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INSULPEX™ pre-insulated PEXa piping system

Technical information which applies to the planning, design and installation of REHAU pre-insulated PEXa piping systems.

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1. SCOPE

This technical information applies to the planning, installation and connection of REHAU pre-insulated PEXa piping systems using PEXa crosslinked polyethylene pipe.


Persons using this guide must be experienced and appropriately licensed designers, with a working knowledge of local codes, principles and practices for design and installation of flexible distribution piping systems.

The information presented in this guide is intended to demonstrate general methods and is not specific to your project conditions. It is the responsibility of the designer to check the prevailing local codes and to verify that technical information presented in this guide is appropriate for a particular installation. This guide does not supersede the recommendations of other manufacturers. If there is conflicting information, the designer must consult with the other manufacturer's representative prior to planning, installing and connecting the energy transfer system.

After reading this guide, designers should attend the Skill Builders Complete seminar offered by the REHAU Academy, where design techniques for pre-insulated PEXa piping systems are more fully explored. Designers should also periodically check the REHAU Resource Center for the latest updates.

This guide should be used in conjunction with the REHAU *Sustainable Building Technology Product Catalog* which provides a detailed description of each system component, REHAU *PEXa Piping Systems Pressure Loss Tables* and REHAU *INSULPEX Installation Guide*. The designer should also review the REHAU *PEXa Limited Warranty* and pertinent supplemental REHAU *Technical Bulletins* before beginning to design an energy transfer system.

If you do not have prior experience with pre-insulated PEX piping systems or require additional assistance, please contact your regional REHAU sales representative.

 This symbol and the signal words DANGER, WARNING or CAUTION alert you to personal injury hazards. If you don't avoid the hazardous situation:

- DANGER! Will result in death or serious injury
- WARNING! Could result in death or serious injury
- CAUTION! Can result in minor or moderate injury

The signal word NOTICE is used to help you avoid property damage. We cannot warn of all hazards; you must also use your own good judgment.

2. DESIGN CONSIDERATIONS

The most critical points in a pre-insulated PEXa piping system design are:

- To ensure the flow requirement and pressure loss are within the circulator's performance capability.
- To design the buried depth to use energy efficiently and to avoid heaving of the pipe in the coldest months.
- To transition to building service piping immediately upon entering the building and to properly secure the transition fitting.

3. SYSTEM OVERVIEW

In view of the increasing need to minimize CO₂ emissions as much as possible, local heating supply technology is becoming increasingly important. Pioneering technologies, combining optimal functionality with low energy losses, are the basis for REHAU INSULPEX pre-insulated PEXa piping systems.

3.1 System Advantages

INSULPEX is flexible, pre-insulated PEXa piping with closed-cell polyurethane (PU) foam bonded insulation.

- Flexible pipe system ensures cost-effective heat distribution
- Minimal linear expansion, as pipe layers are fully bonded together
- No need for expansion bellows or compensators
- Fully bonded pipe layers limit water penetration to absolute minimum
- System components for a variety of applications

3.2 Applications

INSULPEX is used predominantly below ground and is ideal for applications including:

- District heating
- Energy transfer
- Snow and ice melting
- Chilled water
- Process piping
- Hydronic piping
- Geothermal
- Industrial and agricultural
- Outdoor wood furnace

4. SYSTEM COMPONENTS

4.1 INSULPEX Pipe

INSULPEX components – PEXa carrier pipe, insulation and jacket – are explained in detail in this section.

4.1.1 PEXa Carrier Pipes

RAUTHERM™ crosslinked polyethylene (PEXa) pipes are manufactured using REHAU's high-pressure peroxide extrusion method that typically yields the highest, most consistent level of crosslinking. Pioneered by REHAU in 1968, PEXa technology enhances flexibility and thermal memory, providing ease of handling and kink repair while supporting the use of REHAU SDR11 compression-sleeve fittings.

Standards

RAUTHERM is REHAU's trade name for metric-sized SDR11 PEXa pipes in accordance to ISO 15875 and DIN 16892.

Long Term Strength

The pressure and temperature ratings apply to the application of REHAU PEXa pipe for conveying heating and cooling water at a 2.0 safety factor on allowable working pressure.

INSULPEX with RAUTHERM carrier pipe

maximum pressures and temperatures	design factors
125 psi @ 73.4°F (860 kPa @ 23°C)	0.50
80 psi @ 180°F (550 kPa @ 82.2°C)	0.50
65 psi @ 200°F (450 kPa @ 93.3°C)*	0.50

*Elevated Temperature Applications

According to the REHAU *PEXa Limited Warranty*, the carrier pipe warranty period of 25 years is for operating conditions at or below 180°F (82.2°C) in permitted applications when the handling, use, installation and maintenance continually complies with all REHAU technical guidelines. REHAU defines Elevated Temperature Applications as those with operating conditions greater than 180°F (82.2°C). When RAUTHERM pipes are planned to be operated in Elevated Temperature Applications, contact REHAU Engineering to verify your project conditions comply with the REHAU *PEXa Limited Warranty*.

