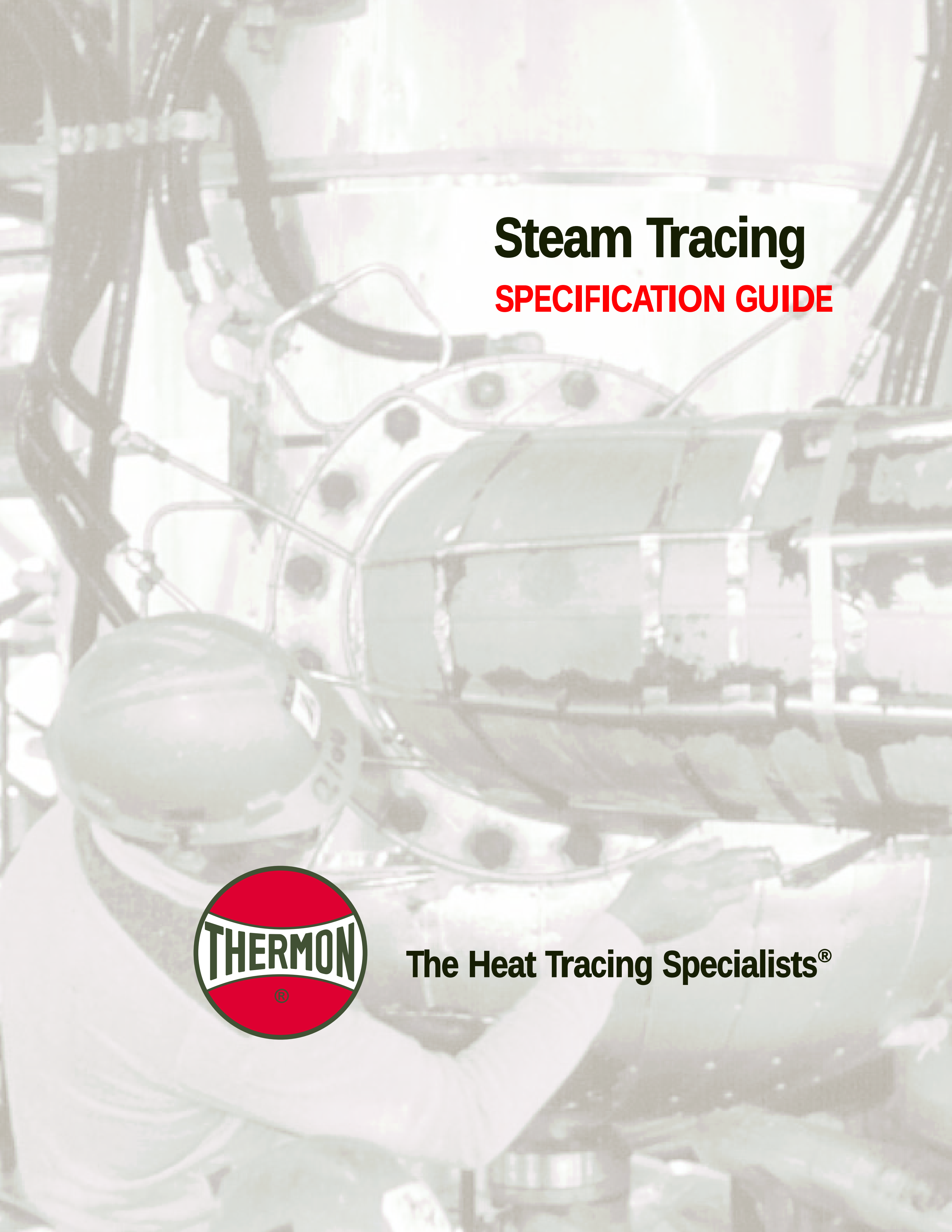

Steam Tracing

SPECIFICATION GUIDE

THERMON®

The Heat Tracing Specialists®

Steam Tracing

SPECIFICATION GUIDE

Contents

Specification Supplements: Piping drawings, product specifications, materials estimating and manufacturer’s installation procedures make up a part of but are not found with this specification.

Steam Tracing

1.0 General Provisions

1.1 Scope: This specification covers basic requirements for the design, materials, installation, inspection and testing of steam tracing systems for plant piping, equipment and instruments.

1.2 Purpose: To ensure the continuity of plant operation, certain process, service and utility pipes, equipment and instruments will require steam tracing to keep contents of fluids such as liquids, gases, vapors, suspensions and slurries from freezing, condensing, crystallizing, separating or becoming too viscous to pump.

1.3 References: One or more of the following drawings and manufacturers' information will supplement this specification:

a) Piping and instrument diagrams.
b) Piping orthographic drawings.
c) Piping isometrics.
d) Piping line index.
e) Product specifications, materials estimating and installation procedures for steam tracing materials.
f) Thermal insulation specifications.

1.4 Steam Tracing Symbols and Legend: Steam tracing will be indicated on the piping and instrument diagrams and the piping isometrics. Lines to be heated will be shown by a dashed line parallel to the pipe line and the appropriate legend after the line number such as:

a) BT or BTS for steam tracing with a *bare* (convection) tracer or a tracer with a safety yellow identification jacket (Thermon Industries, Inc., SafeTrace™ BTS).
b) IT for steam tracing which is isolated from the process pipe by a factory-applied heat retarding material for tracing temperature-sensitive materials or for energy conservation (Thermon's SafeTrace™ SLS-IT or DLS-IT).
c) HTC for steam tracing with heat transfer compounds (Thermon's range of heat transfer materials).

All special conditions, including heat-sensitive materials, lined or specially coated pipe or other such conditions, will be identified on the drawings and schedules.

> **NOTE:** Throughout this specification all references to steam-traced piping is meant to imply all steam-traced piping, fittings, valves, pumps, tanks, vessels, instruments, instrument lines and any other materials or equipment requiring steam tracers.
>
> All heat transfer compounds are not the same, just as all thermal insulation materials are not the same. It is important to check the technical specifications and proof of conductance testing by following guidelines such as Thermon's "Evaluation of Steam Tracer Conductance" procedure.

1.5 Codes and Standards: All work shall comply with applicable federal, state and local codes and industry standards. Since issuance of standards is an ongoing process, the Engineer will identify the issuance date to which the steam tracing project is committed.

Safety precautions shall conform to the applicable requirements of Occupational Safety and Health Standards, 29 CFR 1926.

Unless otherwise indicated, the latest editions and revisions of the following documents are referred to in this specification and shall be used to supplement and define the intentions and requirements of this specification where applicable. For installations outside the U.S.A., all work shall apply to corresponding documents or other applicable codes and standards.

