



Designation: C1847 – 21

Standard Specification for Direct Buried Pre-Insulated and Jacketed Polyurethane Bonded Low Temperature Hot Water Piping Systems¹

This standard is issued under the fixed designation C1847; 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 specification covers direct buried underground pre-insulated, hot water piping systems with an upper temperature limit of 250 °F (121 °C) used to convey pressurized fluids for district heating. In the pre-insulated pipe industry and in this standard, this temperature range is called “low temperature hot water”.

1.2 This specification shall not be used for low-pressure steam systems, steam trap discharge or pressurized condensate systems, since there is a high risk of exceeding the upper temperature limits. Pumped condensate return lines that are vented to atmosphere are considered to be low temperature hot water and are acceptable for this application.

1.3 This specification covers only piping systems insulated and jacketed with bonded polyurethane (PUR) rigid foam. A piping system consists of both straight sections of pre-insulated piping as well as pre-insulated fittings and field closures of the insulation system, and all materials required to ensure a water tight insulation system which will preclude water from entering the insulation from the surrounding soil. This specification does not encompass insulating or jacketing materials, or insulation methods, which do not produce factory, pre-fabricated, insulated and jacketed units for assembly at the field site.

1.4 The insulated piping systems covered by this specification do not possess an air gap between the carrier pipe and the insulation nor between the insulation and jacket. For straight pipe sections of the piping systems covered by this specification, these three components are bonded together.

1.5 The carrier piping that is part of the insulated piping system covered by this specification shall be designed, fabricated, and tested to the requirements of ANSI/ASME B31.1 (Power Piping).

1.6 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathemati-

cal conversions to SI units that are provided for information only and are not considered to be the standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

- A53/A53M Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- A105/A105M Specification for Carbon Steel Forgings for Piping Applications
- A106/A106M Specification for Seamless Carbon Steel Pipe for High-Temperature Service
- A234/A234M Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
- A312/A312M Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
- A403/A403M Specification for Wrought Austenitic Stainless Steel Piping Fittings
- B88 Specification for Seamless Copper Water Tube
- C168 Terminology Relating to Thermal Insulation
- C335 Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
- C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- C1409 Guide for Measuring and Estimating Quantities of Insulated Piping and Components

¹ This specification is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.40 on Insulation Systems.

Current edition approved May 1, 2021. Published June 2021. DOI: 10.1520/C1847-21.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1

Property	Value
Density, minimum lb./ft ³ (kg/m ³)	2.5 (40)
Compressive resistance at 10% deformation or yield, whichever occurs first, parallel to rise, minimum lb./in ² (kPa)	40 (276)
Initial apparent thermal conductivity by Test Method C518 at a mean temperature of 75 °F (24 °C), BTU-in/hr-ft ² -°F (W/m-K)	^A
Maximum aged apparent thermal conductivity, by Test Method C335 or ISO 8497 at mean temperatures shown in Table 2.	Table 2
Closed cell content per Test Method D6226, minimum %	88
Maximum linear change % at 250 °F per Test Method D2126	6
Assembly bond shear strength, minimum lb./in ² (kPa) At 73 °F ± 4 °F (23 °C ± 2 °C) un-aged and thermally aged	17.4 (120)
Assembly bond shear strength, minimum lb./in ² (kPa) Pipe at 284 °F ± 4 °F (140 °C ± 2 °C), un-aged and thermally aged	11.6 (80)
Visual Defects:	
Discolored streaks or areas	None significant
Soft or sticky spots	None significant
Cracks, gaps, disbondments	None significant
Voids	< 5% of cross section area
Largest dimension of any single void	< 25% insulation thickness

^A The Manufacturer shall measure initial apparent thermal conductivity of the insulation on a monthly basis, shall maintain records of these values, and shall make these records available to the purchaser if requested. These initial apparent thermal conductivity values shall not be used to demonstrate compliance with the aged apparent thermal conductivity requirements in Table 2. For monthly quality control, the initial apparent thermal conductivity shall be determined in accordance with Test Method C518.