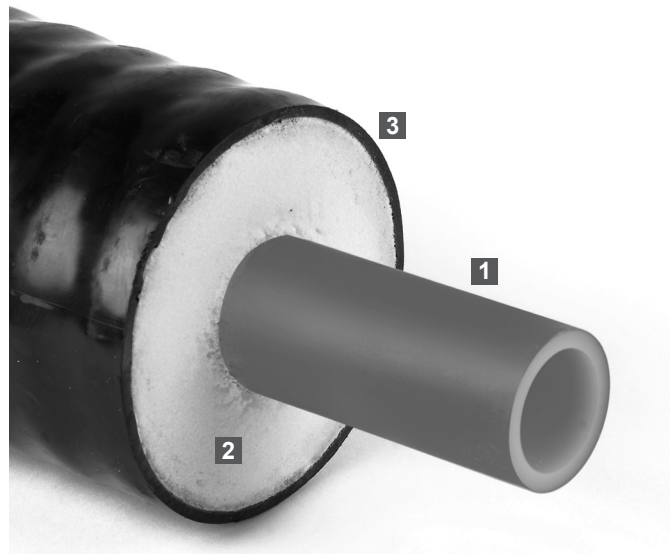


Fig. 4.1: INSULPEX main components: PEXa carrier pipe (1), insulation (2) and jacket (3)

Oxygen Resistance

In pre-insulated PEXa systems, hundreds or thousands of feet of pipe are used, providing a large surface area for potential permeation of oxygen (O₂). The uncontrolled diffusion of oxygen into closed systems is an important issue for system designers.

INSULPEX piping systems consisting of RAUTHERM carrier pipe limit permeability as defined within DIN 4726, the accepted German standard for limiting oxygen transmission. Without a diffusion barrier, oxygen can pass through the pipe wall, dissolve in the heating water and corrode any ferrous components such as pipes, valves, pumps and boilers.

NOTICE: Use only oxygen barrier pipe in closed systems with ferrous components. Excessive oxygen in closed system may damage ferrous components resulting in leaks and operational failures.

Chemical Compatibility

REHAU's PEXa carrier pipe is compatible with ethylene and propylene glycol, and common corrosion inhibitors used in hydronic piping systems. Chemicals that may damage this pipe include (but are not limited to):

- Adhesives
- Oil or petroleum-based products
- Paints
- Solvents
- Oxidizing agents (e.g., bleach)
- Disinfectants (e.g., separate dosing unit integrated into building distribution system)

Many factors, such as exposure time, temperature, pressure and other operating parameters, can influence the performance of a pipe that is exposed to a chemical. To determine the impact of a particular chemical, short- and long-term pressure testing may be required. In some cases, a pipe may be resistant to short-term exposure to the chemical, but not resistant to continuous exposure. Each chemical must be evaluated individually.

NOTICE: Check compatibility before allowing chemicals to come in contact with the exterior or interior of PEXa carrier pipes. Chemicals may damage the pipe resulting in leaks and operational failures.

Ultraviolet Resistance

Plastics are susceptible to damage from exposure to the ultraviolet (UV) radiation in sunlight. REHAU's PEXa carrier pipes can be designed to protect against short-term UV damage, but after some time, UV radiation will reduce the lifespan of the pipe. The extent of the reduction depends on factors such as temperature and pressure, and chlorination levels in potable water. If excessive UV exposure occurs, the PEXa carrier pipes may not last their full design life. REHAU has performed extensive testing of PEXa carrier pipes exposed to natural sunlight, leading to the maximum UV exposure times expressed in accumulated days. Once the pipes leave the manufacturing plant, any exposure to UV, including transportation and storage by the wholesaler, is part of the accumulated exposure time. Maximum accumulated exposure times are listed in the pertinent REHAU *Technical Bulletin*.

Exposure of the PEXa carrier pipe to UV radiation should be prevented. Protective caps or bags placed on the ends of INSULPEX should not be removed until ready to install.

NOTICE: Failure to follow maximum UV exposure limits may damage the pipe resulting in leaks and operational failures, and will negate any warranty provided by REHAU for RAUTHERM pipes.

Friction Loss

The pressure loss in the pre-insulated PEXa system depends on the flow rates, water temperatures and the properties of the fluid. Use the REHAU *LoopCAD® Software* which includes a built-in calculator to determine pipe pressure losses for the given conditions. Or refer to the REHAU *PEXa Piping Systems Pressure Loss Tables* for the applicable pressure loss table presented at typical flow rates and water temperatures for propylene glycol. The pressure loss in the PEXa carrier pipe is based on the application of the D'Arcy-Weisbach equation and fluid properties from ASHRAE *Fundamentals*.

4.1.2 Pipe Insulation

The co-extruded, closed-cell, polyurethane (PUR) foam insulation in INSULPEX provides excellent strength properties while maintaining flexibility. In addition, the polyurethane has low thermal conductivity and very low water absorption.

Table 4.1: Properties of Pipe Insulation

Property	Value	Standard
Maximum Thermal Conductivity	0.15 Btu·in/ft ² ·°F·hr 0.022 W/m·°K	EN 15632
Closed Cellular Structure	>=90%	–
Maximum Water Absorption	<10% (vol)	EN 15632

4.1.3 Pipe Jacket

The jacket of INSULPEX is made of corrugated low-density polyethylene (LDPE) allowing the pipe to withstand rugged job site conditions. The corrugated shape is instrumental in the pipe's resistance to thermal expansion when buried. The LDPE jacket contains a minimum 2.5% carbon black.