- **American National Standards Institute** (ANSI)
  B31.1 Chemical Plant and Petroleum Refinery Piping
  Z535.1 Safety Color Code
- **American Society of Mechanical Engineers** (ASME)
  A13.1 Scheme for the Identification of Piping Systems
- **American Society for Testing and Materials** (ASTM)
  A213 Specifications for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat Exchanger Tubes
  A269 Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
  B68 Specification for Seamless Copper Tube, Bright Annealed
  B75 Specification for Seamless Copper Tube
  VOLUME 0.4.06 Thermal Insulation; Environmental Acoustics (Annual Book of Standards)
- **Manufacturers' Standardization Society** (MSS)
  MSS-SP-58 Pipe Hangers and Supports; Materials Design and Manufacturers
- **American Petroleum Institute** (API)
  550 Part 1 - Process Instrumentation and Control Section 8 - Seals, Purges and Winterizing

1.6 Specification Addenda: Corrections, additions or deletions will be accomplished by issuing addenda to this specification. Any addendum will be in the form of a letter or more formal documents where deemed necessary by the Engineer to:

a) Answer questions raised by bidding Contractors.
b) Effect changes made by the Owner or the Engineer.
c) Correct errors and discrepancies between documents.

Contractor shall submit drawings and descriptions for Owner or Engineer approval of all items which deviate from this specification.

Where reference is made to a manufacturer's product, equivalent alternates may be used after receipt of written approval from Owner or Engineer.

1.7 Conflict of Documents: In case of conflict between this specification and other contract documents, the Contractor shall, regardless of the order of precedence of documents, contact the Engineer in writing before proceeding with the affected work. The Contractor shall only proceed after having received a written answer from the Engineer that the work may proceed.

1.8 Contractual Relationships:

a) Manufacturer/Client: Owner for whom the facility is being constructed.
b) Engineer: Engineering firm undertaking the design and/or construction of the Client's facility.
c) Purchaser: Client or the Engineer.
d) Contractor: Company whose tender has been accepted by the Purchaser.

1.9 Contract Words: These contract words should be particularly noted:

a) The word "shall" is used in connection with acts of the Contractor or with labor, materials and equipment furnished by the Contractor.
b) The word "will" is used in connection with acts of the Owner or Engineer but also applies to the Contractor where steam tracing is provided as a "turnkey" (design, supply and install) package.
c) The word "should" is used only in connection with recommended practices.

1.10 Definition of Plant Piping, Instrumentation and Steam

Tracing Terms:

- **Air Convection Tracing:** Tracers attached to the pipe without the use of heat transfer compounds. Tubing can be bare or may have a polymer jacket. Tracer is attached to the pipe with high temperature tape and heat transfer is by means of air convection movement of heat in the annular space between the thermal insulation and the heated pipe.
- **Ambient Temperature:** The temperature of the air in the surrounding atmosphere.
- **Condensate:** Water that is formed in the steam tracer tube when latent heat is given up by the steam to the heated pipe or equipment. Condensate is usually returned to the boiler for the conversion back into steam.
- **Condensate Header:** The principal line for collecting and routing condensate from steam users to a receiver (or to a sewer when allowed) to be pumped to the boiler plant to reduce the reheat requirement. It may be a single line or have several branches.
- **Conduction Tracing:** Tracer tube thermally bonded to the heated pipe or equipment by heat transfer compound where primary heat transfer means is by conduction directly into the metal wall of the pipe or equipment being heated.
- **Dry Steam:** Steam containing no moisture. It may be either saturated or superheated.
- **Heat Loss:** The rate at which heat flows from a hot surface such as a process pipe to a cooler atmosphere, usually stated in Btu/h•ft. (W/m) of pipe. Generally, the heat loss is from the pipe through the pipe insulation to the cooler atmosphere.
- **Heat Sink:** A surface or mass such as a flange or valve that is at a lower temperature than the warm pipe.
- **Heat Tracing:** The application of hot liquid, vapor or steam tracing tubes or electric heating cables or tapes to pipes, fittings, valves, pumps, tanks, instruments or instrument lines to offset the heat loss through thermal insulation.
- **Heat Transfer Compound:** A heat conductive material with highly efficient thermal characteristics for use on any steam or fluid tracer tube.
- **Heated Pipe:** Any process, service or utility pipe that is heat traced.
- **Heating Media:** Steam, hot water, glycol, hot oils or other heat transfer fluids that flow through tracer tube circuits.
- **Heat-Up:** A steam tracing application where process

pipe or equipment requires the addition of heat to raise its temperature from a lower to a higher level.

- **High Pressure Steam:** Steam at a pressure of 250-600 psig (17.2-41.4 barg).
- **Instruments:** Devices used separately or in combination to measure, analyze or monitor the various aspects of a process.
- **Instruments Piping:** All piping, tubing or tubing bundles, valves and fittings used to connect instruments to process piping and to other instruments and apparatus for measuring, analyzing or monitoring purposes.
- **Isolated Tracing:** Tracing for energy conservation or for sensitive piping and processes where the tracer tube is separated from the pipe or equipment by a low conductive material. Heat transfer is primarily by air convection movement of heat in the annular space between the thermal insulation and the heated pipe.
- **Low Pressure Steam:** Steam at a pressure of 10-50 psig (.7-3.4 barg).
- **Medium Pressure Steam:** Steam at a pressure of 50-250 psig (3.4-17.2 barg).
- **Pockets:** Bends, loops or dips in the tracer tube where condensate can collect.
- **Process Maintenance Temperature:** The temperature level which must be held on plant process pipes and equipment to keep the contents from solidifying, condensing, crystallizing, separating or becoming too viscous to pump. The term is often used to refer to all traced utility, service or process pipes.
- **Process Piping:** Piping used to transport fluids between storage tanks and process units.
- **Saturated Steam:** Steam of a temperature corresponding to its pressure.
- **Service Piping:** Piping used to transport water, brine, steam, air or other substances to process piping or equipment to bring about the successful completion of the process.
- **Steam and Condensate Manifolds:** Modular prefabricated steam supply and condensate collection units designed specifically for steam tracing circuits.
- **Steam and Condensate Return Leads:** Preinsulated tubing with a weather-protective jacket used to interconnect headers to manifolds and manifolds to tracers for steam supply and condensate return. Referred to as leads, runs, lines and takeoffs.
- **Steam Boiler:** A closed vessel in which water is vaporized into steam to provide mechanical power and process heat such as steam for tracing circuits.
- **Steam Header:** The principal steam line supplying steam to all users in an area including tracer circuits. Assumed to be supported on overhead pipe rack and may have several branches.
- **Steam Tracing:** A tube or small pipe carrying steam, which is placed parallel and attached to the surface of the pipe or equipment to be heated. The tube is referred to as the “tracer,” “tracer tube,” or simply “tracing.”
- **Steam Tracing Condensate Subheader:** A line which collects and returns condensate from one or more tracer circuits via a condensate collection manifold to the condensate header.
- **Steam Tracing Subheader:** A branch from the steam header to the steam distribution manifold for tracer circuits.
- **Steam Trap:** Automatic device used to hold steam in a steam tracing circuit until it has given up its latent heat and allows condensate, air and other gases to pass while preventing the passage of steam.
- **Steam-Out:** A process of cleaning out the residue in a pipe by passing steam through it. It is necessary to select a tracer that can withstand exposure to the steam-out temperature.
- **Superheated Steam:** Steam having a temperature higher than that corresponding to its pressure.
- **Temperature Controllers:** Automatic devices used to control steam pressure and/or flow to maintain pipe temperature for freeze protection or process temperature control.
- **Thermal Insulation:** For steam tracing purposes, it refers to materials used to retard the flow of heat from pipes and equipment to the surrounding atmosphere.
- **Utilities Piping:** Piping that transports the primary plant commodities such as fuel gases, fuel oil, water, air, steam and condensate.
- **Vessel:** The term “vessel” in this specification refers to any large surface such as tanks, towers, drums, reactors or exchangers.
- **Weather Barrier:** A protective material covering the outer surface of thermal insulation to repel rain, snow, sleet, hose washdown or any other substance that might negatively affect the thermal insulation.
- **Wet Steam:** Steam containing moisture.

