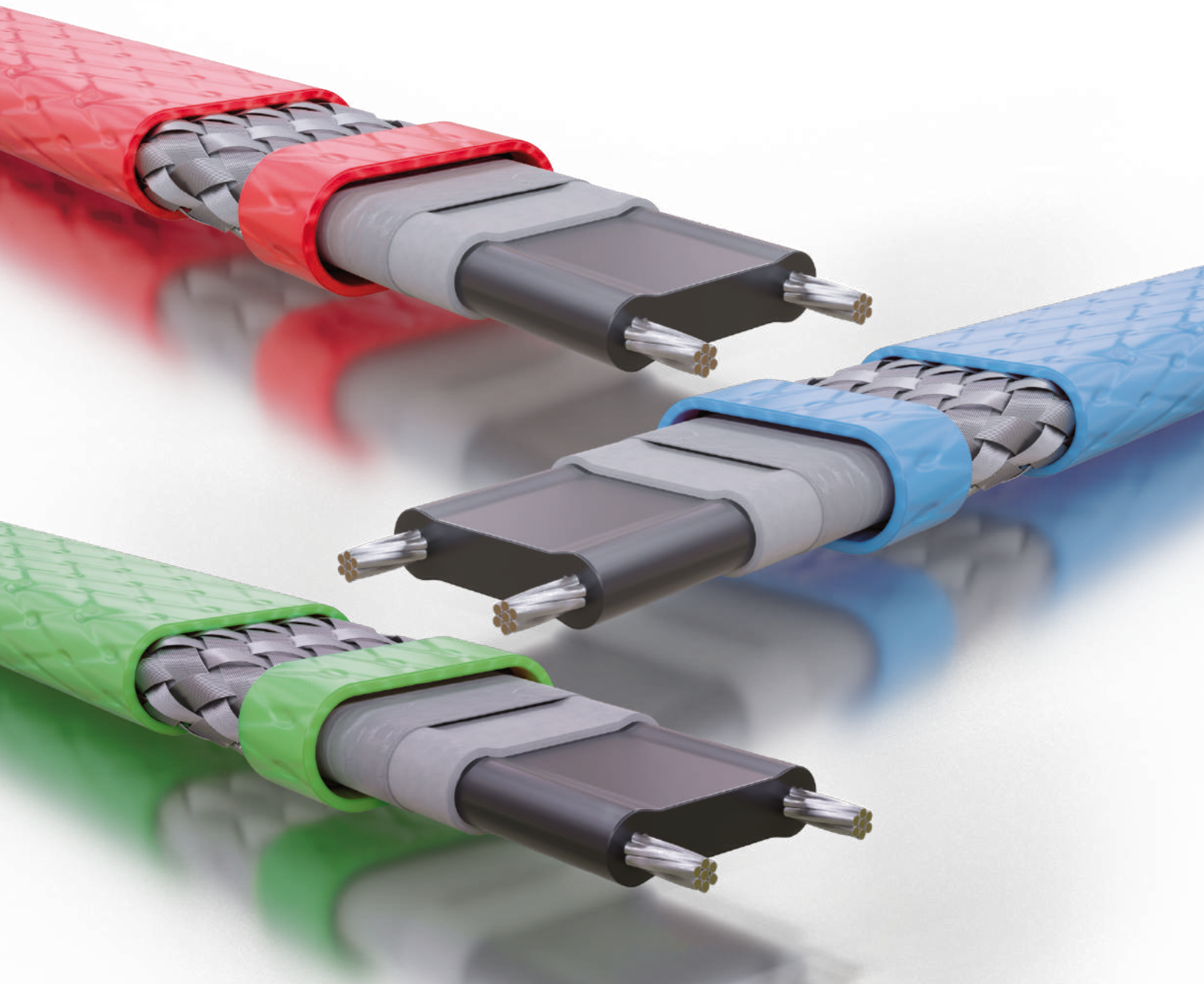




# WarmTrace™

Systems for Hot Water Temperature Maintenance

## DESIGN GUIDE





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## DESIGN GUIDE

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For additional information about systems for hot water temperature maintenance with heat tracing, please review the WarmTrace brochure (Thermon Form CPD1009) and the HSX® 2100 product specifications sheet (Thermon Form CPD1003) or contact TC-E for additional information.

## Introduction

A WarmTrace system replaces heat lost through the thermal insulation on hot water supply piping to maintain the water at desired nominal temperatures without the need for costly insulated recirculation lines, pumps and balancing valves. Preventing the hot water from cooling also ensures readily available hot water when needed.

Like many other systems installed in a facility, the successful installation of a heat tracing system for maintaining<sup>1</sup> hot water requires coordination among the various trades involved. Mechanical, electrical and insulation contractors must be made aware of the specific requirements each must provide.

The information contained in this design guide will take the reader through a step-by-step procedure<sup>2</sup> to:

- Identify the piping which requires heat tracing.
- Determine the maintain temperature and make the proper cable selection.
- Specify the electrical circuit breaker requirements based on the estimated heat tracing circuit lengths.
- Specify the thermal insulation type and thickness to complete the thermal design.
- Incorporate the design information provided into a complete package for a facility.

To further facilitate this interaction, an additional installation, operation and start-up guide has been prepared to provide trouble free installation of the heating cable and accessories.

