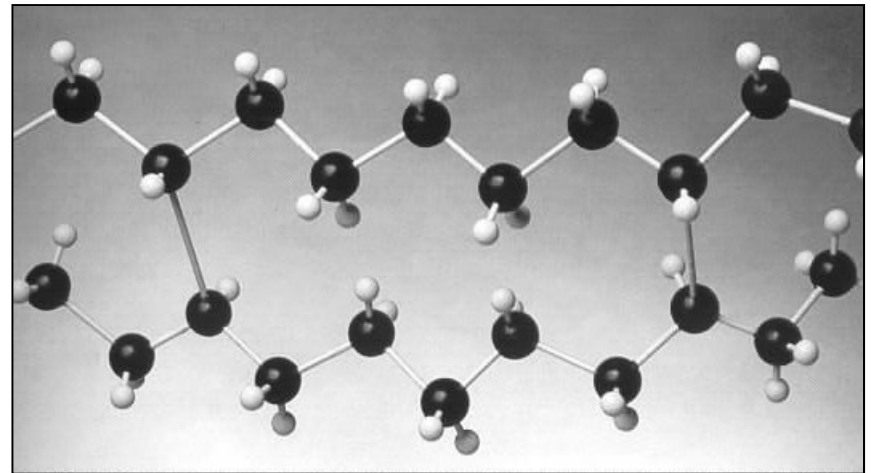
Courtesy REHAU

1. Introduction to PEX Tubing

Formal Definition of Crosslinked Polyethylene (PEX)

- “Crosslinked Polyethylene is a polyethylene material which has undergone a change in molecular structure using a chemical or a physical process whereby the polymer chains are chemically linked.”
- “Crosslinking of polyethylene into PEX for pipes results in improved properties such as elevated temperature strength and performance, chemical resistance, and resistance to slow crack growth.”

Source: PPI Technical Note 17



1. Introduction to PEX Tubing

PEX Types

- PEX plumbing tubing is currently produced in nominal tubing sizes from **1/4** to **3** inch
- PEX is available in natural (white) or colors such as red, white, blue, black, orange
- PEX tubing is available in coils or straight lengths, depending on the customer preference and application



Courtesy BOW

1. Introduction to PEX Tubing

PEX Tubing Production Methods

The three common methods of crosslinking polyethylene are:

- Peroxide (PEX-a)
- Silane (PEX-b)
- Electron beam (PEX-c)

- Letter designations not related to any type of performance rating system

- PEX tubing produced by each of the three methods must meet the **same technical requirements** as specified in the relevant PEX standards

