

**HISTORY OF CROSSLINKED
POLYETHYLENE (PEX) TUBING IN
NORTH AMERICA AND THE
EVOLUTION OF ASTM STANDARD
SPECIFICATION F876 FROM 1984 - 2024**

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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 provide a history of crosslinked polyethylene (PEX) tubing in North America, based on the introduction and evolution of ASTM Standard Specification F876.

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HISTORY OF CROSSLINKED POLYETHYLENE (PEX) TUBING IN NORTH AMERICA AND TIMELINE OF ASTM STANDARD SPECIFICATION F876 FROM 1984 - 2024

PREFACE

The Terminator. Purple Rain. Jeopardy. Floppy discs. Ronald Reagan. Pagers. Ghostbusters. 1984, the album by Van Halen. All launched in 1984, the year.

The year 1984 was forty-plus years ago, and while most of the technology of that year has been replaced by devices that we could not imagine back then, one of the newer technologies of the time, crosslinked polyethylene, was just getting started. It was 1984 when ASTM Standard Specifications **F876** and **F877** were first published, beginning the journey for crosslinked polyethylene tubing to be introduced into the North American market after 10+ years of successful use in Europe as a flexible, high-temperature plastic pipe for heating and plumbing applications.

This report is intended to describe the history of crosslinked polyethylene (PEX) tubing in North America and provide a timeline of the evolution of ASTM Standard Specification F876 from 1984 to 2024.

Note 1: In the piping industry, the term "tubing" refers to products whereby the actual outside diameter (OD) is 1/8 inch larger than the nominal size, such as with copper tubing. Products with an OD that matches copper tubing are sometimes referred to as "nominal tubing size" (NTS) or "copper tube size" (CTS). Most PEX products used for plumbing applications in North America are copper tube sized and are referred to as "tubing". The term "pipe" refers to products whereby the actual outside diameter matches that of iron or steel pipe of the same nominal size. Those products are sometimes referred to as "iron pipe size" (IPS) or "nominal pipe size" (NPS).

Within this technical report, the terms "tubing" and "pipe" may be used interchangeably, although the technically accurate term for the PEX products described in this report is "tubing".

1.0 INTRODUCTION

Crosslinked polyethylene, known as "PEX", is a polyethylene (PE) material which has undergone a change in molecular structure using a chemical or a physical process whereby a majority of the polymer chains are chemically linked, or crosslinked (X). In the PEX pipe industry, high density polyethylene (HDPE) is the type of polyethylene used to produce PEX.

Crosslinking of the polymer chains of polyethylene into PEX for pipes results in a high-temperature pressure-resistant, yet flexible, plastic (polymer) pipe that is rated for use at 180°F (82°C) or higher.

As compared with standard HDPE pipes, PEX has improved properties such as elevated temperature strength and performance, chemical resistance, environmental stress crack resistance (ESCR), and resistance to slow crack growth (SCG), and abrasion. Crosslinking makes PEX a "semi-thermoset" polymer, providing excellent long-term stability.

PEX tubing is approved for potable hot- and cold-water plumbing systems and hydronic heating and cooling systems, as well as several other applications, in all model plumbing, mechanical, and geothermal codes across the USA and Canada. PEX tubing systems are durable, provide security for drinking water, and use reliable connection systems.

Crosslinking technology for polyethylene was developed in Europe in the late 1960s, with the first PEX radiant heating systems installed in 1972 in Europe and has since had a more than fifty-year history of successful use around the world for a variety of demanding applications.

This technical report is intended to provide a history of the use of PEX tubing in North America and the timeline of the development of ASTM F876 *Standard Specification for Crosslinked Polyethylene (PEX) Tubing*, one of the most referenced and active standards published by the ASTM International Technical Committee F17 for Plastic Piping Systems, over its first forty years of publication from 1984 to 2024.

2.0 ACRONYMS AND TERMINOLOGY

- API American Petroleum Institute
- ASME American Society of Mechanical Engineers
- ASTM American Society for Testing and Materials (former name)
- AWWA American Water Works Association
- BOCA Building Officials and Code Administrators
- CSA Canadian Standards Association
- IAPMO International Association of Plumbing and Mechanical Officials
- ICC International Code Council
- ISO International Organization for Standardization
- NSF National Sanitation Foundation (former name)
- PPI Plastics Pipe Institute
- SBCCI Southern Building Code Congress International

3.0 BACKGROUND – THE INVENTION OF PEX TUBING

Polyethylene (PE), a product formed by the joining or polymerization of ethylene molecules into long chains, was first pioneered in the 1930s and developed in the 1940s as an insulation material for radar wiring during WW II. Today, polyethylene is the most widely used type of plastic (i.e., polymer) in the world.

High-density polyethylene (HDPE) is made by the copolymerization of ethylene and a small amount of another hydrocarbon. The resulting base resin density, before additives or pigments, is greater than 0.941 g/cm³, per ASTM D3350 *Standard Specification for Polyethylene Plastics Pipe and Fitting Materials*. HDPE resin is used to produce many different products, including piping through a process known as extrusion.

The idea for crosslinking of polyethylene pipe material to improve its temperature resistance and toughness was first developed and patented by the German inventor Thomas Engel. As reported to and documented by author Dan Holohan, Thomas Engel shared that, "In 1965, I was together with various scientists of the Phillips Petroleum Company in Bartlesville, Oklahoma, and we were discussing the cross-linking of polyethylene. It was possible at that time to cross-link polyethylene by means of highly active radiation.