- **Winterization:** Sometimes referred to as "freeze protection" or "warming services," winterization is the preparation of piping and equipment for operation in winter weather, including cold temperatures, high winds, snow and ice.

2.0 Where to Use Steam Tracing

Steam tracing should be used when it is the practical choice for the plant or specific units of the plant and when it is possible for the contents of the pipes, equipment or instruments to freeze, condense, crystallize, separate or become too viscous to pump under local temperature conditions. Some guidelines are listed below.

Pipes and Equipment That Require Heating:

a) In general, process lines that flow continuously during normal plant operation need not be traced if it is practical to drain the line or displace the material in the line with a low pour-point liquid, air or gas when the plant is shut down.

b) Intermittent flow lines (and lines where it is not practical to drain or displace the process fluid on shutdown) should be traced if the pour point of the fluid is higher than the minimum ambient temperature that is likely to be experienced for a period of time which will cause the fluid to set up in an insulated line without tracing.

c) Insulation alone cannot prevent freezing of lines which handle water or other aqueous solutions in a nonflow condition if ambient temperature remains below freezing for an extended period of time. Insulation can only prolong the time required to freeze and can prevent freezing only if the water flow is maintained at a sufficient rate.

d) Pumps and their suction lines should be traced if the fluid viscosity can become high enough to greatly overload or damage the pumps unless it is more practical to provide for circulation during intermittent operation or for drainage or displacement of the process fluid during shutdowns.

e) Typical fluids that have pour points above 32°F (0°C) and require "process maintain" heat regardless of local ambient temperatures include: acrylic acid, asphalt, certain concentrations of caustic soda, DMT, naphthalene, No. 6 fuel oil, para-xylene, phthalic anhydride, maleic anhydride, viscous oils, styrene, sulfur, tar, phenol, paraffin, urea, polypropylene, neopentyl glycol, ammonium nitrate and many others.

f) Fluids that must be "winterized" include: water, hydrocarbons containing water and other aqueous solutions. Facilities frequently consider all process fluid streams to be water-bearing and process gas streams to be water-saturated.

g) Temperature-sensitive substances that must be kept "warm" but must not be overheated include: acids, amines, caustics, phenolic water, glycerin and others.

h) In addition to main process service and utility lines that require heat tracing, other considerations for "winterization" must include: air lines, cooling towers, pumps and associated piping, knockout pots in suction lines of gas compressors, water "draw-off" sections of vessels, the bottom of air or gas receivers where water can collect, and safety and relief valves that can become restricted by viscous, waxy or freezing material.

Instruments and Connecting Lines That Require Heating:

i) Instruments used to measure and control process gas or fluid streams that have pour points 32°F (0°C) and below. These streams not only include water, they can include gases, light hydrocarbons and distillates that, when wet, form hydrates and solidify when subjected to freezing temperatures. These applications can be referred to as "freeze protection," "winterization," or "warming services."

j) Instruments used to measure and control process gas or fluid streams that have pour points above 32°F (0°C). These streams may contain heavy residuals, pitch or process chemicals such as phenol that solidify at ambient temperatures higher than 32°F (0°C). These installations must be heated above their pour point to ensure free-flow.

k) Instruments and piping systems that need "custom-tailored" protection for proper operation. Process stream analyzer and emissions analyzer sample systems fall into this category.

l) Instruments that have specific temperature limitations imposed by the manufacturer to ensure accurate and reliable operation. Analyzers and recorders fall into this category. These are delicate instruments that do not hold up well in the extreme winter/summer ambient conditions.

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3.0 Selection of Steam Pressure

The heating media should be dry saturated steam. The pressure of the steam is generally contingent upon the heat input requirements of the process piping and equipment and the pressure availability at the tracer location. The lower cost of low pressure steam should be balanced against additional design considerations. The following points should be considered:

a) Low pressure steam offers the maximum amount of latent heat per pound, and the problems of flash steam from the condensate are reduced. However, the pressure at the trap must be high enough to get the condensate into the collection system, including sufficient lift to get into elevated pipeways where necessary. Circuit lengths for trapping increase as steam pressure increases.
b) Low pressure steam systems are more susceptible to freezing where ambient temperatures fall below -20°F (-28.9°C). Where low pressure steam is used, steam traps should be freeze resistant and condensate lines should be properly protected.
c) For ambient temperatures below -20°F (-28.9°C), low pressure steam (below 50 psig, 3.4 barg) should be used only where one tracer with heat transfer compound will suffice to keep process temperatures relatively constant during ambient temperature swings and where total circuit pressure losses can be kept at 10% or lower.
d) Low pressure steam may be required in some cases to provide for lines carrying temperature-sensitive materials. Isolated tracers should be considered for this service.

