



MICRO-LOK® HP GUIDEBOOK

A Complete Guide to
Micro-Lok HP Pipe Insulations

TABLE OF CONTENTS

CHAPTER 1: PRODUCT DESCRIPTION AND BENEFITS 3

Description	3
Jacketing	3
Applications	4
Advantages	4
Qualifications for Use	5
Application Recommendations: ASJ SSL Jacket & Butt Strips	5

CHAPTER 2: SPECIFICATION DATA 6

CHAPTER 3: INSULSPEC™ – CSI SPECIFICATION 8

Scope	8
References	8
Submittals	8
Environmental Requirements	8
Quality Assurance	8
Delivery, Storage and Handling	9
Manufacturers	9
Pipe Insulation	9
Materials	10
Examination	11
Installation – Chilled Water and Dual-Cycle System Insulations	11
Installation – Above Ambient Conditions	12
Field Quality Control	13

CHAPTER 4: INSTALLATION METHODS 14

CHAPTER 5: THICKNESS RECOMMENDATIONS 15

Cold Applications	15
Hot and Cold Applications	16

CHAPTER 6: Heat Transfer Tables 17

CHAPTER 1: PRODUCT DESCRIPTION AND BENEFITS

DESCRIPTION

The Micro-Lok *HP* family includes three products.



Micro-Lok *HP*

Fiberglass pipe insulation with an All Service Jacket (ASJ)



Micro-Lok *HP* Ultra

Fiberglass pipe insulation with a polypropylene-coated ASJ



Micro-Lok *HP* Plain

Fiberglass pipe insulation without any jacketing

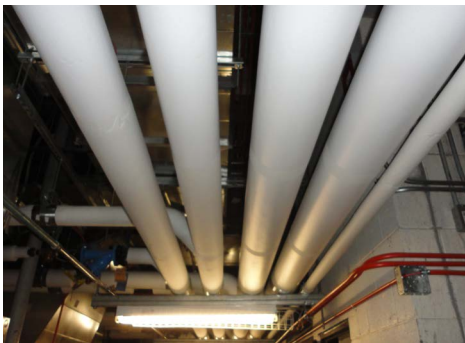
The fiberglass used in Micro-Lok *HP* products is a rigid, one-piece insulation that offers superior insulating capabilities in applications ranging from 0°F to 850°F (-17.8°C to 454°C). It is made from glass fibers bonded with a thermosetting resin.

The Micro-Lok *HP* product line is easily installed and damage-resistant, with high thermal efficiency and exceptional sound absorption properties. In the manufacturing process, 3-foot (0.92 m) sections of Micro-Lok *HP* pipe insulation are cylindrically formed in one piece, then cut longitudinally through one wall and partially through the other. The result is a one-piece “hinged” construction that opens easily and closes firmly and uniformly along the pipe. In addition to simplifying the installation process, the one-piece design used in Micro-Lok *HP* pipe insulation increases thermal effectiveness by creating only one longitudinal joint.

Micro-Lok *HP* pipe insulation is produced in 3-foot (0.92 m) sections for Iron Pipe Sizes (IPS) 1/2” through 24” (13 mm through 610 mm), and Copper Tubing (CT) sizes from 5/8” through 6 1/8” (16 mm through 156 mm), depending on thickness.

Zeston® PVC fitting covers and jacketing are specifically designed to be used with Micro-Lok *HP* fiberglass pipe insulations. Ideal applications for combining Zeston PVC products with Micro-Lok *HP* pipe insulation include chilled water piping, pipe systems that must meet USDA or FDA requirements, and exposed interior or exterior piping.

JACKETING



The jacketing systems on Micro-Lok *HP* and *HP* Ultra serve two purposes, first is as a vapor retarder. The ASJ and Ultra jacket have vapor retarder perm ratings that are robust enough to be used on chilled water systems. The second use for a jacket is for aesthetic applications. The neutral white finish of the insulation often matches walls and ceilings when the pipe system is left exposed. Both jacketing systems are secured with a Self-Sealing Lap (SSL) closure system. The SSL is adhered with a strong acrylic adhesive that permits installation in cold weather conditions down to 20°F (-7°C), and it will not soften or separate when heat and humidity are high. The adhesive is protected by a strip of easy-

lift release paper with a “dry edge” to permit easy removal during installation. Matching pressure-sensitive tape butt strips, using the same adhesive and a quick release paper strip, are supplied in order to totally seal and secure the system, thus eliminating the need for staples.

Micro-Lok HP: All-Service Jacket (ASJ) with a Self-Sealing Lap (SSL) Closure System

The Micro-Lok HP fiber glass pipe insulation jacket is a high-density, white kraft paper bonded to an aluminum foil, reinforced with fiberglass yarn. The kraft paper is chemically treated to enhance fire safety. The ASJ jacket has a moisture vapor permeance rating of < 0.02 perms (per ASTM C1136), making it usable in chilled water applications. Additionally, the longitudinal lap of the jacket is secured with an SSL.

Micro-Lok HP Ultra: Polypropylene-coated (Poly-top) All-Service Jacket with SSL Closure System

The Micro-Lok HP Ultra jacket offers slightly better moisture resistance than the uncoated kraft paper facing of the ASJ jacket. The poly-top coating gives the jacketing on Micro-Lok HP Ultra a moisture vapor permeance rating of < 0.01 perms (per ASTM C1136). While weather-protective jacketing is required for outdoor applications, the poly-top Ultra jacket can also resist temporary exposure to small amounts of moisture as long as the exposed fiberglass ends have been vapor-sealed. This may potentially allow contractors to install the insulation earlier on a jobsite – before the building envelope has been enclosed. Micro-Lok HP Ultra’s jacket is cleanable by wiping it down using a soft, damp cloth.

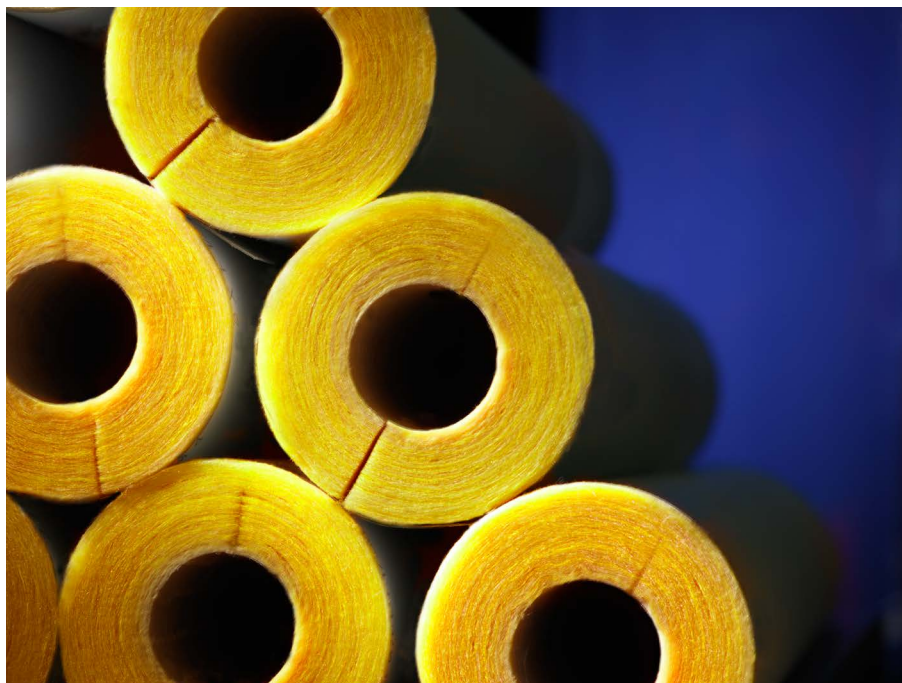
APPLICATIONS

Micro-Lok *HP* pipe insulation products are suitable for heating applications up to 850°F (454°C) (see “Qualifications for Use”). This product family is designed for use on commercial, power or process lines where fire safety and a clean, aesthetic appearance are desired. Micro-Lok HP and Micro-Lok *HP* Ultra pipe insulations can also be used on cold and chilled water lines, brine, refrigerant and special process lines when specifiers have ensured sufficient insulation thickness to prevent condensation from forming on the insulation surface and when the joints are sealed to prevent moisture migration. Metal or Zeston® PVC jacketing can serve as a weather-protective jacket for outdoor applications that use Micro-Lok products. This jacketing can also help protect against abuse-prone environments when the insulation is installed in high traffic areas.

ADVANTAGES

High Insulating Efficiency. Micro-Lok *HP* insulation offers high insulating efficiency for pipe applications. For the thermal conductivity performance curve, refer to graph of “*k*” factors on page 6.

Economical to Apply. Micro-Lok *HP* is light weight, and easy to install, leading to faster installation and lower installation costs than many products used in similar applications. Its simple design enables installers to easily fabricate pieces during installation, and the one-piece construction speeds on-the-job handling and application. The “dry edge,” easy-lift release strip on the SSL makes application simple, even with gloves on.



Some of the advantages of Micro-Lok *HP* pipe insulation that make these cost reductions possible are:

1. One-piece construction with full-length “spring hinge” opening helps speed jobsite installation.
2. For indoor applications, a factory-applied jacket speeds installation and eliminates the need for an extra jacketing step.
3. Micro-Lok *HP* pipe insulation has a unique fiber network pattern that allows for precise and quick fabrication on the job.
4. Micro-Lok *HP* pipe insulation is light weight and easy to handle. Only three carton sizes are required to handle most pipe sizes and thicknesses.

25/50 Rating. Micro-Lok *HP* fiber glass pipe insulation and our Zeston® 2000 PVC fitting covers or metal jacketing provide a complete, integrated system with all components rated for ≤25 flame spread and <50 smoke developed (25/50) per ASTM E84.

QUALIFICATIONS FOR USE



When using Micro-Lok *HP* or Micro-Lok *HP* Ultra, system designers need to be careful to specify the appropriate insulation thickness for above and below ambient applications. In high temperature applications, the insulation should be thick enough to keep the maximum surface temperature of the insulation below 150°F (66°C).

During initial heat-up to operating temperatures above 350°F (177°C), an acrid odor and some smoke may be given off as the organic binders used in the fiber glass pipe insulation begin to decompose. When this occurs, caution should be exercised to ventilate the area well. This loss of binder does not directly affect the thermal performance of the pipe insulation, but it can reduce the compressive strength and resiliency of the product. For applications with excessive physical abuse or vibration at high temperatures, consult Johns Manville for alternate material recommendations.

APPLICATION RECOMMENDATIONS: ASJ SSL JACKET AND BUTT STRIPS

1. Do not apply Micro-Lok *HP* fiber glass pipe insulation if air temperature is below 20°F (-7°C) or above 130°F (54°C) as the tape adhesion during installation can be negatively impacted by the ambient air temperature. When applications fall outside this temperature range, stapling is recommended.
2. If stored below 20°F (-7°C) or above 130°F (54°C), insulation cartons should stand within the recommended temperature range for 24 hours prior to application.
3. Once release paper is removed, the lap should be sealed immediately. Installers should take care to ensure both the jacketing and lap adhesive are kept free of dirt and water prior to sealing the lap.
4. When adhered, the lap and butt strips must be pressurized by rubbing firmly with a plastic squeegee or the back of a knife blade to ensure positive closure.
5. Do not reseal the lap or butt strip once applied. This could compromise the quality of the sealed jacket system.

CHAPTER 2: SPECIFICATION DATA

Physical Properties

Service Temp. Range (ASTM C 411)	0°F to 850°F (-18°C to 454°C)
Moisture Sorption	<5% by weight
Alkalinity	<0.06% expressed as Na ₂ O
Corrosivity (ASTM C 665)	Does not accelerate
Shrinkage (ASTM C 356)	None
Microbial Growth (ASTM C 1338)	Does not promote microbial growth
Surface Burning Characteristics	Composite FHC 25/50 per ASTM E84, CAN/ULC S102.2
Limited Combustibility	NFPA 259

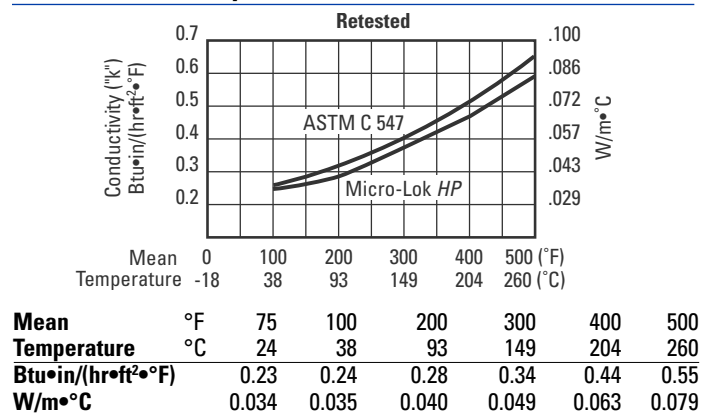
Jacketing	ASTM C 1136 (Type I & II)	Ultra (Type I, II, VII, X)
Water Vapor Permeance (ASTM E96 - Procedure A)	.02 perms max.	.01 perms max.
Bursting Strength (ASTM D774)	55 psi (4.6 Kg/cm ²)	100 psi (8.7.0Kg/CM ²)
Tensile Strength (ASTM D 828)	45 lbs/in (7.9N/mm) width min. (MD) 30 lbs/in (5.23N/mm) width min. (CD)	75 lbs/in (13.1N/mm) width min. (MD) 60 lbs/in (10.5 N/mm) width min. (CD)

Specification Compliance

- ASTM C547 Type I (Replaced HH-I-558B, Form D, Type III, Class 12, Class 13 up to 850 F (454 C))
- ASTM C585 – Dimension Standard for pipe ID only
- ASTM C1136 (Jacketing) (Replaces HH-B-100B, Type I & II)
- MIL-DTL-32585 Type 1, Form 4, Facing A ([unjacketed only](#))
- MIL-I-22344D, MIL-PRF-22344E
- Coast Guard/IMO Approved 164.109/56/0 (plain, unjacketed only – excluding 7/8 x 1/2 [22 mm x 13 mm], 1/2 x 1/2 [13 mm x 13 mm])
- California Bureau of Home Furnishings and Thermal Insulation – Registry Number CA-T040 (CO)
- Firestop Assemblies: Meets requirement for jacketed fiberglass pipe insulation product at or above 3.5 pcf.
- ASTM E84, CAN ULC S102.2 – 25/50 listed and labeled Intertek testing laboratories
- ASTM D2863 – Limiting Oxygen Index (LOI) minimum 31
- NRC 1.36, ASTM C795, Mil-I-24244C, MIL-DTL-24244D*

* When ordering material to comply with ASTM C795, NRC 1.36 & MIL-I-24244 a statement of that fact must appear on the purchase order. Specific lot testing will be conducted and a certification of compliance can be provided.