The problem, however, lay not only in the extremely expensive, and somewhat dangerous, equipment, but also because this method of cross-linking was feasible only for wall thicknesses of up to 0.5 mm. The important uses for cross-linking polyethylene would, however, always be for thick-walled parts, having a wall thickness of 1 to 10 mm."

"I began my studies using an extruder and I very rapidly found that this technique was not feasible. This was followed by lengthy experiments with laser beams. Finally, I decided in favor of a compression method, with intermolecular friction, telling myself that the cross-linking of the molecules would have to be easier if I could heat them rapidly and bring them closer together by high pressure, so as to then cross-link them in the presence of a catalyst.

"Years of intensive research followed, finally culminating in success. The result was a handful of glittering white plastic, which came out of the autoclave.

"With this small treasure in my pocket, I flew back to Phillips Petroleum in the U.S., where we carried out analysis. We found I had actually obtained 97% cross-linking. And as a result, the thread-shaped chains of molecules connected directly to each other. We heated the polyethylene and the plastic simply would no longer melt into a shapeless mass. The joy was immense, but what was to be done with this new plastic, and into what could it be fabricated?"

In the late 1960s, Thomas Engel met with Wirsbo in Sweden (which became Uponor and now Georg Fischer Building Flow Solutions) and REHAU in Germany, and soon licensed his patent to these firms for the production of piping.

However, according to Tomas Lenman, who joined Wirsbo in 1971, "The patent did not include a 'ready to go' production process. Thomas Engel had just been able to produce a few yards at a time. However, the samples produced proved to be very heat resistant and did not melt or deteriorate when exposed to temperatures well above the crystalline melting point of over 130°C [266°F]. A limited number of tubing samples were put under pressure at close to boiling temperature to find out more about long-term resistance.

“Those tests were soon expanded to many more samples and temperatures as soon as funding became available.”

In 1982, Mr. Lenman emigrated to the United States with the goal of introducing PEX tubing to this market. He began by contacting PPI to learn about the development process for plastic piping standards, then he joined ASTM and initiated a project to develop the first ASTM standard for PEX tubing.

4.0 DEVELOPMENT OF PEX STANDARDS

ASTM F876 *Standard Specification for Crosslinked Polyethylene (PEX) Tubing* and ASTM F877 *Standard Specification for Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems* were first published in 1984. F876 contained the primary requirements for the tubing itself, while F877 contained performance requirements for fittings to be used as a system with PEX tubing, as well as other requirements specific to tubing used in hot- and cold-water plumbing systems.

Development of these standards began in 1982 within ASTM Technical Committee F17 “Plastic Piping Systems”, under the leadership of Mr. Lenman. PPI staff was involved in providing guidance for the development of plastic piping standards, and other F17 Technical Committee members provided input to the development of these standards.

Since that time, other industry standards have also been developed which apply to PEX tubing or piping in plumbing and mechanical applications, although these standards are not the focus of this technical report. Two of these standards are **CSA B137.5** *Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications* first published in 1989, and **AWWA C904** *Crosslinked Polyethylene (PEX) Pressure Tubing, 1/2 In. (13 mm) Through 3 In. (76 mm) for Water Service* first published in 2006.

Several other PEX standards for different applications (e.g., API Spec 15PX “for the production and transportation of oil, gas, and non-potable water”, ASTM F3253 for “hydronic heating and cooling systems”, ASTM F2788 for “industrial and general-purpose pipelines, potable water pipelines, and fire-extinguishing pipelines”, ASTM F2905 for “oil and gas producing applications”, and ASTM F2968 for “buried gas distribution and gas transmission pressure piping applications”) have also been developed, based on F876.

5.0 EVOLUTION OF ASTM F876 FROM 1984 – 2024

Thanks to its inherent flexibility, toughness, and resistance to high temperatures, the initial applications for PEX tubing were in heating systems such as radiator connections, hydronic radiant floor heating, and snow and ice melting. Growth in uses for PEX led to new testing requirements to ensure that PEX tubing was suitable for all applications. By the 1990s, PEX was adopted by plumbers who liked its flexibility, long lengths, and ability to use home-run or parallel style plumbing systems in houses.

The original “Engel” method for producing PEX employs organic peroxides that, when heated, generate reactive free radicals that splice HDPE chains together during extrusion. This is sometimes referred to as the “PEXa” process.

Along with market growth came the development of new technologies for crosslinking PE into PEX, and these new technologies were added into F876.

The Silane method for crosslinking PE into PEX was developed in the early 1970s and added into F876 in 1996. This method was invented by Midland Silicone (now Dow Chemical) and involves grafting a reactive silane molecule to the backbone of the polyethylene. After extrusion, tubing is subjected to hot steam or hot water to complete the crosslinking reaction. Sometimes referred to as “PEXb”, there are different versions of Silane crosslinking, but they all must meet the same requirements of ASTM F876.

The Electron-beam method for crosslinking PE into PEX was developed after the Silane method and was added into F876 in 1990. Sometimes referred to as “PEXc” or “irradiation” crosslinking, this method involves subjecting the extruded HDPE pipe to a dose of high energy electrons to produce crosslinking. PEX tubing produced using this method also must meet the same requirements of ASTM F876.