- See *PPI Technical Note 17* for more details about each method

1. Introduction to PEX Tubing

Advantages of PEX Plumbing Systems

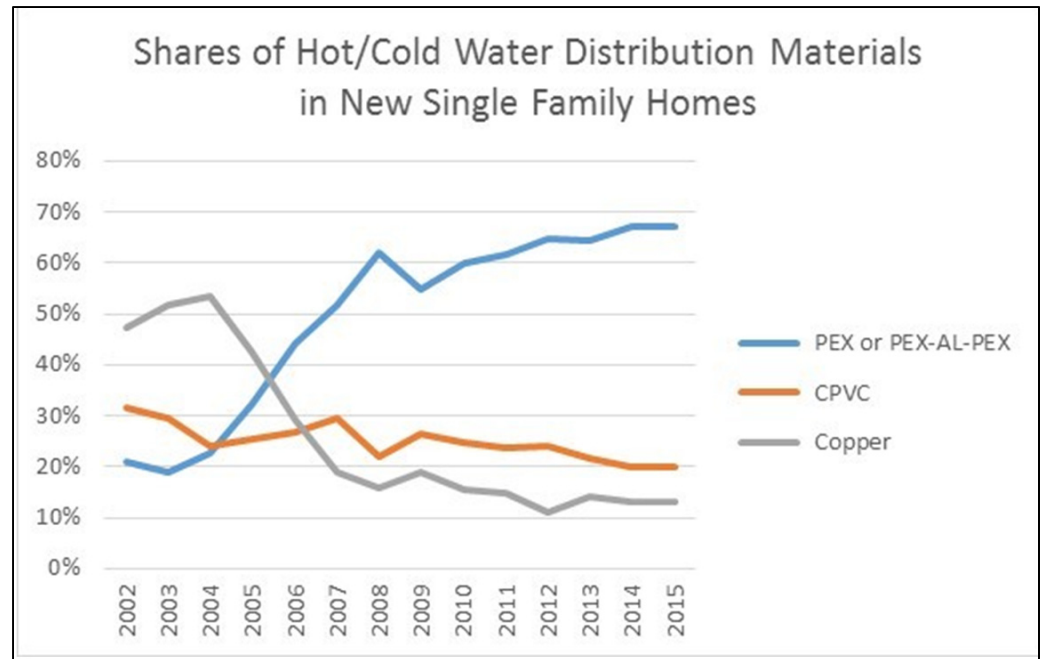
- Safety of potable water and long-term reliability
- Resistance to corrosion, erosion, water disinfectants
- Smooth wall, excellent flow characteristics
- High pressure capability/stability (reduced creep)
- Quiet operation, absorbs pressure surges (reduced water hammer)
- Flexibility to ease installations
- Many fitting and joining options; no open flames
- Proven long life, rigorous certifications, highly tested
- Water conservation is assisted with reduced heat loss



1. Introduction to PEX Tubing

Proven Success

- Since 1997, the usage of PEX tubing in residential plumbing has increased from less than 10% to **more than 60%** (Source: HIRL, Aug. 2016)



2. Industry Standards - Overview

PEX Tubing Standards

- There are two primary standards for PEX tubing in North America:
 - **ASTM F876** *Standard Specification for Crosslinked Polyethylene (PEX) Tubing*
 - **CSA B137.5** *Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications*
- Codes such as **IPC**, **UPC** and the **NPC of Canada** refer to these standards



2. Industry Standards - Overview

PEX Tubing Standards

- **ASTM F876** and **CSA B137.5** establish capabilities and test requirements, such as:
 - Dimensions
 - Long-term pressure ratings
 - Quick burst pressures
 - Chlorine resistance
 - **UV resistance**
 - Excessive pressure-temperature capability
 - Hot-bend and cold-bend tests
 - Marking requirements
 - Even more...




2. Industry Standards - Overview

Categories for Performance – Three Key Properties:

1. Chlorine Resistance
2. UV Resistance
3. Hydrostatic Design Strength (HDS), related to pressure ratings

- Performance categories are defined in the “**Tubing Material Designation Code**”
- See example:

 F876 – 19a					
TABLE 1 Thermoplastic Tubing Material Designation Code Cells for SDR9 PEX					
	PEX	1	1	0	6
Material	↑	↑	↑	↑	↑
Chlorine Resistance (75% at 73°F and 25% at 140°F)		↑	↑	↑	↑
Minimum UV Resistance (1 month)			↑	↑	↑
HDS at 23°C (630 psi)				↑	↑

3. Effects of UV Exposure on PEX

Physical effects

- The long-term performance of PEX will be damaged by **excessive UV radiation** from sunlight, especially when tubing is used in chlorinated hot-water systems after exposure (i.e. potential reduced lifetime)
- PEX should not be stored outdoors
- Users should keep PEX stored indoors in the original packaging prior to installation for protection against UV/sunlight and other potential hazards