Thermal Conductivity (“k”) ASTM C 335



* Apparent thermal conductivity values are determined by applying procedures dictated per ASTM C1045 on test data obtained using ASTM Test Method C335. All values are based on nominal manufacturing and testing parameters, are subject to normal variation, and are not guaranteed for specification purposes or otherwise.

Sustainable Building Attributes

Manufacturing Location	Defiance, Ohio (43512)	
Recycled Content (glass only)	41%	
Recycled Content (total product)	33%	
Volatile Organic Compounds (ASTM D 5116)	Total	0.15 g/l
(Analysis ASTM D 6196 & ASTM D 5197)		
Fiberglass Pipe Insulation	Formaldehyde	0.009 ppm
	Aldehydes	0.009 ppm
	Total	<49 g/l
Volatile Organic Compounds (Calculated) Self-Sealing Lap & Butt Strips		

Sustainable Building Certifications

GREENGUARD	Certified
GREENGUARD Gold	Certified
California Title 24	Compliant
LEED Credits	See JM.com/buildgreen JM
LEED-NC	LEED Credit Guide HIG-1231

GREENGUARD® Certified products have been screened for more than 10,000 volatile organic compounds (VOCs) and meet stringent standards for low chemical emissions based on established criteria from key public health agencies



The maximum use temperature of an insulating material is that temperature above which it no longer provides satisfactory or effective service as a thermal insulation, when applied under conditions of normal usage. A normal condition implies a nondestructive atmosphere, moderate applied loads, limited vibration and moderate thermal stresses.

No single test for determining the maximum use temperature is applicable to all types of insulation or even to any one type of insulation under all possible conditions of use.

Johns Manville uses the following ASTM Test Procedures as guidelines in the evaluation of Micro-Lok *HP* fiberglass pipe insulation and in the determination of the recommended maximum use temperature:

ASTM C 335. Thermal conductivity of pipe insulation.

ASTM C 356. Linear shrinkage of preformed, high temperature thermal insulation subjected to soaking heat. Micro-Lok *HP* pipe insulation shows negligible linear shrinkage and/or warpage after the test period, with the loss in weight not exceeding 10 percent when exposed to the test temperature.

ASTM C 411. Hot surface performance of high temperature thermal insulation. Micro-Lok *HP* fiberglass pipe insulation does not flame, glow, smolder, crack, delaminate or warp after 96-hr. exposure to the heated surface. The fiberglass pipe insulation can produce smoke and/or produce an acrid odor during initial heat-up.

The following ASTM Test Procedures are used as guidelines in the production of Micro-Lok *HP* fiberglass pipe insulation.

ASTM C 585. Inner and outer diameters of rigid thermal insulation, for nominal sizes of pipe and tubing (NPS System). Micro-Lok *HP* fiberglass pipe insulation is produced in standard sizes in order to facilitate double-layer nesting applications or retrofit at a later date. This practice provides that the inner diameter of any section of insulation is consistent with the outer diameter of pipes and tubes.

ASTM E 84. Surface Burning Characteristics of building materials. Micro-Lok *HP* fiberglass pipe insulation has a maximum flame spread rating of 25, maximum smoke developed rating of 50, representing an FHC 25/50.

ASTM C 547. Standard specification for mineral fiber, preformed pipe insulation. Type I is for use up to 850°F (454°C) with a minimum density of 3 pcf (48 kg/m³).

ASTM C 1136. Standard specification for flexible, low permeance vapor retarders for thermal insulation.

ASTM C 1338. Standard test method for determining fungi resistance of insulation materials and facings.

CHAPTER 3: INSULSPEC™ — CSI SPECIFICATION

SECTION 220700 - PLUMBING PIPING INSULATION

SECTION 230700 - HVAC PIPING INSULATION

PART 1 – GENERAL

SCOPE

- A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required for the correct installation of Micro-Lok fiberglass pipe insulation on all chilled water and dual-cycle pipe systems, fittings, valves, controls and all other necessary items connected into the system subject to condensation or loss of heat when using JM Micro-Lok fiberglass pipe insulation.

REFERENCES

- A. ASTM C547 Specification for Mineral Fiber Pipe Insulation.
- B. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems.
- C. ASTM C585 Practice for Inner and Outer Diameter of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
- D. ASTM C795 Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
- E. ASTM C1136 Specification for Flexible, Low Permeance vapor retarders for Thermal Insulation.
- F. ASTM E84 or CAN ULC S102 for Surface Burning Characteristics of Building Materials.
- G. MIL-I-24244 Military Specification Insulation Material with Special Corrosion, Chloride and Fluoride Requirements.
- H. NRC 1.36 Nonmetallic Thermal Insulation for Austenitic Stainless Steel.
- I. NFPA 259 Standard Test Method for Potential Heat of Building Materials.
- J. ASTM C 1729 Standard Specification for Aluminum Jacketing for Insulation
- K. ASTM C 1767 Standard Specification for Stainless Steel Jacketing for Insulation

SUBMITTALS

- A. A. Product Data: Provide product description, list of materials and thickness for each service or equipment scheduled, locations and manufacturer's installation instructions.
- B. Shop Drawings: Submit list of insulation material and thickness to be used for each service. Include installation details for valves, fittings, pipe and all other items to be insulated.
- C. Samples: Submit samples of each insulation system to be used.

ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulating cements.

QUALITY ASSURANCE

- A. Insulation Materials: Fiberglass insulation materials must be manufactured at facilities certified and registered with an approved registrar to conform to ISO 9001 Quality Standard.
 - 1. Pipe insulation shall be pre-formed and furnished in standard lengths with ends cut square, conforming with dimensional requirements of ASTM C585.
 - 2. Insulation materials shall be asbestos free.
 - 3. All insulating products shall have a maximum 25/50 flame spread/smoke developed rating as tested in accordance with ASTM E84.

- B. Workmanship: Where available, all insulation to be installed by a licensed and experienced applicator. Materials shall be applied in accordance with the manufacturer's recommendations.
 - 1. All work shall comply with all applicable federal, state and local codes and laws. This shall include, but shall not be limited to, the Occupational Safety and Health Act.
 - 2. All work shall conform with accepted industry and trade standards for commercial and industrial insulations. Where available, it is recommended to use a National Insulation Association (NIA) certified (or other similarly certified) mechanical insulation inspector throughout the project to inspect and verify the materials and total insulation system have been installed correctly in accordance with the Johns Manville guide specifications.
 - 3. Surfaces to be insulated shall be clean and free of dirt, scale, moisture, corrosion, and oil and grease.
- C. Insulation materials that have become wet or contaminated shall not be installed.

DELIVERY, STORAGE AND HANDLING

- A. Deliver all materials (insulation, coverings, tapes, cements, adhesives, jacketing, coatings, etc.) to the job site in factory containers with manufacturer's label showing manufacturer, product name and where applicable, the ASTM E84 performance information. For all materials that list fire hazard information, technical data sheets shall be provided.
- B. Protect insulation from dirt, water, chemical attack and mechanical damage before, during, and after installation.
- C. Installed insulation that has not been weatherproofed and that is not protected by roof and walls shall be protected from precipitation by waterproof sheeting installed by the contractor. Wet or damaged insulation shall not be installed and, if installed, shall be removed and replaced by the contractor at no additional cost.

PART 2 – PRODUCTS

MANUFACTURERS

- A. Pre-formed fiber glass pipe insulation: Johns Manville's Micro-Lok® HP, Micro-Lok® or Micro-Lok® HP Ultra with all service vapor retarder jacket (ASJ), with white kraft paper or poly-exterior surface, a self-sealing longitudinal closure lap (SSL), and butt strips or approved alternate.
- B. PVC insulation jacketing: Johns Manville's Zeston® or approved alternate.
- C. Fitting insulation insert: Johns Manville's Hi-Lo® Temp fiber glass insulation insert or approved alternate. PVC tape: Johns Manville's Z-Tape® or approved alternate.
- D. Metal jacketing: Johns Manville's Metal Jacketing and Fittings.

PIPE INSULATION, FITTINGS, AND JACKETING MATERIAL

- A. A. All piping shall be insulated with a pre-formed fiber glass pipe insulation, complying with ASTM C547, Class 3 (to 850°F [454°C]), rigid, molded, noncombustible (plain) or limited combustibility (jacketed) pipe insulation.
 - 1. Thermal Conductivity ("k"): 0.23 Btu • in/ (hr • ft² • °F) at 75°F mean temperature (0.033 W/m•°C at 24°C) per ASTM C518.
 - 2. Maximum Service Temperature: 850°F (454°C)
 - 3. Rated to a maximum 25/50 FS/SD per ASTM E84, CAN ULC S102.
 - 4. When being used over austenitic stainless steel, product must comply with the requirements ASTM C795.
 - 5. All-Service vapor retarder Jacket (ASJ): A white, kraft paper or poly exterior, reinforced with a glass fiber yarn and bonded to an aluminum foil with self-sealing longitudinal closure laps (SSL) and butt strips.
 - 6. Install Micro-Lok HP, Micro-Lok and Micro-Lok HP Ultra insulation at the thickness required to prevent condensation as indicated in project drawing as calculated by the NAIMA 3E Plus® program for most severe pipe operating conditions.
 - 7. Material shall be limited-combustible as defined in NFPA 90A with a potential heat value not exceeding 3,500 btu/lb (8141 kJ/kg) when tested in accordance with NFPA 259.
 - 8. When being used over stainless steel product must comply with the requirements of ASTM 795, MIL-I-24244 or NRC 1.36

B. Field-Applied Protective Jackets and Fittings:

1. PVC Plastic: Zeston 2000 Series. One piece, molded type fitting covers and jacketing material, gloss white.
 - a. Securement: Pressure sensitive adhesive, PVC weld cement, or matching vinyl tape. Tacks may be used to hold PVC jacketing and fittings in place on above ambient systems only. For chilled systems, tacks are not recommended.
 - b. Fittings, valves, tees, etc., shall be insulated with Hi-Lo Temp fiber glass insulation, and needs to be covered with Zeston 2000 insulated fitting covers.
 - c. 20 mil (0.5 mm)/30 mil (0.8 mm)/40 mil (1.0 mm) stock thickness.
 - d. UV Resistant (white only).
 - e. For below ambient systems, seal joints with Perma-weld adhesive or Z-Tape.
 - f. Refer to Zeston PVC CI-35 for installation guidelines.
 - g. Jacketing shall have an ASTM E84 flame spread/smoke development rating of maximum 25/50.
2. Aluminum Jacketing and Fittings:
 - a. Compliant with ASTM C1729, Type I, Grade 1, Class A, 0.016" (0.41 mm) thick cut and roll or rolls with smooth or embossed finish, with 2" (51 mm) longitudinal and circumferential laps.
 - b. Two-piece pressed fitting covers ASTM C1729, Type I, Grade 3, Class A 0.024" (0.61mm) thick all with factory heat laminated Polyfilm Moisture Barrier (PFMB) on interior surface.
 - c. Securement: Bands only. No screws, rivets or any other securement device capable of puncturing the underlying vapor retarder shall be used on a chilled system.