4.0 Tracing System Temperature Control Options

Steam tracing economics can be greatly improved if temperature control options are considered. The use of large safety design margins and the tendency to keep the tracing system "live" when there is no heat requirement should be avoided where possible. Proper temperature control based on an assessment of the actual system needs should be provided where economically practical. Control options are:

a) Isolated tracers which provide a low conductive heat path to reduce temperatures and conserve energy.
b) Where process temperatures above winter protection must be held, use self-acting control valves with sensors directly measuring the temperatures of the product or pipe wall.
c) For winterization, use self-acting control valves with sensors responding to the ambient air temperature.
d) Fixed-temperature discharge steam traps or balanced pressure traps which respond to condensate temperature can be used to allow condensate to subcool within the tracer before being discharged. This enables use of some of the sensible heat in the condensate and reduces, or in some cases eliminates, the release of flash steam.
e) To keep the process fluid temperature constant during summer or winter environments, to provide process heat-up after a planned or emergency shutdown without overshooting the maintain temperature, or for ambient temperature-sensing control, a thermostatically controlled solenoid valve can provide off-on operation. The thermostat serves only pilot duty, and off-on control provides the tracer circuit with the full benefit of the heating media during start-up.
f) In many cases, control can be achieved by pressure reducing valves which vary the steam pressure.
g) Self-acting temperature controllers, fixed discharge or balanced pressure traps and pressure reducing valves are manufactured by Armstrong, Spirax Sarco and others. Thermostatically operated solenoid valve controllers are provided by Thermon.

NOTE: Where controllers are used for tracing circuits, the steam traps must be of a design that continuously drains condensate from the circuit in order to prevent water hammer.

5.0 Tracing Methods and Design Considerations

5.1 Tracing Methods:

a) Convection tracing, either "bare" or polymer jacketed (Thermon's SafeTrace™ BTS or Engineer-approved equal).
b) Tracing with heat transfer compound (Thermon heat transfer compounds or Engineer-approved equal).
c) Isolated tracing (Thermon's SafeTrace™ SLS-IT, DLS-IT or Engineer-approved equal).

d) Traced preinsulated instrument tubing bundles and instrument enclosures as provided by Cellex Manufacturing, Inc., or Engineer-approved equal.
e) Tracing with temperature controllers.

5.2 Design Considerations: Steam tracing is used primarily to maintain a specified temperature range in plant piping and equipment by determining the heat loss through the specified thickness of insulation and replacing that heat loss with a steam tracer. A complete steam tracing system incorporates all steam supply lines, steam tracers, heated pipes and equipment, insulation, steam control valves, fittings and steam traps. The system design involves six factors: three factors are given and three are variable. The variable factors must be balanced to establish an appropriate design.

Given	Variable
(1) Nominal pipe size	(4) Tracer type, size and number
(2) Desired pipe temp.	(5) Steam inlet temperature
(3) Low ambient temp.	(6) Insulation type and thickness

The following process design scenarios will be considered before selecting the tracing method to be employed for each plant line:

a) What will be the consequences of an unplanned process shutdown during the worst-case ambient conditions?
b) What are process control normal, upper and lower temperature restrictions?
c) Will the tracing system be required to heat up the pipe or equipment when the contents have become too viscous to pump or are in a solidified state? If so, what is the acceptable heat-up time?

5.3 Heat Losses Through Thermal Insulation:

a) To determine actual heat losses for a given set of conditions, a complete insulation specification, including the thermal conductivity at several mean temperatures, will be provided.
b) All physical and thermal properties of the specified insulant will be available along with information regarding the weather barrier mastic or jacket.
c) For composite insulation systems, conductivity will be the average for the two insulants.
d) Soft insulants (mineral fiber, fiberglass, etc.) of the next largest pipe-size insulation that will accommodate the pipe and the tracer should be selected.
e) Rigid insulation (calcium silicate, expanded Perlite, cellular glass, etc.) may be actual process pipe size, thus requiring board sections cut to fit the longitude joint to compensate for the steam tracer. Preferably, the next largest pipe-size insulation that will accommodate the pipe and tracer should be selected. Rigid abrasive insulants may have an inner liner of mineral or fibrous-type insulation, which may also be considered in heat loss calculations.
f) Heat losses will be calculated using the actual insulation size selected. It will be specified if the insulation is actual size compressed to fit the pipe and tracer or if it is "oversized" leaving an air annulus. The inner insulation surface coefficients will vary depending upon whether or not there is an air annulus and the size of the annular space. The actual insulation size will also have an effect on the outer insulation surface coefficients.
g) Actual thickness of insulation will be used since the actual thickness does not always correspond to the nominal thickness. Refer to ASTM designation C585 "Standard Recommended Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing."
h) A minimum heat loss safety factor of 10% will be used.
i) Increased heat losses from miscellaneous items such as flanges, valves, pipe shoes and supports, plus other components, will be considered on critical process lines where the maintain temperature band is narrow.
j) Insulated pipe supports will be considered on critical temperature maintenance lines.

6.0 Tracer Selection Considerations

Most plants will require a combination of the steam tracing methods discussed in Section 5.0 of this specification. The selection for each heated pipe and piece of equipment will depend upon the process sensitivity and the temperature to be maintained along with the heat load demand, tracer capability and the results of the design scenarios.

a) Isolated tracing is selected in the following situations:
   (1) Where reduced thermal risk is important to aid in compliance with applicable safety standards.
   (2) Where bare tracers will consume more energy than necessary or raise the pipe temperature too high.

(3) Where a controlled, predictable heat transfer rate must be maintained for energy conservation or to prevent corrosion or other unacceptable temperature-related conditions.
(4) Where sensitive products such as caustics, acids, amines, resins, water and other aqueous fluids require low uniform heat for freeze protection.

NOTE: The isolated tracer is a preinsulated tube with a polymer protective jacket that is superior to the traditional "spacer block" method, which suspends a tracer tube just above the pipe on insulating blocks to maintain an air gap between the two. The spacer blocks are difficult to keep in position during installation and frequently slip out from under the tube tracer in service because of expansion and contraction of the tracer. Preinsulated tubing maintains the specified distance between the pipe and is taped in place without involving several trades.

b) Convection tracing, either bare or Thermon's SafeTrace™ BTS, is generally selected for the following conditions:
(1) Where only one convection tracer is needed to hold the required temperature*.
(2) Where winterization is needed for lines carrying such material as air, water, gases or other noncorrosive aqueous solutions.
(3) Where low heat density and flexibility is necessary for high maintenance valves, pumps and other such equipment.
(4) For process lines where ambient temperature fluctuations or emergency shutdown and heat-up requirements will not necessitate more heat than the convection tracer will supply.