Table 4.2: Properties of Pipe Jacket

Property	Value	Standard
Maximum UV Resistance	2 years	–

INSULPEX may be stored outdoors for a maximum accumulated time of two years, including installation time. During outdoor storage the ends of INSULPEX must be covered with UV-blocking caps or bags to protect the PEXa carrier pipes from UV exposure. During construction, keep caps in place until it is time to make a connection, and replace them on remaining pipe ends.

4.1.4 INSULPEX Sizes

Table 4.3: INSULPEX With Metric-sized RAUTHERM SDR11 Carrier Pipe

PEXa Carrier Pipe					Pipe Jacket		INSULPEX	
Nominal Size	Average Outer Diameter d	Minimum Wall Thickness s	Inner Diameter	Capacity	Outer Diameter D	Wall Thickness	Weight	Minimum Bend Radius
in.	in (mm)	in (mm)	in (mm)	gal/ft (l/m)	in (mm)	in (mm)	lb/ft (kg/m)	ft (m)
One-pipe system								
25	0.990 (25.2)	0.091 (2.3)	0.809 (20.6)	0.0263 (0.327)	3.6 (91)	0.083 (2.1)	0.8 (1.2)	2.6 (0.8)
32	1.266 (32.2)	0.114 (2.9)	1.037 (26.4)	0.0434 (0.539)	3.6 (91)	0.083 (2.1)	0.9 (1.4)	2.6 (0.8)
40	1.583 (40.2)	0.146 (3.7)	1.291 (32.8)	0.0672 (0.835)	3.6 (91)	0.083 (2.1)	1.0 (1.5)	2.6 (0.8)
50	1.978 (50.3)	0.181 (4.6)	1.616 (41.1)	0.1052 (1.307)	4.4 (111)	0.091 (2.3)	1.5 (2.2)	3.0 (0.9)
63	2.492 (63.3)	0.228 (5.8)	2.035 (51.7)	0.1683 (2.091)	5.0 (126)	0.106 (2.7)	1.9 (2.9)	3.3 (1.0)
75	2.967 (75.4)	0.268 (6.8)	2.431 (61.8)	0.2384 (2.961)	5.6 (142)	0.118 (3.0)	2.3 (3.4)	3.5 (1.1)
90	3.561 (90.5)	0.323 (8.2)	2.915 (74.1)	0.3425 (4.254)	6.4 (162)	0.125 (3.2)	3.1 (4.6)	4.0 (1.2)
110	4.350 (110.5)	0.394 (10.0)	3.563 (90.5)	0.5123 (6.362)	6.4 (162)	0.125 (3.2)	3.4 (5.1)	4.0 (1.2)
125	4.945 (125.6)	0.449 (11.4)	4.047 (102.8)	0.6537 (8.120)	7.2 (182)	0.130 (3.3)	4.3 (6.4)	4.5 (1.4)
140	5.537 (140.7)	0.500 (12.7)	4.537 (115.3)	0.8300 (10.31)	8.0 (202)	0.130 (3.3)	5.1 (7.6)	4.5 (1.4)
Two-pipe system								
25 + 25	0.990 (25.2)	0.091 (2.3)	0.809 (20.6)	2 x 0.0263 (2 x 0.327)	4.4 (111)	0.091 (2.3)	1.2 (1.9)	3.0 (0.9)
32 + 32	1.266 (32.2)	0.114 (2.9)	1.037 (26.4)	2 x 0.0434 (2 x 0.539)	4.4 (111)	0.091 (2.3)	1.4 (2.1)	3.0 (0.9)
40 + 40	1.583 (40.2)	0.146 (3.7)	1.291 (32.8)	2 x 0.0672 (2 x 0.835)	5.0 (126)	0.106 (2.7)	1.8 (2.7)	3.9 (1.2)
50 + 50	1.978 (50.3)	0.181 (4.6)	1.616 (41.1)	2 x 0.1052 (2 x 1.307)	6.4 (162)	0.125 (3.2)	2.9 (4.3)	4.5 (1.4)
63 + 63	2.492 (63.3)	0.228 (5.8)	2.035 (51.7)	2 x 0.1683 (2 x 2.091)	7.2 (182)	0.130 (3.3)	3.6 (5.3)	4.5 (1.4)

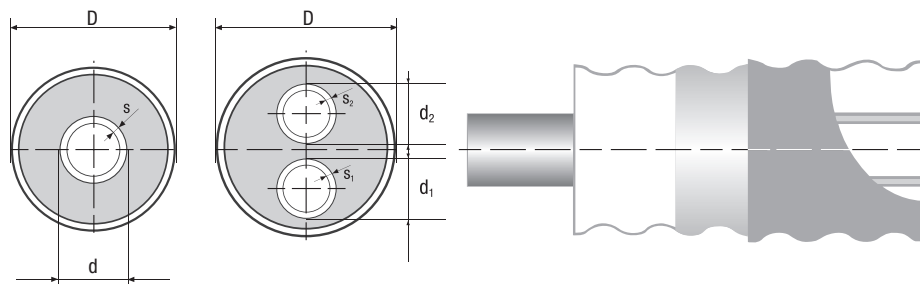


Fig. 4.2: INSULPEX outline diagram

4.2 SDR11 Compression-Sleeve Fitting

SDR11 fittings are available as couplings, reducing couplings, threaded adapters, welding adapters, elbows and tees. SDR11 fittings are manufactured from brass, bronze and carbon steel depending on size and configuration.