Outer Insulation Diameter (in)	Minimum Aluminum Jacket Thickness	
	Rigid Insulation	Non-Rigid Insulation
≤8	0.016 (0.41)	0.016 (0.41)
Over 8 thru 11	0.016 (0.41)	0.020 (0.51)
Over 11 thru 24	0.016 (0.41)	0.024 (0.61)
Over 24 thru 36	0.020 (0.51)	0.032 (0.81)
>36	0.024 (0.61)	0.040 (1.01)

Table 1

3. Stainless Steel Jacketing and Fittings:
 - a. Compliant with ASTM C1767, Type I, Grade 1 or 2, Class A, 0.010" (0.25 mm) thick cut and roll or rolls with smooth or embossed finish, with 2" (51 mm) longitudinal and circumferential laps with factory heat laminated PFMB on interior surface, Type 304 or 316 stainless steel.
 - b. Two-piece pressed fitting covers ASTM C1767, Type I, Grade 2, Class E thickness of 0.016" (0.41 mm); Type 316 (stainless steel elbows do not have factory-applied, heat laminated PFMB).
 - c. Securement: Bands only. No screws, rivets or any other securement device capable of puncturing the underlying vapor retarder shall be used.

C. Accessories:

1. Stainless steel bands, ½" x 0.020" (13 mm x 0.5 mm), grade 304L.
2. Stainless steel sheet metal screws, #6, 8 or 10, ¾" (10 mm) long, hex or pan head. (Not for use with below ambient applications)
3. Aluminum bands, ½" x 0.020" (13 mm x 0.5 mm), alloy T-3003 H-14.
4. Galvanized steel sheet metal screws, #6, 8, 10, ¾" (10 mm) long, hex or pan head. (Not for use with below ambient applications)
5. vapor retarder mastic of equal to or less than 0.02 perms (ASTM E96, method A)

PART 3 - EXECUTION

EXAMINATION

- A. Verify that testing of piping has been completed and that the piping is ready for installation of insulation.
- B. Verify that all surfaces are clean, dry and free from dirt, scale, moisture, corrosion, oil and grease.
- C. Verify that it is physically possible to install the fiber glass pipe insulation in accordance with project drawings, operation performance parameters and limitations of this specification.

INSTALLATION – CHILLED WATER AND DUAL-CYCLE PIPE SYSTEM INSULATIONS

- A. All work activities shall be conducted in accordance with all applicable federal, state and local codes and laws. This shall include, but not be limited to, the Occupational Safety and Health Act.
- B. All insulation shall be installed by a licensed applicator and applied in accordance with the manufacturer’s recommendations.
- C. All work shall conform with accepted industry and trade standards for commercial and industrial insulations.
- D. General installation requirements for indoor piping:
 - 1. Pre-formed fiber glass pipe insulation with ASJ and SSL jacket or poly exterior shall be applied to piping with all joints tightly fitted to eliminate voids.
 - 2. Longitudinal jacket laps and butt strips shall be smoothly secured according to manufacturer’s recommendations.
 - 3. When adhered, the lap and butt strips must be pressurized by rubbing firmly with a plastic squeegee to ensure positive closure.
 - 4. In dual-cycle systems, the installed insulation thickness shall be enough that the outside insulation surface temperature shall be kept below 140°F (60°C).
 - 5. All pipe insulation shall be continuous through wall and ceiling openings and sleeves, except where fire-stop materials are required.
 - 6. Insulation on all surfaces must be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold surfaces must be adequately insulated and vapor sealed to prevent condensation.
 - 7. Stapling is not recommended. If staples are used they shall be sealed with a vapor retarder mastic or covered with a butt strip.
 - 8. The butt end of every fourth pipe insulation section and the ends or raw edges of insulation terminations at equipment connections, fitting and fire stop systems shall be sealed with vapor retarder mastic with a perm rating of equal to or less than 0.02 (ASTM E96, method A)
 - 9. Rigid insulation inserts shall be installed on pipe sizes 1-½” (38 mm) or larger under outside hangers. The thickness of inserts shall be equal to the thickness of the adjoining insulation and shall be provided with vapor retarder seals.
 - 10. Insulation inserts shall not be less than the following lengths:

Pipe Size		Length	
IN.	MM.	IN.	MM.
1 ½-2 ½	40-65	10	254
3-6	80-150	12	305
8-10	200-250	16	406
12 & up	300 & up	22	559

Table 2

- 11. Galvanized metal shields shall be applied between hangers or supports and the pipe insulation. Shields shall be formed to fit the insulation and shall extend up to the center line of the pipe and shall be of the length specified for the insulation hanger inserts less than 4” (102 mm) to allow for vapor-retarding butt joints on each side of the shields.

12. Specified adhesives, mastics and coatings shall be applied at the manufacturer’s recommended minimum coverage.
 13. When PVC jacketing is used, care shall be taken to ensure that the surface temperature of the fitting will be kept below 140°F (60°C) by the use of the proper thickness of insulation and by keeping the PVC cover away from contact with, or exposure to, sources of direct or radiant heat.
- E. For indoor piping in conditioned and concealed spaces exposed to physical abuse or to high humidity, such as mechanical rooms:
1. Finish pipe insulation with Zeston PVC Cut & Curled™ jacketing.
 2. Fittings, valves and flanges shall be insulated to the same thermal performance (R-Value) as the pipe insulation with Hi-Lo Temp insulation inserts or fabricated fitting insulation and covered with Zeston 2000 PVC insulated fitting covers.
 3. All joints in the Zeston PVC Cut & Curled jacketing and Zeston fitting covers shall be sealed with Zeston PVC Z-Tape.
- F. Outdoor piping systems:
1. The insulation shall be finished with Johns Manville aluminum, stainless steel jacketing or Zeston Series PVC jacketing.
 2. Aluminum or stainless steel jacket shall be overlapped 2” to 3” (51 mm to 76 mm) and held in place with metal bands.
 3. Elbows and tees for metal jacketed systems shall be finished with matching two-piece metal fitting covers.
 4. Zeston PVC jacketing shall be white 30 mil (0.8 mm) stock thickness. It shall be secured by overlapping and sealing all joints with Zeston Perma-Weld® solvent welding adhesive per manufacturer’s recommended installation procedures.
 5. Fittings, valves and flanges shall be insulated to the same thermal performance (R-value) as the pipe insulation with Hi-Lo Temp insulation inserts or fabricated fitting insulation and covered with Zeston 300 PVC insulated fitting covers or pre-formed metal fitting covers. All PVC jacketing joints shall be sealed using Zeston Perma-Weld solvent welding adhesive per manufacturer’s recommended installation procedures.

INSTALLATION – ABOVE AMBIENT CONDITIONS

- A. System Insulation:
1. All pipe insulation shall be continuous through wall and ceiling openings and sleeves, except where fire stop materials are required.
 2. All surface finishes are to be extended to protect all surfaces, ends and raw edges of insulation.
 3. Rigid insulation inserts shall be installed on pipe sizes 1-½” (38 mm) or larger under outside hangers. Inserts shall be of equal thickness to the adjoining insulation and shall be provided with vapor retarder seals where required.
 4. Insulation inserts shall not be less than the following lengths:

Pipe Size		Length	
IN.	MM.	IN.	MM.
1½–2½	40–65	10	254
3–6	80–150	12	305
8–10	200–250	16	406
12 & up	300 & up	22	559

Table 3

5. Galvanized metal shields shall be applied between hangers or supports and the pipe insulation. Shields shall be formed to fit the insulation and shall extend up to the centerline of the pipe and the length specified for the insulation hanger inserts less 4” (102 mm) on each side of the shields.
6. Specified adhesives, mastics and coatings shall be applied at the manufacturer’s recommended minimum coverage per gallon.

- B. Indoor piping: this portion of the installation procedure is applicable for piping in all indoor areas, including concealed spaces, mechanical rooms and inhabited areas.
 - 1. Pre-formed fiber glass pipe insulation with all service jacket or poly exterior shall be applied to piping with all joints tightly fitted to eliminate voids.
 - 2. Longitudinal jacket laps and butt strips shall be smoothly secured according to the manufacturer's recommendations.
 - 3. When adhered, the lap and butt strips must be pressurized by rubbing firmly with a plastic squeegee or the back of a knife blade to ensure positive closure.
 - 4. The installed thickness shall be enough that the surface temperature shall be kept below 140°F (60°C).
 - 5. For pipe exposed in mechanical equipment rooms or in finished spaces less than 10' (3 m) above finished floor, finish with Zeston 2000 Cut & Curled PVC or aluminum jacket.
 - 6. Fittings, valves and flanges shall be insulated with Zeston 2000 PVC insulated fitting covers and Hi-Lo temp insulation inserts per the manufacturer's recommendations.
- C. Outdoor piping systems operating up to 850°F (454°C):
 - 1. Micro-Lok pipe insulation shall be installed over clean, dry pipe with all joints firmly butted together. If a vapor retarder is required, jacket system shall be sealed.
 - 2. The insulation shall be finished using a metal jacketing with a PFMB or with Zeston PVC jacketing, in 30 mil (0.8 mm) thickness. Metal jacketing shall be overlapped with 2" to 3" (51 mm to 76 mm) and held in place with sheet metal screws or metal bands. The Zeston PVC jacketing shall be secured by overlapping and sealing all joints with Zeston Perma-Weld solvent welding adhesive, per manufacturer's recommended installation procedures.
 - 3. All insulation fittings for metal jacketed systems shall be finished with matching two-piece metal fitting covers.
 - 4. When Zeston 200 PVC Insulated Fitting Covers are used, care shall be taken to ensure that the surface temperature of the fitting will be kept below 140°F (60°C) by the use of a proper thickness of insulation and by keeping the PVC cover away from contact with, or exposure to, sources of direct or radiant heat.

FIELD QUALITY CONTROL

- A. Upon completion of installation of the insulation and before system start-up, visually inspect and verify that the insulation has been correctly installed.
- B. Confirm that any damage to the vapor retarder jacket has been properly repaired and sealed with vapor retarder mastic or covered with a butt strip.

CHAPTER 4: INSTALLATION METHODS

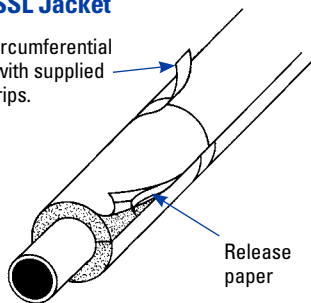
QUALIFICATIONS FOR USE

Fitting Insulation. When the pipe insulation thickness is greater than 1½" (38 mm) or the pipe temperature is greater than 250°F (121°C) or less than 45°F (7°C), additional insulation inserts should be used. A rule of a thumb for these conditions is to use one Hi-Lo Temp insert for each additional 1" (25 mm) of pipe insulation.

Fitting Cover. The temperature of the Zeston 2000 PVC fitting cover must be kept below 150°F (66°C) by the use of a proper thickness of insulation and by keeping the PVC cover away from contact with, or exposure to, sources of direct or radiant heat.

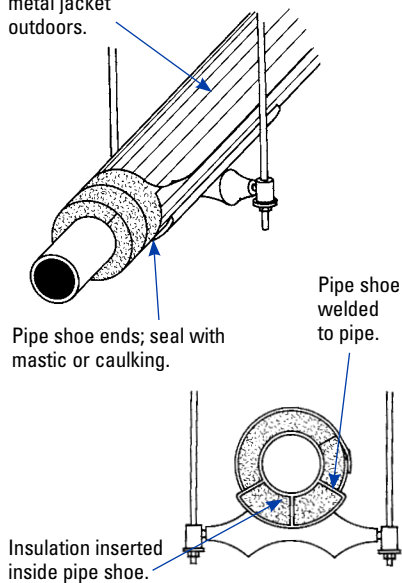
ASJ SSL Jacket

Seal circumferential joints with supplied butt strips.



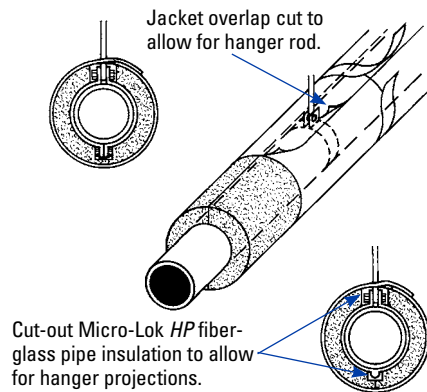
Pipe Shoe on Roller Support

ASJ SSL or metal jacket outdoors.

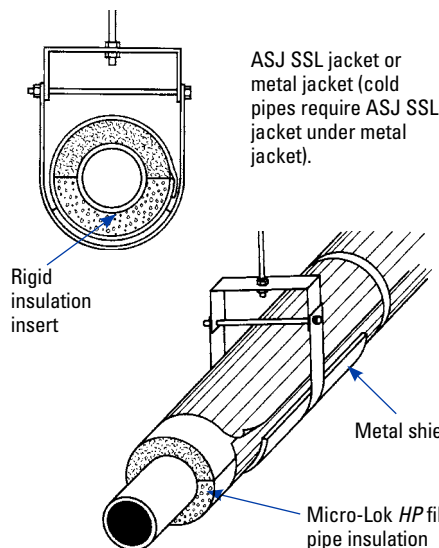


Ring Hangers*

*Not recommended for cold or high temperature pipes.