* Multiple convection tracers cannot be economically justified when one tracer with heat transfer compound will suffice because of the additional steam supply connections and trap assemblies required. However, a convection tracer may be doubled back where allowable pressure drops are not exceeded.

Spiraled convection tracers on horizontal runs are **not acceptable** because circumferential expansion reduces the heat transfer coefficient by increasing the air gap between the tracer and the pipe and the increased number of pockets requires more frequent trapping.

Spiraled convection tracers on vertical runs are not recommended because circumferential expansion reduces the heat transfer coefficient by increasing the air gap between the tracer and the pipe.

c) Tracers with heat transfer compound are chosen in the following situations:
(1) Where more than one convection tracer is required.
(2) In most cases where jacketed pipe or equipment is ordinarily used.
(3) Where fast heat-up is essential after an emergency or a planned shutdown.
(4) Where a more even temperature distribution is required.
(5) Where high heat density and flexibility is required at valves, pumps and other such equipment.

d) Preinsulated instrument tubing bundles and high density polyurethane instrument enclosures are selected for the following situations:
(1) Where closely predicted thermal characteristics are required for pressure and differential pressure transmitters, process analyzers, emissions analyzers and other such applications.
(2) Where space is limited, pretraced and insulated bundles can be shaped to allow layout via the shortest distance with simple supports in locations where field fabricated lines are not practical.
(3) Where factory-applied polymer weather protection is preferred on critical lines.

e) Temperature controllers are selected when:
(1) It is essential to prevent overheating of the product.
(2) Constant viscosity is required for instrumentation.
(3) Energy efficiency is a key requirement.

7.0 Size and Number of Tracers

A comprehensive review of all flow diagrams will be made to determine the steam tracing requirements for each line. Isometric drawings identifying steam supply headers, tracer supply manifolds, tracer routing, tracer trap stations and condensate return lines will be provided to facilitate proper installation of the tracing system.

a) Where tracing is indicated for lines on the engineering flow diagrams, all pumps, valves, fittings, vents, drains, instruments, instrument lines and specialty items associated therewith shall also be heat traced.

b) Instruments and instrument lines shall be heated in high density polyurethane enclosures and preinsulated tubing bundles (Cellex Manufacturing, Inc., or Engineer-approved equal).
c) The size and number of convection tracers or tracers with heat transfer compound required to deliver the necessary heat energy to the traced pipe or equipment will be determined from published design tables (Thermon's Steam Tracing Design Guide) or from computer programs developed for steam tracing design (Thermon's CompuTrace® or other Engineer-approved sources).
d) When heat-sensitive or corrosive fluids are to be traced, care shall be taken to prevent hot spots within the tracing system. Under these conditions, an isolated tracing system utilizing a tracer with a predictable heat transfer rate (Thermon's SafeTrace™ SLS-IT, DLS-IT or Engineer-approved equal) shall be used. A pressure reducing valve shall be provided for this service where lower steam pressures are required.

8.0 Tracer Materials

The tracer in a steam tracing system must be as flexible as possible for the ease of installation and conformance to the shape and layout of the pipes and equipment being heated and must act as a leakproof carrier of the heating media. Whenever possible it is recommended that tubing be used rather than pipe for tracing because the thermal expansion of the tubing is easier to constrain and the tracer can be held closer to the surface of the heated pipe or equipment to provide a higher heat transfer rate. Pipe tracers are inflexible and present difficulties at elbows, flanges, valves, strainers, pumps and other irregular surfaces. Since coils of tubing can be unrolled and easily bent, tracers from tubing will require a minimum number of fittings.

The tracer shall be selected to fulfill the thermal and installation requirements. These requirements are determined by the process pipe material, temperature of the process pipe and tracer, pressure of the heating media and the environment. The tracer shall be of metal close to the potential of the process pipe so as to minimize galvanic corrosion. Recommendations are as follows:

a) Copper tubing tracers shall be soft annealed grade 122 and meet or exceed ASTM Standards B68 and B75. Minimum wall thickness shall be as follows:
3/8" O.D. x .032" wall (10 mm O.D. x 1 mm wall)
1/2" O.D. x .035" wall (12 mm O.D. x 1 mm wall)
3/4" O.D. x .049" wall (20 mm O.D. x 1.2 mm wall)

NOTE: 1/4" O.D. (6 mm O.D.) tracers plug up easily and should be used only where absolutely necessary for heating other relatively small tubes or similar applications.

b) Copper tubing shall be used if the saturated steam pressure or the item being traced does not exceed 400°F (204°C) and there is no corrosion or other deterrent for using copper.
c) Stainless steel tubing tracers shall be type 316 seamless cold drawn and fully annealed with a maximum Rockwell hardness of RB80 and meet or exceed ASTM Standard A269. Minimum wall thickness shall be as follows:
3/8" O.D. x .032" wall (10 mm O.D. x 1 mm wall)
1/2" O.D. x .035" wall (12 mm O.D. x 1 mm wall)
3/4" O.D. x .049" wall (20 mm O.D. x 1.2 mm wall)
d) Stainless steel tubing shall be used if the saturated steam pressure or the item being traced has a maximum temperature above 400°F (204°C) and there is no corrosion or other deterrent for using stainless steel.
e) Carbon steel tracers **shall not** be used for steam tracing circuits. During shutdown periods, the combination of air and moisture on or in the tracers causes rapid rusting.
f) Since the tracer tube is a primary component of the steam tracing system, the tubing shall be thoroughly inspected prior to use to see that it conforms to the specifications, is of the correct diameter and thickness and is not out of round.

8.1 Tracer Tube Cutting and Shaping: Tracer tube bends shall be free of kinks, wrinkles or flattening. Bends shall be made with a mechanical tubing bender. Bend radii should generally be from four to ten times the outside diameter of the tube. The largest functional radius should be used. A tube cutter or hacksaw shall be used to cut the tracer tubes. Guide blocks shall be used with hacksaw cutting to assure a square cut. Outside diameter (O.D.) and inside diameter (I.D.) deburring shall be performed using a file for the O.D. and a deburring tool for the I.D.

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8.2 Tracer Tube Unions: Tubing unions shall be installed in tracers where necessary to permit removal of equipment such as pumps, relief valves, instruments, control valves and strainers. The tubing fittings shall be suitable for the pressure of the steam which they contain. Fittings shall be compression type as manufactured by "Swagelok" or Engineer-approved equivalent. The fittings shall be made of material compatible with the tracer construction material. Tubes shall be formed to join with true alignment to the centerline of the fittings without distortion or tension.