## Product Description

HSX<sup>®</sup> 2100 self-regulating heating cables utilize a specifically formulated carbon matrix heating element which responds to temperature changes. Whenever the temperature in the heat traced piping begins to rise, the cable automatically reduces its heat output. Conversely, when the water temperature begins to drop, the cable reacts by increasing its heat output. This self-regulating feature occurs along the entire length of a heat tracing circuit to ensure each point receives the required amount of heat necessary to maintain thermal equilibrium.

Because the natural layout of a facility requires plumbing to be spread throughout the building, the footage of hot water supply lines and heat tracing requirements can be extensive. To meet these requirements, HSX 2100 is manufactured with 2.3 mm<sup>2</sup> (14 AWG) bus wires. These larger voltage supply wires (larger than any other system currently available) allow longer heat tracing circuit lengths. These longer lengths mean fewer heat tracing circuits and fewer power supply branch circuit breakers.

HSX 2100 is designed to be installed without thermostatic control to maintain 41, 49 or 60°C (105, 120 or 140°F) water temperatures. Projects with more than one maintain temperature can be traced without confusion since HSX 2100 is color-coded for easy identification of each temperature range.

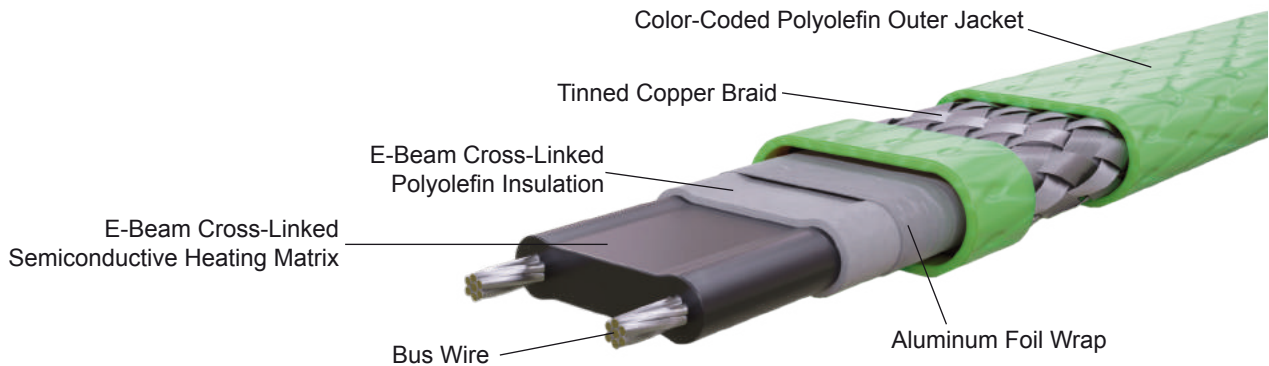
For ease of installation, HSX 2100 is a cut-to-length cable and requires no detailed dimensions of the piping. Taped directly to the hot water supply piping, HSX 2100 requires only ordinary hand tools for installation. Circuit fabrication, in-line splicing and T-splicing kits have been designed specifically for the application to complete a WarmTrace system.

### Notes

1. An electrical heat tracing system is not a substitute for a complete, efficient domestic hot water system; it does not replace the need for an efficient water heater.
2. The examples and descriptions contained in this guide are based on copper water pipe with fiberglass thermal insulation (ASTM Std C-547) and other design conditions typical of most applications. Should design conditions vary from those shown, contact TC-E.