Note 2: See PPI TN-17 *Crosslinked Polyethylene (PEX) Pipe & Tubing Systems* for more information on types of crosslinking.

As test methods and technology continued to evolve, frequent updates to both ASTM F876 and F877 were made. Both standard specifications have been dynamic, attracting ideas for technical improvements and increased clarity, and serving as models for standards for other new piping materials.

In the early years, PEX tubing was required to be tested and certified to *both* F876 and F877, but that was corrected in approximately 2008 when all tubing requirements were moved into F876. Since that time, F877 contains the requirements for “system components” made up of fittings, manifolds, and valves, and provides uniform testing requirements for ensuring the integrity of these components.

Significant updates to F876 in the past forty years have been:

- **ASTM F876-98** introduced the Stabilizer Functionality test.
 - This test requires long-term hydrostatic testing at elevated temperatures of 230°F (110°C) for a minimum test time of 8,000 hours or testing at 248°F (120°C) for a minimum test time of 3,000 hours without failure
- **ASTM F876-99a** added nominal diameter 1/8
- **ASTM F876-01** added nominal diameters 2 ½ to 6
- **ASTM F876-01e1** added nominal diameter 5/16
- **ASTM F876-02** introduced mandatory chlorine resistance testing known as “Oxidative Stability in Chlorinated Potable Water” for tubing intended for potable water with a “minimum extrapolated time-to-failure of 50 years”
- **ASTM F876-03** introduced the alphanumeric material designation code (MDC), using four digits in addition to the designation “PEX”, where:

- The first digit stipulated chlorine resistance as follows:
 - Digit “0” indicates that the tubing has not been tested or does not meet minimum requirements
 - Digit “1” indicates that the tubing has been tested and meets minimum requirements
- The second digit was reserved for a “future property”
- Third and fourth digits were for hydrostatic design stress at 73°F (23°C) in units of 100 psi
- **ASTM F876-08** introduced the Table for “Material Designation Code Cells”
 - Digits of 0, 1, 3, or 5 for the first digit and codes 06 or 08 for the final two digits were available
 - The second digit was not yet used and remained a “0”
- **ASTM F876-08a** added requirements for “Bent Tube Hydrostatic Sustained Pressure Strength” and “Excessive Temperature-Pressure Capacity” which were moved into F876 from F877
- **ASTM F876-09** introduced testing for “outdoor weathering” according to **ASTM F2657** and the Material Designation Code was revised to include “UV resistance” as the second digit
- **ASTM F876-20** introduced mandatory requirements for testing for “outdoor weathering” according to ASTM F2657 for “PEX tubing intended for use in the transport of potable water”
- **ASTM F876-24a** added a new Annex A1 *Method for Determination of a PEX Material Designation Code* which includes requirements for chlorine resistance, UV resistance, and determination of the HDS at 73°F
 - These requirements were relocated into the new Annex A1 from other locations within the document

ASTM F876 has always maintained its relevance by staying current, whereby, in some cases, the standard has been revised more than once in a single year.

Appendix A summarizes the revisions to each of the fifty (50) editions of F876 from the original 1984 edition to the latest 2024 edition.

6.0 ACCEPTANCE OF PEX TUBING IN CODES

Within North American model plumbing codes, PEX was first included in the BOCA National Plumbing Code of 1993, in the National Plumbing Code (NPC) of Canada in 1995, in the SBCCI Standard Plumbing Code (forbearer of the ICC International Plumbing Code) in 1997, and in the IAPMO Uniform Plumbing Code (UPC) in 2000. Over this same 30+ year period, PEX has also been approved in multiple mechanical codes (e.g., ASME B31.9, IMC, UMC, CSA B214, CSA C448) for use as hydronic and geothermal ground heat exchanger piping.

Today, PEX tubing is recognized and approved in model codes across Canada and USA, and boasts widespread use in hot- and cold-water plumbing distribution, water service, building supply lines, fire protection, hydronic heating and cooling, radiant heating and cooling, snow and ice melting, turf conditioning, district energy heating and cooling, chilled water, ground source geothermal piping systems, gas distribution, and gas gathering applications.

7.0 SUMMARY

The PEX piping industry is highly regulated. Product standards, specifications, test methods, and code requirements developed over the past forty years decree tight material and production controls, require hydrostatic temperature ratings at 180°F (82°C), and mandate standardized chlorine resistance and UV resistance testing for tubing intending for potable water and certain other applications. Third-party certification agencies require strenuous quality control testing for PEX piping and components, including frequent unannounced inspections of plants, and annual monitoring and re-testing of products.

Today, the North American PEX industry is thriving in both residential and commercial construction, with PEX tubing being the dominant piping material used in residential hot- and cold-water plumbing and in hydronic radiant heating/cooling systems, as well as snow and ice melting systems, turf conditioning systems, and other applications. According to PPI estimates, more than **2 billion pounds** of PEX pipe and tubing has been shipped in North America in the past forty years. Based on traditional tubing size distribution and weight-per-diameter ratios, this translates to more than **30 billion feet** of PEX shipped into Canada, USA, and Mexico over this period of exceptional growth.

ASTM Standard Specification F876 has provided guidance to manufacturers, certifiers, code officials, system designers, installers, and end-users about the capabilities of PEX tubing systems, helping to foster growth and responsible use of PEX materials across North America.