9.0 Steam Supply and Condensate Trap Stations

The steam supply should be taken from a source which is continuously available even during normal shutdown periods where possible. Steam should be distributed at the highest pressure and reduced to the design requirements of the tracer system using a pressure-reducing valve.

9.1 Tracer Circuit Supply System:

a) The tracing supply header shall be adequately sized to provide the maximum tracer design load and trapped at its low point where practical and located as close as possible to the point of use. Refer to manufacturer's Steam Tracing Design Guide for recommended steam supply header sizes. If three or more tracers are to be supplied from a common header, prefabricated manifolds shall be provided.

b) Each tracer supply line from the header shall be equipped with an isolation valve. Preinsulated tubing with factory-applied insulation and a polymer weather protective jacket (Thermon's ThermoTube® or Engineer-approved equal) shall be used for steam supply and condensate return leads and routed as follows:

   (1) From off the top of the tracer supply header at the highest point possible flowing downward to the tracer distribution manifold subheader.

   (2) From the distribution manifold to the beginning of the tracer circuit.

   (3) From the end of the tracer circuit to the steam trap condensate manifold assembly.

   (4) From the condensate manifold to the condensate return header.

   (5) All preinsulated lines shall be routed symmetrically and run together where possible to maintain a neat appearance. Pockets shall be avoided if possible.

c) Supply manifolds shall be strategically located along the tracing route and shall be accessible from grade, platforms or permanent ladders with a maximum length of 16' (5 m).

d) Each manifold shall be fitted with an isolation valve and suitable strainer, and 15% of the total number of tracer connections shall be spares. A fraction represents one spare connection.

e) The supply manifolds shall be drained via a trap and provided with a diffuser for safe, quiet discharge to the atmosphere when condensate is not returned to the boiler house.

9.2 Trap and Condensate Return Systems:

a) Steam trap condensate manifold assemblies shall be provided with an internal siphon tube for freeze protection of traps that are shut off and a freeze protection valve which senses condensate temperature to drain the manifold if the condensate cools to a given set point.

b) Steam trap manifold assemblies shall be placed in an accessible location where possible to simplify maintenance.

c) Steam trap manufacturers (such as Armstrong and Spirax Sarco) provide steam distribution and condensate collection manifolds designed specifically for steam tracing applications and are the best source of information for the selection of manifolds.

9.3 Identification:

a) Each tracer circuit for process lines shall be identified by corrosion-resistant identification tags. One tag shall be located at the steam supply valve at the manifold and the other at the isolation valve of the steam trap assembly.

b) Steam tracer supply stations and condensate trap stations will be given line numbers. An isometric piping erection drawing will be made for each station. These stations will be assigned numbers which are to be located on the plot plan and the model to indicate unit number, station number and whether they are supply or trap stations.

c) The identification tags shall be fabricated from 16 gauge corrosion-resistant material suitable for the environment and attached to the supply valve and steam trap assembly valve with 16 gauge corrosion-resistant wire.

d) Identification tags shall be stamped with 1/2" (12 mm) numbers and letters using the identification system established for the project.

9.4 Steam Trap Selection and Installation: Effective removal of condensate and air is essential to achieving uniform temperatures and maximum heat transfer rates from steam tracing circuits. Trap manufacturers are the best source of information for the selection and sizing of the steam traps and should be consulted for sizing and proper installation techniques to provide troublefree winter performance. Preassembled steam trapping stations are preferred and can be supplied by the trap manufacturers (such as Spirax Sarco and Armstrong). Several types of traps are available for tracer circuits. The type of traps selected shall meet the design and efficiency requirements of the tracing system.

a) The steam trap shall be installed below the tracer circuit where possible and at a condensate manifold located so as not to interfere with the operation and maintenance of equipment or obstruct access ways.
b) Each tracer circuit shall be trapped individually at the tracer termination point determined from the circuit design information. A new tracer shall be installed for continuing the tracing if the pipe run exceeds the maximum trapping length determined in Section 10.1.
c) Isolation valves shall be installed just before and just after the trap to make servicing easier.
d) If condensate will be discharged to an overhead return line or against a lift, a swing check valve shall be installed in the discharge line just beyond the trap at the bottom of the lift if the trap does not have an integral check valve or is not otherwise designed to prevent backflow. The discharge line from the trap shall feed into the top of the return main.
e) When a trap must discharge to an overhead return line, the pressure due to the lift shall be added to the pressure in the overhead return line to determine the total back pressure against which the trap must discharge. To calculate the pressure due to lift, use 0.5 psi per vertical foot of lift (11.31 kp/m). The back pressure shall not exceed the allowable limit of the selected trap.
f) If the trap does not incorporate a strainer, a strainer with a blow-down valve shall be installed just ahead of the trap to keep rust, dirt and scale out of the trap. A test tee shall be installed just downstream of the trap to allow checking of the trap performance.

10.0 Tracer Location and Routing

a) To facilitate maintenance, tracers serving the same or adjacent items shall be grouped and supplied from a common manifold. Similarly, the condensate shall be returned to a common return manifold.
b) The steam supply shall start (where practical) at the highest point of the lines to be traced, and the tracers shall be arranged so that flow is generally downward avoiding pockets as much as possible. The accumulated vertical tracer rise (pocket height) in feet (.66 x barg for AVTR in meters) shall not exceed 15% of the steam supply pressure.
c) Each tracer shall be continuous from the supply manifold to the trap with no vents, drains or dead-end extensions at intermediate points. In general, branch connections shall be avoided. If branches are required, each branch used shall have its own trap.
d) For ease of installation and serviceability, all tracers shall be installed parallel to and against the heated pipe or equipment and shall be placed on the most accessible surface location in regard to supports, ease of installation, connection and thermal insulation. Multiple tracers shall be equally spaced around the circumference of the pipe.
e) Expansion of bare (convection) tracer tubes shall be absorbed at elbows and flanges where possible. For long straight runs, a 12" (.305 m) diameter horizontal loop shall be provided at 60' to 100' (18-30 m) intervals, preferably midway between fittings. Tracer loops provided specifically for expansion should not contain unions. Tracers with heat transfer compound do not require expansion loops.
f) Tracer loops around flanges shall be horizontal so as to drain on shutdown, and unions shall be provided so that tracers can be disconnected at valves, pumps, tanks or other flange-connected equipment.
g) Tracing shall be included on dead legs and similar heat sinks along the traced line.
h) Each tracer shall be served by a single trap at the end of the tracer circuit.
i) Slots shall be provided in the thermal insulation to accommodate expansion of the tracer where it joins and leaves the traced line. Details will be provided in the insulation specifications.
j) Extra tracer lengths are not generally required at pipe hangers, piping tees and ells.

k) Design shall include extra tracer length for valves or large pieces of equipment. The Engineer will indicate on critical service if pipe supports or flanges require additional tracer length. Insulated pipe supports will be considered on critical temperature maintenance situations.

l) All tracers shall be arranged such that maintenance and removal of valves, instruments and other such equipment is not adversely affected.