Clevis Hanger



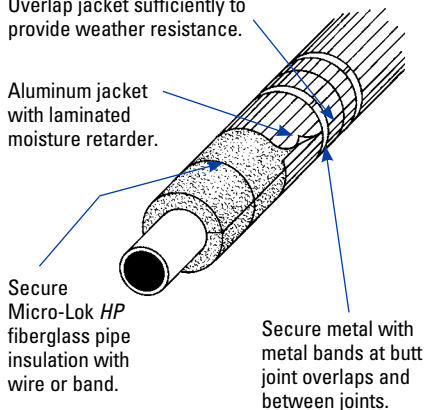
Field-Applied Metal Jacket

Overlap jacket sufficiently to provide weather resistance.

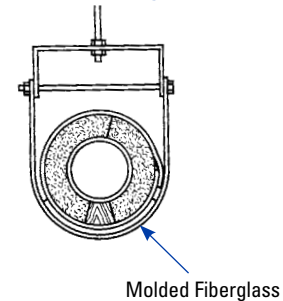
Aluminum jacket with laminated moisture retarder.

Secure Micro-Lok HP fiberglass pipe insulation with wire or band.

Secure metal with metal bands at butt joint overlaps and between joints.



Molded Fiberglass



CHAPTER 5: THICKNESS RECOMMENDATIONS

COLD APPLICATIONS CONDENSATION CONTROL

Minimum Insulation Thickness to Prevent Condensation

(Based on still air and ASJ SSL Jacket)

Operating Pipe Temp. (°F)	80°F & 90% RH		80°F & 70% RH		80°F & 50% RH	
	Pipe Size (in)	Thick. (in)	Pipe Size (in)	Thick. (in)	Pipe Size (in)	Thick. (in)
0 - 34	Up to 1	2	Up to 8 10 to 30	1 1½	Up to 8 10 to 30	1 1
	1¼ to 2	2½				
	2½ to 8	3				
	10 to 30	3½				
35 - 49	Up to 1½	1½	Up to 4 4½ to 30	1 1	Up to 30	1
	2 to 8	2				
	10 to 30	2½				
50 - 70	Up to 3	1½	Up to 30	½	Up to 30	½
	3½ to 20	1½				
	24 to 30	1½				

Operating Pipe Temp. (°C)	27°C & 90% RH		27°C & 70% RH		27°C & 50% RH	
	Pipe Size (mm)	Thick. (mm)	Pipe Size (mm)	Thick. (mm)	Pipe Size (mm)	Thick. (mm)
-18 to 1	Up to 25	51	Up to 200 250 to 750	25 38	Up to 200 250 to 750	25 25
	32 to 50	64				
	65 to 200	76				
	250 to 750	89				
2-9	Up to 40	38	Up to 100 115 to 750	25 25	Up to 750	25
	50 to 200	51				
	250 to 750	64				
10-21	Up to 80	38	Up to 750	13	Up to 750	13
	90 to 500	38				
	600 to 750	38				

HOT AND COLD APPLICATIONS ASHRAE STD. 90.1

Minimum Pipe Insulation

Fluid Design Operating Temperature Range	Insulation Conductivity		Nominal Pipe Diameter					
	Conductivity Range	Mean Rating Temperature	Run Outs ^a up to 2"	1" and less	1¼" to 2"	2½" to 4"	5" & 6"	8" & up
Heating Systems (Steam, Steam Condensate and Hot Water)								
(°F)	Btu•in/(hr•ft ² •°F)	(°F)	(in)	(in)	(in)	(in)	(in)	(in)
Above 350	0.32 - 0.34	250	1.5	2.5	2.5	3.0	3.5	3.5
251 - 350	0.29 - 0.31	200	1.5	2.0	2.5	2.5	3.5	3.5
201 - 250	0.27 - 0.30	150	1.0	1.5	1.5	2.0	2.0	3.5
141 - 200	0.25 - 0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
105 - 140	0.24 - 0.28	100	0.5	1.0	1.0	1.0	1.5	1.5
Domestic and Service Hot Water Systems^b								
105 and Greater	0.24 - 0.28	100	0.5	1.0	1.0	1.5	1.5	1.5
Cooling Systems (Chilled Water, Brine and Refrigerant)^c								
40 - 55	0.23 - 0.27	75	0.5	0.5	0.75	1.0	1.0	1.0
Below 40	0.23 - 0.27	75	1.0	1.0	1.5	1.5	1.5	1.5

^a Runouts to individual terminal units not exceeding 12 ft. (3.66 m) in length.

^b Applies to recirculating sections of service or domestic hot water systems and first 8 ft. (2.44 m) from storage tank for non-recirculating systems.

^c The required minimum thicknesses do not consider water vapor transmission and condensation. Additional insulation, vapor retarders, or both, may be required to limit water vapor transmission and condensation.

HOT AND COLD APPLICATIONS ASHRAE STD. 90.1

Minimum Pipe Insulation

Fluid Design Operating Temperature Range	Insulation Conductivity		Nominal Pipe Diameter				
	Conductivity Range*	Mean Rating Temperature	Less than 1"	1" to less than 1½"	1½" to less than 4"	4" to less than 8"	8" & up
Heating Systems (Steam, Steam Condensate and Hot Water)^{†**}							
(°F)	Btu•in/(hr•ft ² •°F)	(°F)	(in)	(in)	(in)	(in)	(in)
Above 350	0.32 - 0.34	250	2.5	3.0	3.0	4.0	4.0
251 - 350	0.29 - 0.32	200	1.5	2.5	3.0	3.0	3.0
201 - 250	0.27 - 0.30	150	1.5	1.5	2.0	2.0	2.0
141 - 200	0.25 - 0.29	125	1.0	1.0	1.0	1.5	1.5
105 - 140	0.22 - 0.28	100	0.5	0.5	1.0	1.0	1.0
Domestic and Service Hot Water Systems							
105 and Greater	0.22 - 0.28	100	0.5	0.5	1.0	1.0	1.0
Cooling Systems (Chilled Water, Brine and Refrigerant)^{††}							
40 - 60	0.22 - 0.28	100	0.5	0.5	1.0	1.0	1.0
Below 40	0.22 - 0.28	100	0.5	1.0	1.0	1.0	1.5

* For insulation outside the stated conductivity range, the minimum thickness (T) should be determined as follows:

$$T = r \{ (1 + t/r) / k - 1 \}$$

where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu•in/(hr•ft²•°F)); and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

† These thicknesses are based on energy efficiency considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

** Piping insulation is not required between the control valve and coil on run outs when the control valve is located within 4 ft. (1.22 m) of the coil and the pipe size is 1 in. (25 mm) or less.

†† These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

Please consult your local Building Code to determine which version compliance is required.

CHAPTER 6: HEAT TRANSFER TABLES

The following tables list the heat transfer and surface temperatures for bare and insulated steel pipes. The North American Insulation Manufacturers Association (NAIMA) 3E-Plus computer program was used to generate the tables with the following parameters:

- Ambient temperature of 80°F.
- Surface emissivity; .8 for bare pipe; .15 for aluminum jacket; .9 for jacket or similar non-reflective surface.
- Wind velocity of 0.0 mph.
- Pipe and insulation dimensions per ASTM C 585.
- HL: Heat Transfer, Btu/hr. per linear ft.
- ST: Surface Temperature, °F.

Disclaimer: The values listed in these tables are approximate values, and should be used for reference only. Please contact JM for exact values for your application or for economic thickness calculations.

Nominal Pipe Size ½"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	33	150	103	250	197	350	317	450	470	550	662	650	900	750	1192	850
1	7	87	20	96	35	107	55	120	80	134	109	151	146	169	189	190
1½	6	84	16	90	29	97	45	106	64	115	89	126	118	139	152	153
2	5	83	14	88	25	93	40	99	57	106	78	115	104	124	134	135
2½	5	82	12	85	22	89	34	93	50	99	68	105	91	111	117	119
3	4	82	12	84	21	88	32	91	47	96	64	101	85	107	110	113
3½	4	81	11	84	20	86	31	90	44	93	61	98	81	103	104	109
4	4	81	11	83	19	86	29	88	42	92	58	96	77	100	100	105
4½	4	81	10	83	18	85	28	87	41	90	56	94	74	98	96	102
5	4	81	10	83	18	84	27	87	39	89	54	92	72	96	93	100
5½	4	81	10	83	18	84	27	87	39	89	54	92	71	96	92	100
6	3	81	9	82	17	84	26	86	38	88	52	91	69	94	90	98
6½	3	81	9	82	17	84	26	85	37	88	51	90	67	93	87	97
7	3	81	9	82	16	83	25	85	36	87	50	89	66	92	85	95

Nominal Pipe Size ½" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	33	150	103	250	197	350	317	450	470	550	662	650	900	750	1192	850
1	7	92	18	108	33	126	52	146	75	169	104	194	138	223	179	256
1½	5	88	15	99	28	111	43	125	62	141	85	158	114	178	147	201
2	5	86	14	95	25	104	38	115	55	127	76	141	101	157	131	175
2½	4	85	12	91	22	98	34	106	49	115	67	126	89	137	115	151
3	4	84	11	90	20	96	32	102	46	110	63	119	84	130	108	141
3½	4	84	11	88	19	94	30	100	44	107	60	115	80	124	103	134
4	4	83	10	87	19	92	29	98	42	104	57	111	76	119	99	128
4½	4	83	10	87	18	91	28	96	40	101	55	108	73	115	95	123
5	4	83	10	86	17	90	27	94	39	100	53	105	71	112	92	120
5½	3	83	10	86	17	90	27	94	39	99	53	105	71	112	91	119
6	3	82	9	86	17	89	26	93	38	98	52	103	69	109	89	116
6½	3	82	9	85	16	88	25	92	37	97	50	102	67	107	86	114
7	3	82	9	85	16	88	25	91	36	96	49	100	65	105	84	111

Nominal Pipe Size 1"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	50	150	155	250	297	350	480	450	714	550	1009	650	1376	750	1828	850
1	9	87	25	97	45	108	69	122	100	137	138	154	183	173	238	194
1½	7	85	20	91	36	99	57	109	82	119	112	131	149	145	193	160
2	6	83	17	88	31	94	49	101	70	109	97	118	128	129	166	140
2½	6	83	16	87	28	91	44	97	63	103	87	110	115	119	149	128
3	5	82	15	85	26	89	41	94	58	99	80	105	107	112	138	120
3½	5	82	14	85	24	88	38	92	55	96	75	102	100	108	129	115
4	5	82	13	84	23	87	36	90	52	94	71	99	95	104	122	110
4½	4	81	12	83	22	86	34	89	49	92	68	96	90	101	116	106
5	4	81	11	83	20	85	31	87	45	89	62	93	82	96	106	101
5½	4	81	12	83	21	85	32	87	46	90	64	94	84	98	109	102
6	4	81	11	83	20	84	31	87	45	89	62	92	82	96	106	100
6½	4	81	11	82	19	84	30	86	44	89	60	91	79	95	102	99
7	4	81	11	82	19	84	29	86	42	88	58	90	77	94	100	97
7½	4	81	10	82	18	83	29	85	41	87	57	90	75	93	97	96
8	4	81	10	82	18	83	28	85	40	87	55	89	74	92	95	95
8½	4	81	10	82	18	83	27	85	40	86	54	88	72	91	93	94
9	4	81	10	82	17	83	27	84	39	86	53	88	71	90	91	93
9½	3	81	9	82	17	83	26	84	38	86	52	87	69	90	90	92
10	3	81	9	81	17	82	26	84	37	85	51	87	68	89	88	92

Nominal Pipe Size 1" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	50	150	155	250	297	350	480	450	714	550	1009	650	1376	750	1828	850
1	8	93	23	110	42	128	65	149	95	173	130	200	174	230	225	264
1½	7	89	19	101	35	115	54	130	78	147	108	167	143	189	186	214
2	6	87	17	96	30	107	47	118	68	132	94	147	125	165	161	184
2½	5	86	15	93	27	102	43	112	62	123	85	135	113	150	146	166
3	5	85	14	91	25	99	40	107	57	116	79	127	104	139	135	153
3½	5	84	13	90	24	96	37	103	54	112	74	121	98	132	127	144
4	5	84	13	89	23	94	35	101	51	108	70	117	93	126	120	137
4½	4	83	12	88	22	93	34	99	49	105	67	113	89	121	115	131
5	4	83	11	86	20	90	31	95	44	100	61	106	81	113	105	121
5½	4	83	11	87	20	91	32	96	46	102	63	108	83	115	108	124
6	4	83	11	86	20	90	31	95	44	100	61	106	81	113	104	120
6½	4	82	11	86	19	89	30	94	43	98	59	104	78	110	101	117
7	4	82	10	85	19	89	29	93	42	97	57	102	76	108	99	115
7½	4	82	10	85	18	88	28	92	41	96	56	101	74	107	96	113
8	4	82	10	85	18	88	28	91	40	95	55	100	73	105	94	111
8½	4	82	10	84	17	87	27	91	39	94	54	99	71	104	92	109
9	3	82	10	84	17	87	27	90	38	94	53	98	70	102	91	108
9½	3	82	9	84	17	87	26	90	38	93	52	97	69	101	89	106
10	3	82	9	84	17	86	26	89	37	92	51	96	68	100	87	105

