GENERAL GUIDELINES FOR HEATER TUBESKIN THERMOCOUPLES

The following guidelines were put together to be used for the design and installation of all heater tubeskin thermocouples. Please consult a Daily Thermetrics engineer for suggestions on specific applications.

BASIC THERMOCOUPLE SPECIFICATIONS:

- All thermocouples are to be metal sheathed, with magnesium oxide insulation.
- For temperatures up to 2500F, use type K (Chromel – Alumel) thermocouples.
- Skin thermocouples should always be grounded, as this provides the most direct metal-to-metal connection for heat flow. The result is increased accuracy and faster response time.
- Single element thermocouples shall be utilized for their larger element wire sizes. The larger wire size of single element sheaths increases the likelihood that the thermocouple will survive the prolonged heat exposure. Dual elements thermocouples have smaller wires and are thus more likely to burn-out from heat exposure or improper routing. If true redundancy is required, two thermocouples shall be installed side-by-side.
- Suggested metallurgy and sheath OD will vary depending on application and heater specifications. Increased wall thickness may also be required for more severe applications. At a minimum, sheath shall be ¼”OD (outer diameter) for single fired heaters and 3/8”OD for double fired heaters, 310SS.
- Thermocouples are to be special limits of error.
- Heater tubeskin thermocouples are installed from inside the heater. The cold junction end of the thermocouple (the end with the transition housing and lead wires) is fed out of the heater through the heater entry. To facilitate this process and the attachment of the heater entry accessories, thermocouple transition housings should be flush with the thermocouple sheath.
- Heat shields shall always be utilized to increase the thermocouple accuracy and provide extra protection to the thermocouple at the sensing tip.

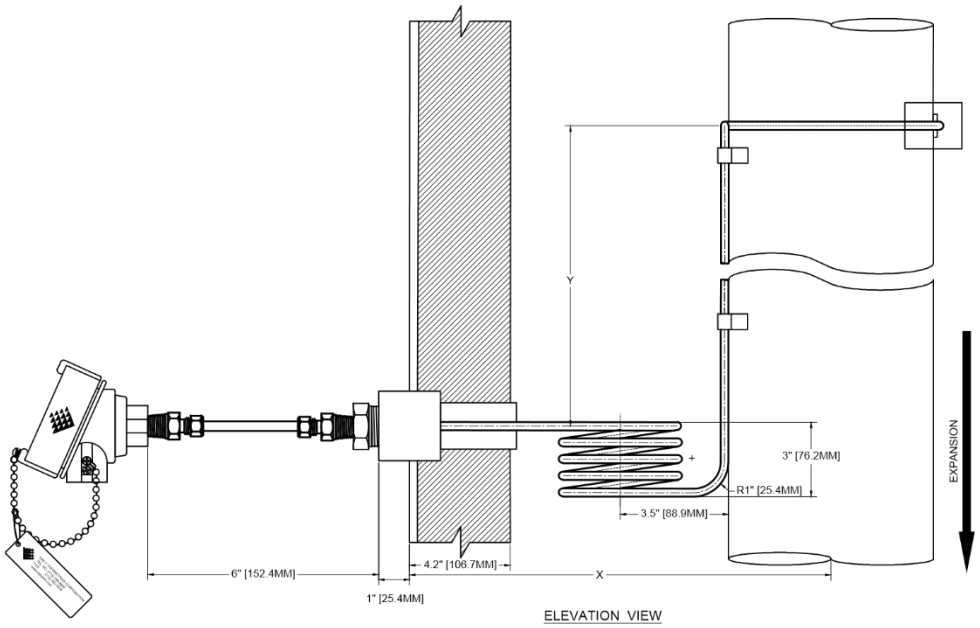
LOCATION:

- Position Thermocouple tip (sensing junction) in such way to minimize the distance between the tip and burner(s), in order to ensure that the hottest part of the tube is being measured.
- Be aware of tube guide supports and tube growth direction. The skin TC sensing junction location should be installed a sufficient distance (10” is typically acceptable) from the guide supports such that after tube growth, the skin TC does not hit the guide support and compromise the TC.