SDR11 fittings are sized according to the corresponding PEXa carrier pipe sizes. Metric-sized SDR11 compression-sleeve fittings are in accordance with ISO 15875.

Steel SDR11 fittings are available as weldable ends and can be custom welded into tees or elbows. Carbon steel SDR11 fittings can be used for closed systems with air removal devices.

SDR11 compression-sleeve fittings have the following advantages:

- Reliable and easy to install
- Connections do not require flame, heat or solvent
- Ready for service as soon as they are connected

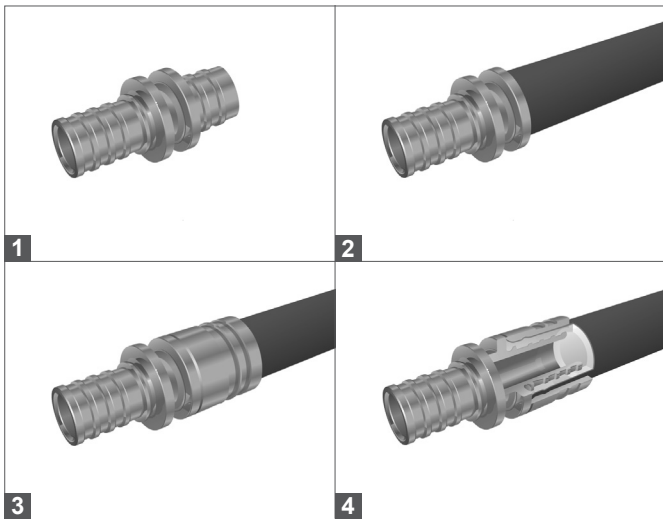


Fig. 4.3: SDR11 compression-sleeve fitting (1), fitting inserted in expanded pipe (2), SDR11 joint (3) and cutaway (4)

4.3 INSULPEX Insulation Kits

Buried fittings must be protected. Insulation kits are designed to seal the connection of two or more INSULPEX pipes. Kits are compatible with SDR11 compression-sleeve fittings. Kits are available in coupling, elbow and tee configurations.



Fig. 4.4: Coupling shroud insulation kit (1), coupling shell insulation kit (2), elbow shell insulation kit (3), tee shell insulation kit (4)

4.4 INSULPEX Installation Accessories

Accessories are used in a variety of energy transfer construction methods.

Heat Shrink End Cap

A watertight, heat-shrinkable pipe end covering for moist areas used to protect the insulation when transitioning INSULPEX to building service piping.



Slip-On End Cap

A light duty, plastic pipe end covering to protect insulation against dust when transitioning INSULPEX to building service piping.



Wall Sealing Ring

A flexible, neoprene ring for watertight sealing of INSULPEX in a wall penetration.



4.5 RAUTOOL PEXa Pipe Installation Tools

RAUTOOLS provide fast, easy and professional installations, and are required to assemble joints comprising REHAU pipes and SDR11 compression-sleeve fittings. Additional information on tools is available in the REHAU INSULPEX Installation Guide.

Pipe Cutting Tools

Cutters provide a clean, square and accurate cutting of PEXa pipe.

Pipe Expansion Tools

PEXa pipe is cold-expanded, then an insert fitting is pushed into the pipe. Pipe expansion occurs via a manual, battery-operated or hydraulic tool and a special geometry expander bit.

SDR11 Compression-sleeve Tools

The sleeve is compressed over PEXa pipe and insert fitting to assemble the joint. Joint compression occurs via a manual, battery-operated or hydraulic tool and a set of compression jaws.

5. SYSTEM PLANNING

Presented below are specific installation details that the system designer must be aware of.

5.1. Trench Installation

Do not install INSULPEX in soil or groundwater conditions which are thought or known to be contaminated with fuels, organic compound, solvents or other possible hazards, as these substances could permeate the pipe and contaminate the water or damage the integrity of the pipe. If contamination is suspected, a chemical analysis of the soil or groundwater must be performed to determine the contaminant and its compatibility with INSULPEX.

A minimum of 4 in (10 cm) of sand should surround INSULPEX in the trench. The sand protects the INSULPEX from sharp objects and is crucial to the thermal compensation of the system.

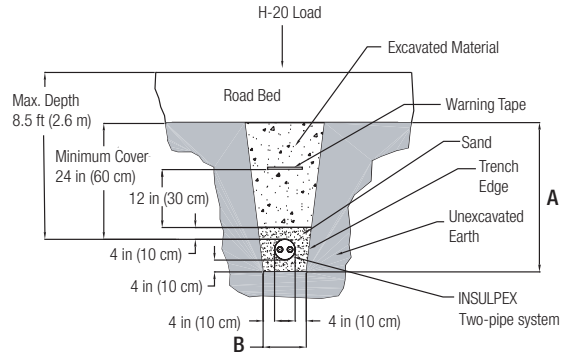
Native soil can be used for the remaining fill, as long as there are no large (greater than 1 1/2 in [4 cm]), frozen or sharp objects such as rocks or debris. Compact the fill material by hand to a height of at least 6 in (15 cm) above the INSULPEX. Above the hand-compacted fill, a mechanical device can be used to compact the soil.

