PIPE FREEZE PROTECTION AND FLOW MAINTENANCE — XL-TRACE SYSTEM

This step-by-step design guide provides the tools necessary to design a nVent RAYCHEM XL-Trace pipe freeze protection or flow maintenance system. For other applications or for design assistance, contact your nVent representative or call (800) 545-6258. Also, visit our web site at nVent.com.

CONTENTS

INTRODUCTION

This design guide presents nVent' recommendation for designing an XL-Trace pipe freeze protection and flow maintenance system for the following applications:

- Freeze protection of general water piping (aboveground and buried)
- Flow maintenance of waste lines (aboveground and buried)
- Flow maintenance of fuel lines (aboveground)

This guide does **not** cover applications in which any of the following conditions exist:

- Hazardous locations, as defined in the national electrical codes
- Pipe temperature other than specified in Table 1 on page 3
- Pipe maintenance temperatures above 150°F (65°C)
- Supply voltage other than 120 V or 208–277 V

 For designing XL-Trace pipe freeze protection system for fire sprinkler piping, please refer to the XL-Trace System for Fire Sprinkler Freeze Protection Design Guide (H58489).

If your application conditions are different, or if you have any questions, contact your nVent representative or call (800) 545-6258.

How to Use this Guide

This design guide presents nVent recommendations for designing an XL-Trace pipe freeze protection or flow maintenance system. It provides design and performance data, electrical sizing information, and application configuration suggestions. Following these recommendations will result in a reliable, energy-efficient system.

Other Required Documents

This guide is not intended to provide comprehensive installation instructions. For complete XL-Trace pipe freeze protection and flow maintenance system installation instructions, please refer to the following additional required documents:

- XL-Trace System Installation and Operation Manual (H58033)
- Additional installation instructions are included with the connection kits, thermostats, controllers, and accessories

If you do not have these documents, you can obtain them from the nVent web site at nVent.com.

For products and applications not covered by this design guide, please contact your nVent representative or call (800) 545-6258.

Safety Guidelines

As with any electrical equipment, the safety and reliability of any system depends on the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system connection kits could damage the system and may result in inadequate performance, overheating, electric shock, or fire. To minimize these risks and to ensure that the system performs reliably, read and carefully follow the information, warnings, and instructions in this guide.

 This symbol identifies important instructions or information.

⚠ This symbol identifies particularly important safety warnings that must be followed.

⚠ **WARNING:** To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of nVent, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Warranty

nVent standard limited warranty applies to all products.

An extension of the limited warranty period to ten (10) years from the date of installation is available if a properly completed online warranty form is submitted within thirty (30) days from the date of installation. You can access the complete warranty on our web site at nVent.com.

SYSTEM OVERVIEW

The XL-Trace system provides freeze protection and flow maintenance for aboveground and buried pipe applications. The XL-Trace system is based on self-regulating heating cable technology. nVent offers the option of three self-regulating heating cables with the XL-Trace system: 5XL, 8XL, and 12XL (208–277 V only) for applications using 120 and 208–277 V power supplies. The cable's output is reduced automatically as the pipe warms, so there is no possibility of failure due to overheating.

An XL-Trace system includes the heating cable, power connection, splice, tee connections, controls, contactors, power distribution panels, accessories, and the tools necessary for a complete installation.

XL-Trace Applications

Identify which of the standard XL-Trace applications below pertain to your installation. Proceed to the appropriate design sections that follow.

TABLE 1 XL-TRACE APPLICATIONS

Application	Description	Specific application requirements
Pipe freeze protection		
General water piping	Freeze protection (40°F [4°C] minimum) of insulated, metal or plastic water piping	"Aboveground piping" on page 9 "Buried piping," page 10
Flow maintenance		
Grease waste lines	Flow maintenance (110°F [43°C] minimum) for insulated grease waste lines	"Aboveground piping" on page 9 "Buried piping," page 10
Fuel lines	Flow maintenance (40°F [4°C] minimum) for insulated metal piping containing #2 fuel oil	"For aboveground piping only," on page 11

Note: If your application does not fit these guidelines, contact your local nVent representative or call (800) 545-6258.

Self-Regulating Heating Cable Construction

RAYCHEM XL-Trace self-regulating heating cables are comprised of two parallel nickel-plated bus wires in a cross-linked polymer core, a tinned copper braid, and a fluoropolymer or polyolefin outer jacket. These cables are cut to length, simplifying the application design and installation.

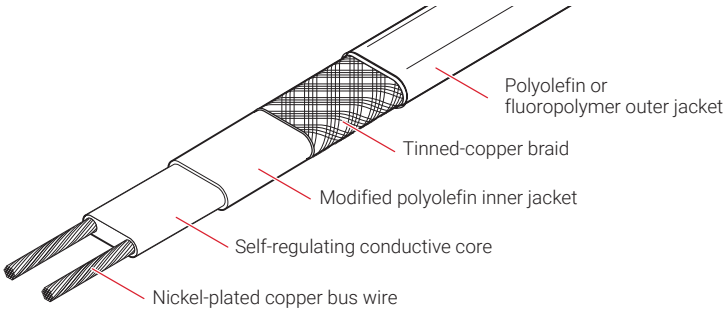


Fig. 1 XL-Trace heating cable construction

With self-regulating technology, the number of electrical paths between bus wires changes in response to temperature fluctuations. As the temperature surrounding the heater decreases, the conductive core contracts microscopically. This contraction decreases electrical resistance and creates numerous electrical paths between the bus wires. Current flows across these paths to warm the core.

As the temperature rises, the core expands microscopically. This expansion increases electrical resistance and the number of electrical paths decreases. The heating cable automatically reduces its output.

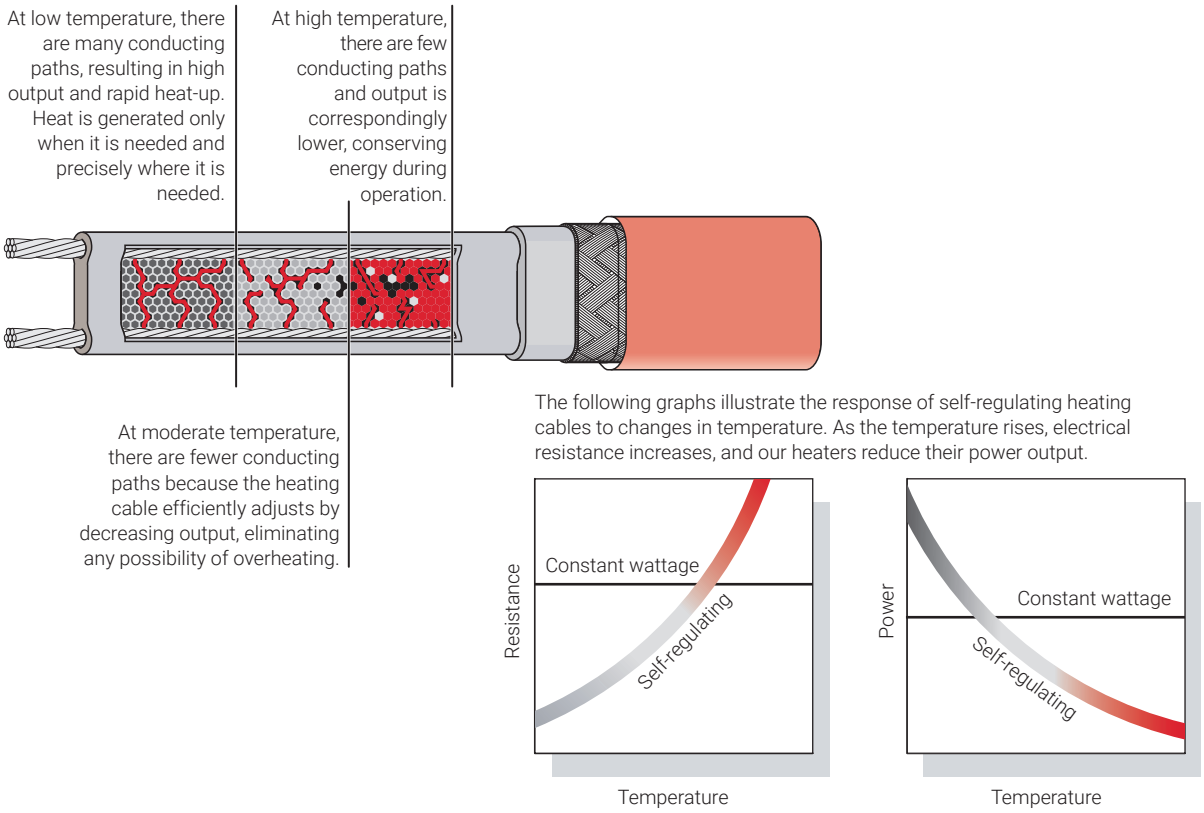


Fig. 2 Self-regulating heating cable technology

PIPE FREEZE PROTECTION APPLICATIONS

A pipe freeze protection system is designed to maintain the pipe temperature at a minimum of 40°F (4°C) to prevent freezing.

Typical Pipe Freeze Protection System

A typical pipe freeze protection system includes the XL-Trace self-regulating heating cables, connection kits, ambient temperature control, and power distribution.

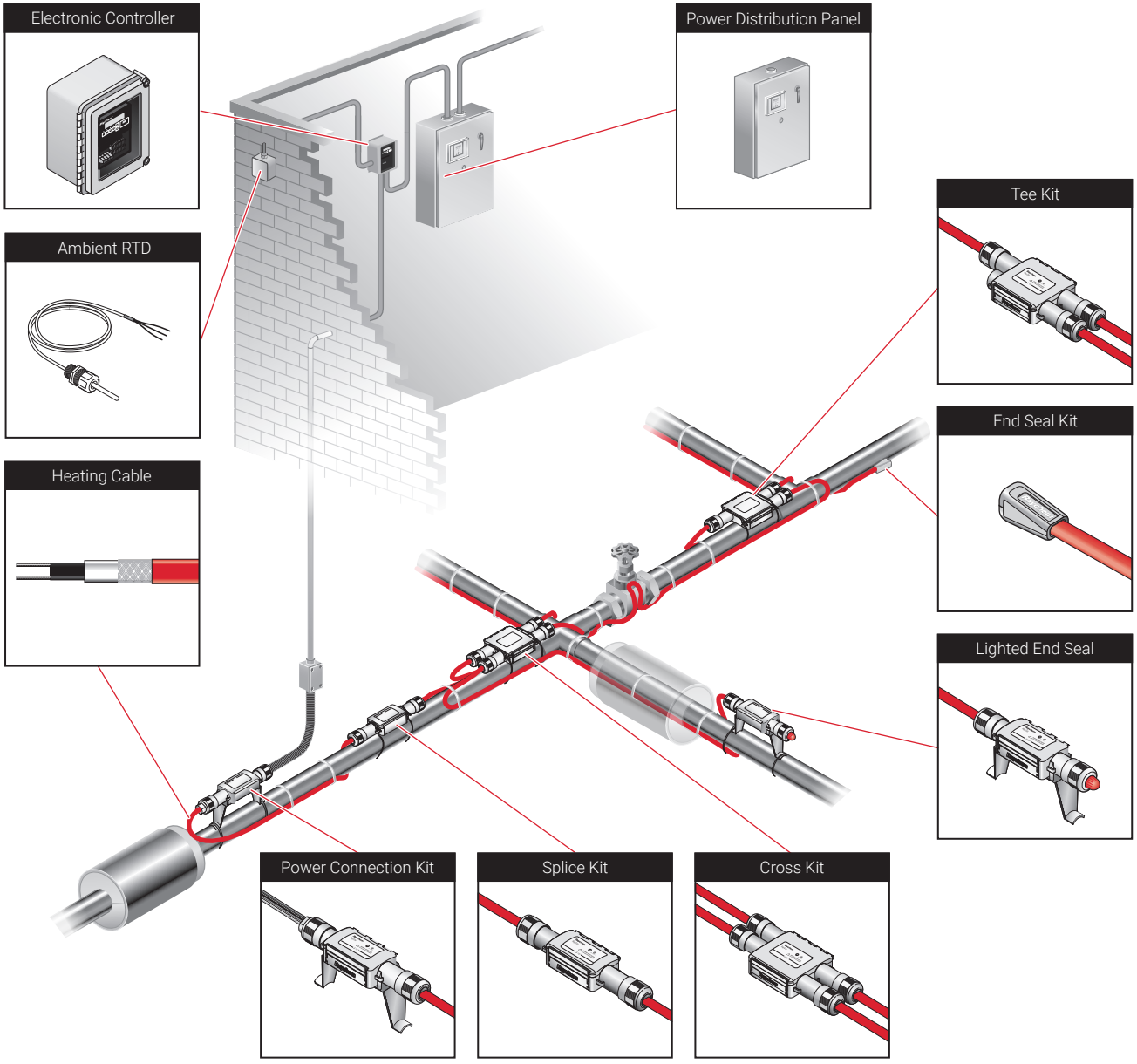


Fig. 3 Typical XL-Trace pipe freeze protection system

General Water Piping

General water piping is defined as metal or plastic water piping located in nonhazardous locations.