8.0 REFERENCED STANDARDS, CODES, AND PUBLICATIONS

- API Spec 15PX Specification for Crosslinked Polyethylene (PEX) Line Pipe
- ASME B31.9 Building Services Piping
- ASTM D3350 Standard Specification for Polyethylene Plastics Pipe and Fitting Materials
- ASTM D3045 Standard Practice for Heat Aging of Plastics Without Load
- ASTM F876 Standard Specification for Crosslinked Polyethylene (PEX) Tubing
- ASTM F877 Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems

- ASTM F1281 Standard Specification for Crosslinked Polyethylene/Aluminum/ Crosslinked Polyethylene (PEX/AL/PEX) Pressure Pipe
- ASTM F2023 Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Pipe, Tubing and Systems to Hot Chlorinated Water
- ASTM F2657 Standard Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing
- ASTM F2788 Standard Specification for Metric- and Inch-sized Crosslinked Polyethylene (PEX) Pipe
- ASTM F2829 Standard Specification for Metric- and Inch-Sized Crosslinked Polyethylene (PEX) Pipe Systems
- ASTM F2905 Standard Specification for Crosslinked Polyethylene (PEX) Line Pipe for Oil and Gas Producing Applications
- ASTM F2968 Standard Specification for Crosslinked Polyethylene (PEX) Pipe for Gas Distribution Applications
- ASTM F3203 Standard Test Method for Determination of Gel Content of Crosslinked Polyethylene (PEX) Pipes and Tubing
- ASTM F3253 Standard Specification for Crosslinked Polyethylene (PEX) Tubing with Oxygen Barrier for Hot- and Cold-Water Hydronic Distribution Systems
- AWWA C904 Crosslinked Polyethylene (PEX) Pressure Tubing, ½ in. Through 3 in. for Water Service
- AWWA M11 Steel Pipe – A Guide for Design and Installation
- CSA B137.5 Crosslinked Polyethylene Tubing Systems for Pressure Applications
- CSA B214 Installation Code for Hydronic Heating Systems
- CSA C448 Design and Installation of Ground Source Heat Pump Systems for Commercial and Residential Buildings
- IAPMO UMC Uniform Mechanical Code
- IAPMO UPC Uniform Plumbing Code
- ICC IMC International Mechanical Code
- ICC IPC International Plumbing Code
- ISO R161-1690 Pipes of Plastics Materials for the Transport of Fluid
- ISO 1167 Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure
- ISO 13760 Plastics pipes for the conveyance of fluids under pressure — Miner's rule — Calculation method for cumulative damage

- ISO 15875 Plastics piping systems for hot and cold water installations — Crosslinked polyethylene (PE-X)
- PPI TR-3 Policies and Procedures for Developing Hydrostatic Design Basis (HDB) Pressure Design Basis (PDB) Strength Design Basis (SDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe
- PPI TR-4 PPI HSB Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB), Minimum Required Strength (MRS) Ratings and Categorized Required Strength (CRS) For Thermoplastic Piping Materials or Pipe

APPENDIX A: ASTM F876 TIMELINE 1984 – 2024

Note: The information in this Appendix is offered in good faith and believed to be accurate at the time of its preparation.

Edition	Published	Content and Significant Revisions from Previous Edition
F876-84	June 1984	<p>First Edition:</p> <ul style="list-style-type: none"> • Includes requirements for material, workmanship, dimensions, sustained pressure at 73°F, 180°F, and 200°F, burst pressure at 73°F, 180°F, and 200°F, environmental stress cracking resistance (ESCR), stabilization migration resistance [per ASTM D3045], density (0.926 - 0.940), degree of crosslinking, and markings • Sizes in nominal tubing size (NTS) from ¼ to 2 • Minimum Base PE is “Class 354434” as defined in ASTM D3350 • Crosslinking is specified as “70 – 89%” and is by peroxide method only
F876-85	Sept. 1985	<ul style="list-style-type: none"> • Revised Section 4.2 <i>Basic Materials</i> to revise “Class 354434 polyethylene” to “polyethylene compounds that shall equal or exceed the cell classification 354400...” and to add “...and Azo compounds...” • Revised Note 3 to revise the cell class for PE compounds and to add “or Azo compounds...” • Revised Section 6.7 <i>Degree of Crosslinking</i> to allow a “range of 65 to 89% inclusive.” Specific minimum values are added: 70% for peroxides and 65% for Azo compounds
F876-88	Dec. 1988	<ul style="list-style-type: none"> • Renumbered Note 1 as Section 3.5 <i>Relation between dimensions, hydrostatic design stress, and pressure ratings</i> with subsequent renumbering of sections • Revised Note 2 related to “PEX tubing intended for use in the transport of potable water...”
F876-89	May 1989	<ul style="list-style-type: none"> • Revised Section 8.1 <i>Retest and Rejection</i> with additional content • Deleted “Bar” as a unit of measure for stress or pressure from Table X1.1.
F876-90	Sept. 1990	<ul style="list-style-type: none"> • Revised Section 4.2 <i>Basic Materials</i> to add “electron beam” as a method of crosslinking, • Revised Section 6.7 <i>Degree of Crosslinking</i> to include minimum 65% crosslinking requirement for electron beam method
F876-93	July 1993	<ul style="list-style-type: none"> • Deleted Section 2.3 <i>ISO Standards</i> and reference to ISO R161-1690 was moved to Footnote 10