10.1 Tracer Length:

a) Refer to manufacturer's Steam Tracing Design Guide to obtain recommended circuit lengths for trapping. Longer tracer runs may be possible based on the actual calculated heat loss for a given pipe under equilibrium conditions and the allowable circuit pressure drop. A computer-generated design from Thermon's CompuTrace® program or other Engineer-approved programs may be used for circuit length optimization.

b) Tracer circuit lengths will be calculated on a maximum allowable pressure drop of 30% of the steam supply pressure but will generally be designed for a 10% pressure drop. Maximum tracer length is measured from the point where the tracer first contacts the line to be heated to the point where it connects to the trap or the preinsulated tubing routed to the trap.

c) Pressure losses for preinsulated tubing runs from the steam manifold to the tracer circuit, from the tracer to the condensate manifold, and from the manifold to the condensate return header will be calculated separately if the length of these runs exceeds 100' (30 m) total.

11.0 Tracers for Valves and Pumps

a) Tracing for valves and pumps shall be tubing in the form of hairpin loops so that the tracer makes the least amount of complete circles. The number of feet of tracer to surface area of valve or pump shall be sufficient to balance the feet of tracer on the straight pipe surface area.

b) Unless otherwise specified, hairpin tubing loops shall be attached to the valve or pump surface with 1/2" x .020" (12 mm x .5 mm) stainless steel bands, high temperature fiberglass tape or No. 16 gauge stainless steel wire (see supplemental tracer installation drawings).

12.0 Tracers on Vessels

a) Unless otherwise specified, external tracing for vessels shall be stainless steel panels prefabricated to the required radius (Thermon's HeetSheet® or Engineer-approved equal).

b) Heating panels shall have a layer of factory-applied nonhardening heat transfer compound between the vessel surface and the back of the heating panel.

c) Small equipment with an outside radius of curvature less than 7" (178 mm) and vessel bottoms with compound curved surfaces may be traced with tubing in the form of hairpin loops in lieu of heating panels.

d) Unless otherwise specified, hairpin circuits shall be embedded in heat transfer compound (see supplemental drawings for installation details).

e) Vessels shall be insulated with double-locking, continuous-standing seam insulation panels (Thermon's ThermaSeam™ or Engineer-approved equal).

13.0 Instrument Tracing

a) Tracing for instruments and instrument impulse lines shall conform with information provided in the supplemental drawings. Preinsulated tubing shall be Cellex's TubeTrace® or Engineer-approved equal.

b) Tracing shall be designed such that instruments can be removed for maintenance without interruption or removing the tracing.

c) Tracing shall be applied only to the process wetted parts of instruments, not to electronic or pneumatic parts.

d) Tracer sizes shall be as follows:
   (1) 1/2" (12 mm) O.D. tubing for gauge glass and external displacer level instruments.
   (2) 1/4" (6 mm), 3/8" (10 mm) and 1/2" (12 mm) O.D. tubing for meter leads.

14.0 Heating Systems for Instrument Enclosures

a) Pressure gauge enclosures shall be heated with the heat from the process line by installing heat conservation insulation up to the enclosure or by continuing the tracer at the gauge connection.

b) Differential pressure transmitters with partial enclosures shall be heated by a steam heater block installed under the instrument. Heater shall have its own flexible thermal insulation cover and be installed where it will not interfere with removal of the transmitter.

c) Transmitters, controllers, recorders, etc., with complete polyurethane enclosures shall be heated with a separate finned steam heater connected by tube fittings to the steam tracer. Heaters and controllers shall be by Cellex Manufacturing Company or Engineer-approved equal.

NOTE: Where possible, preinsulated tubing bundles shall be used in lieu of field traced and insulated instrument lead lines.

15.0 Process Piping and Supports

a) The Pipe Support Group will see that all process piping is properly secured by supports, guides, anchors or hangers in keeping with the piping specifications. To the greatest extent possible, any appendages shall be arranged such that tracers and thermal insulation can be installed in accordance with specified practices.
b) The installation and support of preinsulated instrument tubing bundles and preinsulated steam supply and condensate return lines is given in the supplemental drawings. Generally, however, routing and support is to be determined in the field. Lines shall be run together as much as possible for common support. Preinsulated tubing shall be spaced and located with these considerations:
   (1) Ability to place a durable support at some desired location.
   (2) Keep sag in the line within limits that will permit drainage.
   (3) Avoid bends that exceed the minimum bend radius as recommended by the manufacturer.
   (4) Allow for heat dissipation by keeping a 1/2" (12 mm) space (minimum) between the preinsulated lines.

16.0 Installation of Tracing System

After the process pipe has been installed with proper supports and hangers to allow for correct application of tracers and insulation, the following are major steps for installation of the tracer system:

a) Surface preparation of process piping.
b) Surface preparation of tracer.
c) Installation of tracer and its securement.
d) Pressure testing of tracer.
e) Application of heat transfer compound (where required).
f) Curing of heat transfer compound (if required).
g) Inspection of tracer system (see 17.0).
h) Application of thermal insulation.
i) Application of weather barrier.
j) Inspection of insulation (see 17.0).

16.1 Surface Preparation of Process Pipe and Equipment: In cases where the pipe is located in a corrosive atmosphere or where corrosive leaks or spillage may possibly attack the piping, the coatings and painting engineer will specify corrosion protection coatings that are compatible with the steam tracing system requirements. The following general guidelines should be considered:

a) Before installation of steam tracers, all tracer tubes and pipes or equipment to be traced shall be reasonably clean. Dirt, rust and scale can be removed with a wire brush. Oil and grease films may be removed with a rag and suitable solvent. Where required, mill varnish or other coatings may be removed with a suitable stripper. Preparation for the application of heat transfer compound is covered in the supplemental drawings and installation details.
b) Carbon steel pipe and equipment operating above 175°F (80°C) need not be coated or painted to prevent rusting.
c) Carbon steel pipe and equipment operating below 175°F (80°C) may require a surface preparation and coating specified by the coatings and painting engineer.
d) Stainless steel pipe and equipment in ordinary atmospheres need only to be cleaned as specified in a) above. However, where it may be subjected to chloride or fluoride ions, the corrosion engineer should determine the necessity to paint (coat) the surface.
e) Copper or brass pipe or equipment in ordinary atmospheres need only to be cleaned as specified in a) above.
f) Aluminum pipe or equipment may need to be painted if it is in a highly caustic or salt atmosphere. Surface preparation for the application of heat transfer compound is specified in the supplemental drawings and installation details.