ABOVEGROUND PIPING

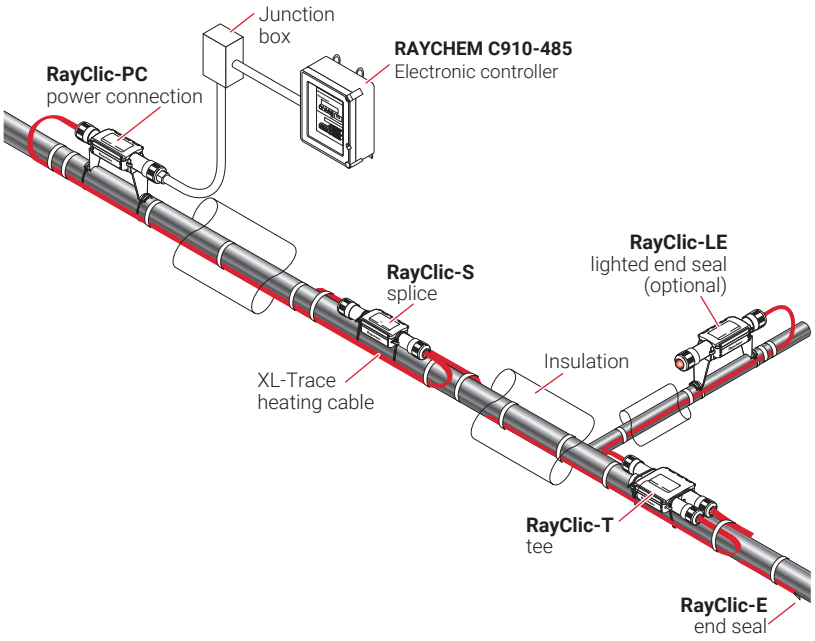


Fig. 4 Typical aboveground piping system

Application Requirements

The system complies with nVent requirements for aboveground general water piping when:

- The heating cable is permanently secured to insulated metal pipes with GT-66 glass tape, or to plastic pipes using AT-180 aluminum tape.
- A 30-mA ground-fault protection device (GFPD) is used.
- The heating cable is installed per manufacturer's instructions with approved RAYCHEM connection kits. See Table 13 on page 27 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

See "Other Required Documents" page 2.

Approvals

UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

UL LISTED	FM APPROVED
5XL1-CR, -CT	8XL1-CR, -CT
5XL2-CR, -CT	8XL2-CR, -CT

C SP -W US		
5XL1-CR, -CT	8XL1-CR, -CT	12XL2-CR, -CT
5XL2-CR, -CT	8XL2-CR, -CT	

BURIED PIPING

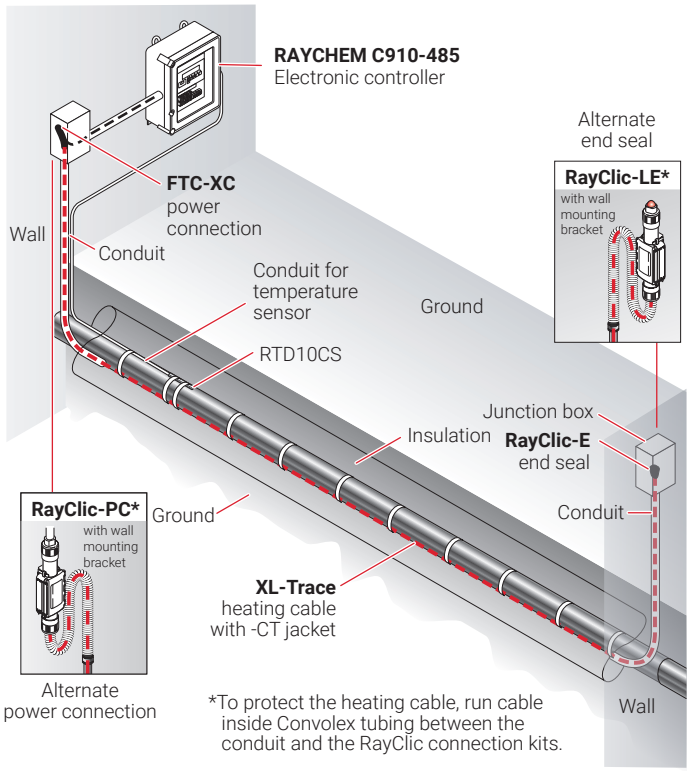


Fig. 5 Typical buried piping system

Application Requirements

The system complies with nVent requirements for use on buried insulated metal or plastic pipe when:

- The heating cable is permanently secured to metal pipes with GT-66 glass tape or to plastic pipes using AT-180 aluminum tape.
- The pipeline is buried at least 2-feet deep.
- All heating cable connections (power, splice, tee, and end termination) are made above-ground. No buried or in-conduit splices or tees are allowed.
- The heating cable has a fluoropolymer outer jacket (-CT).
- The power connection and end seal are made in UL Listed and CSA Certified junction boxes above grade.
- The heating cable is protected from the pipe to the power connection box in UL Listed and CSA Certified water-sealed conduit (minimum 3/4-inch diameter) suitable for the location.
- A 30-mA ground-fault protection device (GFPD) is used.
- Closed-cell, waterproof thermal insulation with fire-retardant, waterproof covering is used.
- The heating cable is installed per manufacturer's instructions with approved nVent connection kits. See Table 15 on page 29 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

See "Pipe Heat Loss Calculations" page 13.

Approvals

UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

UL LISTED	FM APPROVED	CSA -W C US		
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	12XL2-CT

FLOW MAINTENANCE APPLICATIONS

A flow maintenance system is designed to maintain cooking grease waste lines and #2 fuel oil lines above the temperature at which the viscosity inhibits fluid flow.

Typical Flow Maintenance System

A typical flow maintenance system includes the XL-Trace self-regulating heating cables with a fluoropolymer outer jacket, connection kits, line-sensing temperature control and power distribution.

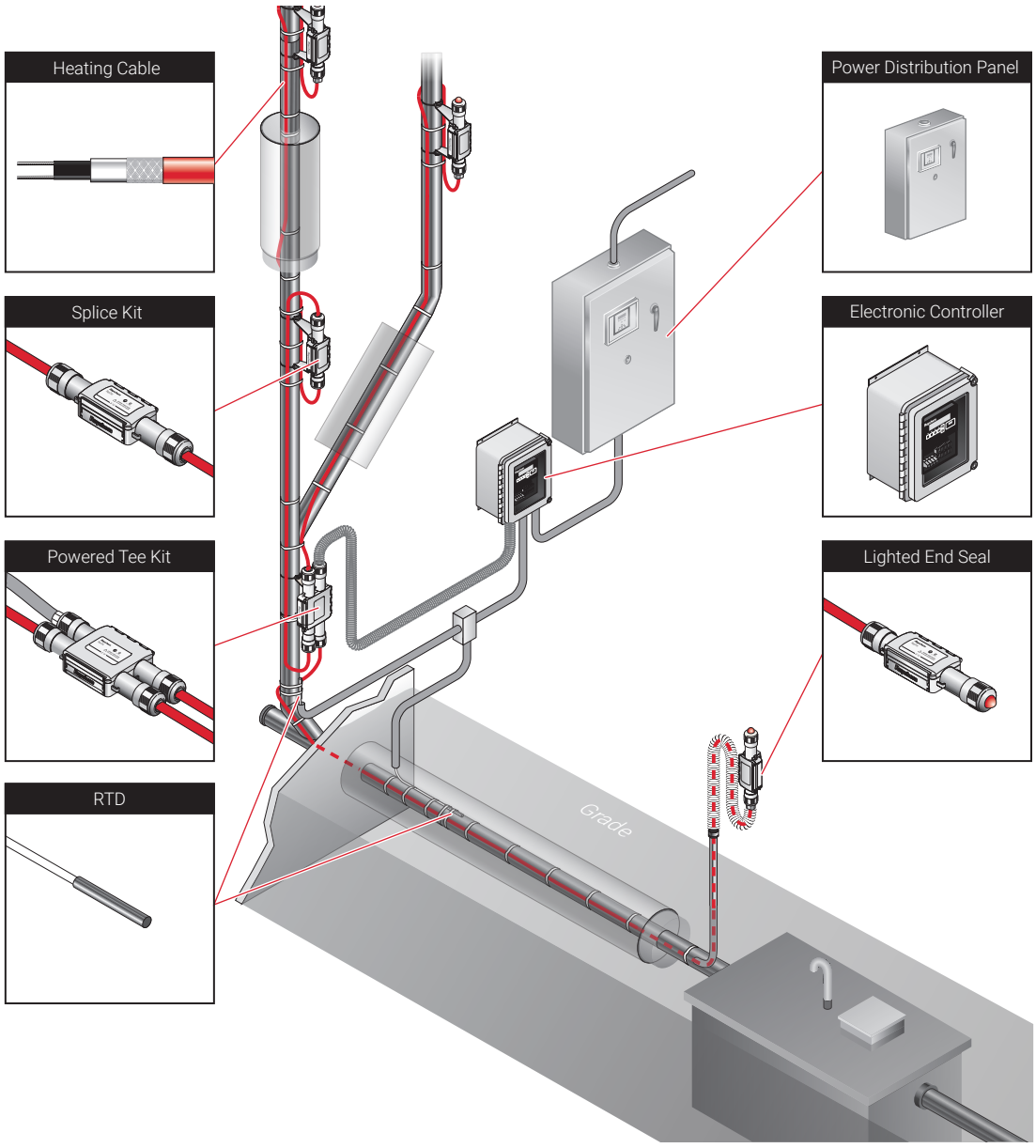


Fig. 6 Typical XL-Trace flow maintenance system

Grease Waste Lines

Grease waste lines are defined as piping used for the disposal of waste oils and fats created in the cooking process. Typical applications include grease waste lines from commercial restaurants. A grease-line flow maintenance system is designed to maintain a 110°F (43°C) minimum fluid temperature.

Aboveground piping

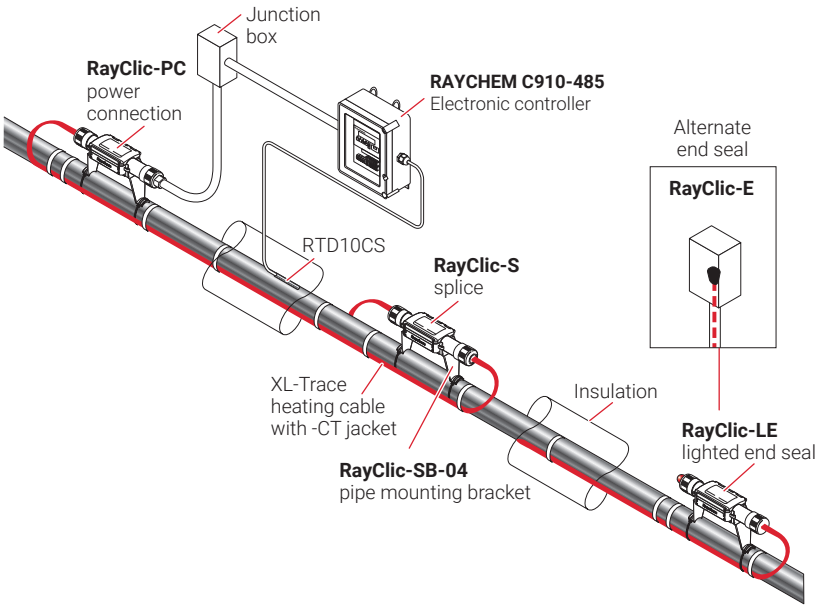


Fig. 7 Typical aboveground piping system

Application Requirements

The system complies with nVent requirements for aboveground grease waste lines when:

- The heating cable is permanently secured to metal pipes with GT-66 glass tape, or to plastic pipes using AT-180 aluminum tape.
- The heating cable must have a fluoropolymer outer jacket (-CT).
- A 30-mA ground-fault protection device (GFPD) is used.
- Tees and splices are installed using pipe mounting brackets, not in direct contact with piping.
- The heating cable is installed per manufacturer's instructions with approved nVent connection kits. See Table 13 on page 27 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

See "Pipe Heat Loss Calculations" page 13.