INSULPEX is suitable for H-20 loading at depths ranging from 2 ft (60 cm) from the roadbed to a maximum 8.5 ft (260 cm).

See Figs. 5.1 and 5.2 for H-20 trench dimensions.

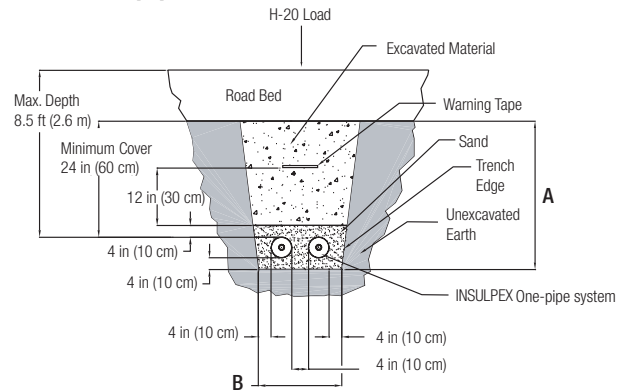
For applications where loading is not a concern, the trench depth should be a minimum of 16 in (40 cm). For better thermal performance an increased burial depth is recommended. Burying the pipe below the frost line can prevent heaving and improve thermal performance.

Table 5.1: One-pipe Trench Dimensions



Jacket OD (mm)	Depth A in (cm)	Width B in (cm)
91	31 (80)	12 (30)
111	33 (85)	12 (30)
126	33 (85)	14 (36)
142	33 (85)	14 (36)
162	35 (90)	14 (36)
182	35 (90)	15 (38)
202	38 (95)	16 (40)

Table 5.2: Two-pipe Trench Dimensions



Jacket OD (mm)	Depth A in (cm)	Width B in (cm)
91	31 (80)	20 (50)
111	33 (85)	22 (55)
128	33 (85)	22 (55)
142	33 (85)	24 (60)
162	35 (90)	26 (65)
182	35 (90)	26 (65)
202	38 (95)	28 (70)

5.2 Above-Ground Installation

Above ground installations of INSULPEX (protected from direct exposure to UV radiation) must be properly supported with either fixed or sliding supports. Local code may define the maximum distances between support devices, otherwise, horizontal and vertical runs should be supported every 40 in (1 m). INSULPEX may not be used for permanent, unsheltered outdoor exposure.

5.2.1 Fixed Supports

Fixed supports are typically applied at fitting locations. When using a fixed support, follow the support manufacturer's recommendation for installation. Place the fixed support on the body of the fitting, not on the INSULPEX jacket nor on the SDR11 compression sleeve.

5.2.2 Sliding Support Device

To allow for expansion and contraction, support devices for INSULPEX should allow for movement with slide linings. Support devices must accommodate the outside diameter of INSULPEX and not squeeze the pipe unnecessarily. Make sure the material contacting the INSULPEX is not abrasive and does not allow sharp edges to protrude into the INSULPEX. The installer should place 3 sliding supports at 90° bends, observing the minimum bend radius.

5.3 Building Penetration

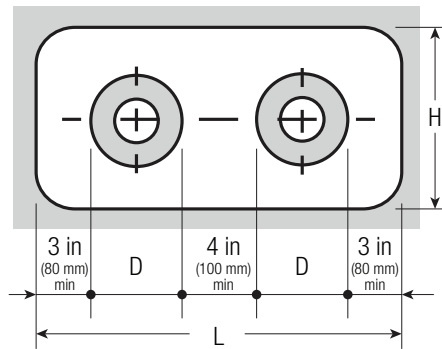
For penetrating through an exterior wall there are two options, bored hole and wall breakthrough. Both options require the use of the wall sealing ring and require filling in the hole with concrete.

For a wall breakthrough make an opening with the dimensions from Table 5.3.

For bored holes make hole(s) with the dimensions from Table 5.4.

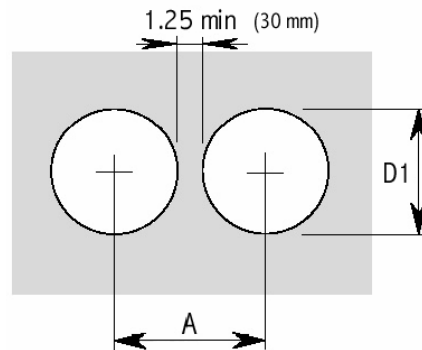
Linked-type sealing rings suitable for polymer pipes can also be used when following manufacturer's instructions. Linked seals do not use mortar and do not require a wall sealing ring, however the bored hole should still be sealed as described above.