Edition	Published	Content and Significant Revisions from Previous Edition
F876-95a	Feb. 1996	<ul style="list-style-type: none"> • Revised Section 5.2 <i>Basic Materials</i> to include tubing that is crosslinked “by other means...”. This section also required that “...crosslinking shall result in a product with long-term hydrostatic stress ratings equal to or better than those shown in Table 5, when determined in accordance with procedures no less restrictive than those of PPI TR-3/92.” • Deleted Note 2 • Revised Section 6.7 <i>Degree of Crosslinking</i> to include “silane compound additions” with a minimum degree of crosslinking of 65% • Revised Section 8.1 <i>Retest and Rejection</i> • Added Section 11 <i>Keywords</i>
F876-96		<ul style="list-style-type: none"> • This edition not available at the publication of this document
F876-96a	Aug. 1996	<p>These revisions were made between F876-95a and F876-96a, including F876-96</p> <ul style="list-style-type: none"> • Added Note 2 regarding “other processes for producing crosslinked polyethylene” • Table X1.1 <i>Hydrostatic Design Stresses and Pressure Ratings</i> becomes Table 1 • Table 1 is renumbered as Table 2; Table 2 is renumbered as Table 3; Table 3 is renumbered as Table 4; Table 4 is renumbered as Table 5 • Deleted Minimum PE cell classification from Section 5.2 <i>Basic Materials.</i> • Revised 6.7 <i>Degree of crosslinking</i> (minor) • Revised Section X1.3 to refer to Table 1 instead of X1.1
F876-96b	Nov. 1996	<ul style="list-style-type: none"> • Revised Footnote 1 • Deleted Footnote 5 reference to ASTM Standards Volume 8.03 and renumbered subsequent footnotes • Revised Section 3.2.2 <i>Definition for hydrostatic design stress</i> • Note 2 “Tubing produced by crosslinking by peroxides...” was added • Revised Section 6.1 <i>Workmanship</i> to remove “The inside and outside surfaces shall be matte or glossy in appearance.” • A portion of Section 7.6.4 <i>Seepage or Weeping</i>, “At lower pressures, the tubing may carry liquids without evidence of loss of the liquid”, is positioned as Note 4 with renumbering of subsequent notes • Revised Section 8.1 <i>Retest and Rejection</i> to change requirements; permissive language is deleted

Edition	Published	Content and Significant Revisions from Previous Edition
F876-97	Nov. 1997	<ul style="list-style-type: none"> • Revised Section 6.3 <i>Density</i> to eliminate the maximum value of 0.940 Mg/m³ • Revised Table 2 <i>Outside Diameters and Tolerances</i> with new <i>Out of Roundness</i> values • Revised Section 7.7 <i>Burst Pressure</i> with correct reference to Table 5 instead of Table 4 • Revised Section 9.1.5 to delete inclusion of “F876” in required markings
F876-98	March 1999	<ul style="list-style-type: none"> • Deleted Section 7.10 <i>Stabilizer Migration Resistance</i> • Added Section 7.10 <i>Stabilizer Functionality</i> including options for testing for 3000 h at a hoop stress of 0.70 MPa at 120°C (248°F) or testing for 8000 h at a hoop stress of 2.80 MPa at 110°C (230°F) • Added Sections 7.10.1 <i>Procedure</i> and 7.10.2 <i>Significance</i> • Added Sections X1.5 on stabilizer functionality test and X1.6 <i>Stabilizer Verification</i> • Added Note X1.1 regarding lack of a P&B statement for OIT testing
F876-99	June 1999	<ul style="list-style-type: none"> • Section 6.8 <i>Stabilizer Migration Resistance</i> is replaced with <i>Stabilizer Functionality</i>, referring to the requirements in Section 7.10 that were added in the 1998 edition • Revised Section 9.1.2 (part of “Markings”) to refer to Section 3.2.6
F876-99a	Nov. 1999	<ul style="list-style-type: none"> • Revised Section 3.2.5 <i>Standard dimension ratio (SDR)</i> to add exception for certain sizes • Added 1/8 nominal tubing to Tables 2, 3, 4, and 5
F876-00	July 2000	<ul style="list-style-type: none"> • Footnote 8 was moved to Section 2.6 <i>ISO Standard</i> with reference to ISO R 161-1690 (source of the ISO Hoop Stress equation) • Added “Average Wall Thickness” values to Table 3
F876-01	March 2001	<ul style="list-style-type: none"> • Added nominal diameters 2 ½ - 6 to Tables 2 and 3
F876-01e1	March 2001	<ul style="list-style-type: none"> • Editorial updates to Tables 2 and 3 • Added 5/16 diameter tubing to Table 2 • Deleted “Average Wall Thickness” values from Table 3
F876-01e2	March 2001	<ul style="list-style-type: none"> • Revised Section 10.1 editorially to clarify that “this designation” means “F876”