Nominal Pipe Size 1½"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	70	150	216	250	414	350	672	450	1002	550	1419	650	1940	750	2584	850
1	12	88	32	99	58	112	90	127	130	144	179	163	238	184	308	207
1½	9	85	25	93	46	102	71	112	103	124	141	137	188	153	243	170
2	7	83	20	88	36	94	56	101	81	109	112	118	148	128	192	140
2½	7	83	18	87	33	91	51	97	73	103	101	111	134	119	173	129
3	6	82	17	86	30	90	47	94	68	100	93	106	123	113	160	122
3½	6	82	16	85	28	88	44	92	63	97	87	102	115	109	149	116
4	5	82	15	84	27	87	41	90	59	94	82	99	108	105	140	111
4½	5	81	14	84	25	86	39	89	57	93	78	97	103	102	134	108
5	5	81	14	83	24	86	38	88	54	92	75	95	99	100	128	105
5½	5	81	13	83	24	85	37	88	54	91	74	95	98	100	127	105
6	5	81	13	83	23	85	36	87	52	90	71	94	95	98	123	102
6½	5	81	13	83	22	84	35	87	50	89	69	93	92	96	118	100
7	4	81	12	82	22	84	34	86	49	89	67	92	89	95	115	99
7½	4	81	12	82	21	84	33	86	47	88	65	91	86	94	112	97
8	4	81	12	82	21	84	32	85	46	87	64	90	84	93	109	96
8½	4	81	11	82	20	83	31	85	45	87	62	89	82	92	107	95
9	4	81	11	82	20	83	31	85	44	87	61	89	81	91	104	94
9½	4	81	11	82	19	83	30	84	43	86	60	88	79	91	102	93
10	4	81	11	82	19	83	30	84	43	86	58	88	78	90	100	93

Nominal Pipe Size 1½" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	70	150	216	250	414	350	672	450	1002	550	1419	650	1940	750	2584	850
1	10	94	29	113	54	134	84	157	122	184	168	214	223	248	289	285
1½	9	90	24	104	43	119	68	136	98	155	135	177	180	202	233	230
2	7	87	19	96	35	107	54	118	79	132	108	147	144	165	186	184
2½	6	86	18	94	32	102	49	112	71	124	98	137	131	151	169	168
3	6	85	16	92	29	99	46	108	66	118	91	129	121	141	156	156
3½	6	84	15	90	28	97	43	104	62	113	85	123	113	134	147	147
4	5	84	14	89	26	95	40	101	58	109	80	118	106	128	138	139
4½	5	83	14	88	25	94	39	99	56	106	77	114	102	123	132	133
5	5	83	13	88	24	92	37	98	53	104	73	111	98	119	126	129
5½	5	83	13	87	24	92	37	97	53	104	73	111	97	119	125	128
6	5	83	13	87	23	91	36	96	51	102	70	108	94	116	121	124
6½	4	83	12	86	22	90	34	95	50	100	68	106	91	113	117	121
7	4	82	12	86	21	90	33	94	48	99	66	105	88	111	114	118
7½	4	82	12	85	21	89	33	93	47	98	64	103	86	109	111	116
8	4	82	11	85	20	88	32	92	46	97	63	102	83	107	108	114
8½	4	82	11	85	20	88	31	92	45	96	61	100	82	106	106	112
9	4	82	11	85	20	88	30	91	44	95	60	99	80	104	103	110
9½	4	82	11	84	19	87	30	90	43	94	59	98	78	103	101	109
10	4	82	10	84	19	87	29	90	42	93	58	97	77	102	99	107

Nominal Pipe Size 2"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	85	150	265	250	508	350	827	450	1236	550	1753	650	2401	750	3201	850
1	14	88	37	100	68	114	106	129	152	147	210	166	279	189	362	213
1½	11	85	29	93	52	102	81	113	117	125	161	139	214	155	277	172
2	9	84	24	90	44	97	68	105	99	114	136	125	180	137	233	150
2½	8	83	22	88	39	93	61	100	87	107	120	116	159	126	206	137
3	7	83	20	86	35	91	55	96	79	103	109	110	145	118	187	128
3½	7	82	18	85	33	89	51	94	73	99	101	106	134	113	173	121
4	6	82	17	85	30	88	47	92	68	96	94	102	124	108	161	115
4½	6	82	16	84	29	87	45	90	65	95	89	99	118	105	152	111
5	6	81	15	84	28	86	43	89	62	93	85	97	112	102	145	108
5½	5	81	15	83	27	86	42	89	60	92	82	96	109	101	141	106
6	5	81	14	83	26	85	40	88	57	91	79	95	105	99	135	104
6½	5	81	14	83	25	85	39	87	55	90	76	93	101	97	131	102
7	5	81	13	83	24	84	37	87	54	89	74	92	98	96	127	100
7½	5	81	13	82	23	84	36	86	52	89	72	91	95	95	123	99
8	5	81	13	82	23	84	35	86	51	88	70	91	92	94	120	97
8½	5	81	12	82	22	84	34	85	50	87	68	90	90	93	117	96
9	4	81	12	82	22	83	34	85	48	87	66	89	88	92	114	95
9½	4	81	12	82	21	83	33	85	47	87	65	89	86	91	112	94
10	4	81	12	82	21	83	32	84	46	86	64	88	85	91	109	93

Nominal Pipe Size 2" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	85	150	265	250	508	350	827	450	1236	550	1753	650	2401	750	3201	850
1	12	95	34	115	63	136	98	161	142	189	196	220	261	256	337	295
1½	10	91	27	105	49	120	77	138	111	158	153	180	204	206	264	234
2	8	88	23	99	42	111	66	125	95	141	131	159	174	179	225	201
2½	8	87	21	96	38	106	59	117	85	130	117	145	155	162	201	181
3	7	86	19	94	34	102	54	112	77	123	106	136	141	150	183	166
3½	6	85	18	92	32	99	50	108	72	117	99	128	131	141	170	155
4	6	84	16	90	30	97	46	104	67	113	92	122	122	133	158	146
4½	6	84	16	89	28	95	44	102	63	109	87	118	116	128	150	139
5	5	84	15	88	27	94	42	100	61	107	83	115	110	124	143	134
5½	5	83	15	88	26	93	41	99	59	105	81	113	107	121	139	131
6	5	83	14	87	25	92	39	97	57	103	78	110	103	118	134	127
6½	5	83	14	87	24	91	38	96	55	101	75	108	100	115	129	123
7	5	83	13	86	24	90	37	95	53	100	73	106	97	113	125	121
7½	5	82	13	86	23	90	36	94	51	99	71	104	94	111	122	118
8	5	82	12	85	22	89	35	93	50	98	69	103	91	109	118	116
8½	4	82	12	85	22	88	34	92	49	97	67	102	89	107	116	114
9	4	82	12	85	21	88	33	92	48	96	66	100	87	106	113	112
9½	4	82	12	85	21	88	33	91	47	95	64	99	85	105	111	110
10	4	82	11	84	21	87	32	90	46	94	63	98	84	103	108	109

Nominal Pipe Size 2½"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	102	150	315	250	605	350	986	450	1476	550	2098	650	2876	750	3840	850
1	16	88	43	101	78	115	121	131	175	149	242	170	321	192	416	217
1½	11	85	30	92	53	100	83	109	120	120	165	133	219	147	284	162
2	9	84	26	89	46	95	72	103	104	112	143	122	189	133	245	146
2½	8	83	23	87	41	93	64	99	93	106	127	114	169	124	219	134
3	8	82	21	86	38	91	59	96	85	102	116	109	154	117	200	126
3½	7	82	19	85	35	89	54	93	78	99	107	105	142	112	184	119
4	7	82	18	85	33	88	51	92	73	96	100	102	133	108	173	115
4½	6	82	17	84	31	87	48	90	69	94	95	99	126	105	164	111
5	6	81	16	84	29	86	45	89	65	93	90	97	119	102	154	107
5½	6	81	16	84	29	86	46	89	66	93	90	97	120	102	155	107
6	6	81	16	83	28	86	44	88	63	92	86	95	115	100	148	105
6½	6	81	15	83	27	85	42	88	61	91	83	94	110	98	143	103
7	5	81	15	83	26	85	41	87	59	90	80	93	107	97	138	101
7½	5	81	14	82	25	84	39	86	57	89	78	92	103	95	134	100
8	5	81	14	82	25	84	38	86	55	88	76	91	100	94	130	98
8½	5	81	13	82	24	84	37	86	54	88	74	90	98	93	127	97
9	5	81	13	82	23	83	36	85	52	87	72	90	96	93	123	96
9½	5	81	13	82	23	83	36	85	51	87	70	89	93	92	121	95
10	5	81	13	82	22	83	35	85	50	86	69	89	91	91	118	94

Nominal Pipe Size 2½" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	102	150	315	250	605	350	986	450	1476	550	2098	650	2876	750	3840	850
1	14	95	39	116	72	139	112	164	163	193	225	226	299	262	387	302
1½	10	90	28	102	51	116	79	132	115	151	158	171	210	195	272	221
2	9	88	25	98	44	110	69	123	100	137	138	154	183	173	237	195
2½	8	87	22	95	40	105	62	116	90	128	124	143	164	159	213	177
3	7	86	20	93	37	101	57	111	82	122	113	134	151	148	195	164
3½	7	85	19	91	34	99	53	107	76	116	105	127	139	139	180	153
4	6	84	18	90	32	97	50	104	72	112	99	122	131	133	169	145
4½	6	84	17	89	30	95	47	102	68	109	94	118	124	128	161	139
5	6	83	16	88	29	93	45	99	64	106	88	114	117	123	152	133
5½	6	83	16	88	29	94	45	99	64	106	89	114	118	123	152	133
6	6	83	15	88	28	92	43	98	62	104	85	112	113	120	146	129
6½	5	83	15	87	27	91	41	97	60	103	82	109	109	117	141	126
7	5	83	14	87	26	91	40	96	58	101	79	107	105	114	136	123
7½	5	83	14	86	25	90	39	95	56	100	77	106	102	112	132	120
8	5	82	14	86	24	89	38	94	54	98	75	104	99	110	129	118
8½	5	82	13	85	24	89	37	93	53	97	73	103	97	109	125	115
9	5	82	13	85	23	88	36	92	52	97	71	101	95	107	122	114
9½	5	82	13	85	23	88	35	92	51	96	70	100	92	106	120	112
10	5	82	12	85	22	88	34	91	50	95	68	99	91	105	117	110

Nominal Pipe Size 3"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	121	150	376	250	724	350	1181	450	1771	550	2521	650	3460	750	4625	850
1	18	89	51	102	92	117	143	133	207	153	284	174	378	198	491	224
1½	14	86	38	95	69	105	108	117	155	130	214	145	284	163	368	182
2	12	84	32	91	58	99	90	108	129	118	177	130	236	144	305	159
2½	10	84	28	89	50	95	78	102	112	111	154	120	205	132	265	144
3	9	83	25	87	45	92	70	98	101	106	138	114	184	123	238	134
3½	8	82	23	86	41	90	63	95	91	101	125	108	166	116	215	125
4	8	82	21	85	38	89	59	93	85	99	116	105	154	112	200	119
4½	7	82	20	85	36	88	55	92	80	96	110	102	145	108	188	115
5	7	82	19	84	33	87	52	90	75	94	102	99	136	104	176	111
5½	7	81	18	84	32	86	50	90	73	93	100	98	132	103	171	109
6	6	81	17	83	31	86	48	89	69	92	95	96	126	101	163	106
6½	6	81	17	83	30	85	46	88	67	91	92	95	121	99	157	104
7	6	81	16	83	29	85	45	87	64	90	88	94	117	98	151	102
7½	6	81	16	83	28	85	43	87	62	89	85	93	113	96	147	101
8	6	81	15	82	27	84	42	86	60	89	83	92	110	95	142	99
8½	5	81	15	82	26	84	41	86	59	88	81	91	107	94	138	98
9	5	81	14	82	26	84	40	86	57	88	79	90	104	93	135	97
9½	5	81	14	82	25	83	39	85	56	87	77	90	102	93	131	96
10	5	81	14	82	24	83	38	85	55	87	75	89	99	92	129	95

Nominal Pipe Size 3" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	121	150	376	250	724	350	1181	450	1771	550	2521	650	3460	750	4625	850
1	16	96	46	118	84	142	132	169	191	199	263	233	350	272	453	314
1½	13	92	36	107	65	125	102	144	147	166	203	191	269	220	349	251
2	11	89	30	102	55	115	85	131	124	148	170	168	226	191	293	216
2½	10	88	27	98	48	109	75	122	108	136	149	153	198	172	257	193
3	9	86	24	95	43	105	68	116	98	128	134	142	179	158	232	176
3½	8	86	22	93	39	101	61	110	89	121	122	133	162	147	210	163
4	7	85	20	91	37	99	57	107	83	116	114	127	151	140	196	153
4½	7	84	19	90	35	97	54	104	78	113	107	123	143	134	185	146
5	7	84	18	89	33	95	51	102	73	109	100	118	133	128	173	139
5½	6	84	18	89	32	94	49	101	71	108	98	116	130	126	168	136
6	6	83	17	88	30	93	47	99	68	106	94	113	124	122	161	132
6½	6	83	16	87	29	92	46	98	66	104	90	111	120	119	155	128
7	6	83	16	87	28	91	44	96	63	102	87	109	116	116	150	125
7½	6	83	15	86	27	91	43	95	61	101	84	107	112	114	145	122
8	5	83	15	86	27	90	41	94	60	99	82	105	109	112	141	120
8½	5	82	14	86	26	89	40	94	58	98	80	104	106	110	137	117
9	5	82	14	85	25	89	39	93	57	97	78	103	103	109	133	115
9½	5	82	14	85	25	88	38	92	55	97	76	101	101	107	130	114
10	5	82	13	85	24	88	37	92	54	96	74	100	98	106	127	112