Approvals

XL-Trace systems (-CT only) are UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

UL LISTED	FM APPROVED	CSA C US -W		
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	12XL2-CT

BURIED PIPING

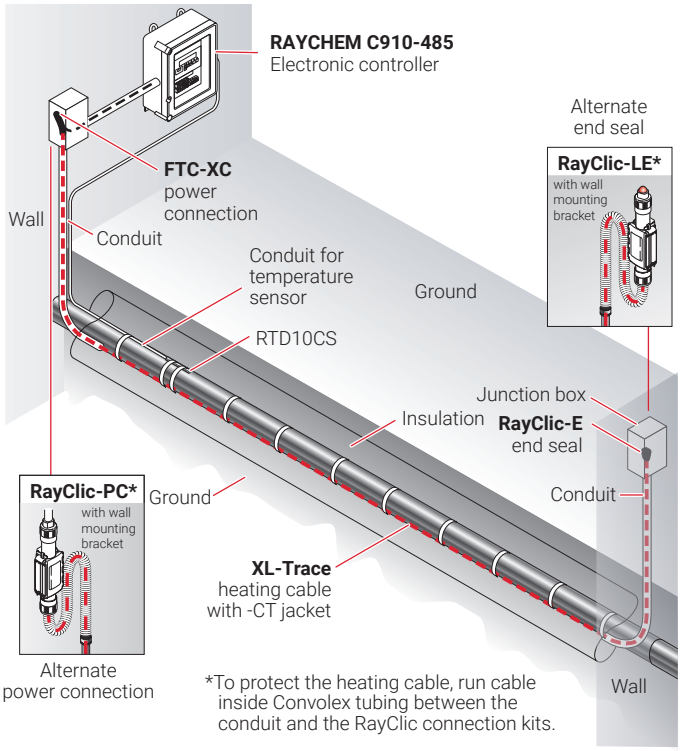


Fig. 8 Typical buried grease waste line

Application Requirements

The system complies with nVent requirements for buried grease waste lines when:

- The heating cable is permanently secured to metal pipes with GT-66 glass tape, or to plastic pipes using AT-180 aluminum tape.
- The heating cable must have a fluoropolymer outer jacket (-CT).
- The pipeline is buried at least 2-feet deep.
- All heating cable splices or tees are made aboveground. No buried or in-conduit splices or tees are allowed.
- The power connection and end seal are made in UL Listed and CSA Certified junction boxes above grade.
- The heating cable is protected from the pipe to the power connection box in UL Listed and CSA Certified conduit (minimum 3/4-inch diameter) suitable for the location.
- A 30-mA ground-fault protection device (GFPD) is used.
- Closed-cell, waterproof thermal insulation with fire-retardant, waterproof covering is used.
- The heating cable is installed per manufacturer's instructions with approved nVent connection kits. See Table 15 on page 29 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

See "Heating Cable Catalog Number" on page 17.

Approvals

XL-Trace systems (-CT only) are UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

UL LISTED	FM APPROVED
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT

SP -W C US		
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	12XL2-CT

Fuel Lines

Fuel lines are defined as those carrying #2 fuel oil. A fuel line flow maintenance system is designed to maintain a 40°F (4°C) minimum fluid temperature to maintain flow.

FOR ABOVEGROUND PIPING ONLY

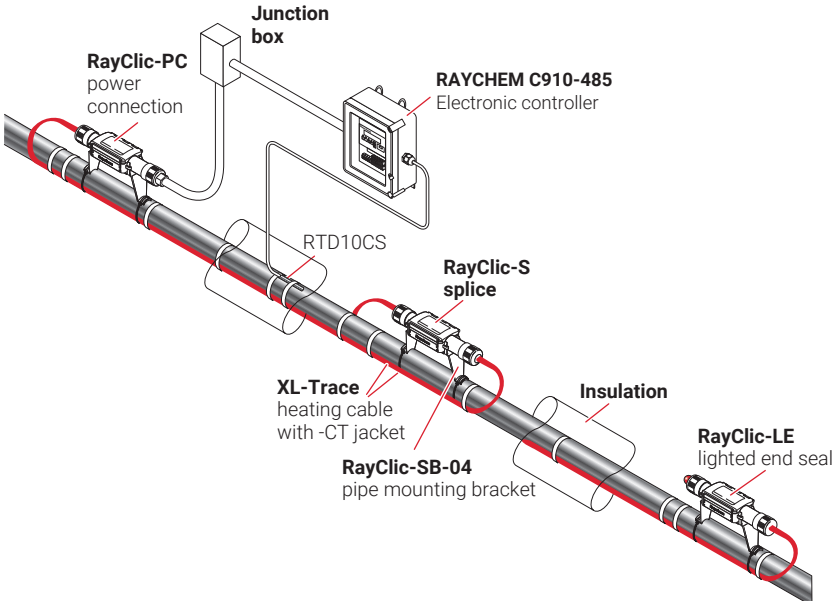


Fig. 9 Typical aboveground piping system

Application Requirements

The system complies with nVent requirements for aboveground #2 fuel oil piping when:

- The heating cable is permanently secured to metal pipes with GT-66 glass tape or to plastic pipes using AT-180 aluminum tape.
- The heating cable must have a fluoropolymer outer jacket (-CT).
- Tees and splices are installed using pipe mounting brackets, not in direct contact with piping.
- A 30-mA ground-fault protection device (GFPD) is used.
- The heating cable is installed per manufacturer's instructions with approved nVent connection kits. See Table 13 on page 27 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

See "Pipe Heat Loss Calculations" page 13.

Approvals

XL-Trace systems (-CT only) are UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

UL LISTED	FM APPROVED
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT

CSA -W C US		
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	12XL2-CT

PIPE FREEZE PROTECTION AND FLOW MAINTENANCE DESIGN

This section details the design steps necessary to design your application. The examples provided in each step are intended to incrementally illustrate the project parameter output for two sample designs from start to finish. As you go through each step, use the "XL-Trace System Pipe Freeze Protection and Flow Maintenance Design Worksheet" page 36, to document your project parameters, so that by the end of this section you will have the information you need for your Bill of Materials.

TraceCalc Pro

TraceCalc Pro for Buildings is an online design tool available to help you create simple or complex heat-tracing designs for pipe freeze protection or flow maintenance applications. It is available at nVent.com.

Design Step by Step

Your system design requires the following essential steps.

1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 1 Determine design conditions and pipe heat loss

Collect the following information to determine your design conditions:

- XL-Trace application (from Table 1))
- Location
  - Indoors
  - Outdoors
  - Aboveground
  - Buried
- Maintain temperature (T_M)
- Maximum system temperature (T_{MAX})
- Minimum ambient temperature (T_A)
- Pipe diameter and material
- Pipe length
- Thermal insulation type and thickness
- Supply voltage

Example: Pipe Freeze Protection – Water Piping

Location	Aboveground, outdoor
Maintain temperature (T_M)	40°F (4°C)
Maximum system temperature (T_{MAX})	80°F (27°C)
Minimum ambient temperature (T_A)	–20°F (–29°C)
Pipe diameter and material	2-inch plastic
Pipe length	300 ft (91 m)
Thermal insulation type and thickness	1-inch fiberglass
Supply voltage	120 V

Example: Pipe Freeze Protection – Grease Waste Line

Location	Buried
Maintain temperature (T_M)	110°F (43°C)
Maximum system temperature (T_{MAX})	125°F (52°C)
Minimum ambient temperature (T_A)	50°F (10°C) (soil temperature)
Pipe diameter and material	4-inch metal
Pipe length	200 ft (61 m)
Thermal insulation type and thickness	1-inch rigid cellular urethane
Supply voltage	208 V

Pipe Heat Loss Calculations

To select the proper heating cable you must first determine the pipe heat loss. To do this you must first calculate the temperature differential (ΔT) between the pipe maintain temperature and the minimum ambient temperature.

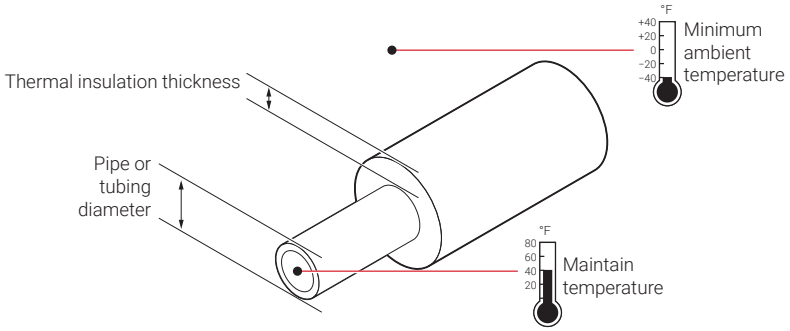


Fig. 10 Pipe heat loss

Calculate temperature differential ΔT

To calculate the temperature differential (ΔT), use the formula below:

$\Delta T = T_M - T_A$

Example: Pipe Freeze Protection – Water Piping

T_M 40°F (4°C)

T_A –20°F (–29°C)

ΔT = 40°F – (–20°F) = **60°F**

ΔT = 4°C – (–29°F) = **33°C**

Example: Flow Maintenance – Grease Waste Line

T_M 110°F (43°C)

T_A 50°F (10°C)

ΔT = 110°F – (50°F) = **60°F**

ΔT = 43°C – (10°C) = **33°C**

Determine the pipe heat loss

Match the pipe size, insulation thickness, and temperature differential (ΔT) from Table 2 to determine the base heat loss of the pipe (Q_B).

Example: Pipe Freeze Protection – Water Piping

Pipe diameter	2 inch
Insulation thickness	1 inch
ΔT	60°F (33°C)

Heat loss (Q_B) for 60°F must be calculated through interpolation between ΔT at 50°F and ΔT at 100°F from . For difference between the ΔT of 50°F and the ΔT of 100°F:

Q_{B-50}	3.2 W/ft (from)
Q_{B-100}	6.8 W/ft (from)
ΔT interpolation	ΔT 60°F is 20% of the distance between ΔT 50°F and ΔT 100°F
Q_{B-60}	Q_B-50 + [0.20 x (Q_B-100 – Q_B-50)] = 3.2 + [0.20 x (6.8 – 3.2)] = 3.9 W/ft
Pipe heat loss (Q_B)	**3.9 W/ft @ Tm 40°F (12.9 W/m @ Tm 4°C)**

Example: Flow Maintenance – Grease Waste Line

Pipe diameter	4 inch
Insulation thickness	1 inch
ΔT	60°F (33°C)

Q_B for 60°F must be calculated through interpolation between ΔT at 50°F and ΔT at 100°F from . For difference between the ΔT of 50°F and the ΔT of 100°F:

Q_{B-50}	5.4 W/ft (from)
Q_{B-100}	11.2 W/ft (from)
ΔT interpolation	ΔT 60°F is 20% of the distance between ΔT 50°F and ΔT 100°F
Q_{B-60}	Q_B-50 + [0.20 x (Q_B-100 – Q_B-50)] = 5.4 + [0.20 x (11.2 – 5.4)] = 6.6 W/ft
Pipe heat loss Q_B	**6.6 W/ft @ Tm 110°F (21.5 W/m @Tm 43°C)**

Compensate for insulation type and pipe location

The base heat loss is calculated for a pipe insulated with thermal insulation with a k-factor ranging from 0.2 to 0.3 BTU/hr–°F-ft²/in (fiberglass or foamed elastomer) in an outdoor, or buried application. To get the heat loss for pipes insulated with alternate types of thermal insulation and for pipes installed indoors, multiply the base heat loss of the pipe (Q_B) from Step 3 by the insulation multiple from and the indoor multiple from Table 3 to get the corrected heat loss:

$Q_{CORRECTED}$ = Q_B x Insulation multiple x Indoor multiple

Example: Pipe Freeze Protection – Water Piping

Location	Aboveground, outdoor
Thermal insulation thickness and type	1-inch fiberglass
Pipe heat loss Q_B	3.9 W/ft @ T_M 40°F (12.9 W/m @ T_M 4°C)
$Q_{CORRECTED}$	3.9 W/ft x 1.00 x 1.00 = **3.9 W/ft @ Tm 40°F (12.9 W/m @ Tm 4°C)**

Example: Flow Maintenance – Grease Waste Line

Location	Buried
Thermal insulation type and thickness	1-inch rigid cellular urethane
Pipe heat loss Q_B =	6.6 W/ft @ T_M 110°F (21.5 W/m @ T_M 43°C)
$Q_{CORRECTED}$ =	6.6 W/ft x 0.6 x 1.00 = **4.0 W/ft @ Tm 110°F (13.1 W/m @ Tm 43°C)**