Table 5.3: Wall Breakthrough Dimensions



Jacket OD mm	L min		H	
	in	cm	in	cm
91	20	50	10	25
111	20	50	12	30
126	21 3/4	55	12	30
142	23 3/4	60	13 3/4	35
162	25 1/2	65	13 3/4	35
182	25 1/2	65	13 3/4	35
202	27 1/2	70	15 3/4	40

Table 5.4: Bored Hole Dimensions



Jacket OD mm	A min		D1	
	in	cm	in	cm
91	9	23	8	20
111	10	25	9	22
126	10 3/4	27	9 1/2	24
142	11 1/2	29	10 1/4	26
162	12 1/4	31	11	28
182	12 3/4	32	11 1/2	29
202	13 3/4	35	12 1/2	32

5.4 Thermal Expansion

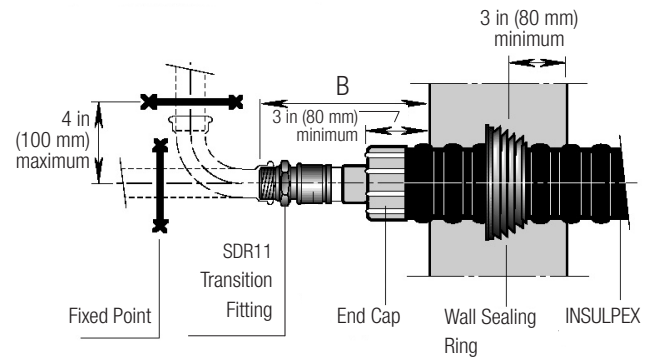
The unique property of INSULPEX is that it is self-compensating when buried in accordance with the instructions in the REHAU *INSULPEX Installation Guide*. The friction force between the fill sand around the INSULPEX and the outer casing is sufficient to limit thermal expansion of the pipe under typical operating conditions.

However, when INSULPEX is installed in a non-buried application, the system design must account for the natural tendency of the pipe to expand due to temperature change.

5.5 Transition to Building Service Piping

To keep the thermal expansion within acceptable limits when connecting to a building, INSULPEX pipes should not extend beyond the exterior wall into the building more than the distances specified in Table 5.5. If the end caps are fully inside the wall, these distances can be reduced by 2.3 in (6 cm). The PEXa carrier pipe requires properly designed and installed fixed brackets inside the building suitable for the thermal expansion forces. Fixed brackets may be attached to the fitting body, but not to the SDR11 compression sleeve.

Table 5.5: Transition to Building Service Piping



Pipe Size	Maximum B Distances			
	Anchor Force		SDR11 Transition Fitting	
	lbf	kN	in	cm
25 mm	410	1.8	10 3/4	27
32 mm	590	2.6	10 3/4	27
40 mm	900	4.0	10 3/4	27
50 mm	1310	5.8	10 3/4	27
63 mm	1890	8.4	11 3/4	30
75 mm	2390	10.6	11 3/4	30
90 mm	2700	12.0	11 3/4	30
110 mm	2840	12.6	11 3/4	30
125 mm	3510	15.6	13 3/4	35
140 mm	4410	19.6	13 3/4	35

6. SYSTEM DESIGN

This section outlines the procedures required for a complete INSULPEX system design. A full analysis of system performance and requirements involves the following design elements:

- INSULPEX length determination
- Total heat load estimation
- Flow rate estimation
- INSULPEX size determination
- INSULPEX heat loss calculation
- INSULPEX pressure loss calculation

The detailed descriptions that follow are expressed in terms of heat load and heat loss, however the same principles and procedures apply to cooling loads and heat gains.

Terms and Symbols

C_p = specific heat of fluid (Btu/lb·°F)

D_b = depth of burial to centerline of INSULPEX pipe (in)

L = INSULPEX length (ft)

ρ = fluid density (lb/gallon)

q_{INS} = heat loss through INSULPEX (Btu/h)

q_{load} = heating load of an area or sub-area (Btu/h)

q_{tot} = total heating load including loss through INSULPEX (Btu/h)

R_{tot} = total thermal resistance (h·ft·°F/Btu)

T_{ave} = average of system supply and return fluid temperatures (°F)

T_{soil} = soil temperature (°F)

ΔT = difference between supply and return fluid temperatures (°F)

6.1 Step 1: Determine Length

- Calculate the distance of the INSULPEX route in feet. When planning the route, be sure to check with utility companies and other trades to account for obstructions.
- Add 4.5 ft (1.4 m) of length for every 90° bend in the pipe.
- Be sure to account for both the supply and return legs of the route if you are not using two-pipe INSULPEX.
- Ensure there is at least 20 in (51 cm) of clearance (from pipe end), if using the RAUTOOL G2 toolkit.

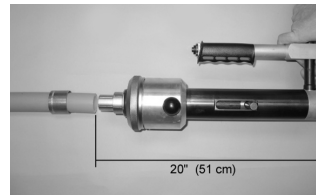


Fig. 6.1: Tool clearance

Observe the minimum bend radii listed in Chapter 4. If a coupling or tee connection must be placed on a bend, ensure that the radius is 13 ft (4 m) or more

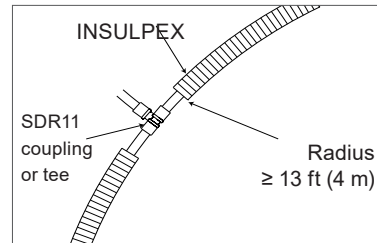


Fig. 6.2: Bend radius at connection

6.2 Step 2: Estimate Total Heat Load

A system heat load calculation should take into account heat lost through the INSULPEX pipe. An initial rough estimate of the total heat loss can be obtained by using:

$$q_{tot} = q_{load} + 10(\text{Btu/h ft}) \times L$$

This assumes a loss of 10 Btu/h per foot of pipe, based on:

- Average INSULPEX size
- T_{ave} of 135°F, T_{soil} of 50°F
- Medium soil thermal conductivity condition

Example, given:

$$q_{load} = 600,000 \text{ Btu/h}$$

$$L = 800 \text{ ft (400 ft supply + 400 ft return)}$$

$$q_{tot} = 600,000 + 10 \times 800 = 608,000 \text{ Btu/h}$$

6.3 Step 3: Estimate Flow Rate

Having estimated the total heat load, q_{tot} the designer may proceed with the flow rate (where 60 converts hours to minutes) estimation by using:

$$USGPM = q_{tot}/(\rho \times C_p \times 60 \times \Delta T)$$

The designer of the heating system should provide the ΔT . This equation calculates the required flow rate of the heating fluid in the INSULPEX based on fluid properties and desired ΔT .