Nominal Pipe Size 3½"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	137	150	425	250	819	350	1337	450	2007	550	2859	650	3928	750	5255	850
1	17	87	48	98	86	110	134	124	193	140	266	158	353	178	458	200
1½	14	85	38	93	69	102	107	112	154	124	212	138	281	154	364	171
2	12	84	32	90	58	97	91	105	131	115	180	126	239	138	309	152
2½	10	83	29	88	52	94	80	101	115	109	159	118	211	128	272	140
3	9	83	26	87	46	92	72	97	103	104	142	111	188	120	243	130
3½	9	82	24	86	42	90	66	95	95	101	131	107	173	115	224	123
4	8	82	22	85	40	89	62	93	89	98	122	104	161	111	209	118
4½	8	82	22	85	40	89	62	93	89	98	122	104	162	111	209	118
5	8	82	20	84	37	87	57	91	82	96	113	101	150	107	194	113
5½	7	82	19	84	35	87	54	90	78	94	107	99	142	104	184	110
6	7	81	19	84	33	86	52	89	74	93	102	97	136	102	175	107
6½	7	81	18	83	32	86	50	88	71	92	98	95	130	100	168	105
7	6	81	17	83	31	85	48	88	69	91	94	94	125	98	162	103
7½	6	81	17	83	30	85	46	87	66	90	91	93	121	97	157	101
8	6	81	16	83	29	84	45	87	64	89	88	92	117	96	152	100
8½	6	81	16	82	28	84	43	86	63	89	86	91	114	95	147	99
9	6	81	15	82	27	84	42	86	61	88	84	91	111	94	143	97
9½	5	81	15	82	27	84	41	85	59	88	81	90	108	93	140	96
10	5	81	14	82	26	83	40	85	58	87	80	89	106	92	137	95

Nominal Pipe Size 3½" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	137	150	425	250	819	350	1337	450	2007	550	2859	650	3928	750	5255	850
1	16	94	44	112	80	132	125	155	181	181	249	211	331	244	429	280
1½	13	91	36	105	65	120	101	138	147	158	202	181	268	207	348	235
2	11	89	31	100	56	113	87	127	126	143	173	162	230	183	298	207
2½	10	87	27	97	49	107	77	120	112	133	153	149	204	167	264	187
3	9	86	25	94	44	103	69	114	100	125	138	139	183	154	237	171
3½	8	85	23	93	41	101	64	110	93	120	127	132	169	145	219	160
4	8	85	21	91	38	98	60	106	87	116	119	126	158	138	205	152
4½	8	85	21	91	39	98	60	107	87	116	119	127	159	139	205	152
5	7	84	20	90	36	96	56	103	81	112	111	121	147	132	191	144
5½	7	84	19	89	34	95	53	101	76	109	105	117	140	127	181	138
6	7	83	18	88	33	94	51	100	73	106	100	114	133	123	173	134
6½	6	83	17	88	31	93	49	98	70	105	97	112	128	120	166	130
7	6	83	17	87	30	92	47	97	68	103	93	110	124	118	160	126
7½	6	83	16	87	29	91	45	96	65	101	90	108	119	115	155	123
8	6	83	16	86	28	90	44	95	64	100	87	106	116	113	150	121
8½	6	82	15	86	28	90	43	94	62	99	85	105	113	111	146	119
9	5	82	15	86	27	89	42	93	60	98	83	103	110	110	142	117
9½	5	82	15	85	26	89	41	93	59	97	81	102	107	108	138	115
10	5	82	14	85	26	88	40	92	57	96	79	101	105	107	135	113

Nominal Pipe Size 4"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	152	150	473	250	913	350	1492	450	2241	550	3195	650	4394	750	5881	850
1	22	89	61	102	110	117	172	135	249	154	343	176	456	200	591	227
1½	17	86	46	95	83	106	130	118	187	133	258	149	343	167	444	186
2	14	85	38	92	69	100	107	109	154	120	212	133	281	147	364	163
2½	12	84	33	89	59	96	92	104	133	113	183	123	243	135	314	148
3	11	83	29	88	52	93	81	99	117	107	160	115	213	125	276	136
3½	10	83	26	86	48	91	74	96	106	103	146	110	194	118	251	128
4	9	82	24	86	44	90	68	94	98	100	135	106	179	114	232	122
4½	8	82	23	85	41	88	63	92	91	97	125	103	165	109	214	116
5	8	82	21	84	38	87	60	91	86	95	118	100	156	106	202	113
5½	8	82	21	84	37	87	58	90	83	94	114	99	152	105	196	111
6	7	81	20	84	35	86	55	89	79	93	109	97	145	102	187	108
6½	7	81	19	83	34	86	53	89	76	92	104	96	139	101	179	106
7	7	81	18	83	33	85	51	88	73	91	100	95	133	99	172	104
7½	6	81	18	83	32	85	49	87	71	90	97	94	129	98	166	102
8	6	81	17	83	31	84	47	87	68	89	94	93	124	96	161	101
8½	6	81	17	82	30	84	46	86	66	89	91	92	121	95	156	99
9	6	81	16	82	29	84	45	86	64	88	88	91	117	94	152	98
9½	6	81	16	82	28	84	44	86	63	88	86	90	114	93	148	97
10	6	81	15	82	27	83	43	85	61	87	84	90	112	93	144	96

Nominal Pipe Size 4" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	152	150	473	250	913	350	1492	450	2241	550	3195	650	4394	750	5881	850
1	20	97	55	119	101	144	158	171	229	203	316	238	420	277	543	320
1½	15	92	43	109	78	127	122	147	177	171	243	197	324	227	419	260
2	13	90	36	103	65	117	102	134	147	152	203	173	269	197	349	224
2½	11	88	31	99	57	111	89	124	128	140	176	157	234	177	304	199
3	10	87	28	96	50	106	78	117	113	130	156	145	207	162	268	180
3½	9	86	25	94	46	102	72	112	103	124	142	137	189	151	245	168
4	9	85	24	92	43	100	66	109	96	119	132	130	175	144	227	158
4½	8	85	22	91	39	98	61	105	89	114	122	124	162	136	210	149
5	8	84	21	90	37	96	58	103	84	111	115	120	153	131	198	143
5½	7	84	20	89	36	95	57	102	82	110	112	119	149	129	193	140
6	7	84	19	89	35	94	54	100	78	107	107	115	142	125	184	135
6½	7	83	19	88	33	93	52	99	75	105	103	113	136	122	177	131
7	6	83	18	87	32	92	50	97	72	104	99	111	131	119	170	128
7½	6	83	17	87	31	91	48	96	70	102	96	109	127	116	164	125
8	6	83	17	86	30	91	47	95	67	101	93	107	123	114	159	122
8½	6	83	16	86	29	90	45	94	65	100	90	105	119	112	154	120
9	6	82	16	86	28	89	44	94	64	99	87	104	116	110	150	118
9½	6	82	15	85	28	89	43	93	62	98	85	103	113	109	146	116
10	5	82	15	85	27	88	42	92	61	97	83	102	110	108	143	114

Nominal Pipe Size 6"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	217	150	675	250	1304	350	2138	450	3221	550	4604	650	6347	750	8514	850
1	32	90	90	105	162	122	253	142	366	164	504	188	671	215	871	244
1½	24	87	65	97	118	109	184	123	265	139	365	157	485	176	628	198
2	19	85	51	93	93	102	144	112	208	124	286	137	380	153	491	170
2½	16	84	44	90	79	97	123	106	177	116	243	127	323	139	418	154
3	14	83	39	89	69	94	108	102	156	110	214	119	284	130	367	142
3½	12	83	34	87	61	92	95	98	137	105	188	113	249	121	323	132
4	11	82	31	86	56	90	87	95	126	102	172	108	229	116	296	125
4½	11	82	29	85	52	89	81	94	116	99	160	105	212	112	275	120
5	10	82	27	85	48	88	75	92	108	97	149	102	198	109	256	116
5½	10	82	26	84	47	88	73	91	105	96	144	101	191	107	247	114
6	9	82	25	84	45	87	69	90	100	94	137	99	181	105	235	111
6½	9	81	24	84	42	86	66	90	95	93	130	98	173	103	224	109
7	8	81	23	83	41	86	63	89	91	92	125	96	166	101	214	106
7½	8	81	22	83	39	85	61	88	87	91	120	95	159	99	206	104
8	8	81	21	83	38	85	58	88	84	91	116	94	153	98	198	103
8½	7	81	20	83	36	85	57	87	81	90	112	93	148	97	192	101
9	7	81	20	83	35	84	55	87	79	89	108	92	144	96	186	100
9½	7	81	19	82	34	84	53	86	77	89	105	92	140	95	180	99
10	7	81	19	82	33	84	52	86	75	88	102	91	136	94	176	98

Nominal Pipe Size 6" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	217	150	675	250	1304	350	2138	450	3221	550	4604	650	6347	750	8514	850
1	28	99	80	124	146	152	228	183	331	218	457	258	607	301	786	349
1½	21	94	60	112	109	133	171	156	247	182	341	211	454	244	588	281
2	17	91	48	105	87	121	136	138	197	159	272	182	361	208	468	236
2½	15	89	41	101	75	114	117	129	169	146	233	165	310	187	402	211
3	13	88	37	98	67	109	104	122	150	136	206	153	275	171	356	192
3½	12	86	33	95	59	104	92	115	132	128	182	142	242	158	314	175
4	11	86	30	93	54	102	85	111	122	122	168	135	223	149	289	165
4½	10	85	28	92	50	100	79	108	114	118	156	130	208	142	269	157
5	10	85	26	91	47	98	73	105	106	114	146	125	194	136	251	149
5½	9	84	25	90	46	97	71	104	103	113	141	123	188	134	243	146
6	9	84	24	89	43	95	68	102	98	110	134	119	178	130	231	141
6½	8	84	23	89	41	94	65	101	93	108	128	116	170	126	220	137
7	8	83	22	88	40	93	62	99	89	106	123	114	163	123	211	133
7½	8	83	21	88	38	92	60	98	86	104	118	112	157	120	203	130
8	7	83	21	87	37	92	57	97	83	103	114	110	151	118	196	127
8½	7	83	20	87	36	91	56	96	80	102	110	108	146	116	189	124
9	7	83	19	86	35	90	54	95	78	100	107	107	142	114	184	122
9½	7	83	19	86	34	90	52	94	76	99	104	105	138	112	178	119
10	7	82	18	86	33	89	51	94	74	98	101	104	134	110	174	117

Nominal Pipe Size 8"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	277	150	860	250	1666	350	2736	450	4130	550	5915	650	8167	750	10971	850
1	40	90	109	105	198	122	309	142	447	163	616	188	820	214	1063	243
1½	29	87	79	97	142	109	222	123	321	139	441	157	586	177	760	199
2	23	85	64	93	114	103	178	114	257	126	353	140	469	156	608	174
2½	19	84	52	90	93	97	145	106	209	116	287	127	381	140	494	154
3	17	83	46	89	82	95	128	102	184	110	253	120	335	131	434	143
3½	15	83	41	87	74	93	115	99	165	106	227	114	302	124	390	135
4	14	83	38	86	67	91	105	96	151	103	207	110	275	119	356	128
4½	13	82	35	86	62	90	97	95	139	100	191	107	254	114	329	123
5	12	82	32	85	58	89	90	93	130	98	179	104	237	111	307	119
5½	11	82	31	85	56	88	87	92	125	97	171	103	227	109	294	116
6	11	82	29	84	53	87	82	91	118	95	162	101	215	106	278	113
6½	10	82	28	84	50	87	78	90	112	94	154	99	204	104	264	111
7	10	81	27	84	48	86	74	89	107	93	147	97	195	102	252	108
7½	9	81	26	83	46	86	71	89	102	92	141	96	187	101	241	106
8	9	81	25	83	44	85	68	88	98	91	135	95	179	99	232	104
8½	9	81	24	83	42	85	66	88	95	90	130	94	173	98	224	103
9	8	81	23	83	41	85	64	87	92	90	126	93	167	97	216	101
9½	8	81	22	83	40	84	62	87	89	89	122	92	162	96	210	100
10	8	81	22	82	39	84	60	86	86	89	119	92	157	95	204	99