TABLE 2 PIPE HEAT LOSS (Q_B) FOR OUTDOOR OR BURIED PIPE (W/FT) FOR 1/2 TO 3-1/2 INCHES

Insulation thickness (in)	(ΔT)		Pipe diameter (IPS) in inches								
	°F	°C	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2
0.5	20	11	1.0	1.2	1.4	1.6	1.8	2.2	2.5	3.0	3.4
	50	28	2.5	2.9	3.5	4.1	4.6	5.5	6.5	7.7	8.6
	100	56	5.2	6.1	7.2	8.6	9.6	11.5	13.5	16.0	18.0
	150	83	8.1	9.5	11.2	13.4	14.9	17.9	21.1	25.0	28.1
1.0	20	11	0.6	0.7	0.8	1.0	1.1	1.3	1.5	1.7	1.9
	50	28	1.6	1.9	2.2	2.5	2.8	3.2	3.8	4.4	4.9
	100	56	3.4	3.9	4.5	5.2	5.8	6.8	7.8	9.1	10.2
	150	83	5.3	6.1	7.0	8.2	9.0	10.6	12.2	14.2	15.9
1.5	20	11	0.5	0.6	0.7	0.8	0.8	1.0	1.1	1.3	1.4
	50	28	1.3	1.5	1.7	1.9	2.1	2.4	2.8	3.2	3.6
	100	56	2.8	3.1	3.5	4.0	4.4	5.1	5.8	6.7	7.4
	150	83	4.3	4.8	5.5	6.3	6.9	8.0	9.1	10.5	11.6
2.0	20	11	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1
	50	28	1.1	1.3	1.4	1.6	1.8	2.0	2.3	2.6	2.9
	100	56	2.4	2.7	3.0	3.4	3.7	4.2	4.8	5.5	6.0
	150	83	3.7	4.2	4.7	5.3	5.8	6.6	7.5	8.5	9.4
2.5	20	11	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0
	50	28	1.0	1.2	1.3	1.4	1.6	1.8	2.0	2.3	2.5
	100	56	2.2	2.4	2.7	3.0	3.3	3.7	4.2	4.7	5.2
	150	83	3.4	3.7	4.2	4.7	5.1	5.8	6.5	7.4	8.1
3.0	20	11	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9
	50	28	1.0	1.1	1.2	1.3	1.4	1.6	1.8	2.0	2.2
	100	56	2.0	2.2	2.4	2.7	2.9	3.3	3.7	4.2	4.6
	150	83	3.1	3.4	3.8	4.3	4.6	5.2	5.8	6.6	7.1
4.0	20	11	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.7
	50	28	0.9	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.8
	100	56	1.8	2.0	2.1	2.4	2.5	2.9	3.2	3.5	3.8
	150	83	2.8	3.0	3.4	3.7	4.0	4.4	4.9	5.5	6.0

Note: Multiply the W/ft heat loss values by 3.28 for W/m.

TABLE 1.2 CONTINUED PIPE HEAT LOSS (Q_B) FOR OUTDOOR OR BURIED PIPE (W/FT) FOR 4 TO 20 INCHES

Insulation thickness (in)	(ΔT)		Pipe diameter (IPS) in inches								
	°F	°C	4	6	8	10	12	14	16	18	20
0.5	20	11	3.8	5.3	6.8	8.4	9.9	10.8	12.2	13.7	15.2
	50	28	9.6	13.6	17.4	21.4	25.2	27.5	31.3	35.0	38.8
	100	56	20.0	28.4	36.3	44.6	52.5	57.4	65.2	73.0	80.8
	150	83	31.2	44.3	56.6	69.6	81.9	89.5	101.7	113.8	126.0
1.0	20	11	2.1	2.9	3.7	4.5	5.3	5.8	6.5	7.3	8.0
	50	28	5.4	7.5	9.4	11.5	13.5	14.7	16.6	18.6	20.5
	100	56	11.2	15.6	19.7	24.0	28.1	30.6	34.7	38.7	42.8
	150	83	17.5	24.3	30.7	37.4	43.8	47.8	54.1	60.4	66.7
1.5	20	11	1.5	2.1	2.6	3.2	3.7	4.0	4.5	5.0	5.5
	50	28	3.9	5.3	6.7	8.1	9.4	10.2	11.5	12.9	14.2
	100	56	8.1	11.1	13.9	16.8	19.6	21.3	24.0	26.8	29.5
	150	83	12.7	17.3	21.6	26.2	30.5	33.2	37.5	41.8	46.1
2.0	20	11	1.2	1.7	2.1	2.5	2.9	3.1	3.5	3.9	4.3
	50	28	3.1	4.2	5.2	6.3	7.3	7.9	8.9	9.9	10.9
	100	56	6.6	8.8	10.9	13.1	15.2	16.5	18.6	20.7	22.8
	150	83	10.2	13.8	17.0	20.5	23.8	25.8	29.0	32.3	35.5
2.5	20	11	1.1	1.4	1.7	2.1	2.4	2.6	2.9	3.2	3.5
	50	28	2.7	3.6	4.4	5.2	6.1	6.6	7.4	8.2	9.0
	100	56	5.6	7.4	9.1	10.9	12.6	13.7	15.3	17.0	18.7
	150	83	8.7	11.6	14.2	17.0	19.7	21.3	23.9	26.5	29.1
3.0	20	11	0.9	1.2	1.5	1.8	2.0	2.2	2.5	2.7	3.0
	50	28	2.4	3.1	3.8	4.5	5.2	5.6	6.3	7.0	7.6
	100	56	4.9	6.5	7.9	9.4	10.8	11.7	13.1	14.5	15.9
	150	83	7.7	10.1	12.4	14.7	16.9	18.3	20.5	22.6	24.8
4.0	20	11	0.8	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3
	50	28	2.0	2.5	3.1	3.6	4.1	4.4	5.0	5.5	6.0
	100	56	4.1	5.3	6.4	7.5	8.6	9.3	10.3	11.4	12.4
	150	83	6.4	8.3	10.0	11.8	13.4	14.5	16.1	17.8	19.4

Note: Multiply the W/ft heat loss values by 3.28 for W/m.

TABLE 3 INDOOR PIPE HEAT LOSS MULTIPLES

Fiberglass thickness (in)	Indoor multiple
0.5	0.79
1	0.88
1.5	0.91
2	0.93
2.5	0.94
3	0.95
4	0.97

TABLE 4 INSULATION HEAT LOSS MULTIPLES

k factor at 50°F (10°C) (BTU/hr–°F-ft²/in)	Insulation multiple	Examples of preformed pipe insulation
0.1–0.2	0.6	Rigid cellular urethane (ASTM C591)
0.2–0.3	1.0	Glass fiber (ASTM C547) Foamed elastomer (ASTM C534)
0.3–0.4	1.4	Cellular glass (ASTM C552) Mineral fiber blanket (ASTM C553)

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 2 Select the heating cable

To select the appropriate XL-Trace heating cable for your application, you must determine your cable supply voltage, power output, and outer jacket. Once you select these, you will be able to determine the catalog number for your cable.

Heating Cable Catalog Number

Before beginning, take a moment to understand the structure underlying heating cable catalog numbers. You will refer to this numbering convention throughout the product selection process. Your goal is to determine the catalog number for the product that best suits your needs.

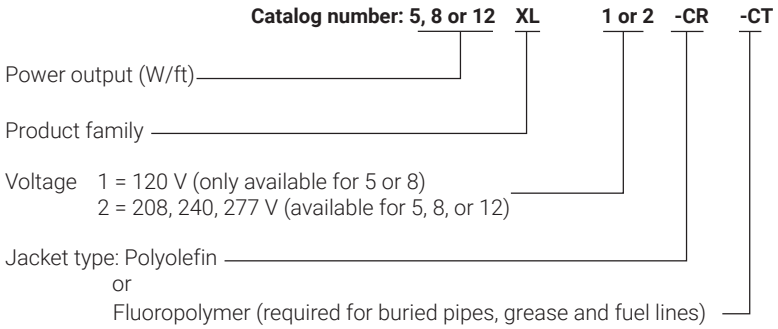


Fig. 11 Heating cable catalog number

Select the heating cable from Fig. 12 that provides the required power output to match the corrected heat loss for your application. Fig. 12 shows the power output for the heating cables on metal pipe at 120/208 volts. To correct the power output for other applied voltage or plastic pipes multiply the power output at the desired maintain temperature by the factors listed in . If the pipe heat loss, $Q_{CORRECTED}$, is between the two heating cable power output curves, select the higher-rated heating cable.

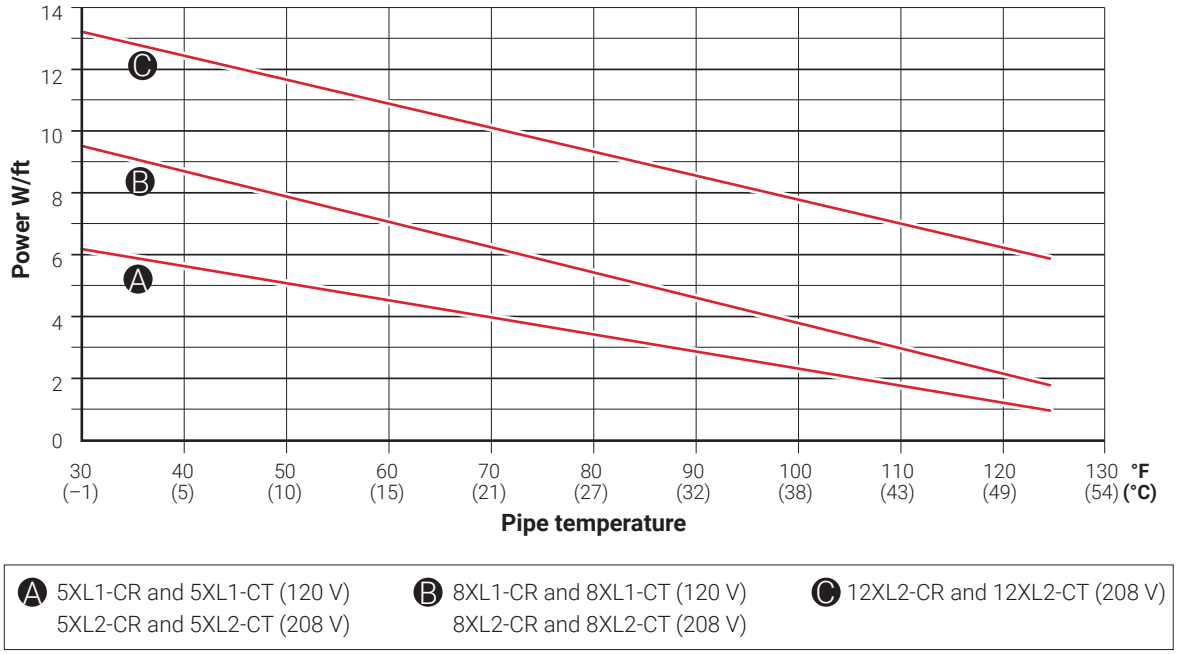


Fig. 12 Heating cable power output on metal pipe

TABLE 5 POWER OUTPUT CORRECTION FACTORS

Voltage correction factors	5XL1	8XL1	5XL2	8XL2	12XL2
120 V	1.00	1.00	–	–	–
208 V	–	–	1.00	1.00	1.00
240 V	–	–	1.12	1.12	1.14
277 V	–	–	1.29	1.27	1.30
Plastic pipe correction factor (With AT-180 Aluminum tape)	0.75	0.75	0.75	0.75	0.75

Confirm that the corrected power output of the heating cable selected is greater than the corrected pipe heat loss ($Q_{CORRECTED}$). If $Q_{CORRECTED}$ is greater than the power output of the highest-rated heating cable, you can:

- Use two or more heating cables run in parallel
- Use thicker insulation to reduce heat loss
- Use insulation material with a lower k factor to reduce heat loss

Example: Pipe Freeze Protection – Water Piping

Pipe maintain temperature (T_M)	40°F (4°C) (from Step 1)
$Q_{CORRECTED}$	$Q_{CORRECTED}$ = 3.9 W/ft @ T_M 40°F (13.1 W/m @ T_M 4°C)
Supply voltage	120 V (from Step 1)
Pipe material	Plastic (from Step 1)
Select heating cable:	Q_B = 3.9 W/ft @ T_M 40°F (from Step 1)
	5XL1= 5.6 W/ft @ 40°F (from Fig. 12)
Supply voltage correction factor	1.00 (from Table 5)
Pipe material correction factor	Plastic = 0.75 (from Table 5)
Corrected heating cable power	5.6 W/ft x 1.00 x 0.75 = 4.2 W/ft
Selected heating cable	**5XL1**

Example: Flow Maintenance – Grease Waste Line

Pipe maintain temperature (T_M)	110°F (43°C) (from Step 1)
$Q_{CORRECTED}$	3.9 W/ft @ T_M 110°F (13.1 W/m @ T_M 43°C)
Supply voltage	208 V (from Step 1)
Pipe material	Metal (from Step 1)
Select heating cable:	Q_B = 3.9 W/ft @ T_M 110°F (from Step 1)
	12XL2= 7.0 W/ft @110°F (from Fig. 12)
Supply voltage correction factor	1.00 (from Table 5)
Pipe material correction factor	Metal = 1.00
Corrected heating cable power	7.0 x 1.00 x 1.00 = 7.0 W/ft
Selected heating cable	**12XL2**

Confirm exposure temperature rating for the heating cable

Refer to to verify that the maximum system temperature does not exceed the exposure temperature of the selected heating cable.