# WarmTrace™ Systems for Hot Water Temperature Maintenance

## Characteristics

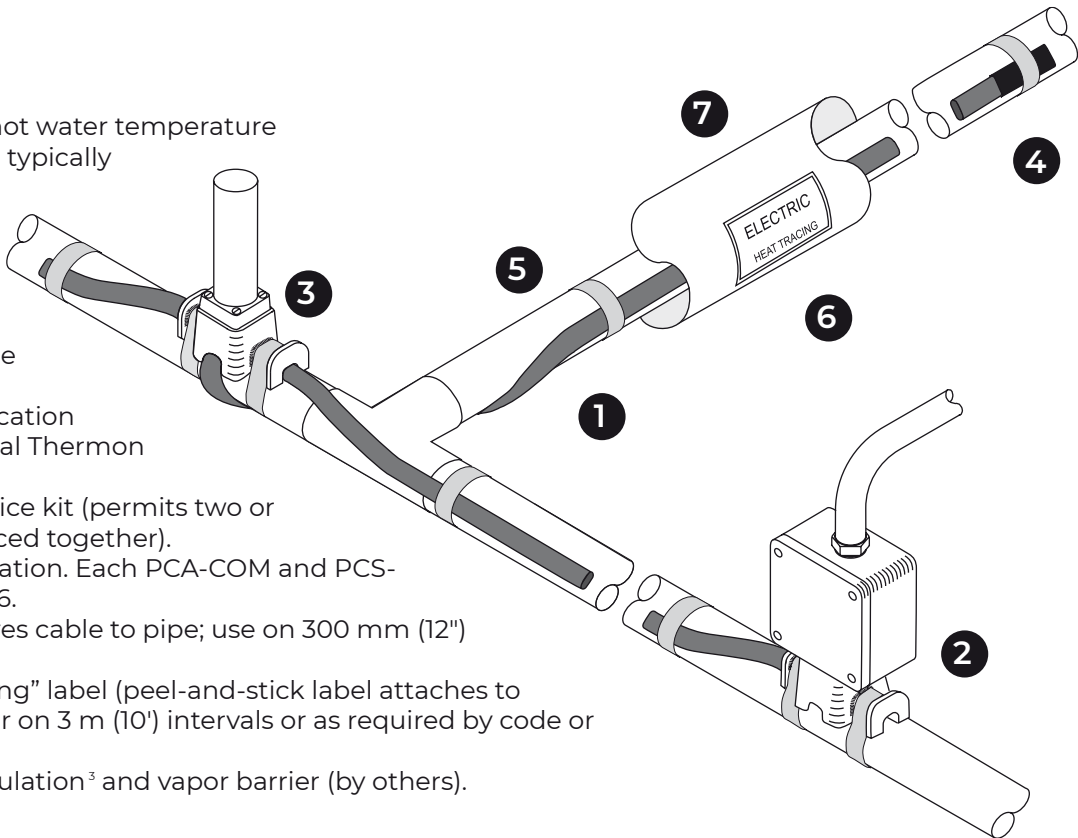


Bus wire .....	2.3 mm <sup>2</sup> (14 AWG) nickel-plated copper
Semiconductive Heating Matrix.....	E-Beam cross-linked polyolefin
Primary dielectric insulation .....	E-Beam cross-linked polyolefin
Metallic braid.....	tinned copper
Outer jacket .....	polyolefin
Minimum bend radius.....	10 mm @ -15 °C, 32 mm @ -60 °C (0.38" @ 5°F, 1.25" @ -76°F)
Supply voltage.....	208 Vac
Circuit protection <sup>1</sup> .....	30 mA ground fault protection required

## System Components

A WarmTrace HSX 2100 hot water temperature maintenance system will typically include the following components:

1. **HSX 2100** self-regulating heating cable (refer to cable selection chart on page 11 for proper cable).
2. **PCA-COM** circuit fabrication kit<sup>2</sup> shown with optional Thermon supplied junction box.
3. **PCS-COM** in-line/T-splice kit (permits two or three cables to be spliced together).
4. **ET-6** cable end termination. Each PCA-COM and PCS-COM includes one ET-6.
5. **FT-1L** fixing tape secures cable to pipe; use on 300 mm (12") intervals.
6. **CL** "Electric Heat Tracing" label (peel-and-stick label attaches to insulation vapor barrier on 3 m (10') intervals or as required by code or specification).
7. Fiberglass thermal insulation<sup>3</sup> and vapor barrier (by others).



### Notes

1. 30 mA ground fault equipment protection is required for all hot water temperature maintenance heat tracing circuits.
2. Circuit fabrication kits do not include electrical junction boxes.
3. All heat traced lines must be thermally insulated with fiberglass. Refer to Table 4.1 on page 12 for insulation information.

## Basis for a Good Design

### Step 1: Identify Piping Which Requires Heat Tracing

Typically, the main and branch lines 3/4" and larger are the primary applications for a WarmTrace hot water temperature maintenance system. Where a recirculation system would only be able to provide temperature maintenance within the recirculation loop, a heat traced line can maintain hot water to every point of use. Systems which have different pressure or temperature zones can be easily accommodated in the design and layout of HSX 2100 heating circuits.

Determining the amount of piping that will require heat tracing is easy. The extent of the heat tracing is dictated by the layout of the building and the need for water conservation.

Deciding on how close to the point of use the heat tracing should be installed is dependent on the following conditions:

- The gallons per minute (GPM) of the fixture.
- The diameter of the "runout" line.
- The number of times per day the fixture will be used.
- Any acceptable time period waiting on water to get hot.
- Any acceptable level of water waste per fixture per use.
- Special requirements at the point of use.

A wait of 15 or 20 seconds for the water to get hot at a utility room mop sink may be acceptable; however, it would not be appropriate for a public washroom. Here the need to have water hot when the faucet is operated would dictate installing heating cable to the rough-in point.

Most new facilities require the use of lavatory and shower fixtures that have GPM flow limits. As a result, the length of piping not recirculated or heat traced has become increasingly important. Tables 1.1 and 1.2 show the time correlation between fixture flow rate and length of runout piping that is not temperature maintained. Table 1.3 shows the water wasted while waiting for temperatures to reach proper levels where low flow fixtures are used.