Example continues, given:

$$q_{tot} = 608,000 \text{ Btu/h}$$

$$\Delta T = 35^\circ\text{F}$$

Water as a heating fluid

$$(\rho = 8.22 \text{ lb/gallon}, C_p = 1 \text{ Btu/lb}\cdot^\circ\text{F @ } 135^\circ\text{F [57}^\circ\text{C]})$$

$$USGPM = (608,000 \text{ Btu/h}) / (8.22 \text{ lb/gallon} \times 1 \text{ Btu/lb}\cdot^\circ\text{F} \times 60 \text{ min/hr} \times 35^\circ\text{F}) = 35 \text{ gpm}$$

Note: If the heating fluid includes antifreeze, be sure to use the correct values of density and specific heat corresponding to the type and concentration of antifreeze in the water. Table 6.1 shows the combined properties of common heating fluid mixtures and concentrations.

6.4 Step 4: Determine Pipe Size

Correct sizing of the system pump(s) and other components requires selection of the appropriate INSULPEX carrier pipe size.

The

INSULPEX pipe should be chosen based on the estimated flow rate and the resulting head loss (see REHAU *PEXa Piping Systems*

Pressure Loss Tables). The suggested range of head loss through the pipe is 10 to 20 ft of head. Additional losses through system components must be taken into account when sizing pump(s) and other equipment.

Table 6.1: Glycol Properties

Glycol Content @ 100°F (37°C)	ρ (lb/gal)		C_p (Btu/lb °F)		$\rho \times C_p \times 60$	
	Propylene	Ethylene	Propylene	Ethylene	Propylene	Ethylene
10%	8.37	8.41	0.981	0.957	492	483
20%	8.45	8.55	0.959	0.922	486	473
30%	8.52	8.67	0.931	0.883	476	459
40%	8.58	8.79	0.899	0.843	463	444
50%	8.63	8.90	0.861	0.800	446	427

Source: ASHRAE *Fundamentals*

6.5 Step 5: Calculate Heat Loss

Once the appropriate pipe size has been identified, the following equations are used to more precisely calculate heat loss through buried pipe:

$$q_{INS} = (T_{ave} - T_{soil})/R_{tot}$$

Note: For non-buried applications, use a suitable heat loss method. INSULPEX may not be used for permanent, unsheltered outdoor exposure.

Example continues, given:

$$\text{Supply fluid temperature} = 150^\circ\text{F}$$

$$\text{Return fluid temperature} = 120^\circ\text{F}$$

$$T_{ave} = (150 + 120)/2 = 135^\circ\text{F}$$

Use the lowest ground temperature if you are calculating heat loss, or the highest temperature for heat gain.

Note: The lowest or highest temperature does not necessarily occur in winter or summer. In some locations the most extreme ground temperature lags by a season.

R_{tot}: Total Thermal Resistance

The total thermal resistance must be determined, see Table 6.3.

The following variables must be determined to derive an accurate

R_{tot} value:

- D_b: Depth of Bury to Pipe Centerline

Determine the depth from the top of the trench to the horizontal centerline of the pipe(s) in inches.

- Soil Type

Thermal conductivity of the soil depends on factors such as soil composition, particle size and nature, water and air content and drainage. For the purposes of this heat loss calculation, we will

classify three kinds of soil, shown in Table 6.2.

Note: The REHAU *INSULPEX Installation Guide* states that the trench should be filled with sand around the INSULPEX.

However, for the purposes of the calculation, soil type selection should be based on the native soil properties.

Once the heat loss through the INSULPEX is known, calculate a more precise total heat load by using:

$$q_{tot} = q_{load} + q_{INS}$$

Compare this to the q_{tot} estimated in the total heat load estimation. If the values differ by more than 5%, use the new q_{tot} to calculate a corrected flow rate. Then, using the new flow rate, verify that the appropriate pipe size has been chosen.