D883 Terminology Relating to Plastics

D1621 Test Method for Compressive Properties of Rigid Cellular Plastics

D1622 Test Method for Apparent Density of Rigid Cellular Plastics

D2126 Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging

D2310 Classification for Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe (Withdrawn 2017)³

D2996 Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

D6226 Test Method for Open Cell Content of Rigid Cellular Plastics

D7091 Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

2.2 ANSI/ASME Standards:⁴

B16.9 Butt Welded Fittings

B16.11 Forged Fittings, Socket Welding and Threaded

B16.22 Wrought Copper Fittings

B31.1 Power Piping

2.3 SSPC/NACE Standards:⁵

SP-10 (NACE-2) Near-White Blast Cleaning

NACE-RP-0394 Application, Performance and Quality Control of Plant Applied Fusion Bonded Epoxy External Pipe Coating

3. Terminology

3.1 For descriptions of terms used in this specification, refer to Terminologies C168 and D883.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *bonded, v*—a pre-insulated pipe insulation system where the insulation is sufficiently adhered to both the carrier pipe and jacket such that the system passes the testing for adhesive/bond strength required in Table 1.

3.2.2 *carrier pipe and fitting coating, n*—a tightly adhered layer of material that provides anti-corrosive protection to the external surface of the carrier pipe material.

3.2.3 *carrier pipe and fittings, n*—hollow tubular products capable of handling the pressures, temperatures, velocities, and damaging effects (corrosion, erosion, etc.) of the fluid being transported by the thermal distribution system.

3.2.4 *centering device, n*—a method or appliance used to assure the concentricity of the carrier pipe and fittings, thermal insulation, and insulation jacket.

3.2.5 *insulation jacket, n*—a casing or jacket of protective material applied around the thermal insulation under controlled

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Available from NACE International (NACE), 15835 Park Ten Pl., Houston, TX 77084, <http://www.nace.org>.

conditions at the time and location of application of the thermal system component thermal insulation.

3.2.6 *jacket outside diameter, n*—the sum of the carrier pipe outside diameter and twice the sum of the optional carrier pipe dry film coating thickness, insulation thickness, and jacket thickness.

3.2.7 *joining, v*—a method of connecting together two units of the thermal distribution system that maintains the strength and fluid tightness of the carrier pipe and fittings and the continuity and integrity of the insulation and jacket.

3.2.8 *leakage-free joint, n*—a group of methods for joining carrier piping sections and components using welding for steel and stainless steel, and brazing for copper that create rigid, pressure testable joints with zero leakage.

3.2.8.1 *Discussion*—All other joint types, including mechanical joints such as bell and spigot joints, sliding joints, and deformable gasket type joints are specifically not considered to be leakage-free and do not meet the requirement of this standard.

3.2.9 *pre-insulated, adj*—thermal insulation applied to the carrier pipe and fittings at the system supplier's manufacturing facilities.

3.2.9.1 *Discussion*—Thermal insulation applied at or near the system installation site by an installer or other organization not engaged in manufacturing pre-insulated system components does not conform to this definition.

3.2.10 *vapor (water) stop, n*—a device or method used at the terminations of a thermal distribution system (such as building and manhole entries) that prevent the ingress of water into the thermal insulation; alternatively a device or method that seals the ends of individual thermal distribution system units.

4. Ordering Information

4.1 Orders for thermal distribution systems purchased under this specification shall include the following information:

4.1.1 Thermal system service pressure, temperature and transported fluids.

4.1.2 Insulation thickness or heat transfer losses (or gains) per unit length of carrier pipe required, and the system environmental conditions that apply such as burial depth, soil conditions, and soil temperatures, etc.

4.1.3 Statutory or code requirements applicable to the carrier piping system design, fabrication, testing, inspection, and installation (see [Annex A1](#)).

4.1.4 Carrier pipe and fitting material specification and grade, size, pressure rating or wall thickness, configuration and end preparations (see [Annex A1](#)).