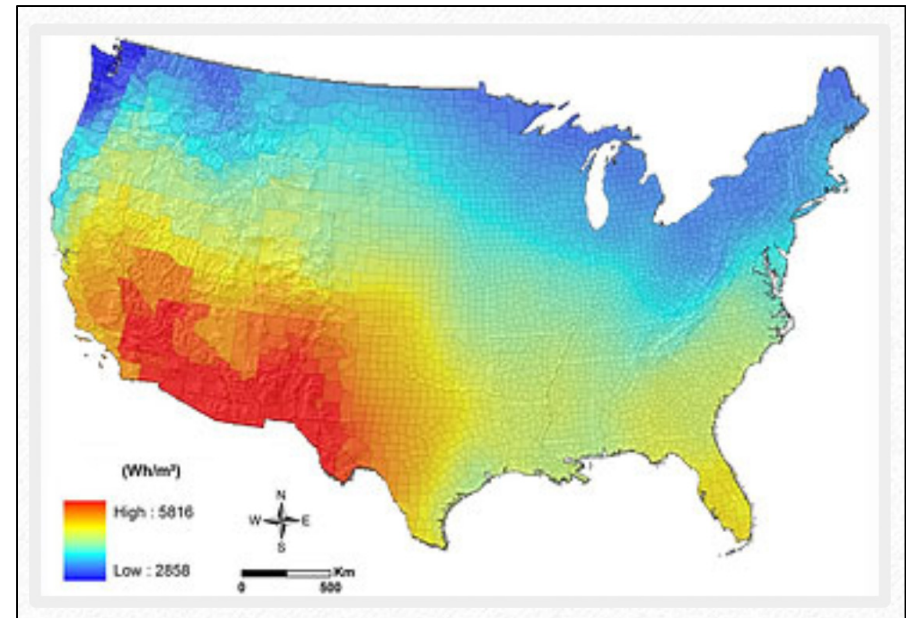
From ASTM F876:

- *3.2.7.3 Discussion—PEX tubing is not designed for outdoor use. Data from short-term exposure testing in accordance with this test method can be used to judge the relative performance of PEX tubing stored outdoors for short periods of time prior to installation completely shielded from sunlight*

3. Effects of UV Exposure on PEX

Potential Threats

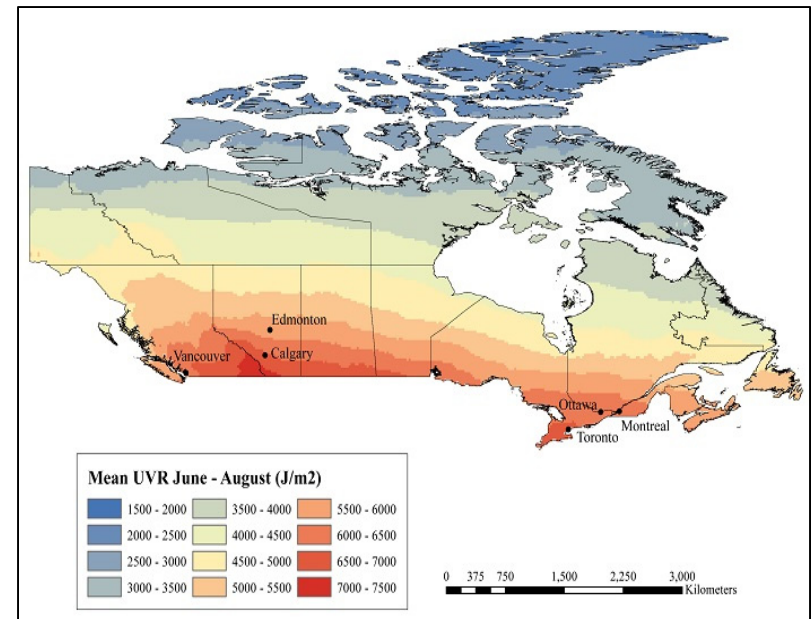
- Actual UV intensity varies greatly across the US and Canada
- Example Map: *County Level UV Exposure Data for the Continental United States*
- <https://gis.cancer.gov/tools/uv-exposure/>



3. Effects of UV Exposure on PEX

Potential Threats

- Actual UV intensity varies greatly across the US and Canada
- Example Map: *Mean ultraviolet radiation for June through August, Canada, 1980-1990*
- <https://www150.statcan.gc.ca/n1/daily-quotidien/170517/mc-b001-eng.htm>