TABLE 6 HEATING CABLE TEMPERATURE RATINGS

	5XL1	5XL2	8XL1	8XL2	12XL2
Maximum maintain temperature (T_M)	150°F (65°C)	150°F (65°C)	150°F (65°C)	150°F (65°C)	150°F (65°C)
Maximum exposure temperature (T_{EXP})	150°F (65°C)	150°F (65°C)	150°F (65°C)	150°F (65°C)	185°F (85°C)

Example: Pipe Freeze Protection – Water Piping

Maximum system temperature (T_{MAX})	80°F (27°C) (from Step 1)
Selected heating cable	5XL1 (from previous step)
Maximum heating cable exposure temperature (T_{EXP})	150°F (65°C) (from Table 6)
$T_{MAX} < T_{EXP}$	**Yes**

Example: Flow Maintenance - Grease Waste Line

Maximum system temperature (T_{MAX})	125°F (52°C) (from Step 1)
Selected heating cable	12XL2 (from previous step)
Maximum heating cable exposure temperature (T_{EXP})	185°F (85°C)(from Table 6)
$T_{MAX} < T_{EXP}$	**Yes**

Select Outer Jacket

Select the appropriate heating cable outer jacket for the application.
Jacket options are:

-CR Compatible with most XL-Trace applications

-CT Required for buried pipe freeze protection and for grease and fuel line flow maintenance; may be used in other XL-Trace applications for improved mechanical strength and chemical resistance.

Example: Pipe Freeze Protection – Water Piping

Selection: 5XL1-CR

Example: Flow Maintenance - Grease Waste Line

Selection: 12XL2-CT

Step 3 Determine the heating cable length

In Step 2 you selected the appropriate heating cable and the number of runs of heating cable required for the pipe. Multiply the length of the pipe by the number of heating cable runs for the heating cable length.

Heating cable length = Pipe length x No. heating cable runs

Additional heating cable will be required for heat sinks and connection kits. Use Table 7 and Table 8 to determine the additional footage required for heat sinks (valves, flanges, and pipe supports). You will determine the additional heating cable for connection kits in Step 5. Round up fractional lengths to ensure heating cable lengths are sufficient.

Total heating cable length required = (Pipe length x No. heating cable runs) + Additional heating cable for heat sinks (valves, pipe supports, and flanges)

TABLE 7 ADDITIONAL HEATING CABLE FOR VALVES

Pipe diameter (IPS) (inches)	Heating cable (feet (meters))	
1/2	0.8	(0.24)
3/4	1.3	(0.4)
1	2.0	(0.6)
1-1/4	3.3	(1.1)
1-1/2	4.3	(1.3)
2	4.3	(1.3)
3	4.3	(1.3)
4	4.3	(1.3)
6	5.0	(1.5)
8	5.0	(1.5)
10	5.6	(1.7)
12	5.9	(1.9)
14	7.3	(2.2)
18	9.4	(2.9)
20	10.5	(3.2)

TABLE 8 ADDITIONAL HEATING CABLE FOR PIPE SUPPORTS AND FLANGES

Support	Additional cable
Pipe hangers (insulated)	No additional heating cable
Pipe hangers noninsulated and U-bolt supports	Add 2x pipe diameter
Welded support shoes	Add 3x the length of the shoe
Flanges	**Add 2x pipe diameter**

Note: For applications where more than one heating cable is required per foot of pipe, this correction factor applies for each cable run.

Example: Pipe Freeze Protection – Water Piping

Pipe length	300 ft (91 m) (from Step 1)
Pipe diameter	2-inch plastic (from Step 1)
Number of heating cable runs	1 (from Step 2)
Valves	3 gate valves 4.3 ft x 3 gate valves = 12.9 ft (3.9 m)
Pipe supports	5 pipe hangers with U-bolts 2-inch pipe diameter = 2 / 12 = 0.17 ft [0.17 ft pipe diameter x 2] x 5 pipe supports = 1.7 ft (0.5 m)
Flanges	0
Total heating cable for heat sinks	12.9 ft (3.9 m) + 1.7 ft (0.5 m) = 14.6 ft (4.4 m) Rounded up to 15 ft (5 m)
Total heating cable length required	300 ft (91 m) x 1 run + 15 ft = **315 ft (96 m) of 5XL1-CR** (**Note:** AT-180 Aluminum tape is required for installing heating cable on plastic pipe.)

Example: Flow Maintenance – Grease Waste Line

Pipe length	200 ft (61 m) (from Step 1)
Pipe diameter	4-inch metal (from Step 1)
Number of heating cable runs	1 (from Step 2)
Valves	2 gate valves [4.3 ft x 2 gate valves] x 1 run = 8.6 ft (2.6 m)
Pipe supports	2 non-insulated hangers 4-inch pipe diameter = 4 /12 = 0.33 ft [(0.33 ft pipe diameter x 2) x 2 pipe supports] x 1 run = 1.3 ft (0.4 m)
Flanges	2 4-inch pipe diameter = 4 /12 = 0.33 ft [(2 x 0.33 ft (pipe diameter)) x 2 flanges] x 1 run = 1.3 ft (0.4 m)
Total heating cable for heat sinks	8.6 ft (2.6 m) + 1.3 ft (0.4 m) + 1.3 ft (0.4 m) = 11.2 ft (2.2 m) Rounded up to 12 ft (3 m)
Total heating cable length required	200 ft x 1 run + 12 ft = **212 ft (65 m) of 12XL2-CT**

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 4 Determine the electrical parameters

To determine the electrical requirements for your application, you must determine the number of circuits and calculate the transformer load.

Determine Number of Circuits

To determine the number of circuits, you need to know:

- Total heating cable length
- Supply voltage
- Minimum start-up temperature

Use Table 9 to determine the maximum circuit length allowed. If the total heating cable length exceeds the maximum circuit length for the expected start-up temperature, more than one circuit will be required.

$$\text{Number of circuits} = \frac{\text{Heating cable length required}}{\text{Maximum heating cable circuit length}}$$

Important: Select the smallest appropriate ground-fault circuit breaker size.

WARNING: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of nVent, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

TABLE 9 MAXIMUM CIRCUIT LENGTH IN FEET

Start-up temperature (°F)	40°F / 110°F Maintain*										
	CB size (A)	5XL1	8XL1	5XL2			8XL2			12XL2		
		120 V	120 V	208 V	240 V	277 V	208 V	240 V	277 V	208 V	240 V	277 V
–20°F	15	101	76	174	178	183	131	138	146	111	114	117
	20	134	101	232	237	245	175	184	194	148	151	156
	30	201	151	349	356	367	262	276	291	223	227	234
	40	270	201	465	474	478	349	368	388	297	303	312
0°F	15	115	86	199	203	209	149	157	166	120	122	126
	20	153	115	265	271	279	199	209	221	160	163	168
	30	230	172	398	406	419	298	314	331	239	244	252
	40	270	210	470	490	530	370/399	390/420	420/443	319	326	336
20°F	15	134	100	232	237	244	173	182	192	126	129	133
	20	178	133	309	315	325	231	243	257	169	172	177
	30	270	200	464	473	488	346	365	385	253	258	266
	40	270	210	470	490	530	370/462	390/486	420/513	340/349	344	355
40°F	15	160	119	278	283	292	206	217	229	142	145	150
	20	214	159	370	378	390	275	290	306	190	194	200
	30	270	210	470	490	530	370/416	390/438	420/462	285	291	300
	40	270	210	470	490	530	370/554	390/584	420/616	340/398	360/406	380/419
50°F (buried)	15	–	–	–	–	–	228	240	254	152	155	160
	20	–	–	–	–	–	304	320	338	203	207	213
	30	–	–	–	–	–	457	481	507	304	310	320
	40	–	–	–	–	–	609	641	676	405	414	427
65°F (indoors grease)	15	–	–	–	–	–	272	286	302	169	172	178
	20	–	–	–	–	–	362	381	402	225	230	237
	30	–	–	–	–	–	543	572	603	338	345	356
	40	–	–	–	–	–	610	660	720	430	460	490

*When maximum circuit length is listed in:
- black type, the value is for applications with a 40°F maintain
- red type, the value is for applications with a 110°F maintain

TABLE 10 MAXIMUM CIRCUIT LENGTH IN METERS

Start-up temperature (°C)	4°C / 43°C Maintain*										
	CB size (A)	5XL1	8XL1	5XL2			8XL2			12XL2		
		120 V	120 V	208 V	240 V	277 V	208 V	240 V	277 V	208 V	240 V	277 V
−29°C	15	31	23	53	54	56	40	42	44	34	35	36
	20	41	31	71	72	75	53	56	59	45	46	48
	30	61	46	106	108	112	80	84	89	68	69	71
	40	82	61	142	145	149	106	112	118	90	92	95
−18°C	15	35	26	61	62	64	45	48	51	36	37	38
	20	47	35	81	83	85	61	64	67	49	50	51
	30	70	52	121	124	128	91	96	101	73	74	77
	40	82	64	143	149	162	113/122	119/128	128/135	97	99	102
−7°C	15	41	31	71	72	74	53	56	59	39	39	41
	20	54	41	94	96	99	70	74	78	51	52	54
	30	82	61	141	144	149	106	111	117	77	79	81
	40	82	64	143	149	162	113/141	119/148	128/156	104/106	105	108
4°C	15	49	36	85	86	89	63	66	70	43	44	46
	20	65	48	113	115	119	84	88	93	58	59	61
	30	82	64	143	149	162	113/127	119/134	128/141	87	89	91
	40	82	64	143	149	162	113/169	119/178	128/188	104/121	110/124	116/128
10°C (buried grease)	15	–	–	–	–	–	70	73	77	46	47	49
	20	–	–	–	–	–	93	98	103	62	63	65
	30	–	–	–	–	–	139	147	155	93	95	98
	40	–	–	–	–	–	186	195	206	124	126	130
18°C (indoors grease)	15	–	–	–	–	–	83	87	92	52	53	54
	20	–	–	–	–	–	110	116	123	69	70	72
	30	–	–	–	–	–	166	174	184	103	105	108
	40	–	–	–	–	–	186	201	220	131	140	149

* When maximum circuit length is listed in:
• black type, the value is for applications with a 4°C maintain
• red type, the value is for applications with a 43°C maintain

Example: Pipe Freeze Protection – Water Piping

Total heating cable length	315 ft of 5XL1-CR (from Step 3)
Supply voltage	120 V (from Step 1)
Minimum start-up temperature	−20°F (−29°C) (from Step 1)
Number of circuits	315 ft / (201 ft max CL) = 1.6 circuits
	Round up to 2 circuits

Example: Flow Maintenance – Grease Waste Line

Total heating cable length	223 ft of 12XL2-CT (from Step 3)
Supply voltage	208 V (from Step 1)
Minimum start-up temperature	50°F (10°C) (from Step 1)
Number of circuits	223 ft / 304 ft = 0.7 circuits
	Round up to 1 circuit

DETERMINE TRANSFORMER LOAD

Transformers must be sized to handle the load of the heating cable. Use the following tables to calculate the total transformer load.