16.2 Surface Preparation of Tracers: All tracers shall be free of dirt, grease, oil, loose scale or any other nonspecified material before installation on piping and equipment and prior to application of heat transfer compound when applicable.

16.3 Tracer Securement to Process Lines: It is important to prevent stress in the tracer tubing by providing for expansion where required and by properly securing the tracer to the process pipe. Tracers are fastened to plant piping and equipment with wire, bands and high temperature tapes. Some tracers are covered with galvanized or stainless steel channels before final attachment. Each method of tracing in this specification (bare convection tracing, tracing with heat transfer compound and isolated tracers) shall be installed in accordance with the installation instructions provided in the supplemental drawings. Care shall be taken to use fastening materials that are galvanically compatible with the pipe and tracer materials. High temperature tapes shall be virtually free of chlorides or halides if used to secure stainless steel pipe or tubing.

16.4 Pressure Testing and Cleaning:

a) Steam supply headers and pipe or tubing runs to tracers shall be blown clean with steam or air before connection to trap assemblies.
b) After all tracer connections to the supply header and trap have been completed, the circuit shall be tested for leaks by subjecting it to a steam pressure equal to or greater than that which is to be used in the system or by suitable hydrostatic tests. All leaks shall be repaired and the system retested prior to the installation of heat conducting compound (when used) and insulation.
c) Performance of traps, gauges, pressure relief valves, and pressure and/or temperature controlling devices shall be periodically checked at prescribed intervals during start-up and the first 48 hours of normal operation.

16.5 Selection and Application of Heat Transfer Compounds: Various formulations of heat transfer compounds are available to cover a wide range of tracing applications. The selection of the proper formulation will involve consideration of all the following:

a) Minimum and maximum temperatures to which heat transfer compounds will be exposed under both normal and abnormal operating conditions.
b) Ambient conditions under which installation of heat transfer compounds must occur.
c) Piping and equipment size and configuration.
d) Total installed cost for the heat transfer compounds.
e) Feasibility of carrying out start-up curing procedures (where required).
f) Solubility resistance of the heat transfer compounds.

To make the proper selection, basic characteristics of the various formulations are detailed in the supplemental drawings and installation details.

Heat transfer compounds shall be supplied by an ISO 9001 certified manufacturer such as Thermon Industries, Inc., or Engineer-approved equal.

16.6 Insulation Selection and Application for Steam-Traced Piping and Equipment:

a) The insulation material to be used on steam-traced piping and equipment shall be selected with care. Important aspects to be considered are:
   (1) Thermal insulating characteristics.
   (2) Mechanical strength characteristics.
   (3) Chemical stability characteristics under both normal and abnormal conditions.
   (4) Moisture absorption characteristics.
   (5) Personnel health and safety aspects.
   (6) Installed cost.
b) The following thermal insulation materials and the corresponding ASTM Standard are commonly used for steam-traced piping:

Type	ASTM Standard
Calcium Silicate	C533
Cellular Glass	C552
Fiberglass and Mineral Wool	C547, C553, C592
Expanded Perlite	C610

c) The insulation materials listed in b) above all have upper temperature limits beyond the level required for steam tracing systems. For process temperatures below 212°F (100°C), insulation materials with a low moisture permeability should be considered for use. The manufacturer's maximum and minimum temperature limits shall be adhered to when specifying the insulation material.
d) Pipe insulation is dimensionally described by the standard pipe size that it is designed to fit and by its nominal insulation thickness. For example, a 4" x 1-1/2"

(100 mm x 38 mm) pipe insulation is designed to fit snugly around the actual 4.5" (114.3 mm) outside diameter of the pipe and will be nominally 1-1/2" (38 mm) in thickness. In some cases, the actual thickness may be as much as 25% greater than the nominal values.

e) Manufacturer specifications shall be consulted for actual dimensional data. ASTM C585, "Standard Recommended Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing," is an additional data source.
f) Dimensions for prefabricated fittings can be found under ASTM C450, "Prefabrication and Field Fabrication of Thermal Insulation Fitting Covers for NPS Piping."
g) Insulation covers for valves, flanges, pipe supports and other line equipment shall be fabricated from block or curved segments of the same material and thickness used for the adjacent straight piping. Cracks and joints shall be appropriately filled and sealed to assure uniform heat loss throughout the length of the line.
h) Thermal insulation sizes to fit over steam tracers are provided in the supplemental drawings and installation information.

16.7 Selection and Application of Weather Barriers: The proper operation of any tracing system depends upon the insulation being dry. Properly designed and installed weather barriers minimize the migration of water into the insulation and are therefore a very necessary part of an effective insulation system. The two types of weather barriers most commonly used are jacketing and mastic.

Manufacturers are the best source of information for weather barriers, mastics and other insulation accessories. ASTM Standards provide another source of data. Jacketing materials such as aluminum, ASJ, FPR and stainless steel are covered in ASTM C921 along with banding and other accessories. The various mastic materials used for weatherproofing may be located in ASTM C647.

Double-locking, continuous-standing seam insulation panels (Thermon's ThermaSeam™ or Engineer-approved equal) shall be used for tank insulation and weather protection requirements.

17.0 Inspection of System

The Inspectors shall ensure that all phases of the installation are in accordance with the materials and application specifications. The Inspector shall make certain that:

a) All materials used are as specified and in good condition.
b) All materials are stored in accordance with recommendations.
c) Surface preparations are as specified.
d) Tracer systems are installed in accordance with the design.
e) All tracing supply headers, preinsulated supply and condensate tubing runs, tracer tubes and manifolds are steam cleaned prior to connection to trap assemblies.
f) All tracer circuits and process pipe runs are pressure tested after all connections are completed.
g) Heat transfer compounds are installed in accordance with these specifications.
h) Heat transfer compounds are properly cured.
i) Water soluble heat transfer compounds are protected from rain and other moisture prior to installing the thermal insulation and weather barrier.
j) High temperature insulation is of proper thickness and installed in accordance with specifications.
k) Insulation was dry when installed and protected from rain and moisture until weather barrier was installed.
l) All insulation on vessels is properly supported.
m) Suitable insulation expansion joints are installed.
n) Weather protection is of type specified, installed in accordance with specifications and recommendations and dry thickness of mastic is of specified dimension.
o) All weather barriers are watertight and projections and terminations are properly sealed.

NOTES:

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