3. Effects of UV Exposure on PEX

Potential Threats

1. Outdoor storage: storing PEX tubing outdoors – not allowed
2. Outdoor installation
3. Delays in construction



3. Effects of UV Exposure on PEX

Potential Threats

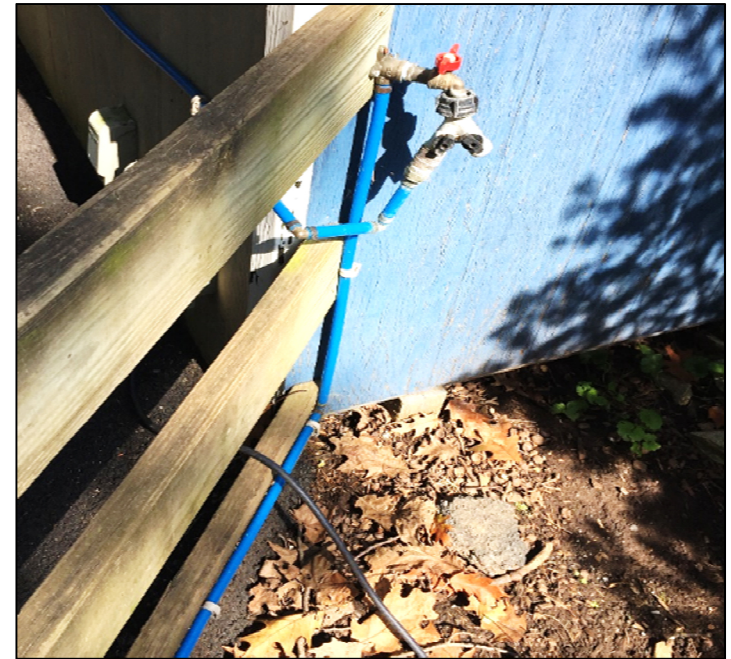
1. Outdoor storage
- 2. Outdoor installation: PEX tubing installed outdoors – not allowed**
3. Delays in construction



3. Effects of UV Exposure on PEX

Potential Threats

1. Outdoor storage
2. **Outdoor installation: PEX tubing installed outdoors – not allowed**
3. Delays in construction



3. Effects of UV Exposure on PEX

Potential Threats

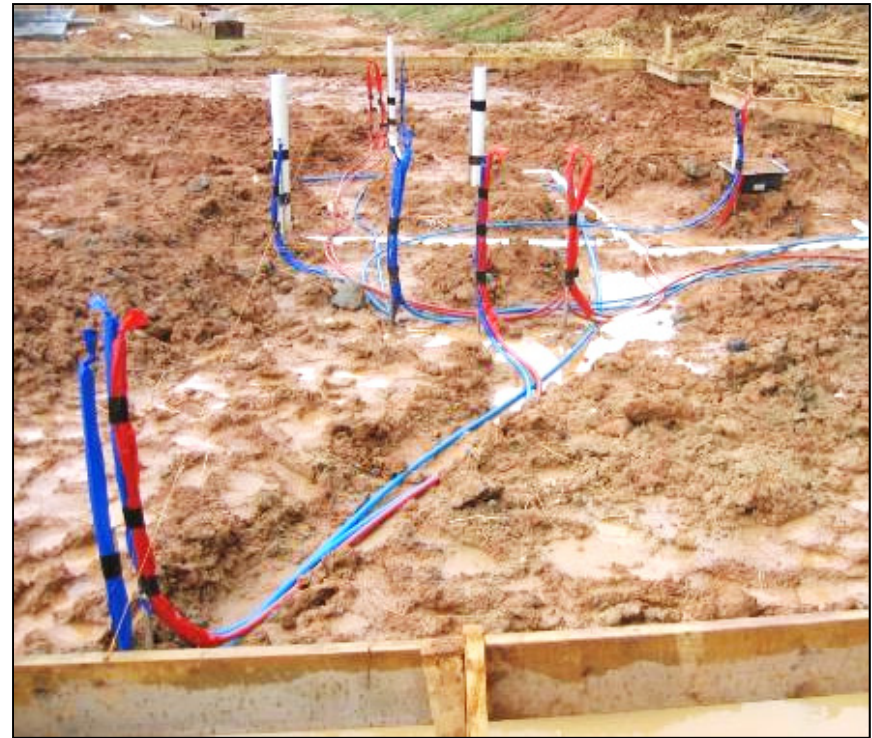
1. Outdoor storage
- 2. Outdoor installation: tubing may be left outdoors/exposed during installation**
3. Delays in construction