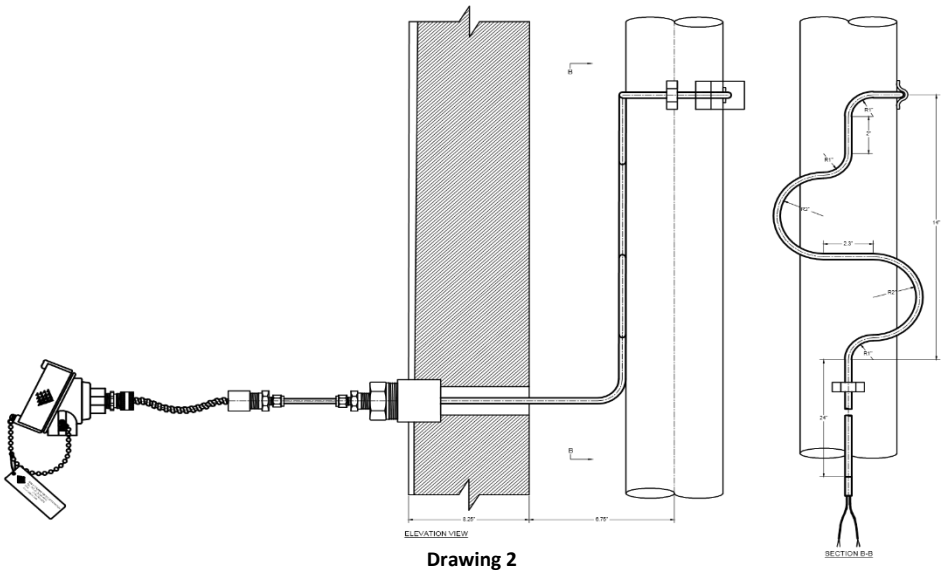
- Typical quantity is three to five (3-5) thermocouples per pass. At a minimum, one (1) thermocouple should be installed per pass in the radiant and convections sections of the heater.
- Heater entries should be positioned as to minimize the distance from the entry to the sensing junction to minimize the length of sheath that is exposed to the intense heat.

INSTALLATION AND ROUTING:

- Whenever possible, route tubeskin thermocouples on the coldest side of the pipe, i.e. the side not facing the flame. The pipe protects the thermocouple by shielding it from the flame. The length of thermocouple cable that is not shielded by the pipe shall be minimal.
- If thermocouples are longer than required, coil any excess MI cable outside of the heater.
- Install thermocouples such that transition housings are at least 6” outside of the insulation of the heater. Installing the transition housing too close to the heater and heater insulation can cause the epoxy to melt, causing inaccurate readings and/or failure.
- Engineers with acute knowledge of heater tubeskin thermocouples shall supervise all heater tubeskin thermocouple installations. The largest cause of heater tubeskin thermocouple failure is improper routing and installation, both of which may be easily prevented through supervision by a properly trained and knowledgeable engineer.



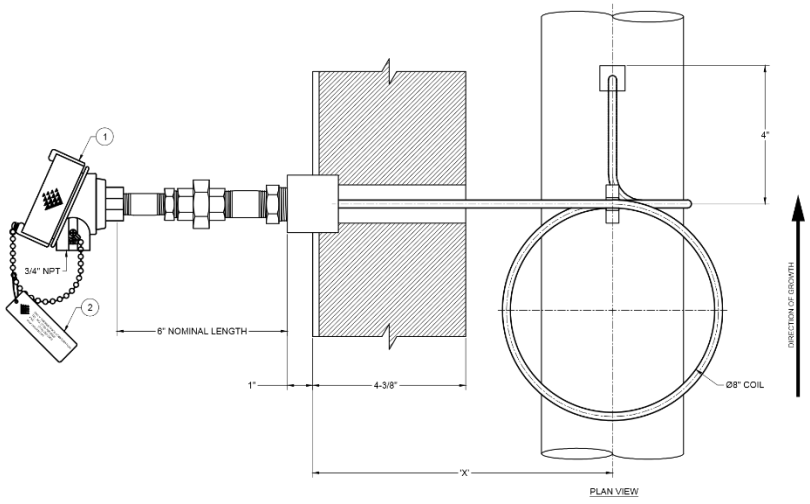
Drawing 1



Drawing 2

EXPANSION COILS AND BENDS

- Include Expansion coils (Drawing 1), S-bends (Drawing 2), Omega bends, Single loops (Drawing 3), and any other loops or bends as required to compensate for the anticipated amount of expansion.
- Orientation of bends/coils should be such that they unwind/unwrap as the tube grows.
- When tube growth is unavailable or unknown, growth should be assumed to be a minimum of 6” away from any fixed point. S bends may be used to allow for expansion in either direction, if direction of growth is unsure.
- Bending thermocouples decreases the space between the wires, increasing the chance of forming an extra junction and false reading. To reduce the risk of problems caused by bending, the minimum suggested bend radius is 4X (four times) the thermocouple OD. Radius should be measured on the inside of the curve.



Drawing 3

WELD CLIPS:

- Install weld clips along lengths where the thermocouple sheath runs parallel to the pipe, at maximum intervals of every 36”. Additional weld clips may be employed to secure thermocouple wherever necessary.
- Do not use weld clips when thermocouple is running across (perpendicular to) multiple pipes. Pipes may grow at different rates or in different directions, putting additional strain on the thermocouple.
- Weld clips should be sufficiently loose such that thermocouple sheath can move, unhindered.