Edition	Published	Content and Significant Revisions from Previous Edition
F876-02	March 2003	<ul style="list-style-type: none"> • Revised Section 2.1 <i>Reference standards</i> to include ASTM F2023 • Added Section 6.9 <i>Oxidative Stability in Chlorinated Potable Water</i> with mandatory “minimum extrapolated time-to-time failure of 50 years...” • Added Section 7.11 <i>Oxidative Stability in Potable Chlorinated Water Applications</i> and 7.11.1 <i>Significance</i> • Added Note 6 regarding the applicability of 7.11 extrapolations
F876-03	Aug. 2003	<ul style="list-style-type: none"> • Added Section 2.7 <i>PPI Standard</i> with PPI TR-4 listed • Added the alphanumeric material designation code in Section 3.2.6 <i>Standard thermoplastic tubing materials designation code</i>, using four digits in addition to the designation “PEX” <ul style="list-style-type: none"> ○ The first digit is for chlorine resistance. Digit “1” indicates the tubing has been tested and meets minimum requirements. A digit “0” means the tubing has not been tested or does not meet minimum requirements ○ The second digit designated as “0” and “is reserved for another PEX tubing property” ○ Third and fourth digits are for hydrostatic design stress for water at 73°F in units of 100 psi • Deleted Section 6.9 <i>Oxidative Stability in Potable Chlorinated Water Applications</i> [in error] • Deleted Section 7.11 <i>Oxidative Stability in Potable Chlorinated Water Applications</i> [in error] • Deleted Note 6 [in error]
F876-03e1	Aug. 2003	<ul style="list-style-type: none"> • Section 6.9 <i>Oxidative Stability in Potable Chlorinated Water Applications</i>, Section 7.11 <i>Oxidative Stability in Potable Chlorinated Water Applications</i>, and Note 6 were editorially reinstated
F876-03a	Sept. 2003	<ul style="list-style-type: none"> • Revised Section 7.4.1 <i>Outside Diameter</i> to specify the use of a “circumferential wrap tape” (i.e., Pi tape) as the referee method
F876-04	May 2004	<ul style="list-style-type: none"> • Deleted Section 6.2.3 <i>Wall thickness range</i> • Added footnote A to Table 3 <i>Wall Thickness and Tolerances</i>
F876-05	Dec. 2005	<ul style="list-style-type: none"> • Added Appendix X.2 <i>UV Labeling Guidelines for PEX Tubing</i>
F876-06	Jan. 2007	<ul style="list-style-type: none"> • ASTM D3045 and ASTM D3350 deleted from Section 2 • Revised Section 3.2.2 <i>Hydrostatic Design Stress (HDS)</i> • Added Section 3.2.3 <i>Hydrostatic Design Basis (HDB)</i>

Edition	Published	Content and Significant Revisions from Previous Edition
F876-07	Jan. 2008	<ul style="list-style-type: none"> • Revised Table 4 test pressures for NTS ¼ and 3/8 tubing (four changes) • Revised Table 5 test pressures for NTS ¼ tubing (three temperatures)
F876-08	Aug. 2008	<ul style="list-style-type: none"> • Revised Section 1.3 related to use of SI units • Added ISO 1167 and ISO 13760 to Section 2.6 • Added new Table 1 “Material Designation Code Cells” <ul style="list-style-type: none"> ○ This was the introduction of two new categories of chlorine resistance: (3) 50% of the time at 73°F & 50% of the time at 140°F, and (5) 100% of the time at 140°F ○ Digits of “0”, “1”, “3”, or “5” for the first digit and codes “06” or “08” for the final two digits were available ○ The second digit was not yet used and remained a “0” • Added Section 3.2.3.1 <i>Discussion</i> addressing HDB and HDS values • Added Sections 3.2.7.1, 3.2.7.2, and 3.2.7.3 <i>Discussion</i> addressing material designation code values • Other Tables renumbered • Note 4 added to give an example of a material designation code • Added Sections 7.11.1, 7.11.2, and 7.11.3 to describe calculation methods for the three categories of chlorine resistance per Table 1

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F876-08a	Sept. 2008	<ul style="list-style-type: none"> • Revised Section 1.1 <i>Scope</i> to match current test requirements • Table 1 is renumbered as Table 2; Table 2 is renumbered as Table 3; Table 3 is renumbered as Table 4; Table 4 is renumbered as Table 1 • Revised 3.2.7.2 <i>Discussion</i> (minor) • Revised Section 4.2 <i>SDR</i> • Revised title of Table 5 • Added Section 6.2 <i>Out of Roundness</i> • Added Note 3 related to minimum wall thickness • Added Section 6.11 <i>Bent Tube Hydrostatic Sustained Pressure Strength</i> test requirement, including Note 6 [moved from ASTM F877] • Added Section 6.12 <i>Excessive Temperature- Pressure Capacity</i> test requirement. [moved from ASTM F877] • Added Section 7.12 <i>Excessive Temperature- Pressure Capability</i> with test requirements • Added Section 9 <i>Certification</i> • Added Section 10.1 <i>Quality of Marking</i> • Revised Marking requirements to include “the date of production” • Added Section 10.8 to require marking for “standard designation(s) of the fitting system(s) for which the tubing is recommended for use by the tubing manufacturer.” • Added Appendix X3 <i>Design, Assembly, and Installation Considerations</i> • Added Appendix X4 <i>Optional Performance Qualification and In-Plant Quality Control program for PEX...</i>
F876-08b	Jan. 2009	<ul style="list-style-type: none"> • Revised Section 1.1 <i>Scope</i> to include “that incorporates an optional polymeric inner, middle or outer layer...” • Added ASTM F1281 to Section 2 <i>Reference Standards</i> • Revised Section 5.2 <i>Materials</i> to include “optional layer” • Revised Section 6.3.1 <i>Outside diameters</i> • Added Section 6.3.1.1 <i>Layer</i> with dimensional requirements for optional layers • Added Section 6.8.1 <i>Layer</i> with requirements for tubing with optional layer(s) • Added Section 6.11 <i>Adhesion Test</i> with requirements for tubing with optional layer(s) • Added Section 7.4.2.1 <i>Layer</i> with test requirements for tubing with optional layer(s) • Added Section 7.6.5 <i>Delamination</i> with requirements for tubing with optional layer(s) • Added Section 10.2.4 with marking requirements for tubing with optional layer(s)