TABLE 11 TRANSFORMER SIZING (AMPERES/FOOT)

Minimum start-up temperature (°F)	5XL1	8XL1	5XL2			8XL2			12XL2		
	120	120	208	240	277	208	240	277	208	240	277
–20	0.119	0.159	0.069	0.067	0.065	0.092	0.087	0.082	0.108	0.106	0.102
0	0.105	0.139	0.060	0.059	0.057	0.080	0.076	0.072	0.100	0.098	0.095
20	0.090	0.120	0.052	0.051	0.049	0.069	0.066	0.062	0.095	0.093	0.090
40	0.075	0.101	0.043	0.042	0.041	0.058	0.055	0.052	0.084	0.083	0.080
50	–	–	–	–	–	0.053	0.050	0.047	0.079	0.077	0.075
65	–	–	–	–	–	0.044	0.042	0.040	0.072	0.070	0.067

TABLE 12 TRANSFORMER SIZING (AMPERES/METER)

Minimum start-up temperature (°C)	5XL1	8XL1	5XL2			8XL2			12XL2		
	120	120	208	240	277	208	240	277	208	240	277
–20	0.391	0.521	0.226	0.221	0.215	0.301	0.286	0.270	0.354	0.347	0.336
–18	0.343	0.457	0.198	0.194	0.188	0.264	0.251	0.238	0.329	0.322	0.312
–7	0.294	0.394	0.170	0.166	0.161	0.227	0.216	0.205	0.311	0.305	0.296
4	0.246	0.331	0.142	0.139	0.135	0.191	0.181	0.172	0.276	0.271	0.263
10	–	–	–	–	–	0.172	0.164	0.155	0.259	0.254	0.246
18	–	–	–	–	–	0.145	0.138	0.130	0.233	0.228	0.221

Use Table 11 or to determine the applied voltage and the maximum A/ft (A/m) at the minimum start up temperature to calculate the transformer load as follows:

$$\frac{\text{Max A/ft at minimum start-up temperature} \times \text{Heating cable length (ft)} \times \text{Supply voltage}}{1000} = \text{Transformer load (kW)}$$

Example: Pipe Freeze Protection – Water Piping

Total heating cable length	315 ft of 5XL1-CR (from Step 3)
Minimum start-up temperature	–20°F (–29°C) (from Step 1)
Circuit breaker sizing	30 A

$$\frac{\text{Max A/ft at } -20°\text{F} \times \text{Total feet} \times \text{Supply voltage}}{1000} = (0.119 \text{ A/ft} \times 315 \text{ ft} \times 120 \text{ V}) / 1000$$

Transformer load (kW) = 4.5 kW

Example: Flow Maintenance – Grease Waste Line

Total heating cable length	212 ft of 12XL2-CT (from Step 3)
Supply voltage	208 V
Minimum start-up temperature	50°F (10°C) (from Step 1)

$$\frac{\text{Max A/ft at 50°F} \times \text{Total feet} \times \text{Supply voltage}}{1000} = (0.079 \text{ A/ft} \times 212 \text{ ft} \times 208 \text{ V}) / 1000$$

Transformer load (kW) = 3.5 kW

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 5 Select the connection kits and accessories

All XL-Trace systems require a power connection and end seal kit. Splice and tee kits are used as required. Use Table 13 on page 27 (for aboveground applications) and Table 15 on page 29 (for buried applications) to select the appropriate connection kits.

Note: Add extra cable on your Bill of Materials for power connections, tees, and end seals. See Table 13 on page 27, Table 15 on page 29, and Table 16 on page 30 for more information.

WARNING: Approvals and performance are based on the use of nVent-specified parts only. Do not substitute parts or use vinyl electrical tape.

ABOVEGROUND PIPING

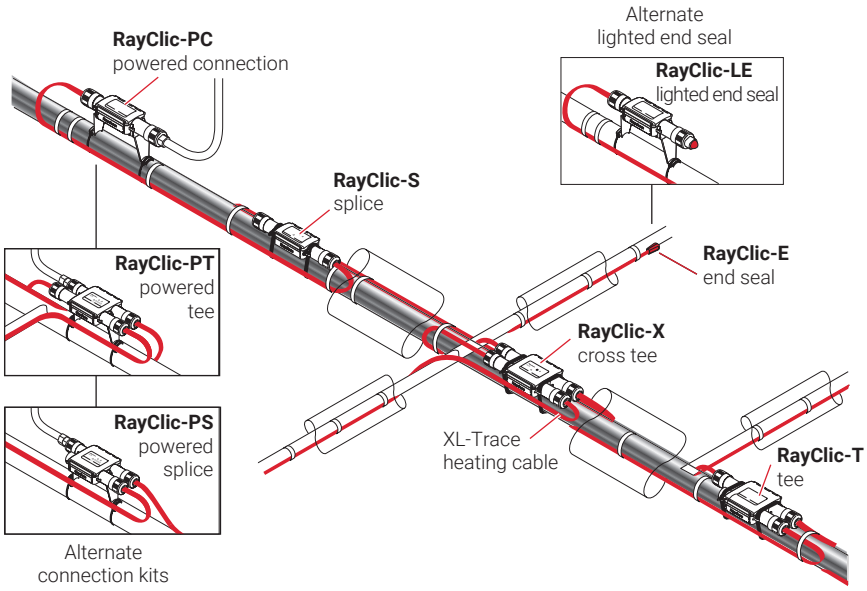


Fig. 13 RayClic connection system

Use the following table for general piping, and grease waste and fuel lines. Develop a bill of materials from the connection kits listed in this table.

Note: Connection kits must be off the pipe when installed on grease waste, fuel oil, or pipes exceeding 150°F (65°C).

TABLE 13 CONNECTION KITS AND ACCESSORIES FOR ABOVEGROUND PIPING

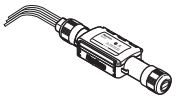
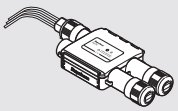
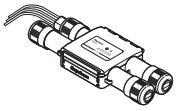
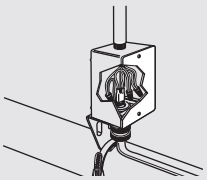
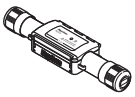
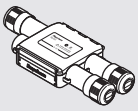
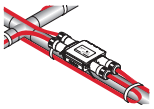
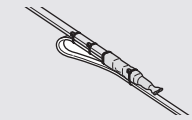
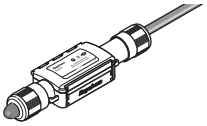
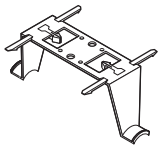
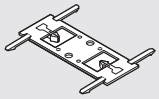
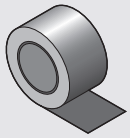
	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
Connection kits					
	RayClic-PC	Power connection and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	2 ft (0.6 m)
	RayClic-PS	Powered splice and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	4 ft (1.2 m)
	RayClic-PT	Powered tee and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	6 ft (1.8 m)
	FTC-P[2]	Power connection and end seal kit **Note:** FTC-P is required for circuits requiring 40 A circuit breakers.	1	1 per circuit	2 ft (0.6 m)
	RayClic-S	Splice used to join two sections of heating cable	1	As required	2 ft (0.6 m)
	RayClic-T	Tee kit with end seal; use as needed for pipe branches	1	As required	2 ft (0.6 m)
	RayClic-X	Cross connection to connect four heating cables	1	As required	8 ft (2.4 m)
	FTC-HST[3]	Low-profile splice/tee; use as needed for pipe branches	2	As required	3 ft (0.9 m)
	RayClic-LE	Lighted end seal (RayClic-SB-04 pipe mounting bracket included)	1	Alternate end seal	2 ft (0.6 m)
	RayClic-E	Replacement end seal	1	Additional end seal	0.3 ft (0.1 m)

TABLE 13 CONNECTION KITS AND ACCESSORIES FOR ABOVEGROUND PIPING

	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
Accessories					
	RayClic-SB-04	Pipe mounting bracket. Required for mounting the kits off the pipe for exposure temperatures greater than 150°F (65°C) and for grease and fuel line splices and tees.	1	As required	–
	RayClic-SB-02	Wall mounting bracket	1	As required	–
	ETL	"Electric Traced" label (use 1 label per 10 feet of pipe)	1	1 label per 10 feet (3 m) of pipe	–
	GT-66	Glass cloth adhesive tape for attaching heating cable to pipe at 40°F (4°C) or above.	66 ft (20 m)	See "Table 14"	–
	GS-54	Glass cloth adhesive tape for attaching heating cable to pipe above –40°F (–40°C).	54 ft (20 m)	See "Table 14"	–
	AT-180	Aluminum tape. Required for attaching heating cable to plastic pipe (use 1 foot of tape per foot of heating cable).	180 ft (55 m)	1 ft/ft [0.3 m/m] of heating cable	–

[1] Allow extra heating cable for ease of component installation.
[2] Junction box not included.
[3] One RayClic-E end seal is required for each FTC-HST used as a tee kit.

TABLE 14 QUANTITY OF GLASS CLOTH ADHESIVE TAPE REQUIRED (ATTACH AT 1-FOOT INTERVALS)

Pipe size (in)	<2	3	4	6	8	10
Feet of pipe per GT-66 roll	60 (18 m)	50 (15 m)	40 (12 m)	25 (8 m)	20 (6 m)	15 (5 m)
Feet of pipe per GS-54 roll	49 (15 m)	41 (13 m)	33 (10 m)	20 (6 m)	16 (5 m)	12 (4 m)

Buried Piping

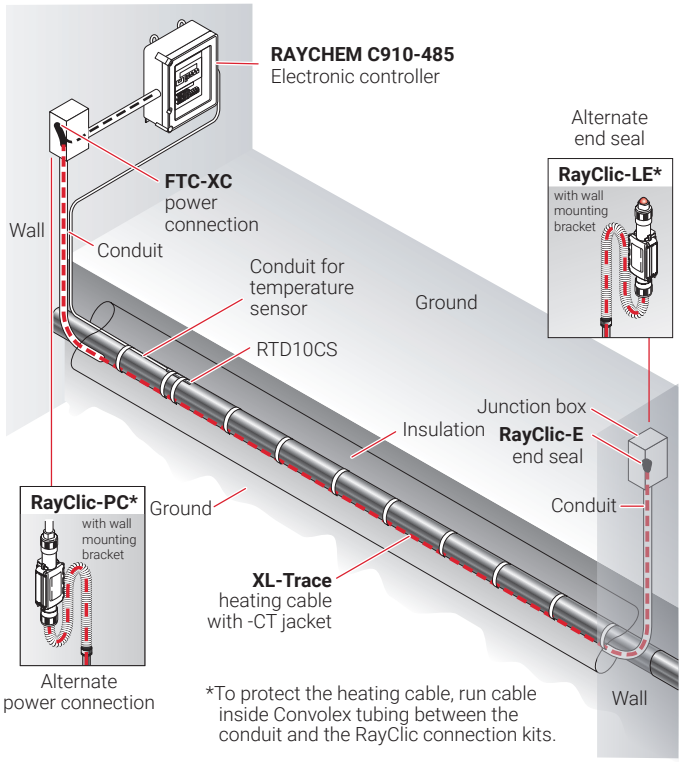


Fig. 14 Typical buried piping system

Use the following for buried water piping and grease waste lines. Note that all connections must be aboveground and that no splices/tees are allowed. Develop a bill of materials from the connection kits in this table.

TABLE 15 CONNECTION KITS AND ACCESSORIES FOR BURIED PIPING

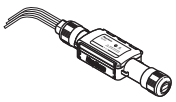
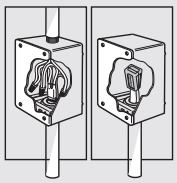
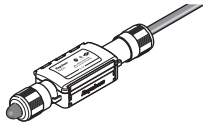
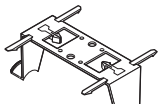
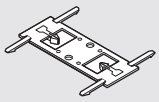
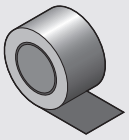
	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
	RayClic-PC	Power connection and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	2 ft (0.6 m)
	FTC-XC	The FTC-XC power connection and end seal kit is for use with XL-Trace heating cable that is run through conduit to a junction box. Materials for one power connection and end seal is included in the kit. **Note:** FTC-XC is required for circuits requiring 40 A circuit breakers.	1	1 per circuit	2 ft (0.6 m)
	RayClic-LE	Lighted end seal (RayClic-SB-04 pipe mounting bracket included)	1	Alternate end seal	2 ft (0.6 m)
	RayClic-E	Replacement end seal	1	Additional end seal	0.3 ft (0.1 m)

TABLE 15 CONNECTION KITS AND ACCESSORIES FOR BURIED PIPING

	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
Accessories					
	RayClic-SB-04	Pipe mounting bracket	1	As required	–
	RayClic-SB-02	Wall mounting bracket	1	As required	–
	ETL	"Electric Traced" label (use 1 label per 10 feet of pipe)	1	1 label per 10 feet (3 m) of pipe	–
	GT-66	Glass cloth adhesive tape for attaching heating cable to pipe at 40°F (4°C) or above.	66 ft (20 m)	See Table 16	–
	GS-54	Glass cloth adhesive tape for attaching heating cable to pipe above −40°F (−40°C).	54 ft (20 m)	See Table 16	–
	AT-180	Aluminum tape. Required for attaching heating cable to plastic pipe (use 1 foot of tape per foot of heating cable).	180 ft (55 m)	1 ft/ft [0.3 m/m] of heating cable	–

[1] Allow extra heating cable for ease of component installation.