**Table 1.1**  
**Time Correlation for 3/4" Type L Copper Tubing<sup>1</sup>**  
(time in seconds for hot water to reach fixture)

Fixture Flow Rate GPM	Distance From End of Heat Tracing Circuit to Point of Use				
	15'	20'	25'	30'	40'
1	23	30	38	45	60
1.5	15	20	25	30	40
2	11	15	19	23	30
2.5	9	12	15	18	24
3	8	10	13	15	20
3.5	6	9	11	13	17
4	6	8	9	11	15
4.5	7	8	10	13	
5	6	8	9	12	

**Table 1.2**  
**Time Correlation for 1" Type L Copper Tubing<sup>1</sup>**  
(time in seconds for hot water to reach fixture)

Fixture Flow Rate GPM	Distance From End of Heat Tracing Circuit to Point of Use				
	15'	20'	25'	30'	40'
1	39	51	64	77	103
1.5	26	34	43	51	69
2	19	26	32	39	51
2.5	15	21	26	31	41
3	13	17	21	26	34
3.5	11	15	18	22	29
4	10	13	16	19	26
4.5	9	11	14	17	23
5	8	10	13	15	21

**Table 1.3**  
**Water Wasted While Waiting for Hot Water<sup>2</sup>**  
(in ounces and based on line diameter/distance from end of temperature maintenance)

Type L Copper nom. dia.	Distance From End of Heat Tracing Circuit to Point of Use				
	15'	20'	25'	30'	40'
1/2"	23	31	39	47	62
3/4"	48	64	80	97	129
1"	82	110	137	164	219

#### Notes

1. Based on flow rates, line diameter and distance from end of temperature maintenance to fixture.
2. Remember to add up all the fixtures throughout a facility and multiply by both the waste number shown plus the expected number of usages per day.



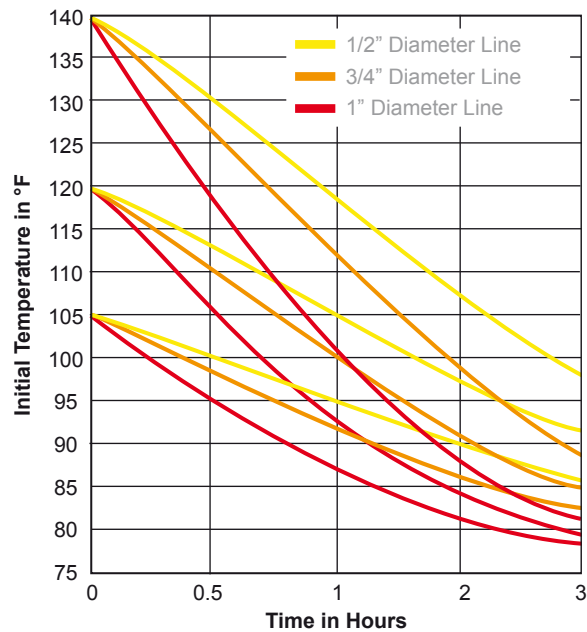
# WarmTrace™ Systems for Hot Water Temperature Maintenance

## Unheated Water Cools Fast

Although protected by means of the fiberglass thermal insulation, hot water lines will lose their heat to the surrounding ambient in a very short period of time.

While Tables 1.1, 1.2 and 1.3 identify the amount of time and/or water lost during the waiting process, Graph 1.1 demonstrates how quickly the cooling process occurs.

**Graph 1.1**  
**1/2", 3/4" & 1" Diameter Lines with 25 mm (1") Fiberglass Insulation**



## Coordinating Design Information

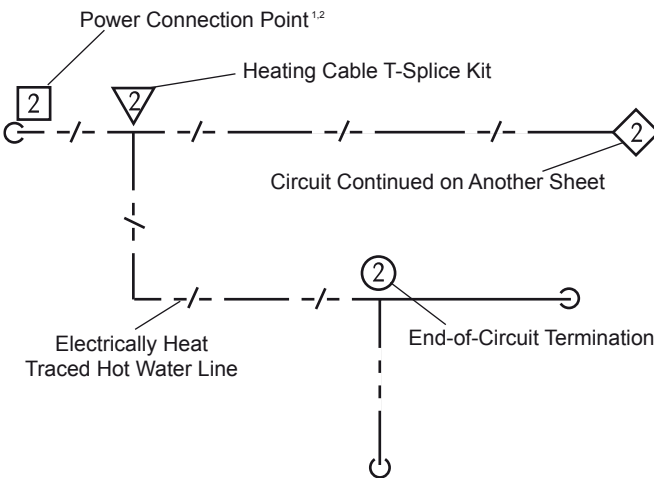
To get the most from each heat tracing circuit, establish the maximum circuit length based on the available circuit breakers for the project. (Note that maximum circuit lengths will vary based on voltage and temperature selection.) Regardless of the shape and size of a building, Thermon recommends that the heat tracing circuits be organized to provide a means of recording the layout of the cable. For ease of identification during the layout process and for effective communication in the contract drawings, it is recommended that the pipes requiring heat tracing be identified. This is a simple process that can also include locating power connection points, end terminations and heating cable T-splice locations. The symbols at right are routinely used to show the various components of a heat traced hot water supply system.

**Example:** A lavatory faucet located in a hospital patient room is used an average of six times per day with a minimum time between each use of one hour.

### Design Parameters

Pipe ..... 3/4" nominal diameter copper  
Insulation ..... 25 mm (1") fiberglass  
Maintain temperature ..... 49°C (120°F)  
Ambient temperature ..... 24°C (75°F)  
Fixture flow rate ..... 5.7 l/min (1.5 gal/min)  
Uses per day ..... 6 (average)  
Time between uses ..... 1 hour (minimum)  
Unmaintained distance ..... 6 m (20')

After only one hour of nonuse, the water in the insulated (but not heat traced) line will drop from the 49°C (120°F) initial temperature to just over 38°C (100°F). Additionally, each time the faucet is opened, 20 seconds will pass before the water gets hot. During this time approximately 1.9 liters (½ gallon) of water will be wasted. When these values are extended to every patient room for a 250 bed facility with a 75% occupancy rate, the annual water wasted is significant.