3. Effects of UV Exposure on PEX

Potential Threats

1. Outdoor storage
2. Outdoor installation
3. **Delays in construction: tubing may be left exposed due to bad weather or other unforeseen construction delays**



3. Effects of UV Exposure on PEX

Achieving UV Resistance

Creating a UV-resistant PEX tubing material is achieved through various methods:

- 1. Formulations:** Add UV Stabilizers or carbon black into the HDPE compound
- 2. Coatings:** Add UV-blocking and -absorbing barrier layers to exterior of the PEX wall



4. ASTM Test Method F2657 & UV Ratings

Evaluating UV Resistance of PEX Tubing

- ASTM Standard Test Method **F2657** provides manufacturers with a recognized test method for establishing claims of UV resistance; first published in **2007**



Designation: F2657 – 07 (Reapproved 2018)

Standard Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing¹

This standard is issued under the fixed designation F2657; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes the procedure for exposing crosslinked polyethylene (PEX) tubing produced in accordance with Specification **F876** to natural (sunlight) ultraviolet (UV) radiation and evaluating the effects of the exposure. This test method outlines the requirements for specimen size and preparation, exposure orientation, minimum UV exposure energy, post exposure testing and reporting.

2. Referenced Documents

2.1 *ASTM Standards*:²

- D1435** Practice for Outdoor Weathering of Plastics
- D1598** Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
- D1600** Terminology for Abbreviated Terms Relating to Plastics
- F412** Terminology Relating to Plastic Piping Systems

4. ASTM Test Method F2657 & UV Ratings

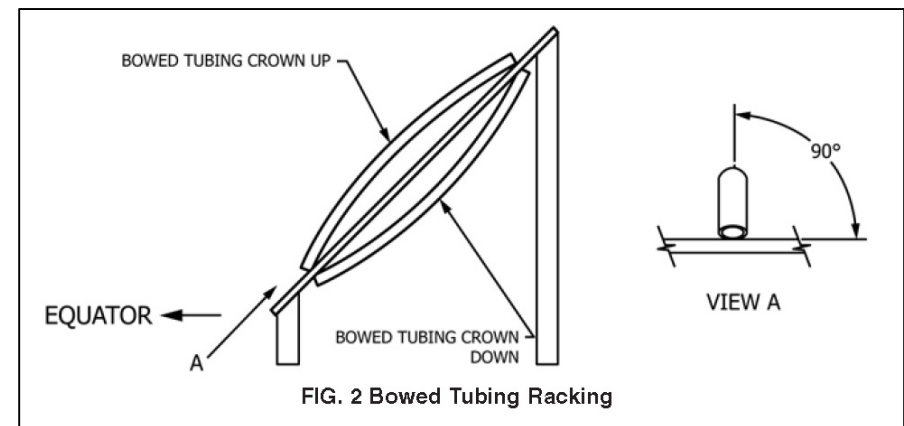
Evaluating UV Resistance of PEX Tubing

- Natural exposure is based on worst-case North American location (near Phoenix, AZ)

From ASTM F2657:

- 3.2.6.1 *Discussion* - UV Energy for Central Arizona was selected as it represents the worst case North American location based on a 4-year average of 1998 through 2001. This information was provided by Atlas Material Testing Technology LLC.