TABLE 16 QUANTITY OF GLASS CLOTH ADHESIVE TAPE REQUIRED (ATTACH AT 1-FOOT INTERVALS)

Pipe size (in)	<2	3	4	6	8	10
Feet of pipe per GT-66 roll	60 (18 m)	50 (15 m)	40 (12 m)	25 (8 m)	20 (6 m)	15 (5 m)
Feet of pipe per GS-54 roll	49 (15 m)	41 (13 m)	33 (10 m)	20 (6 m)	16 (5 m)	12 (4 m)

Step 6 Select the control system

Temperature controls save energy by ensuring that the system is energized only when necessary. nVent offers a wide variety of monitoring and control options, including:

- Electronic thermostats provide higher accuracy of the heating cable circuit with thermistor sensors and built-in ground-fault protection.
- Electronic controllers provide superior accuracy with RTD temperature sensors, built-in ground-fault protection, monitoring and alarm output.
- Modbus® protocol communication over RS-485 system is supported using RAYCHEM ProtoNode multi-protocol gateways.

Note: Grease waste flow maintenance requires line sensing controllers such as the RAYCHEM ECW-GF, C910-485, or the ACS-30.

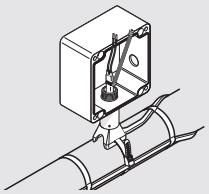
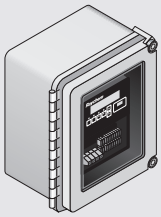
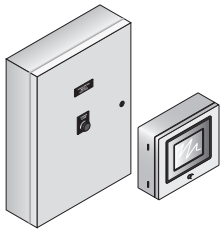
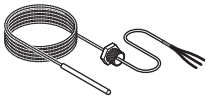
Use the following table to identify the control system suitable for your application. Contact your nVent representative or contact nVent directly at (800) 545-6258 for more information.

TABLE 17 TEMPERATURE CONTROL OPTIONS

Application	Electronic thermostat	Electronic controllers	
		Single-point	Multipoint
	ECW-GF	C910-485	ACS-30
Ambient sensing	x	x	x
Line sensing	x	x	x
Buried pipe	x	x	x
Sensor	Thermistor	RTD*	RTD*
Sensor length	35 ft	multiple options	multiple options
Set point range	32°F to 200°F (0°C to 93°C)	−76°F to 1058°F (−60°C to 570°C)	"
Enclosure	NEMA 4X	NEMA 4X	"
Deadband	2°F to 10°F (2°C to 6°C)	3°F (1.6°C)	"
Enclosure limits	−40°F to 140°F (−40°C to 60°C)	−40°F to 140°F (−40°C to 60°C)	"
Switch rating	30 A	30 A	"
Switch type	DPST	DPST	"
Electrical rating	100–277 V	100–277 V	"
Approvals	c-UL-us	c-CSA-us	"
Ground-fault protection	30 mA fixed	20 mA to 250 mA	"
Alarm outputs			"
AC relay	2 A at 277 Vac	100–277 V, 0.75 A max.	"
Dry contact relay	2 A at 48 Vdc	48 Vac/dc, 500 mA max.	"

* not included with unit

TABLE 18 CONTROL SYSTEMS

	Catalog number	Description
Electronic Thermostats and Accessories		
	ECW-GF	The ECW-GF electronic controller provides accurate temperature control with integrated 30-mA ground-fault protection. The controller can be programmed to maintain temperatures up to 200°F (93°C) at voltages from 100 to 277 V and can switch current up to 30 Amperes. The ECW-GF is complete with a 25-ft (7.6-m) temperature sensor for line, slab or ambient sensing temperature control, and is housed in a NEMA 4X rated enclosure. The controller features an AC/DC dry alarm contact relay.
	ECW-GF-DP	An optional remote display panel (ECW-GF-DP) can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	FTC-PSK	The FTC-PSK pipe stand and power connection kit is for use with XL-Trace heating cables. The stand is designed specifically for the RAYCHEM ECW-GF electronic controllers and is compatible with other junction boxes that have 1 inch NPT entries, threaded or non-threaded. Materials for one power connection and end seal are included in the kit.
Electronic Controllers and Sensors		
	C910-485	The C910-485 is a compact, full-featured microprocessor-based single-point heat-trace controller. The C910-485 provides control and monitoring of electrical heat-tracing circuits for both freeze protection and temperature maintenance, and can be set to monitor and alarm for high and low temperature, high and low current, ground-fault level, and voltage. The RAYCHEM C910-485 controller is available with an electromechanical relay (EMR) for use in ordinary areas. The C910-485 comes with an RS-485 communication module.
	ACS-UIT2 ACS-PCM2-5	The RAYCHEM ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in commercial freeze protection and flow maintenance applications. The RAYCHEM ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, with a single ACS-UIT2 user interface terminal. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electromechanical relays rated at 30 A up to 277 V.
	ProtoNode-RER	The RAYCHEM ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the RAYCHEM ACS-30 or C910-485 controllers. The ProtoNode-RER is for BACnet® or Metasys® N2 systems.
	RTD-200 RTD3CS RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with RAYCHEM C910-485 and ACS-30 controllers. RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing RTD3CS: temperature sensor with a 3-ft (0.9 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing RTD50CS: temperature sensor with a 50-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 7 Select the power distribution

Once the heating cable circuits have been defined, you must select how to provide power to them. Power to the XL-Trace heating cables can be provided in several ways: directly through the temperature control, through external contactors, or through HTPG power distribution panels.

Single circuit control

Heating cable circuits that do not exceed the current rating of the selected temperature control device shown in Table 18 can be switched directly (see Fig. 15).

Group control

If the current draw exceeds the switch rating, or if the controller will activate more than one circuit (group control, an external contactor must be used (see Fig. 15 on page 33).

Large systems with many circuits should use an HTPG power distribution panel. The HTPG is a dedicated power-distribution, control, ground-fault protection, monitoring, and alarm panel for freeze protection and broad temperature maintenance heat-tracing applications. This enclosure contains an assembled circuit-breaker panelboard. Panels are equipped with ground-fault circuit breakers with or without alarm contacts. The group control package allows the system to operate automatically in conjunction with an ambient-sensing thermostat, individual electronic, or duty cycle controller.

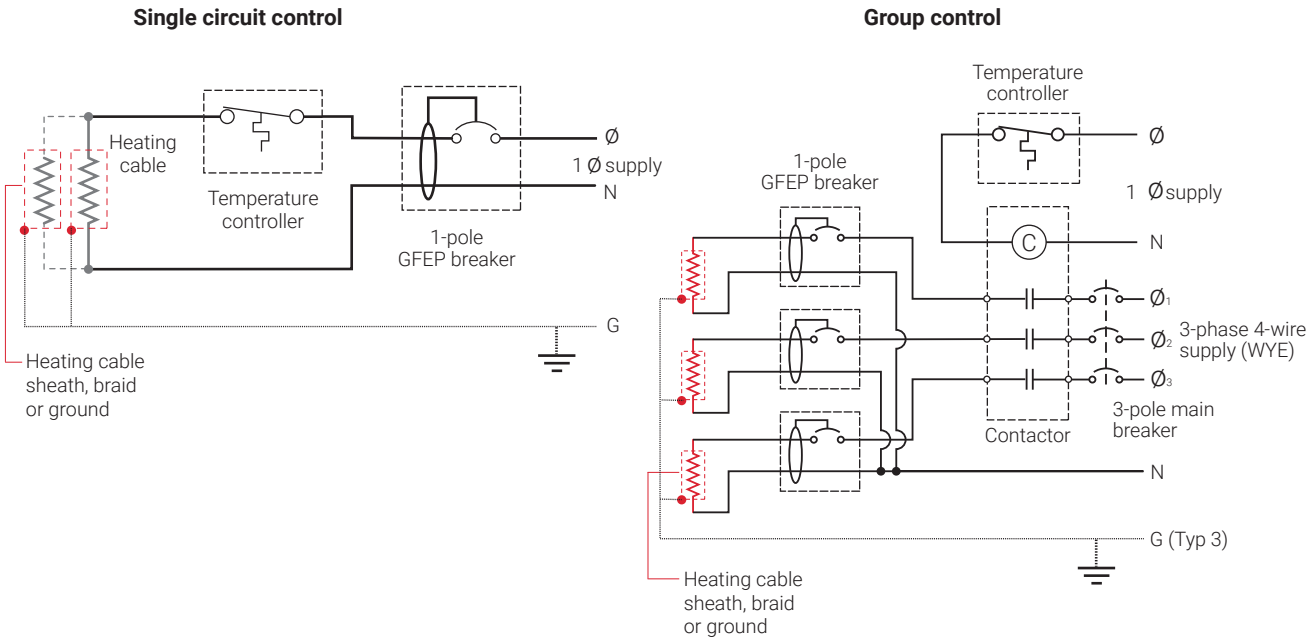


Fig. 15 Single circuit and group control

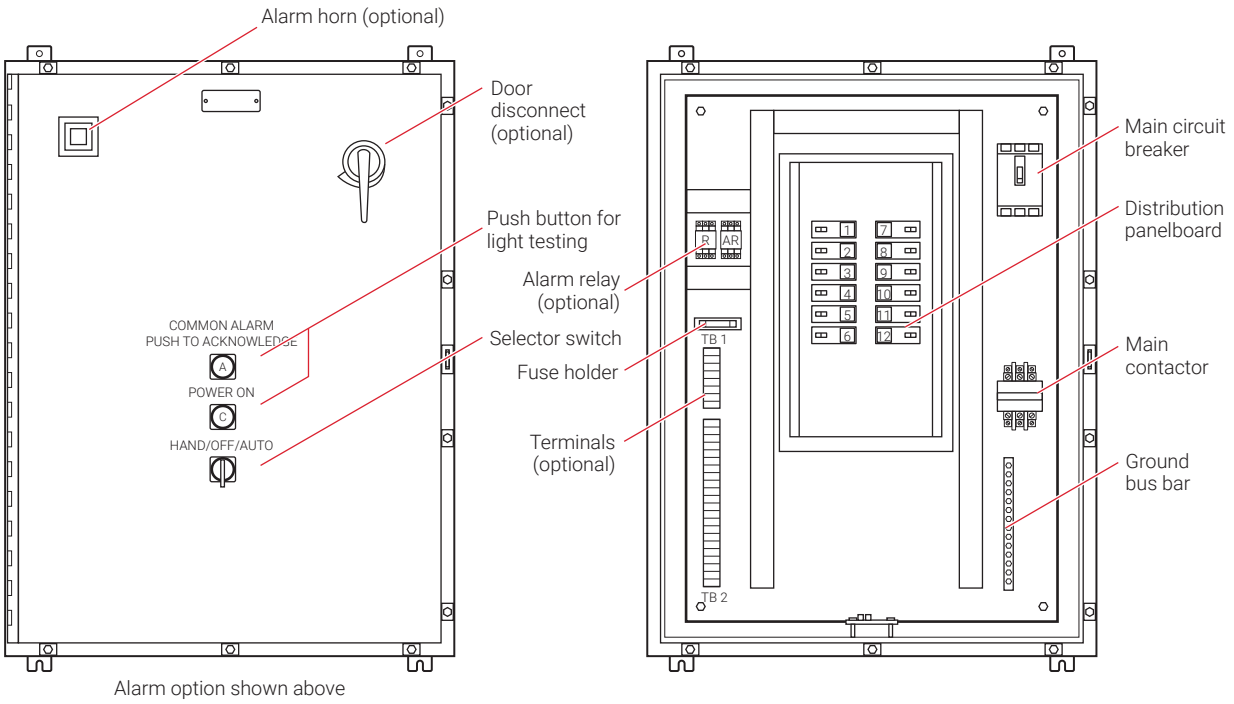


Fig. 16 HTPG power distribution panel

Three-phase, 4 wire supply (Wye)

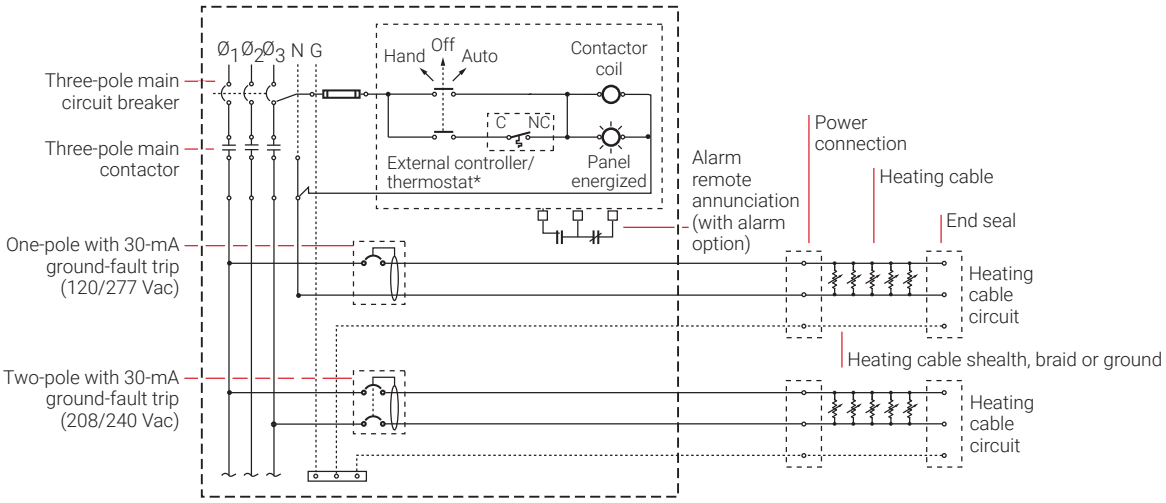


Fig. 17 HTPG power schematic

TABLE 19 POWER DISTRIBUTION

	Catalog number	Description
Power Distribution		
	HTPG	Heat-tracing power distribution panel with ground-fault and monitoring for group control.