4.1.5 Optional carrier pipe and fitting coatings (see [5.2](#)).

4.1.6 Thermal insulation material (see [5.3](#)).

4.1.7 Thermal insulation jacket material (see [5.4](#)).

4.1.8 Physical sizes and dimensions (see [Section 7](#)).

4.1.9 Field closure joint preferences (see [Section 8](#)).

4.1.10 Certification, inspection and testing requirements in addition to those specified (see [Section 15](#)).

4.1.11 Unit marking in addition to those specified (see [Sections 16](#) and [17](#)).

4.1.12 Shipping method if other than specified (see [Section 18](#)).

4.2 Order quantities for thermal distribution systems purchased under this specification shall be specified by providing all necessary point to point layout dimensional information, including slopes, termination points, direction changes, expansion loops, and all unique components and features. Thermal distribution systems purchased by this method are then provided as a fully engineered and pre-fabricated system comprised of units and joining materials that minimize installation time and the number of field joints required to complete the system.

4.3 Order quantities for thermal distribution systems purchased under this specification are in some cases specified by unit count. System orders under this method must be agreed between purchaser and supplier as to definitions and dimensions of system units, components, and materials. [Guide C1409](#) is a useful guide for reaching agreement on layout measurement methods, unit and component definitions, and terminology. Thermal distribution systems purchased by this method require cutting standard unit lengths to size at least once in each run length and in most situations will result in a higher number of field joints, lower quality of the installation, and longer installation times.

5. Materials and Manufacture

5.1 *Carrier Pipe and Pipe Fitting Materials*—Carrier pipe and carrier pipe fitting material shall be selected from those materials listed in [Annex A1](#) and shall meet the statutory and code requirements for design and service appropriate for the fluid temperature, pressure, longevity, chemical compatibility, and resistance to the damaging effects of corrosion.

5.2 *Optional Coating of Carbon Steel Carrier Pipe and Fittings*—When carbon steel carrier pipe and fitting materials have been specified, they are in some cases coated, as an option, to enhance corrosion resistance and service life. When this option has been ordered by the purchaser, the steel pipe and fitting outside surfaces shall be prepared by abrasive blasting to near white condition in accordance with SSPC-SP10 and primed or coated without delay to prevent the formation of rust bloom. The coating materials listed below are effective when applied by suitable spray techniques to the minimum thicknesses indicated. The dry film coating thickness shall be determined in accordance with [Practice D7091](#).

5.2.1 *Epoxy Coating*, shall typically be a two part system consisting of a base material and curing agent (hardener). Factory applied fusion bonded epoxy to the requirements of NACE-RP-0394 is also acceptable. Dry film coating thickness shall be a minimum of 0.008 in. (200 μ m).

5.2.2 *Zinc Rich Coating*, shall be a high solids, inorganic material consisting of a liquid vehicle and dry powdered zinc flake. Dry film coating thickness shall be a minimum of 0.003 in. (76 μ m).

5.2.3 *Polymer Coating*, shall be an elastomeric polymer (plastic) usually consisting of polyurethane, polyurea, or a blend of both. Dry film coating thickness shall be a minimum of 0.020 in. (500 μ m).

5.2.4 The coating selected and applied shall have been shown to be capable of withstanding the service temperature over the system life which is to be taken as 20 years unless otherwise specified. The coating selected shall be applied in compliance with the coating manufacturer's directions.

5.3 *Thermal Insulation Materials*—The thermal insulation shall be of closed cell, rigid, polyurethane (PUR) foam applied by spray or by injection. The PUR shall be free of color streaks, voids, cracks or gaps, soft spots, or other visual defects. The PUR insulation shall be bonded to the carrier pipe or optional coating to which it has been applied, and to the outer jacket. Open cell or un-bonded insulations do not meet the requirements of this specification.

5.4 *Thermal Insulation Jacket Materials*—The thermal insulation jacket shall be either high density polyethylene (HDPE) in accordance with 5.4.1 or filament wound, fiberglass reinforced polymer (FRP) in accordance with 5.4.2.

5.4.1 HDPE insulation jacket material shall meet the requirements of Specification D3350, with a minimum cell classification per Table 1 of Specification D3350 of PE 345444C. The HDPE jacket shall be applied by continuous extrusion or by fitting a tube of HDPE over the carrier pipe with centering devices prior to injecting the annular space with foam insulation. Both jacketing methods must provide permanent concentricity, within 15% of the insulation thickness, of carrier pipe, insulation and HDPE jacket and be fully bonded to the insulation without gaps or voids.