COMMON & SUGGESTED MATERIALS

- Selecting the proper sheath material can be critical to ensuring a thermocouple’s long life.
- If maximum box temperature is less than 2100°F, then 310SS welded components may be used to reduce cost.
- The below are to be used only as general guidelines. Consult Daily Thermetrics engineering for best suggestions based on specific applications.

Gas Fired Heaters:

- 310SS: Suggested for use in temperatures up to 1200°F
  Actual maximum temperature: 2100°F
- Inconel 600: Suggested for use in temperatures of 1200°F to 1600°F,
  Retains higher strength than 310SS at elevated temperatures
  Do not use if sulfur is present
  Actual maximum temperature: 2150°F
- Hastelloy X: Suggested for use in temperatures of 1600°F to 2200°F

Oil Fired Heaters:

- Hastelloy X: Suggested for use in temperatures of 1600°F to 2200°F
- HR160: Suggested for use in temperatures of 1800°F to 2200°F
  To be used in the most severe applications

TESTING AND INSPECTION

- Before adding lead wire, thermocouples should read an insulation resistance of 10gOhm, as a minimum. Moisture inside the sheath can create extra junctions that cause false readings in normal thermocouples. Heater tubeskin thermocouples are particularly susceptible to damage by moisture because the heat can cause the moisture to expand. Insulation resistance for grounded thermocouples can only be tested before the grounding junction is made.

- All thermocouples shall undergo single point calibration (minimum) to ensure proper functionality and accuracy.
- Thermocouples should undergo radiographic testing of the thermocouple junction and transition housing, to ensure that thermocouple wires are connected correctly.
- Please note that Daily Thermetrics provides RT, IR, and Calibration testing all free of charge. We can provide certificates confirming that thermocouples passed this testing. (Actual reports from testing will be an extra cost.)

INCLUDED DRAWINGS

- Drawing 1: Typical layout for radiant section of can heaters and box heaters with vertical tubes; utilizing nipple-union-nipple style heater attachment and expansion coils.
  Note: nipple-union-nipples for heater tubeskin thermocouples should include a compression fitting inside the union to form a seal and hold the thermocouple sheath.
- Drawing 2: Optional layout, used for a variety of reasons, employing remote mount heater attachment and S bend.
- Drawing 3: Typical layout for convection section, including double compression fitting type heater attachment and single expansion bend.

WELDING PROCEDURES

NOTE: The specifications shown below are common specifications use used by various refineries. Not all welding combinations are listed. Always defer to site standards if in place.

Furnace Tube Material	Filler Material(1)	AWS/ASME Filler Material Spec	Welding Process	Preheat (min)	Interpass Temp. (max)(2)	PWHT	Pad, Clip, Heat Shield Material
Carbon Steel	Inconel 82	ERNi Cr-3	GTAW	300 °F–400 °F (150 °C–205 °C)	—	None Required	Hastelloy X
Carbon Steel	ER309	ER309	GTAW	50 °F–70 °F (10 °C–21 °C)	—	None Required	310SS
347/347H	Inconel 82	ERNi Cr-3	GTAW	450 °F (232 °C)	—	None Required	310SS
HK-40 Incoloy	Inconel 82	ERNi Cr-3	GTAW	50 °F (10 °C)	350 °F (175 °C)	None Required	Hastelloy X

C-1/2 Mo	Inconel 82	ERNi Cr-3	GTAW	300 °F–400 °F (150 °C–205 °C)	400 °F (205 °C)	None Required	Hastelloy X
1 1/4 Cr-1/2 Mo .	Inconel 82	ERNi Cr-3	GTAW	400 °F–500 °F (205 °C–260 °C)	500 °F (260 °C)	None Required	Hastelloy X
2 1/4 Cr-1 Mo 5 Cr-1/2 Mo 7 Cr-1/2 Mo 9 Cr-1 Mo	Inconel 82	ERNi Cr-3	GTAW	400 °F–500 °F (205 °C–260 °C)	400 °F–500 °F (205 °C–260 °C)	None Required	Hastelloy X
2 1/4 Cr-1 Mo 5 Cr-1/2 Mo 7 Cr-1/2 Mo 9 Cr-1 Mo	Inconel 82	ERNi Cr-3	GTAW	400 °F–500 °F (205 °C–260 °C)	—	Heat to 600 °F (316°C) Wrap with Kaowool and slow cool.	310SS

Note: All welds should be visually inspected for any defects, particularly cracks. Dye Penetrant Testing should be utilized to ensure a quality weld was performed.

If you have any questions or would like to request a quote, please contact: STM@dailyinst.com