Nominal Pipe Size 8" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	277	150	860	250	1666	350	2736	450	4130	550	5915	650	8167	750	10971	850
1	34	99	97	124	177	152	278	184	403	219	556	259	739	303	956	351
1½	26	94	72	113	131	133	206	157	298	183	411	213	547	247	709	283
2	21	91	59	106	107	123	168	142	243	163	334	187	445	214	577	244
2½	18	89	49	101	88	114	138	129	200	146	275	166	366	188	474	212
3	16	88	43	98	78	109	122	122	177	137	244	154	324	173	420	195
3½	14	87	39	96	71	106	111	117	160	131	220	145	292	162	379	181
4	13	86	36	94	65	103	101	113	147	125	202	138	268	154	347	171
4½	12	85	33	93	60	101	94	110	136	121	187	133	248	146	321	162
5	11	85	31	92	56	99	88	107	127	117	175	128	232	141	300	155
5½	11	85	30	91	54	98	84	106	122	115	168	125	223	137	288	151
6	10	84	28	90	51	97	80	104	115	112	159	122	211	133	273	145
6½	10	84	27	89	49	95	76	102	110	110	151	119	200	129	259	141
7	9	84	26	89	47	94	73	101	105	108	144	116	191	126	248	137
7½	9	83	25	88	45	93	70	99	101	106	138	114	184	123	238	133
8	9	83	24	88	43	93	67	98	97	105	133	112	177	120	229	130
8½	8	83	23	87	42	92	65	97	93	103	128	110	171	118	221	127
9	8	83	22	87	40	91	63	96	90	102	124	108	165	116	214	124
9½	8	83	22	86	39	90	61	95	88	101	121	107	160	114	207	122
10	8	83	21	86	38	90	59	94	85	100	117	105	155	112	201	120

Nominal Pipe Size 10"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	339	150	1054	250	2045	350	3365	450	5087	550	7297	650	10088	750	13567	850
1	48	90	133	106	241	123	377	143	545	165	750	190	999	217	1296	247
1½	34	87	93	97	167	109	260	123	376	139	517	157	688	176	891	198
2	27	85	75	93	134	103	209	114	302	126	415	140	551	157	714	174
2½	23	84	63	91	113	99	177	108	255	118	350	130	465	143	602	158
3	20	84	55	89	99	96	154	103	222	112	305	122	405	134	524	147
3½	18	83	49	88	88	93	138	100	198	108	272	117	362	127	468	138
4	16	83	45	87	80	92	125	98	180	104	247	112	328	121	425	131
4½	15	82	41	86	74	90	115	95	165	102	227	109	301	117	390	126
5	14	82	38	85	69	89	107	94	154	99	211	106	280	113	362	121
5½	13	82	36	85	65	89	101	93	145	98	200	104	265	110	343	118
6	12	82	34	85	61	88	95	92	137	96	188	102	250	108	323	115
6½	12	82	32	84	58	87	90	91	130	95	178	100	237	106	306	112
7	11	81	31	84	55	87	86	90	124	94	170	98	225	104	291	110
7½	11	81	29	84	53	86	82	89	118	93	162	97	215	102	278	108
8	10	81	28	83	51	86	79	88	113	92	156	96	206	100	267	106
8½	10	81	27	83	49	85	76	88	109	91	150	95	199	99	257	104
9	10	81	26	83	47	85	73	87	105	90	144	94	192	98	248	103
9½	9	81	25	83	46	85	71	87	102	90	140	93	185	97	240	101
10	9	81	25	83	44	84	68	87	99	89	135	92	180	96	232	100

Nominal Pipe Size 10" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	339	150	1054	250	2045	350	3365	450	5087	550	7297	650	10088	750	13567	850
1	41	99	117	126	215	155	337	187	489	224	674	264	896	309	1159	358
1½	30	94	85	113	154	134	241	157	349	184	482	214	641	248	830	285
2	25	91	69	107	126	123	197	143	285	164	392	189	522	216	676	247
2½	21	90	59	102	107	116	168	133	243	151	334	172	444	195	576	221
3	19	88	52	99	94	111	147	125	213	141	293	159	390	180	505	202
3½	17	87	47	97	85	108	132	120	191	134	263	150	350	168	453	188
4	16	86	43	95	77	105	121	116	174	128	240	142	319	158	413	177
4½	14	86	40	94	71	102	111	112	160	123	221	136	293	151	380	167
5	13	85	37	92	66	100	104	109	149	119	206	131	273	145	354	160
5½	13	85	35	92	63	99	98	107	142	117	195	128	259	140	336	154
6	12	85	33	91	60	97	93	105	134	114	184	124	245	136	317	149
6½	11	84	31	90	57	96	88	103	127	112	175	121	232	132	300	144
7	11	84	30	89	54	95	84	102	121	109	166	118	221	128	286	140
7½	10	84	29	89	52	94	80	100	116	107	159	116	212	125	274	136
8	10	83	28	88	50	93	77	99	111	106	153	113	203	122	263	132
8½	10	83	27	88	48	92	74	98	107	104	147	111	196	120	253	129
9	9	83	26	87	46	92	72	97	104	103	142	110	189	118	244	126
9½	9	83	25	87	45	91	70	96	100	102	138	108	183	115	237	124
10	9	83	24	86	43	90	67	95	97	100	134	107	177	114	229	122

Nominal Pipe Size 12"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	397	150	1235	250	2397	350	3949	450	5978	550	8584	650	11879	750	15990	850
1	56	91	156	106	282	124	440	144	636	167	877	192	1168	219	1515	249
1½	39	87	108	98	194	110	302	124	437	140	601	158	799	178	1035	201
2	31	85	86	94	155	103	242	115	349	127	480	142	637	158	825	177
2½	27	84	73	91	131	99	203	108	293	119	403	131	535	145	693	160
3	23	84	63	89	114	96	177	104	255	113	350	123	465	135	602	149
3½	21	83	56	88	101	94	157	101	227	109	312	118	414	128	535	140
4	19	83	51	87	92	92	142	98	205	105	282	113	374	122	484	133
4½	17	82	47	86	84	91	130	96	188	102	258	110	343	118	443	127
5	16	82	43	86	78	90	121	94	174	100	239	107	317	114	411	123
5½	15	82	41	85	74	89	114	93	165	99	226	105	300	112	388	120
6	14	82	39	85	69	88	107	92	155	97	212	102	282	109	365	116
6½	13	82	36	84	65	87	102	91	146	95	201	101	267	107	345	113
7	13	82	35	84	62	87	96	90	139	94	191	99	253	105	327	111
7½	12	81	33	84	59	86	92	89	133	93	182	98	242	103	312	109
8	12	81	32	83	57	86	88	89	127	92	174	96	231	101	299	107
8½	11	81	30	83	55	85	85	88	122	92	167	95	222	100	287	105
9	11	81	29	83	53	85	82	88	117	91	161	94	214	99	277	103
9½	10	81	28	83	51	85	79	87	113	90	156	94	207	98	267	102
10	10	81	27	83	49	85	76	87	110	90	151	93	200	97	259	101

Nominal Pipe Size 12" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	397	150	1235	250	2397	350	3949	450	5978	550	8584	650	11879	750	15990	850
1	48	100	136	127	250	156	392	190	569	227	784	268	1042	314	1349	364
1½	35	94	98	114	178	135	279	159	405	187	558	218	742	252	961	290
2	29	92	80	107	145	125	227	144	328	167	452	192	602	220	780	252
2½	24	90	68	103	123	118	193	134	279	153	384	175	511	199	662	225
3	22	88	60	100	108	113	169	127	244	143	336	162	447	183	579	206
3½	19	87	54	98	97	109	151	121	218	136	300	152	400	171	518	192
4	18	87	49	96	88	106	137	117	198	130	273	145	363	161	470	180
4½	16	86	45	94	81	103	126	113	182	125	251	138	333	153	432	170
5	15	85	42	93	75	101	117	110	169	121	233	133	310	147	401	163
5½	14	85	40	92	71	100	111	108	160	118	221	130	293	143	379	157
6	14	85	37	91	67	98	105	106	151	115	208	126	276	138	357	151
6½	13	84	35	90	64	97	99	104	143	113	197	122	261	134	338	146
7	12	84	34	90	61	96	94	102	136	110	187	120	249	130	322	141
7½	12	84	32	89	58	95	90	101	130	108	179	117	237	127	307	138
8	11	83	31	88	56	94	86	100	125	107	171	115	228	124	294	134
8½	11	83	30	88	53	93	83	98	120	105	165	113	219	121	283	131
9	10	83	29	87	52	92	80	97	116	104	159	111	211	119	273	128
9½	10	83	28	87	50	91	77	97	112	102	153	109	204	117	264	126
10	10	83	27	87	48	91	75	96	108	101	149	108	197	115	255	123

Nominal Pipe Size 14"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	432	150	1346	250	2615	350	4312	450	6532	550	9384	650	12994	750	17499	850
1	62	91	170	107	307	124	479	145	693	167	956	193	1273	221	1651	250
1½	45	88	125	99	225	112	351	128	507	145	697	164	928	186	1202	209
2	36	86	98	95	177	105	275	117	397	131	546	146	726	163	940	183
2½	30	85	82	92	147	100	229	110	330	121	453	134	602	149	780	165
3	26	84	70	90	127	97	197	105	284	115	391	126	519	138	671	152
3½	23	83	62	89	112	95	174	102	251	110	345	120	458	130	593	143
4	20	83	55	87	99	92	153	98	221	106	304	114	403	123	521	134
4½	19	83	51	87	93	91	144	97	207	103	285	111	378	120	489	130
5	17	82	48	86	85	90	133	95	191	101	263	108	348	116	451	125
5½	16	82	44	85	79	89	123	94	177	99	242	105	322	112	416	120
6	15	82	41	85	74	88	115	92	166	97	228	103	302	109	391	117
6½	14	82	39	84	70	88	109	91	156	96	215	101	285	107	369	114
7	14	82	37	84	66	87	103	90	149	95	204	99	271	105	350	111
7½	13	81	35	84	63	86	98	90	142	93	194	98	258	103	334	109
8	12	81	34	83	61	86	94	89	135	93	186	97	247	102	319	107
8½	12	81	32	83	58	86	90	88	130	92	178	96	237	100	306	105
9	11	81	31	83	56	85	87	88	125	91	172	95	228	99	295	104
9½	11	81	30	83	54	85	84	87	121	90	166	94	220	98	284	103
10	11	81	29	83	52	85	81	87	117	90	160	93	213	97	275	101

Nominal Pipe Size 14" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	432	150	1346	250	2615	350	4312	450	6532	550	9384	650	12994	750	17499	850
1	52	100	148	127	271	157	426	191	618	229	852	271	1133	317	1466	367
1½	40	95	113	116	205	139	322	165	466	195	643	228	855	264	1108	304
2	32	92	90	109	164	128	257	148	372	172	513	199	683	229	884	262
2½	27	90	76	104	138	120	216	137	313	157	431	180	573	205	742	233
3	24	89	66	101	120	114	188	129	271	147	374	166	497	188	644	213
3½	21	88	59	98	107	110	167	123	241	138	332	156	442	175	572	197
4	19	87	52	96	95	106	148	118	213	131	294	146	390	163	506	182
4½	18	86	49	95	89	104	139	115	201	127	276	141	367	157	475	175
5	17	86	46	93	82	102	129	112	186	123	255	136	339	150	439	167
5½	15	85	42	92	76	100	119	109	172	119	236	131	314	144	407	159
6	15	85	40	91	72	98	112	106	162	116	222	127	295	139	382	152
6½	14	84	38	90	68	97	106	105	153	113	210	123	279	134	362	147
7	13	84	36	90	65	96	101	103	145	111	200	120	265	131	344	143
7½	12	84	34	89	62	95	96	101	139	109	191	118	253	127	328	139
8	12	84	33	88	59	94	92	100	133	107	183	115	243	125	314	135
8½	12	83	32	88	57	93	89	99	128	106	175	113	233	122	302	132
9	11	83	30	87	55	92	85	98	123	104	169	111	224	120	290	129
9½	11	83	29	87	53	92	82	97	119	103	163	110	217	118	280	126
10	10	83	28	87	51	91	80	96	115	102	158	108	210	116	271	124

Nominal Pipe Size 16"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	489	150	1524	250	2962	350	4889	450	7413	550	10659	650	14770	750	19904	850
1	70	91	192	107	347	125	543	145	785	168	1082	194	1441	222	1869	252
1½	51	88	141	100	254	113	396	128	572	146	787	165	1047	187	1357	211
2	40	86	110	95	199	105	310	118	447	131	615	147	817	165	1058	184
2½	33	85	92	92	165	101	257	111	370	122	509	135	676	150	875	166
3	29	84	79	90	142	97	221	106	318	116	437	127	581	139	751	154
3½	25	83	70	89	125	95	195	102	280	111	385	120	512	132	662	144
4	22	83	61	87	110	93	171	99	246	106	338	115	449	124	581	135
4½	21	83	57	87	103	92	160	97	230	104	316	112	420	121	543	131
5	19	82	53	86	95	90	147	95	212	102	291	109	387	117	500	126
5½	18	82	49	85	87	89	136	94	196	99	269	106	356	113	461	121
6	17	82	46	85	82	88	127	93	183	98	252	103	334	110	432	118
6½	16	82	43	85	77	88	120	92	173	96	237	102	315	108	407	115
7	15	82	41	84	73	87	114	91	164	95	225	100	298	106	386	112
7½	14	81	39	84	70	87	108	90	156	94	214	98	284	104	367	110
8	14	81	37	84	67	86	103	89	149	93	204	97	271	102	351	108
8½	13	81	36	83	64	86	99	89	143	92	196	96	260	101	336	106
9	13	81	34	83	61	85	95	88	137	91	188	95	250	100	323	105
9½	12	81	33	83	59	85	92	88	132	91	181	94	241	98	311	103
10	12	81	32	83	57	85	89	87	127	90	175	93	233	97	301	102