### Notes

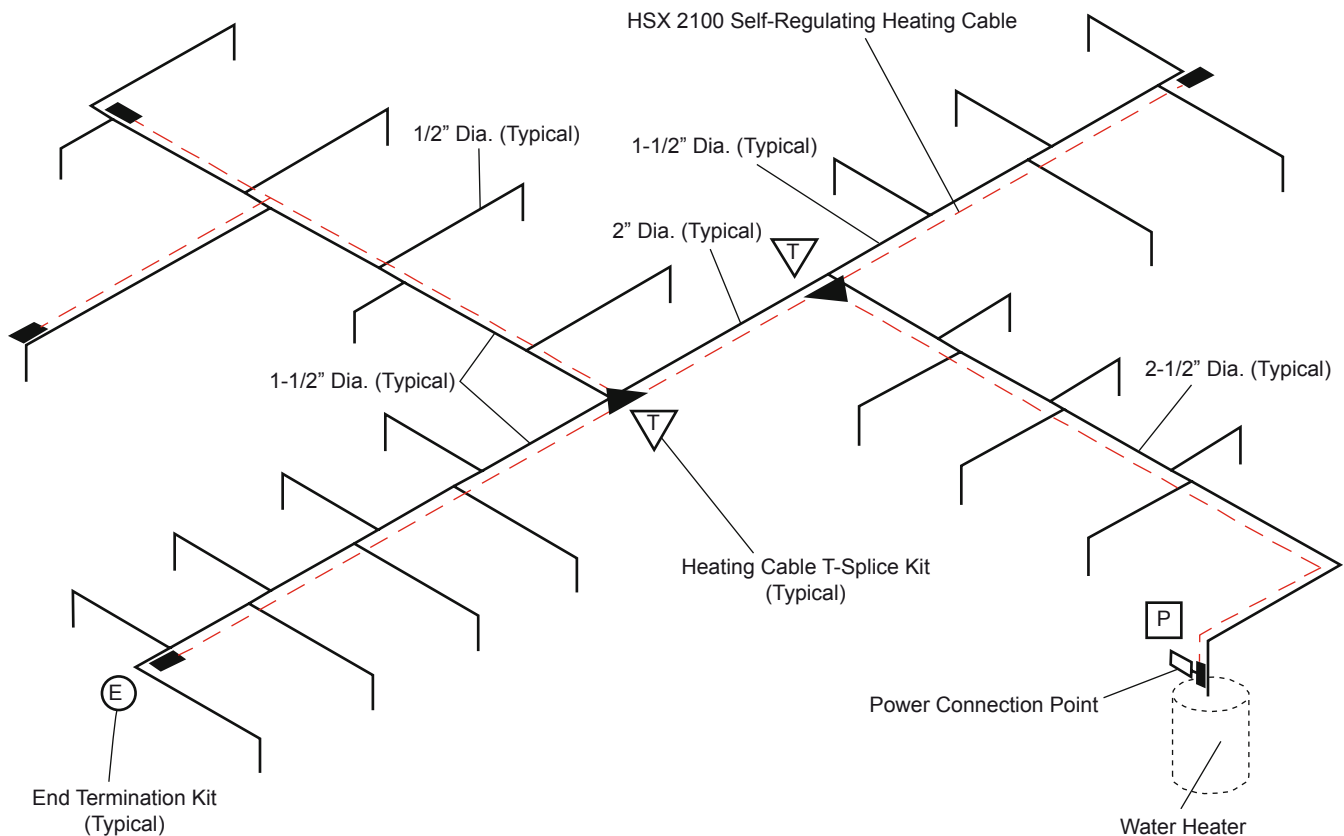
1. Circuit number is shown inside symbol.
2. While the indication of heating cable, power connection, end termination and T-splice kits are shown on the plumbing drawings, only the power connection points will need referencing on the electrical drawings.

## Heat Tracing Horizontal Mains

Designing a heat tracing temperature maintenance system for horizontal mains and branch lines can be done on the plumbing plan drawings. By referring to the heating cable selection chart (see Table 2.1, page 11) for the desired maintain temperature, the maximum heating cable circuit length can be determined for different circuit breaker sizes (refer to Table 3.1, page 11). Coordinating the layout of the hot water lines with the heating cable circuit length information will allow optimum use of the extended circuit lengths possible with HSX 2100.

Note that the main and branch lines are heat traced and insulated while the short runouts are only

insulated. (The runouts that feed the individual points of use would typically contain minimal amounts of water. If the faucet flow rate was above 1-1/2 gallons per minute, hot water would reach the point of use within ten seconds.) Should the distance between the branch line and the runout be much longer or the flow rate be lower, the amount of water potentially wasted and the time required for hot water to reach the point of use may be beyond the acceptable level for the facility. To remedy this condition, simply heat trace closer to the point of use.