5.4.2 FRP insulation-jacket material shall be applied directly to the thermal insulation by machine filament winding, by chopped filament spray-up techniques, or by fitting a tube of FRP pipe over the carrier pipe with centering devices prior to injecting the annular space with foam insulation.

5.4.3 Both jacketing methods must provide permanent concentricity, within 15% of the insulation thickness, of carrier pipe, insulation and FRP jacket and be fully bonded to the insulation without gaps or voids. FRP pipe, when used, shall be in accordance with Specification D2996 and Classification D2310. All fittings shall be either a hand lay-up or chopped filament spray-up and have the same thickness and standards as the FRP jacket.

5.4.4 PVC jacket materials are not allowed. Tape type products constructed from any material are not permitted.

5.5 *Straight Pipe Units*—Straight pipe units manufactured to this specification shall meet the following requirements:

5.5.1 Both ends of the units shall be free of insulation and insulation jacket material for a distance of 6.0 ± 1.0 in. (150 $\pm$ 25 mm) to facilitate welding of the carrier pipe field joints without damage to the insulation system. When special welding equipment is to be used by the purchaser or by purchaser's

system installers, the purchaser shall specify alternate end conditions and tolerance.

5.5.2 Units shall be free of bulges that exceed the nominal outside diameter by 5% or 1.0 in. (25 mm), whichever is less. Flat spots or areas of outside diameter reduction (necking) shall not deviate from the nominal outside diameter by more than 5% or 0.5 in. (13 mm), whichever is less.

5.6 *Pipe Fitting Units*—Pipe fitting units manufactured to this specification shall meet the following requirements:

5.6.1 Both ends of the units shall be free of insulation and insulation jacket material for a distance of 6.0 ± 1.0 in. (150 $\pm$ 25 mm) to facilitate welding of the carrier pipe field joints without damage to the insulation system. When special welding equipment is to be used by the purchaser or by purchaser's system installers, the purchaser shall specify alternate end conditions and tolerance.

5.6.2 Due to the complex shapes characteristic of pipe fittings such as "tees", reducers, and elbows, the insulation is optionally applied by building up sections of rigid foam or by injection conforming to the requirements of section 5.3. Regardless of method, all interstitial spaces and gaps created during build-up or injection shall be filled with foam. No voids or gaps are permitted.

5.6.3 The thermal insulation jackets of pipe fitting units shall be either high density polyethylene (HDPE) in accordance with 5.4.1 or fiberglass reinforced polymer (FRP) in accordance with 5.4.2, and shall match the jacket material of the straight units. HDPE insulation jackets are in some cases formed using built up sections, or by integral jackets produced by rotational molding or other methods that produce a single unit insulation jacket that conforms to 5.4.1. When the build-up method is used, the sections of HDPE jacket shall be joined by reinforced extrusion welds. Tapes, hot air welds, or shrink products are not permitted.

6. Performance Requirements

6.1 The units of the thermal distribution system shall be pre-insulated and supplied as a complete and compatible system to assure all components will be joined in accordance with the manufacturer's procedures.

6.2 The PUR shall meet the physical and thermal requirements of Table 1 and Table 2.

6.3 Insulation testing for process quality control shall be carried out on a monthly basis to ensure properties are in accordance with this specification. Specimens shall be taken from production units. Laboratory or specially prepared specimens do not comply with this specification except as noted in 6.3.3.

TABLE 2 Maximum Aged Apparent Thermal Conductivity

Required Mean Temp °F (°C)	Maximum Value BTU-in/hr-ft ² -°F (W/m-K)	Example Ambient Temp. °F (°C)	Example Pipe Temp °F (°C)
160 $\pm$ 5 (71 $\pm$ 3)	0.23 (0.032)	70 (21)	250 (121)
140 $\pm$ 5 (60 $\pm$ 3)	0.21 (0.030)	70 (21)	210 (99)
120 $\pm$ 5 (49 $\pm$ 3)	0.20 (0.029)	70 (21)	170 (77)