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F876-09	Sept. 2009	<ul style="list-style-type: none"> • Added ASTM F2657 to Section 2 <i>Reference Standards</i> • Revised Table 2 <i>Material Designation Code</i> to include “Minimum UV Resistance” as an additional characteristic <ul style="list-style-type: none"> ○ Digits of 0, 1, 3, or 6 were added as options for the second digit • Added Section 3.2.7.2 and 3.2.7.3 <i>Discussion</i> to explain the requirements and testing criteria for UV resistance for both potable and non-potable PEX tubing
F876-10	March 2010	<ul style="list-style-type: none"> • Revised Section 6.2 <i>Out of Roundness</i> to state “Tubing shall be measured prior to coiling”
F876-10e1	March 2010	<ul style="list-style-type: none"> • Editorial adjustment to Section 3.2.7.2 <i>Discussion</i>
F876-13	April 2013	<ul style="list-style-type: none"> • Revised Section 3.2.1 <i>Definition</i> of “crosslinked polyethylene”
F876-13a	Aug. 2013	<ul style="list-style-type: none"> • Revised Section 1.1 <i>Scope</i> editorially • Revised Section 3.2.7.2 <i>Discussion</i> on UV resistance
F876-15	Sept. 2015	<ul style="list-style-type: none"> • Revised Section 3.2.7.1 <i>Discussion</i> parts (2), (4), and (6) to reference Section 6.10 instead of F876
F876-15a	Nov. 2015	<ul style="list-style-type: none"> • Revised X3.1.5 <i>Horizontal Support Spacing</i> to add statement on nominal sizes 1 ¼ and larger

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F876-17	Sept. 2017	<ul style="list-style-type: none"> • Revised 1.1 <i>Scope</i> to list specific applications for PEX • Added Section 1.5 related to “recognized principles on standardization...” • Table 1 becomes Table 3; Table 2 becomes Table 1; Table 3 becomes Table 4; Table 4 becomes Table 2 • Revised title of Table 1 to include “Thermoplastic Tubing...” • Deleted “mm” nominal tubing sizes from all Tables • Revised “mm” dimensions in Tables to “(mm)” • Revised Table 3 <i>Wall Thickness and Tolerances</i> to add footnote B for 5/16 tubing • Revised Section 3.2.1 <i>Definition for crosslinked polyethylene</i> • Revised 3.2.7 on <i>Thermoplastic tubing materials designation code</i> • Added 3.2.7.3 <i>Discussion</i> stating “PEX tubing is not designed for outdoor use...” • Revised 5.2 <i>Basic Materials</i> and Note 2 to delete “Azo compounds” • Revised Section 6.1 <i>Workmanship</i> • Added Section 6.2.4 <i>Coil diameters</i> with minimum coil diameter requirements • Revised Section 6.7 to delete “Azo compounds” • Revised Section 7.6 <i>Hydrostatic Sustained Pressure Test</i> • Revised Section 7.9 <i>Degree of crosslinking</i> to add a tolerance to strip thickness; Note 7 revised for same purpose • Revised 7.11.1, 7.11.2, and 7.11.3 stress conversion of “551.7 kPa” to “550 kPa” • Revised Note 8 to clarify limitations of chlorine resistance extrapolations • Deleted Section X3.1.2 <i>Water Heaters</i> • Revised Section X3.2.2 <i>Repairs</i> • Revised Sections X4.1.1 and X4.1.2 changing “components” to “tubing” • Table X4.1 becomes Table X4.2; Table X4.2 becomes Table X4.1 • Revised Table X4.1 to include “Chlorine resistance” and “UV resistance” • Revised “73.4°F” to “73°F” throughout • Revised “± 3.6°F” to “± 4°F” throughout • Other minor editorial adjustments
F876-19	July 2019	<ul style="list-style-type: none"> • Revised Section 10.2.6 <i>Markings</i> to specify how the pressure ratings are determined • Added Note 9 allowing manufacturers to add additional pressure ratings