Nominal Pipe Size 16" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	489	150	1524	250	2962	350	4889	450	7413	550	10659	650	14770	750	19904	850
1	59	100	167	128	306	159	481	193	697	231	961	274	1278	320	1654	371
1½	45	96	127	117	231	140	362	167	525	197	723	230	963	268	1247	308
2	36	93	101	110	184	129	289	150	418	174	576	201	766	232	993	266
2½	31	91	85	105	155	121	242	139	350	159	482	182	642	208	832	237
3	27	89	74	101	134	115	210	130	303	148	418	168	556	191	720	216
3½	24	88	66	99	119	111	186	124	269	140	370	158	493	178	638	200
4	21	87	58	96	105	107	164	119	237	132	327	148	434	165	562	185
4½	20	86	55	95	99	105	154	116	223	128	307	143	408	159	528	177
5	18	86	51	94	91	102	143	112	206	124	283	137	376	152	487	168
5½	17	85	47	92	85	100	132	109	190	120	262	132	348	145	450	160
6	16	85	44	91	79	99	124	107	179	117	246	128	326	140	423	154
6½	15	84	42	91	75	97	117	105	169	114	232	124	308	136	399	149
7	14	84	40	90	71	96	111	103	160	112	220	121	292	132	379	144
7½	14	84	38	89	68	95	106	102	153	110	210	118	279	129	361	140
8	13	84	36	89	65	94	101	101	146	108	201	116	267	126	345	136
8½	13	83	35	88	62	93	97	99	140	106	192	114	256	123	331	133
9	12	83	33	88	60	93	93	98	135	105	185	112	246	121	318	130
9½	12	83	32	87	58	92	90	97	130	103	179	110	237	119	307	128
10	11	83	31	87	56	91	87	96	126	102	173	109	229	117	297	125

Nominal Pipe Size 18"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	546	150	1700	250	3307	350	5463	450	8289	550	11927	650	16539	750	22301	850
1	78	91	215	107	388	125	606	146	876	169	1208	195	1608	223	2087	254
1½	57	88	157	100	283	113	441	129	637	146	877	166	1166	188	1511	213
2	45	86	123	95	221	106	344	118	497	132	683	148	908	166	1176	185
2½	37	85	102	92	183	101	285	111	410	123	564	136	749	151	970	168
3	32	84	87	90	157	98	244	106	352	116	484	127	642	140	831	155
3½	28	83	77	89	138	95	215	103	310	111	425	121	565	132	731	145
4	25	83	67	88	121	93	188	99	271	107	372	115	494	125	640	136
4½	23	83	63	87	113	92	176	98	253	104	348	112	462	121	598	131
5	21	82	58	86	104	91	162	96	233	102	320	109	425	117	550	126
5½	20	82	53	86	96	89	149	94	214	100	294	106	391	113	506	122
6	18	82	50	85	90	89	139	93	201	98	276	104	366	111	473	118
6½	17	82	47	85	84	88	131	92	189	97	259	102	344	108	445	115
7	16	82	44	84	80	87	124	91	179	95	245	100	326	106	421	113
7½	15	82	42	84	76	87	118	90	170	94	233	99	310	104	400	111
8	15	81	40	84	72	86	113	89	162	93	223	98	295	103	382	109
8½	14	81	39	83	69	86	108	89	155	92	213	96	283	101	366	107
9	14	81	37	83	67	86	104	88	149	92	205	95	272	100	351	105
9½	13	81	36	83	64	85	100	88	144	91	197	95	261	99	338	104
10	13	81	34	83	62	85	96	87	139	90	190	94	252	98	326	102

Nominal Pipe Size 18" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	546	150	1700	250	3307	350	5463	450	8289	550	11927	650	16539	750	22301	850
1	66	101	186	129	341	160	535	194	776	233	1070	276	1423	323	1841	374
1½	50	96	141	118	257	141	402	168	583	199	804	233	1070	270	1385	312
2	40	93	112	110	204	129	320	151	463	176	639	204	850	235	1101	269
2½	34	91	94	105	171	121	268	140	388	161	534	184	710	210	921	240
3	30	89	82	102	148	116	232	132	335	150	462	170	614	193	795	219
3½	26	88	73	99	132	111	205	125	297	141	409	159	543	179	704	202
4	23	87	64	97	116	107	181	119	261	133	360	149	478	166	619	186
4½	22	87	60	95	109	105	170	116	245	129	337	144	448	160	580	178
5	20	86	56	94	100	103	157	113	226	125	311	138	413	153	535	170
5½	19	85	51	93	93	101	144	110	209	120	287	132	381	146	494	161
6	18	85	48	92	87	99	135	108	196	117	269	128	357	141	463	155
6½	17	85	46	91	82	98	128	106	184	115	254	125	337	137	436	150
7	16	84	43	90	78	97	121	104	175	112	240	122	319	133	413	145
7½	15	84	41	89	74	95	115	102	166	110	229	119	304	129	393	141
8	14	84	39	89	71	95	110	101	159	108	218	117	290	127	376	137
8½	14	84	38	88	68	94	106	100	152	107	209	115	278	124	360	134
9	13	83	36	88	65	93	102	99	146	105	201	113	267	122	346	131
9½	13	83	35	87	63	92	98	98	141	104	194	111	258	119	333	129
10	12	83	34	87	61	92	95	97	136	103	187	110	249	117	322	126

Nominal Pipe Size 20"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	602	150	1874	250	3650	350	6033	450	9161	550	13191	650	18302	750	24690	850
1	86	91	237	107	428	126	669	147	967	170	1333	196	1776	224	2304	255
1½	63	88	173	100	312	114	486	129	702	147	966	167	1285	189	1666	214
2	49	86	135	95	243	106	378	118	546	133	751	149	998	167	1293	187
2½	41	85	112	92	201	101	312	111	450	123	619	137	823	152	1065	168
3	35	84	96	90	172	98	268	106	386	116	530	128	704	141	911	155
3½	31	84	84	89	151	95	235	103	339	112	466	122	618	133	800	146
4	27	83	74	88	132	93	205	99	296	107	407	116	540	125	699	136
4½	25	83	69	87	123	92	192	98	277	105	380	113	504	122	652	132
5	23	82	63	86	113	91	176	96	254	102	349	109	463	118	599	127
5½	21	82	58	86	104	90	162	94	233	100	320	106	425	114	550	122
6	20	82	54	85	97	89	151	93	218	98	299	104	397	111	514	119
6½	19	82	51	85	92	88	142	92	205	97	281	102	374	109	483	116
7	18	82	48	84	87	87	135	91	194	95	266	101	353	107	457	113
7½	17	82	46	84	82	87	128	90	184	94	253	99	335	105	434	111
8	16	81	44	84	78	86	122	90	175	93	241	98	320	103	413	109
8½	15	81	42	83	75	86	116	89	168	93	230	97	306	102	395	107
9	15	81	40	83	72	86	112	88	161	92	221	96	293	100	379	106
9½	14	81	39	83	69	85	108	88	155	91	212	95	282	99	365	104
10	14	81	37	83	67	85	104	88	149	91	205	94	272	98	352	103

Nominal Pipe Size 20" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	602	150	1874	250	3650	350	6033	450	9161	550	13191	650	18302	750	24690	850
1	72	101	205	129	375	161	589	196	854	235	1178	278	1567	326	2027	378
1½	55	96	155	118	282	142	442	169	641	200	884	235	1176	273	1524	315
2	44	93	123	111	224	130	351	152	509	177	701	205	933	237	1209	272
2½	37	91	104	106	188	122	294	141	425	162	586	185	779	212	1010	242
3	32	89	90	102	163	116	254	132	367	150	506	171	673	194	871	220
3½	29	88	80	99	144	112	225	126	325	142	447	160	594	180	770	203
4	25	87	70	97	127	107	197	120	285	134	393	149	522	167	676	187
4½	24	87	66	96	119	105	185	117	267	130	368	144	489	161	633	180
5	22	86	61	94	109	103	170	113	246	125	339	139	450	154	583	171
5½	20	85	56	93	101	101	157	110	227	121	312	133	415	147	537	163
6	19	85	52	92	94	99	147	108	212	118	292	129	388	142	502	156
6½	18	85	49	91	89	98	139	106	200	115	275	126	366	138	473	151
7	17	84	47	90	84	97	131	104	189	113	260	123	346	134	448	146
7½	16	84	45	90	80	96	125	103	180	111	248	120	329	130	426	142
8	15	84	43	89	77	95	119	101	172	109	236	117	314	127	406	138
8½	15	84	41	88	73	94	114	100	165	107	226	115	301	125	389	135
9	14	83	39	88	70	93	110	99	158	106	217	113	289	122	373	132
9½	14	83	38	88	68	92	106	98	152	104	209	112	278	120	359	130
10	13	83	36	87	65	92	102	97	147	103	202	110	268	118	347	127

Nominal Pipe Size 24"

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	713	150	2221	250	4329	350	7166	450	10894	550	15704	650	21810	750	29449	850
1	102	91	282	108	509	126	795	147	1150	171	1586	197	2112	226	2740	256
1½	75	88	205	100	370	114	576	130	832	148	1146	168	1524	191	1975	215
2	58	86	159	96	287	106	447	119	646	133	888	149	1180	168	1529	188
2½	48	85	131	93	237	102	368	112	531	124	730	137	970	153	1256	170
3	41	84	112	91	202	98	314	107	453	117	623	129	827	142	1071	157
3½	36	84	99	89	177	96	276	103	397	112	546	122	725	134	938	147
4	31	83	86	88	154	93	240	100	346	107	475	116	631	126	816	138
4½	29	83	80	87	144	92	224	98	322	105	443	113	588	123	761	133
5	27	83	73	86	132	91	205	96	295	103	406	110	539	119	697	128
5½	25	82	67	86	121	90	188	95	271	100	372	107	494	115	638	123
6	23	82	63	85	113	89	175	93	253	99	347	105	460	112	595	120
6½	22	82	59	85	106	88	165	92	237	97	325	103	432	110	559	117
7	20	82	56	84	100	88	155	91	224	96	307	101	407	107	527	114
7½	19	82	53	84	95	87	147	91	212	95	291	100	386	106	499	112
8	18	81	50	84	90	87	140	90	202	94	277	99	367	104	475	110
8½	18	81	48	84	86	86	134	89	193	93	264	97	351	102	454	108
9	17	81	46	83	82	86	128	89	184	92	253	96	336	101	435	107
9½	16	81	44	83	79	86	123	88	177	92	243	95	323	100	417	105
10	16	81	42	83	76	85	118	88	171	91	234	95	311	99	402	104

Nominal Pipe Size 24" Metal Jacket

Insulation Thickness (inches)	Pipe Operating Temperature (°F)															
	150		250		350		450		550		650		750		850	
	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST	HL	ST
Bare	713	150	2221	250	4329	350	7166	450	10894	550	15704	650	21810	750	29449	850
1	85	101	243	130	444	162	698	197	1013	237	1397	281	1857	329	2403	381
1½	65	96	183	119	334	143	524	171	759	202	1046	237	1393	275	1804	317
2	52	93	146	111	265	131	415	153	601	178	828	207	1102	238	1428	273
2½	44	91	122	106	221	123	346	141	501	163	690	187	918	214	1189	244
3	38	90	105	102	191	117	298	133	431	151	594	172	790	196	1023	222
3½	34	88	93	100	168	112	263	126	380	143	523	161	696	182	902	205
4	30	87	82	97	148	108	231	120	333	134	458	151	610	169	790	189
4½	28	87	77	96	138	106	216	117	311	131	429	146	570	163	738	182
5	26	86	70	94	127	104	198	114	286	126	394	140	523	155	678	173
5½	24	86	65	93	117	101	182	111	263	122	362	134	481	149	623	164
6	22	85	61	92	109	100	170	109	246	119	338	130	449	143	582	158
6½	21	85	57	91	103	98	160	107	231	116	318	127	422	139	547	153
7	20	84	54	90	97	97	151	105	218	114	300	124	399	135	517	148
7½	19	84	51	90	92	96	144	103	207	112	285	121	379	132	490	144
8	18	84	49	89	88	95	137	102	198	110	272	119	361	129	467	140
8½	17	84	47	89	84	94	131	101	189	108	260	116	345	126	446	137
9	16	83	45	88	81	94	126	100	181	107	249	114	331	124	428	134
9½	16	83	43	88	78	93	121	99	174	105	239	113	318	121	411	131
10	15	83	42	87	75	92	116	98	168	104	231	111	306	119	396	129



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