**Figure 1.1**  
Partial Simplified System Typical of Hospitals, Correctional Facilities and Hotels

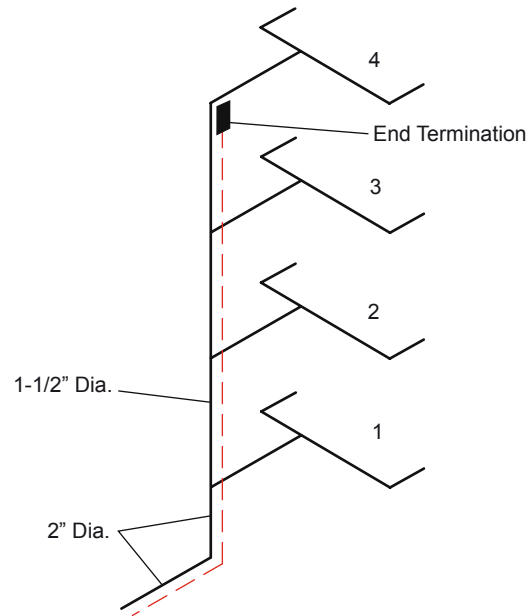
# WarmTrace™ Systems for Hot Water Temperature Maintenance

## Heat Tracing Riser Lines

Riser lines that extend three floors or less should be heat traced in the same manner as horizontal piping. In a facility where a riser extends beyond three floors, some additional design conditions should be considered. IEEE Std 515.1 ([IEEE Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Commercial Applications](#)) Section 6.1.5.2 indicates that "line sensing temperature control should be considered for extended vertical risers greater than 9 m (30 feet)"

Because the riser configuration will vary with each facility, it is recommended that the designer/engineer responsible for the plumbing system contact TC-E.

When the horizontal runouts from a riser are long enough to require temperature maintenance, each floor should be treated as a separate heat tracing circuit. This will simplify the layout and installation process plus facilitate future building renovations or expansions.



**Figure 1.2**  
Typical Partial Simplified System for High Rise Buildings

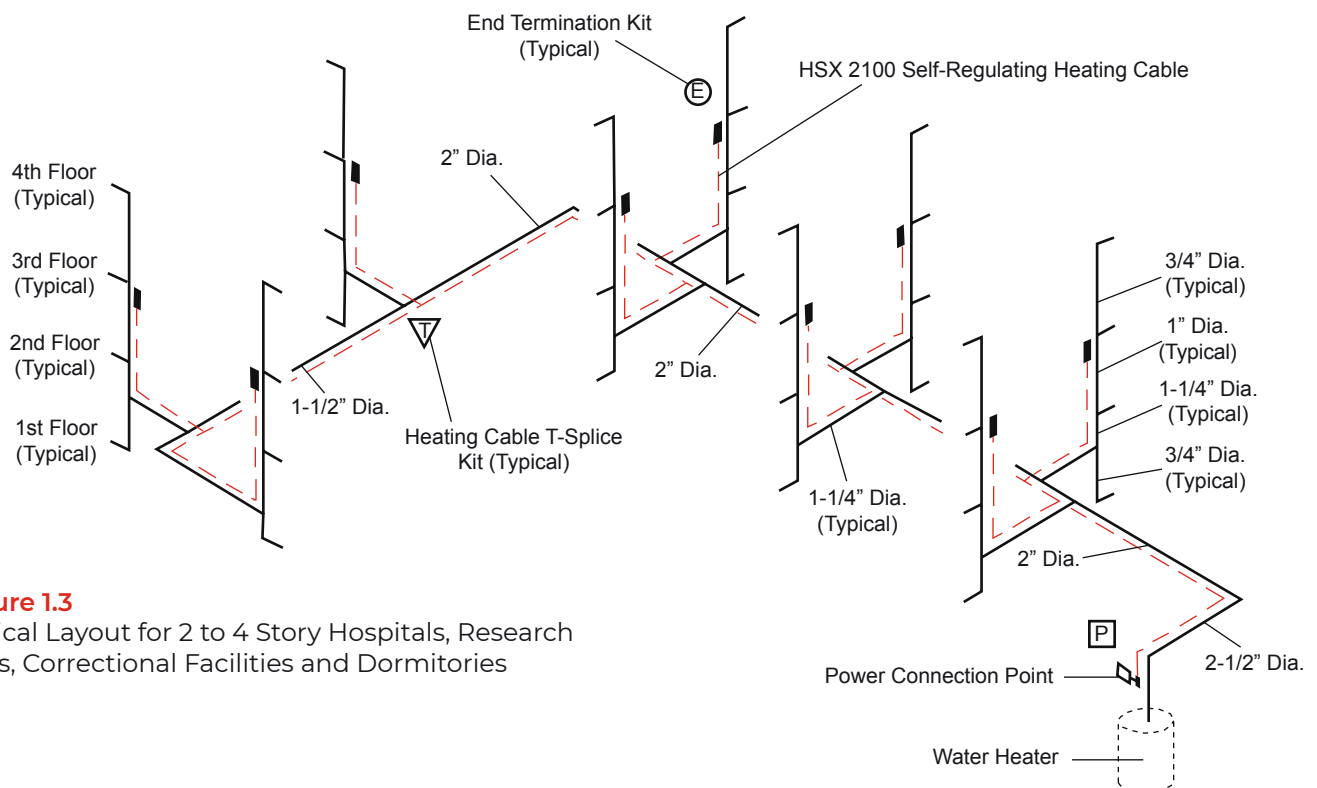


## Combining Horizontal Mains with Supply Risers

Many multilevel facilities duplicate floor plans over several levels. This practice simplifies the layout of electrical, HVAC and mechanical equipment. Hot water supply lines are no exception to this ease of layout unless a maze of recirculation piping and balancing valves are required. Figure 1.3 shows a typical layout found in two to four story facilities such as hospitals, research labs, correctional facilities and campus dormitories.