- Tubing samples are mounted outdoors, facing **South**
- Samples are left outdoors until the required amount of UV exposure is accumulated (e.g. 30 days, 90 days..)
- Actual UV exposure is measured daily



4. ASTM Test Method F2657 & UV Ratings

Evaluating UV Resistance of PEX Tubing

- Natural exposure is based on worst-case North American location (Phoenix, AZ)
- Required UV exposures are based on historical values
- Each month is different
- A month near Phoenix may be equivalent to 2-3 months in other locations
- See **Table X1.1** of F2657

TABLE X1.1 TUV Energy by Month for Central Arizona, 5° off Horizontal for the 4 Year Period of 1998 through 2001

Nominal Exposure Time Period	Monthly TUV Solar Radiation MJ/m ²	Cumulative TUV Solar Radiation MJ/m ²
January	17	17
February	19	36
March	28	64
April	33	97
May	40	137
June	40	177
July	39	216
August	35	251
September	31	282
October	24	306
November	18	324
December	15	339

4. ASTM Test Method F2657 & UV Ratings

Evaluating UV Resistance of PEX Tubing

- Natural exposure is based on worst-case North American location (Phoenix, AZ)

- Test samples must be exposed to **Total UV Energy** as defined in **Table 1**

- After exposure, samples are evaluated using testing to measure their resistance to hot chlorinated water according to **ASTM Test Method F2023** (potable PEX)

- Non-potable PEX uses the **Stabilizer Functionality** test

TABLE 1 Total UV (TUV) Energy per Monthly Time Period^A

Nominal Exposure Time Period	TUV Solar Radiation MJ/m ²	Highest Consecutive UV Month Range
1 month	40	June
2 months	80	May-June
3 months	119	May-July
4 months	154	May-August
5 months	187	April-August
6 months	218	April-September
7 months	246	March-September
8 months	270	March-October
9 months	289	February-October
10 months	307	February-November
11 months	324	January-November
12 months	339	January-December

^ASolar UV radiation is based on Central Arizona 5° off horizontal for the 4 year period of 1998 through 2001 as reported by Atlas and Testing and Technology LLC.

4. ASTM Test Method F2657 & UV Ratings

UV Resistance: Four (4) Categories of Performance in ASTM F876

- 0** = Not tested or not rated
- 1** = 1 month
- 2** = 3 months
- 3** = 6 months or more Minimum UV resistance

From ASTM F876, **Table 1**

Property	Standard	0	1	2	3	4	5	6	7	8	9
Chlorine Resistance	F2023	Not tested or rated	75 % at 73°F and 25 % at 140°F	Reserved	50 % at 73°F and 50 % at 140°F	Reserved	100 % at 140°F	...	...	...	...
Minimum UV Resistance	F2657	Not tested or rated	1 month	3 months	6 months	...	...	...	...	...	...
HDS for water at 73°F	...	...	...	...	...	...	...	630	...	800	...

4. ASTM Test Method F2657 & UV Ratings

Summary (Example):

- If *Manufacturer X* wants to claim **6-month UV resistance** for potable PEX, they must:

1. Submit PEX samples to test lab (e.g. third-party certifier)
2. Lab exposes samples to UV exposure that is equivalent to worst **6 months** (218 MJ)
3. After exposure, lab performs chlorine testing on samples to see if performance is degraded, as compared with unexposed samples of the same PEX material
4. If chlorine test result is satisfactory, then **6-month** UV claim is verified

That PEX would earn a **'3'** for UV Resistance in the **Material Designation Code**



5. PPI PEX LABELING GUIDELINES

PPI TN-32 *UV Labeling Guidelines for Crosslinked Polyethylene (PEX)*

- PPI TN-32 provides recommended UV labeling guidelines for PEX manufacturers
- *Originally published in 2004*
- Sample label language:

CAUTION

- The long-term performance of PEX will be damaged by excessive UV radiation from sunlight.
- Do not store unprotected PEX outdoors.
- Keep PEX stored indoors in the original packaging prior to installation for protection against UV/sunlight and other potential hazards.
- To prevent UV damage, ensure that exposure to sunlight during installation does not exceed the maximum recommended UV exposure time of X days.
- UV damage is not visible to the naked eye, but will degrade the material and may reduce its service life.