Example continues, given:

INSULPEX 63 mm

D_b = 39 in. to centerline

R_{tot}/L of 8.0 h·ft·°F/Btu

$$q_{tot} = 600,000 + (135 - 50) \times 800/8.0 = 608,500 \text{ Btu/h}$$

Table 6.2: Thermal Conductivity of Soil

Soil Type	Description	Thermal Conductivity Btu·in/h·ft ² ·°F
Dry	Well to excessively drained, coarse-textured particles	1
Medium	Well drained with moderately fine or medium-textured particles, or, poorly drained with moderately coarse-textured soil	8
Moist	Poor to very poorly drained fine-textured soils or peats	15

6.6 Step 6: Calculate Head Loss

Refer to the pressure tables to calculate the pressure loss of the fluid in the INSULPEX pipes. Find the table that corresponds most closely to the amount of glycol in the fluid, if any. Find the intersection of the row corresponding to the flow rate of the fluid, and the column of the correct fluid temperature and pipe size. The number at the intersection is the psi loss per 100 ft of INSULPEX pipe. Multiply that number by the number of 100's of feet of pipe in the system, as shown:

Example continues, given:

0.89 psi loss per 100 ft @ T_{ave} = 120°F

0.79 psi loss per 100 ft @ T_{ave} = 180°F

Through linear interpolation this calculates to:

0.85 psi loss per 100 ft @ T_{ave} = 135°F

$$\text{Pressure loss} = 0.85 \times 8 = 6.8 \text{ psi}$$

The design must ensure the flow requirement and pressure loss are within the circulator's performance capability. To express pressure loss in feet of head, multiply by 2.307.

Table 6.3: Total Thermal Resistance for INSULPEX

		Total Thermal Resistance Per Foot of Pipe R_{tot}/L (h-ft ² °F/Btu)					
		Depth of Bury to INSULPEX Centerline					
Carrier Pipe/ Outer Jacket	Soil Condition	19 in (48 cm)	27 in (69 cm)	39 in (99 cm)	51 in (130 cm)	75 in (190 cm)	105 in (266 cm)
One-pipe system							
25 / 91	Dry	24.9	26.2	27.5	28.6	30.0	31.3
	Medium	17.0	17.2	17.3	17.4	17.6	17.8
	Moist	16.5	16.6	16.6	16.7	16.8	16.9
32 / 91	Dry	21.7	23.0	24.4	25.4	26.9	28.2
	Medium	13.9	14.0	14.2	14.3	14.5	14.6
	Moist	13.4	13.4	13.5	13.6	13.7	13.7
40 / 91	Dry	18.9	20.2	21.6	22.6	24.1	25.3
	Medium	11.0	11.2	11.3	11.5	11.6	11.8
	Moist	10.5	10.6	10.7	10.7	10.8	10.9
50 / 111	Dry	18.1	19.4	20.8	21.8	23.2	24.5
	Medium	10.7	10.9	11.0	11.2	11.3	11.5
	Moist	10.2	10.3	10.4	10.4	10.5	10.6
63 / 126	Dry	16.4	17.7	19.1	20.1	21.6	22.8
	Medium	9.4	9.5	9.7	9.8	10.0	10.1
	Moist	8.9	9.0	9.0	9.1	9.2	9.3
75 / 142	Dry	15.4	16.7	18.0	19.1	20.5	21.8
	Medium	8.6	8.8	8.9	9.1	9.2	9.4
	Moist	8.2	8.3	8.3	8.4	8.5	8.6
90 / 162	Dry	14.4	15.7	17.0	18.0	19.5	20.8
	Medium	8.0	8.1	8.3	8.4	8.6	8.7
	Moist	7.5	7.6	7.7	7.8	7.8	7.9
110 / 162	Dry	11.8	13.1	14.5	15.5	16.9	18.2
	Medium	5.4	5.6	5.7	5.9	6.0	6.2
	Moist	5.0	5.1	5.1	5.2	5.3	5.4
125 / 182	Dry	11.4	12.6	14.0	15.0	16.5	17.8
	Medium	5.3	5.4	5.6	5.7	5.9	6.0
	Moist	4.9	4.9	5.0	5.1	5.2	5.2
140 / 202	Dry	11.0	12.2	13.6	14.6	16.1	17.3
	Medium	5.2	5.3	5.5	5.6	5.8	5.9
	Moist	4.8	4.8	4.9	5.0	5.1	5.1
Two-pipe system							
25 + 25 / 111	Dry	14.6	15.4	16.0	16.5	17.2	17.9
	Medium	10.1	10.2	10.2	10.3	10.4	10.5
	Moist	9.8	9.8	9.9	9.9	9.9	10.0
32 + 32 / 111	Dry	12.6	13.3	13.9	14.5	15.2	15.9
	Medium	8.0	8.1	8.2	8.2	8.3	8.4
	Moist	7.7	7.8	7.8	7.8	7.9	7.9
40 + 40 / 126	Dry	12.0	12.7	13.3	13.8	14.6	15.2
	Medium	7.6	7.7	7.8	7.8	8.0	8.0
	Moist	7.3	7.4	7.4	7.4	7.5	7.5
50 + 50 / 162	Dry	11.7	12.4	13.0	13.6	14.3	14.9
	Medium	7.7	7.8	7.9	8.0	8.0	8.1
	Moist	7.4	7.5	7.5	7.6	7.6	7.7
63 + 63 / 182	Dry	10.2	11.0	11.6	12.1	12.9	13.5
	Medium	6.3	6.4	6.5	6.5	6.6	6.7
	Moist	6.0	6.1	6.1	6.2	6.2	6.2

7. SYSTEM TESTING

REHAU only provides the general guidelines for performing a pressure test on a REHAU pre-insulated PEXa piping system as set forth in the *INSULPEX Pre-insulated PEXa Piping Installation Guide 855.632*.

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REHAU stands behind our products with a 25-year limited warranty on PEXa pipe and fittings.

www.na.rehau.com/warranties

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