In this example, the supply main is located in the interstitial space between the first floor ceiling and the second floor. Because each floor has roughly the same layout with water use points stacked, a riser and drop would supply water at each plumbing

location. Electric heat tracing has been installed on the horizontal mains and risers. Since the distance between the horizontal piping and the first floor runouts is minimal (less than 15 feet), it would typically not require heating cable beyond the horizontal line connecting the main to the riser. As the example shown is for a four story facility, it is recommended that heating cable be installed up to the feed point for the third floor. The line feeding from level three to level four would again be within 15 feet and, under most conditions, would not require heat tracing. The untraced lines should be insulated to prevent rapid heat loss between usages.



**Figure 1.3**  
Typical Layout for 2 to 4 Story Hospitals, Research Labs, Correctional Facilities and Dormitories

# WarmTrace™ Systems for Hot Water Temperature Maintenance

## Step 2: Determine the Maintain Temperature and Make Cable Selection

The desired maintenance temperatures for most applications are listed in Table 2.1. Based on the maintain temperature desired, choose the

appropriate HSX 2100 self-regulating cable. For temperatures other than those shown below, contact TC-E.

**Table 2.1**  
**Nominal Maintain Temperature**

	41°C (105°F)	49°C (120°F)	60°C (140°F)
	Hospitals, Nursing Homes, Correctional Facilities	Hospitals, Hotels, Condos, Correctional Facilities, Schools	Kitchens, Laundries
Ambient Range <sup>1</sup> .....	24–27°C (75–80°F)	22–27°C (72–80°F)	22–27°C (72–80°F)
Cable Jacket Color .....	Blue	Green	Red
208 Vac <sup>2</sup> Power Supply .....	HSX 2105-2	HSX 2120-2	HSX 2140-2

### Notes

1. Ambient temperature ranges other than those listed are possible; contact TC-E.
2. HSX 2100 cables can be operated on 240 and 277 Vac with design assistance from TC-E.

## Step 3: Specify Circuit Breaker Requirements Based on Heat Tracing Circuit Lengths

After determining the extent of the hot water supply piping to be heat traced, determine the quantities to be maintained at 41, 49 and/or 60°C (105, 120 and/or 140°F). At this point, the total footage of each type of HSX 2100 self-regulating cable can be determined.

Because HSX 2100 is designed specifically for hot water temperature maintenance and is manufactured with 2.3 mm<sup>2</sup> (14 AWG) nickel-plated copper bus wires, the maximum circuit length possible is far greater than any other product approved for hot water temperature maintenance.

These maximum circuit lengths must be observed to prevent excessive electrical currents in the bus wires of the heating cable. The maximum circuit length is defined as total length of cable that can be fed from a single power connection point, inclusive of all splices and tees. Note that longer circuit lengths may require larger circuit breakers. Be sure to verify the available amperages of the branch circuit breakers supplying power to the heat tracing.

Table 3.1 outlines the maximum length possible with each type of HSX 2100 self-regulating cable.

**Table 3.1**  
**Maximum Circuit Length vs. Circuit Breaker Size**

Catalog Number	Service Voltage (Vac)	Steady-State Current Draw <sup>1</sup> A/m (A/ft)	Breaker Size		
			15 A m (ft)	20 A m (ft)	30 A m (ft)
HSX 2105-2 (Blue) .....	208 .....	0.016 (0.005) .....	331 (1,085) .....	366 (1,200) .....	366 (1,200)
HSX 2120-2 (Green) .....	208 .....	0.026 (0.008) .....	146 (480) .....	195 (640) .....	293 (960)
HSX 2140-2 (Red) .....	208 .....	0.036 (0.011) .....	84 (275) .....	113 (370) .....	169 (555)

### Note

1. Steady-state current draw is defined as the theoretical current draw of the heating cable at the desired maintain temperature. Because temperature fluctuations will exist, this current should be used for reference purposes only. Current during start-up when the water in the piping is at ambient temperature will be greater and should be accounted for when sizing circuit breakers.

## Step 4: Specify Insulation Thickness

The following information should be made part of the thermal insulation specification. Variations to this insulation schedule may result in different maintain temperatures.