UV Labeling Guidelines for Crosslinked Polyethylene (PEX) Tubing and Pipe

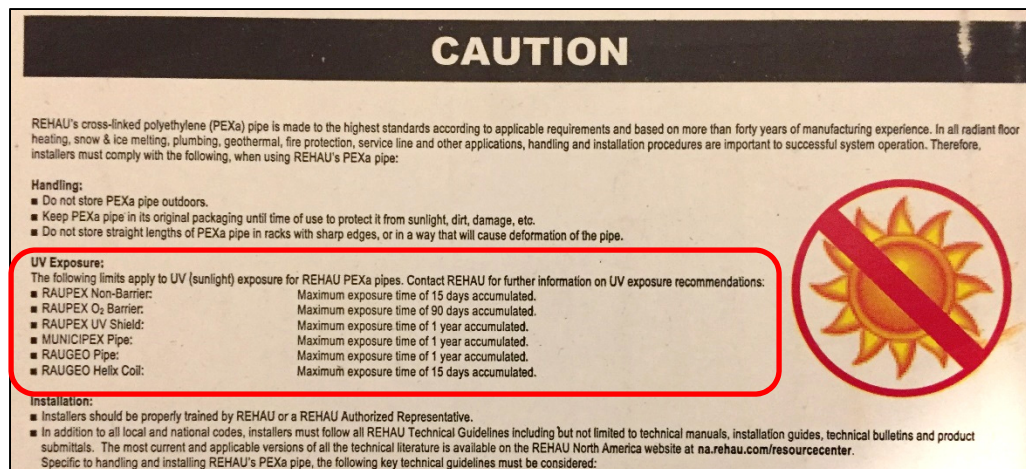
TN-32

2017

5. PPI PEX LABELING GUIDELINES

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- *Originally published in 2004*
- Actual example:



UV Labeling Guidelines for Crosslinked Polyethylene (PEX) Tubing and Pipe

TN-32

2017

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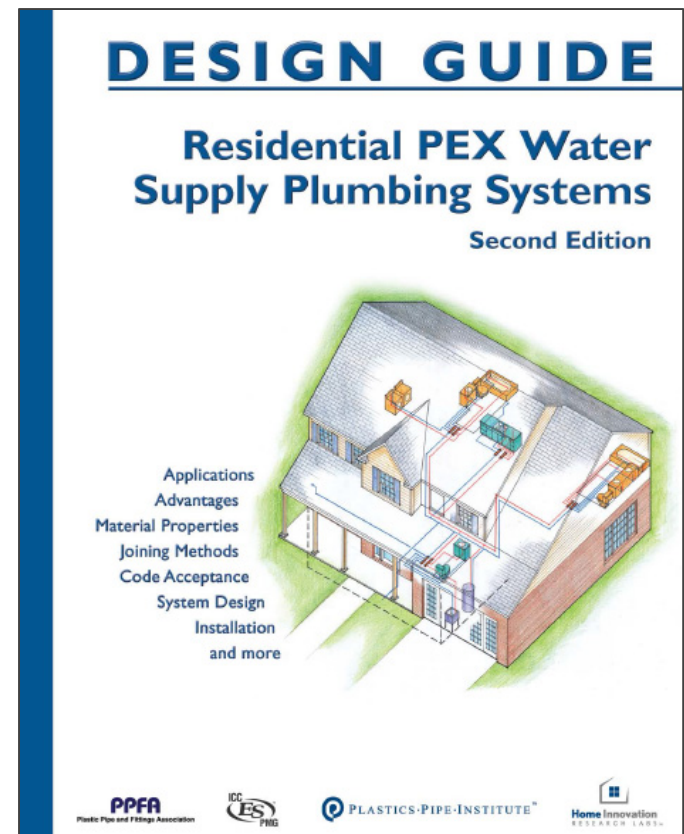
Additional Information

More PEX Plumbing Information

- See PEX Plumbing DESIGN GUIDE

Free download from:

- PPI Building & Construction Division
www.plasticpipe.org/building-construction
- Home Innovation Research Labs
www.homeinnovation.com



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