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F876-19a	Aug. 2019	<ul style="list-style-type: none"> • Added ASTM F3203 to Section 2 <i>Referenced Standards</i> • Revised Section 7.9 <i>Degree of Crosslinking</i> to allow the use of Test Method F3203 for “routine quality control and monitoring only” to determine gel content (i.e., degree of crosslinking)
F876-20	July 2020	<ul style="list-style-type: none"> • Revised Section 1.1 <i>Scope</i> to include “UV resistance” • Revised Section 6.9 <i>Oxidative Stability in Chlorinated Potable Water</i> for better clarity • Added Section 6.10 <i>Oxidative Stability in Outdoor Weathering Exposure (Ultraviolet)</i> to make UV resistance mandatory for PEX tubing intended for potable water • Added Note 5 regarding the scope and purpose of ASTM Test Method F2657
F876-20a	Nov. 2020	<ul style="list-style-type: none"> • Added ASTM F877 and ISO 15875 to Section 2 <i>Referenced Standards</i> • Added Table 6 <i>Minimum 165-Hour Hydrostatic Sustained Pressure Requirements</i> • Revised Section 6.4 <i>Hydrostatic Sustained Pressure Strength</i> to include reference to new Table 6 • Revised Section 7.6 <i>Hydrostatic Sustained Pressure Test</i> to include reference to new Table 6 • Revised Sections 7.6.1, 7.6.2, 7.6.3, 7.6.4, and 7.6.5 to add new requirements for sustained pressures testing • Added Note 7 regarding the test pressures of Table 5 and Table 6 • Revised Table 7 Footnote A to change “fiber stress” to “hoop stress” and add “(NTS)” abbreviation • Revised Section 7.7 <i>Hydrostatic Burst Pressure</i> • Added Section 7.7.1 clarifying the significance of burst pressure testing • Revised Section 7.8 <i>Environmental Stress Cracking Test</i> to allow ESCR testing at 200°F (93°C) only and added tolerances to ESCR test conditions • Added Section 7.8.1, 7.8.2, 7.8.3, 7.8.4, and Note 8, Note 9, Note 10, and Note 11 related to the Environmental Stress Cracking Test
F876-20b	Jan. 2021	<ul style="list-style-type: none"> • Revised Section 6.13.1 <i>Excessive Temperature-Pressure Capacity</i> • Deleted Section 6.13.2 and added Note 7 providing rationale for 6.13.1 requirements

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F876-22	Feb. 2022	<ul style="list-style-type: none"> • Revised Section 1.3 regarding SI units of measure • Revised Section 5.1 <i>General</i> to delete statement about correlation between density of PEX and short-term strength • Deleted existing Note 1 about certification for potable water applications and renumbered subsequent notes • Revised Section 6.3 <i>Density</i> to delete “material” • Revised Note 6 on <i>Excessive Temperature - Pressure Capacity</i> to delete mandatory language • Revised Section 7.6.5 and added Section 7.6.6 on failures and retesting for <i>Hydrostatic Sustained Pressure Tests</i> • Revised Section 9 <i>Certification</i> to update NSF standard designations
F876-22a	April 2022	<ul style="list-style-type: none"> • Editorially corrected Minimum Burst Pressures for 165-Hour Sustained Pressure Testing in Table 6
F876-22ae1	April 2022	<ul style="list-style-type: none"> • Editorially corrected header in Table 6, changing “Minimum Burst Pressures” to “Pressure Required for test”
F876-23	Feb. 2023	<ul style="list-style-type: none"> • Revised Section 1.1 <i>Scope</i> to include “building supply lines” as an intended application
F876-23a	Dec. 2023	<ul style="list-style-type: none"> • Revised Section 7.1 <i>Conditioning</i> and Section 7.2 <i>Test Conditions</i> to adjust tolerances for temperature and RH
F876-24	Feb. 2024	<ul style="list-style-type: none"> • Add Section 6.14 <i>Tubing Qualification with Fitting System(s)</i> • Add Note 7 regarding test of “tubing and fitting assemblies” • Revised Section 10.2.9 regarding tubing markings for “qualified” fitting(s)

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F876-24a	Oct. 2024	<ul style="list-style-type: none"> • Revised Section 2.1 in <i>Reference Standards</i> to delete D1600 [withdrawn] • Deleted Section 2.2 with ANSI B36.10 • Added Section 2.2. with AWWA Manual M11 • Revised Section 2.6 to delete ISO 13760 • Deleted Table 1; relocated as Table A1.1, with minor revisions • Revised Section 3.2.2 with definition for <i>Hydrostatic design basis (HDB)</i> • Added Section 3.2.4 <i>PEX Material Designation Code</i> definition and 3.2.4.1 <i>Discussion</i> • Deleted 3.2.5 • Revised Section 3.2.6 <i>Standard dimension ratio</i> and separated a portion into 3.2.6.1 <i>Discussion</i> • Deleted Section 3.2.7 <i>Thermoplastic tubing material designation code</i> • Revised 4.1 <i>General</i> • Revised Section 5.2 <i>Basic Materials</i> • Revised Note 1 to focus on determination of HDS • Revised Section 5.3 <i>PEX Material Designation Code</i> • Table 4 becomes Table 1 • Table 5 becomes Table 4; title revised • Table 6 becomes Table 5 • Table 7 becomes Table 6 • Revised Section 6.9 with reference to Annex A1.3 • Revised Section 6.10 with reference to Annex A1.4 • Revised Note 4 • Revised Sections 7.5, 7.6.1, 7.7.1, 7.10, and 7.10.2 changing “compound” to “material” • Deleted Section 7.11 • Deleted Note 14 • Revised Section 10.2.3 in <i>Markings</i> to change reference to Annex A1 • Revised Section 10.2.6 in <i>Markings</i> to regarding pressure ratings • Added new Annex A1 <i>Method for Determination of a PEX Material Designation Code</i> which includes requirements for chlorine resistance, UV resistance, and determination of the HDS at 73°F
F876-24b	Nov. 2024	<ul style="list-style-type: none"> • Revised “pipe” to “tubing” in Sections 1.1, 4.2, Table 3, 7.10, 7.10.1, 7.10.2, 7.11.1.1, X1.5, X1.6, and X3.2.4 for consistency with title and scope of the standard