**Table 4.1**  
**Fiberglass Insulation Schedule<sup>1</sup> for WarmTrace Systems**

Insulation <sup>2</sup> Thickness	Nominal Pipe Size <sup>3</sup>	Nominal Insulation Size
25 mm (1")	1/2"	20 mm (3/4")
	3/4"	25 mm (1")
	1"	32 mm (1 1/4")
40 mm (1.5")	1-1/4"	40 mm (1 1/2")
	1-1/2"	40 mm (1 1/2")
	2"	50 mm (2")
50 mm (2")	2-1/2"	64 mm (2 1/2")
	3"	76 mm (3")
	4"	102 mm (4")

### Notes

1. This insulation schedule is applicable for 41, 49 and/or 60°C (105, 120 and/or 140°F) WarmTrace systems.
2. All selections are based on using fiberglass insulation with a kraft paper moisture vapor barrier. Before using other types of thermal insulation, consult TC-E.
3. To accommodate the heating cable on copper piping that is 2" or less in diameter, the thermal insulation will need to be one line size larger than the nominal pipe diameter.

## General Specification Hot Water Temperature Maintenance Electric Heat Tracing

### Part 1 General

Furnish and install a complete system of heaters and components approved specifically for maintaining hot water at selected temperatures. The heat tracing system shall conform to ANSI/IEEE Standard 515.1.

### Part 2 Products

1. The self-regulating heater shall consist of two 2.3 mm<sup>2</sup> (14 AWG) nickel-plated copper bus wires embedded in parallel in a e-beam cross-linked self-regulating conductive polymer core specifically designed for hot water temperature maintenance. The heater shall be capable of varying its heat output along its entire length to maintain the water in the selected temperature range. The heater shall be covered by a polyolefin dielectric jacket rated 300 Vac at 105°C (41°F), a tinned copper braid (2.3 mm<sup>2</sup> (14 AWG) equivalent wire size) and a nominal 1 mm (40 mil) polyolefin outer jacket color-coded for easy identification.
2. The heater shall operate on a line voltage of 208 Vac without the use of thermostats.
3. Self-regulating cable must be designed and specifically approved for maintaining hot water. Cables used for freeze protection of water lines will not be allowed.
4. All heating cable core shall be permanently marked with the manufacturer's identification number for traceability.
5. Quality assurance test certificates are to accompany each reel of heating cable signed by the manufacturer's quality control officer. Certificates are to indicate cable type, cable rating, watts per foot, voltage rating, test date, batch number, reel number and length of cable, test voltage and test amperage reading.
6. Acceptable products and manufacturers: HSX<sup>®</sup> 2100 cable as manufactured by Thermon.
7. Refer to the manufacturer's hot water temperature maintenance design guide for design details, insulation requirements, maximum circuit lengths and accessory information.

### Part 3 System Performance

1. Heat-traced and insulated piping shall maintain nominal hot water temperatures in the supply lines at [select 41, 49 and/or 60°C (105, 120 and/or 140°F)] when powered at 208 Vac.
2. For each hot water maintenance temperature selected, only one product will be allowed. All cables must be installed in parallel passes; no spiral wrapping will be allowed.
3. Power retention of the heating element shall be in accordance with IEEE Standard 515.1, Item 4.2.6, Performance After Thermal Aging.

### Part 4 Manufacturer

1. The manufacturer shall demonstrate experience maintaining hot water supply lines with self-regulating heating cables. This experience may be documented with a list of \_\_\_\_ projects utilizing at least 600 m (2,000 ft) of self-regulating heating cable specifically for hot water temperature maintenance.
2. Manufacturer's Quality Assurance Program shall be certified to the ISO 9001 Standard.

### Part 5 Installation

1. Heating cable shall be installed on the hot water supply piping in areas indicated on the plumbing drawings.
2. Refer to the manufacturer's installation instructions and design guide for proper installation and layout methods. Where riser piping extends more than 9 vertical meters (30 vertical feet), obtain engineering design assistance from manufacturer. Deviations from these instructions could result in performance characteristics different than intended.
3. All installations and terminations must conform to the National Electrical Code and any other applicable national or local code requirements.
4. Circuit breakers supplying power to the heat tracing shall be equipped with 30 mA minimum ground-fault equipment protection.

5. Hot water lines shall be pressure tested prior to installation of heating cable and thermal insulation. Thermal insulation shall not be installed until heating cable installation is complete and a megohmmeter (megger) test has been passed (see Testing, Part 6). Heat traced hot water lines shall be insulated within two weeks of the heat tracing installation.
6. The insulation shall not be installed with staples. Insulation jackets should be closed with tape or adhesive to avoid damage to the heating cable.
7. All drops, runouts, valves, tees and elbows on domestic hot water piping shall be insulated in accordance with the insulation specification, Division \_\_\_\_\_.
8. Heating cables shall be installed to within \_\_\_\_\_ feet of fixtures.
9. System shall be connected to power by the electrician (see Division 16-Electrical).

### Part 6 Testing

1. Heat trace shall be tested with a megohmmeter (megger) between the heat trace bus wires and the metallic ground braid. While a 2,500 Vdc megger test is recommended, the minimum acceptable level for testing is 500 Vdc. This test should be performed a minimum of three times:
  - a. Prior to installation while the heat trace is still on reel(s).
  - b. After installation of heat trace and completion of circuit fabrication kits (including any splice kits) but prior to installation of thermal insulation.
  - c. After installation of thermal insulation but prior to connection to power.
2. The minimum acceptable level for the megger readings is 20 megohms, regardless of the circuit length.
3. Test shall be witnessed by the construction manager for the project and the heating cable manufacturer or authorized representative. Results of the megger readings shall be recorded and submitted to the construction manager.