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 8 Complete the Bill of Materials

If you used the Design Worksheet to document all your design parameters, you should have all the details necessary complete your Bill of Materials.

XL-TRACE SYSTEM PIPE FREEZE PROTECTION AND FLOW MAINTENANCE DESIGN WORKSHEET

Step 1 Determine design conditions and pipe heat loss

Design conditions

XL-Trace application	Location		Maintain temp. (T_M)	Max. system temp. (T_{MAX})	Min. ambient temp. (T_A)	Pipe diameter and material		Pipe length	Thermal insulation type and thickness	
Pipe freeze protection										
❑ Water piping	❑ Indoors ❑ Outdoors	❑ Aboveground ❑ Buried	_____	_____	_____	___ in	❑ Metal ❑ Plastic	___ ft (m)	❑ Fiberglass ❑ _____	___ in
Flow maintenance										
❑ Grease waste lines	❑ Indoors ❑ Outdoors	❑ Aboveground ❑ Buried	_____	_____	_____	___ in	❑ Metal ❑ Plastic	___ ft (m)	❑ Fiberglass ❑ _____	___ in
❑ Fuel lines	❑ Indoors ❑ Outdoors	❑ Aboveground ❑ Buried	_____	_____	_____	___ in	❑ Metal ❑ Plastic	___ ft (m)	❑ Fiberglass ❑ _____	___ in
Example: **✔ Water piping**	**✔ Aboveground** **✔ Outdoor**		**40°F**	**80°F**	**–20°F**	**2 in**	**✔ Plastic**	**300 ft**	**✔ Fiberglass**	**1 in**

Pipe heat loss

Calculate temperature differential ΔT

Pipe maintain temperature (T_M) _____ °F (°C)

Ambient temperature (T_A) _____ °F (°C)

_____ (T_M) – _____ (T_A) ⟶ = _____ **ΔT**

Example: Pipe Freeze Protection – Water Piping

Pipe maintain temperature (T_M) 40 °F °F **(from Step 1)**

Ambient temperature (T_A) –20 °F °F **(from Step 1)**

40 °F (T_M) – –20 °F (T_A) ⟶ = **60 °F** **ΔT**

Determine the pipe heat loss: See Table 2 for the base heat loss of the pipe (Q_B). If the ΔT for your system is not listed, interpolate between the two closest values.

$Q_{B\text{-}50}$ ΔT1	_____ W/ft (W/m)
$Q_{B\text{-}100}$ ΔT2	_____ W/ft (W/m)
Q_B	_____ W/ft (W/m)
Pipe diameter	_____ in
Insulation thickness	_____ in
ΔT	_____ °F (°C)
$Q_{B\text{-}50}$	_____ W/ft (W/m)
$Q_{B\text{-}50}$	_____ W/ft (W/m)

Example: Pipe Freeze Protection – Water Piping

Pipe diameter	2 in
Insulation thickness	1 in
ΔT	60°F
$Q_{B\text{-}50}$	3.2 W/ft
$Q_{B\text{-}100}$	6.8 W/ft
ΔT interpolation	ΔT 60°F is 20% of the distance between ΔT 50°F and ΔT 100°F $Q_{B\text{-}50} + [0.20 \times (Q_{B\text{-}100} - Q_{B\text{-}50})]$
$Q_{B\text{-}60}$	$3.2 + [0.20 \times (6.8 - 3.2)] = 3.9$ W/ft
Pipe heat loss ($Q_{B\text{-}60}$)	**3.9 W/ft @ T_M 40°F**

Compensate for insulation type and pipe location

See Table 2 for the pipe heat loss (Q_B). If the ΔT for your system is not listed, interpolate between the two closest values.
See Table 3 for indoor multiple
See Table 4 for insulation multiple

Location _____

Insulation thickness and type _____

Q_B _____ W/ft (W/m)

Insulation multiple _____

Indoor multiple (if applicable) _____

$$\frac{\text{_____}}{Q_B} \times \frac{\text{_____}}{\text{Insulation multiple}} \times \frac{\text{_____}}{\text{Indoor multiple (if applicable)}} = Q_{CORRECTED}$$

Example: Pipe Freeze Protection – Water Piping

Location: Aboveground, indoor

Thermal insulation thickness and type: 1-in fiberglass

Q_B: 3.9 W/ft @ T_M 40°F

Insulation multiple: 1.00

Indoor multiple: N/A

$$Q_{CORRECTED} = \frac{3.9\ \text{W/ft}}{Q_B} \times \frac{1.00}{\text{Insulation multiple}} = \textbf{3.9 W/ft @ } \mathbf{T_M}\ \textbf{40°F}$$

Step 2 Select the heating cable

Power output data: See Fig. 12
Power output correction factors: See Table 5
Heating cable temperature ratings: See Table 6

Pipe maintain temperature (T_M) _____ (from Step 1)

Corrected heat loss ($Q_{CORRECTED}$) _____ (from Step 1)

Supply voltage _____ (from Step 1)

Pipe material (metal or plastic) _____ (from Step 1)

XL-Trace application (water, fuel oil, or greasy waste) (from Step 1)

Pipe freeze protection: general water piping, sprinkler piping _____

Flow maintenance: greasy waste lines, fuel lines _____

Maximum system use temperature (T_{MAX}) _____ (from Step 1)

Heating cable selected _____ (from Step 1)

Power at T_M (120/208 V) _____

Power output correction factor _____ (from Step 1)

Plastic pipe correction factor _____

_____ x _____ = _____

Power at rated V factor | Plastic pipe correction factor | Corrected power

Is the heating cable power output ($P_{CORRECTED}$) ≥ the corrected heat loss? ❑ Yes ❑ No

If No, then design with additional runs of heating cable or thicker thermal insulation.

Example: Pipe Freeze Protection – Water Piping

Maintain temperature (T_M) 40°F

Corrected heat loss ($Q_{CORRECTED}$) 3.9 W/ft @ T_M 40°F

Supply voltage 120 V

Pipe material (metal or plastic*) plastic
(*AT-180 aluminum tape required for installing heating cable on plastic pipes)

Q_B = 3.9 W/ft @ T_M 40°F
Select curve C: 5XL1 = **5.6 W/ft @ 40°F**
Power output correction factor: 120 V = 1.00
Pipe material correction factor: Plastic = 0.75
Corrected heating cable power: 5.6 @/ft x 1.00 x 0.75 = **4.2 W/ft**
Select: **5XL1**
Maximum system temperature (T_{MAX}): 80°F
Maximum heating cable exposure temperature (T_{EXP}): 150°F
T_{MAX} < T_{EXP}: Yes

Select outer jacket

❑ -CR
❑ -CT

Example: Pipe Freeze Protection – Water Piping

5XL1-CR

Step 3 Determine the heating cable length

For additional heating cable allowance for valves: See Table 7.
For additional heating cable allowance for pipe supports and flanges: See Table 8.

Heat sinks

Type of valves	→ How many	x Additional heating cable	= **Total heating cable for valves**
Type of pipe supports	→ How many	x Additional heating cable *2-in pipe diameter = 0.17 ft	= **Total heating cable for pipe supports**
Type of flanges	→ How many	x Additional heating cable	= **Total heating cable for flanges**

Total heating cable for heat sinks: _____

Total heating cable length

(Pipe length x Number of heating cable runs) + Additional cable for valves, pipe supports, and flanges = **Total heating cable length required**

Example:

Heat sinks

Gate valves	→ 3	x 4.3 ft	= **12.9 ft**
Type of valves	How many	Additional heating cable	**Total**
Pipe hangers noninsulated and U-bolt supports	→ 5	x (0.17 ft* x 2 = 0.34 ft)	= **1.7 ft**
Type of pipe supports	How many	Additional heating cable *2-in pipe diameter = 0.17 ft	**Total**
n/a	→ 0	x 0	= **0 ft**
Type of flanges	How many	Additional heating cable	**Total**

Total: 14.6 ft rounded up to 15 ft

Total heating cable length

(300 ft Pipe length x 1 Number of heating cable runs) + 15 ft Additional cable for valves, pipe supports, and flanges = **315 ft Total heating cable length required**

Step 4 Determine the electrical parameters

Determine maximum circuit length and number of circuits

See Table 9 and Table 10.

Total heating cable length required _____

Supply voltage: ❑ 120 V ❑ 208 V ❑ 240 V ❑ 277 V

Circuit breaker size: ❑ 15 A ❑ 20 A ❑ 30 A ❑ 40 A

Minimum start-up temperature _____

Maximum circuit length _____

_____ / _____ = _____

Total heating cable length required / Maximum heating cable circuit length = **Number of circuits**

Example:

Total heating cable length required 315 ft of 5XL1-CR

Supply voltage: ☑ 120 V ❑ 208 V ❑ 240 V ❑ 277 V

Circuit breaker size: ❑ 15 A ❑ 20 A ☑ 30 A ❑ 40 A

Minimum start-up temperature −20°F

Maximum circuit length 201 ft

315 ft / 201 ft = **1.6 circuits, round up to 2**

Total heating cable length required / Maximum heating cable circuit length = **Number of circuits**

Determine transformer load

See Table 11 and Table 12

_____ x _____ x _____ / 1000 = _____

Max A/ft at minimum start-up temperature x Heating cable length x Supply voltage / 1000 = **Transformer load (kW)**

Example:

0.119 A/ft x 315 ft x 120 V / 1000 = **4.5 kW**

Max A/ft at minimum start-up temperature x Heating cable length x Supply voltage / 1000 = **Transformer load (kW)**

Step 5 Select the connection kits and accessories

See Table 13

Connection kits – Aboveground	Description	Quantity	Heating cable allowance
❑ RayClic-PC	Power connection and end seal	_____	_____
❑ RayClic-PS	Power splice and end seal	_____	_____
❑ RayClic-PT	Powered tee and end seal	_____	_____
❑ FTC-P	Power connection and end seal	_____	_____
❑ RayClic-S	Splice	_____	_____
❑ RayClic-T	Tee kit with end seal	_____	_____
❑ RayClic-X	Cross connection	_____	_____
❑ FTC-HST	Low-profile splice/tee	_____	_____
❑ FTC-PSK	Pipe stand and power connection kit	_____	_____
❑ RayClic-LE	Lighted end seal	_____	_____
❑ RayClic-E	Extra end seal	_____	_____

Connection kits – Buried	Description	Quantity	Heating cable allowance
❑ RayClic-PC	Power connection and end seal	_____	_____
❑ FTC-XC	Power splice and end seal	_____	_____
❑ RayClic-LE	Lighted end seal	_____	_____
❑ RayClic-E	Extra end seal	_____	_____

Accessories – Aboveground and buried	Description	Quantity
❑ RayClic-SB-04	Pipe mounting bracket	_____
❑ RayClic-SB-02	Wall mounting bracket	_____
❑ ETL	“Electric-Traced” label	_____
❑ GT-66	Glass cloth adhesive tape	_____
❑ GS-54	Glass cloth adhesive tape	_____
❑ AT-180	Aluminum tape (for plastic pipes)	_____

_____
Total heating cable allowance for connection kits

_____ + _____ = _____

Total heating cable length | Total heating cable allowance for connection kits | **Total heating cable length required**

Step 6 Select the control system

See Table 18

Thermostats, controllers and accessories	Description	Quantity
❑ ECW-GF	Electronic thermostat with 25-ft sensor	_____
❑ ECW-GF-DP	Remote display panel for ECW-GF	_____
❑ C910-485	Microprocessor-based single-point heat-tracing controller	_____
❑ ACS-UIT2	ACS-30 user interface terminal	_____
❑ ACS-PCM2-5	ACS-30 power control panel	_____
❑ ProtoNode-RER	Multi-protocol gateway	_____
❑ RTD3CS	Resistance temperature device	_____
❑ RTD10CS	Resistance temperature device	_____
❑ RTD-200	Resistance temperature device	_____
❑ RTD50CS	Resistance temperature device	_____

Step 7 Select the power distribution

See Table 19

Power distribution	Description	Quantity
❑ HTPG	Heat-tracing power distribution panel for group control	_____

Step 8 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

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