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1. **Scope**

This Practice provides the design requirements for temperature measurement equipment selection and for the design of temperature measurement systems.

2. **References**

Applicable parts of the following Practices and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 **Process Industry Practices (PIP)**

- PIP PCFTE100 - Thermowell Fabrication Details
- PIP PCITE200 - RTD/Thermocouple Installation Details
- PIP PNF0200 - Vents, Drains, and Instrument Connection Details

2.2 **Industry Codes and Standards**

- American Society of Mechanical Engineers (ASME)
  - ASME PTC 19.3 TW - Performance Test Code - Temperature Measurement
- American Society for Testing and Materials (ASTM)
- Compressed Gas Association (CGA)
  - CGA G-4.4 - Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems
- International Electrotechnical Commission (IEC)
  - IEC 60751 - Industrial Platinum Resistance Thermometer Sensors (International Equivalent of Standard DIN 43760)
- The International Society of Automation (ISA)
  - ISA S20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves
  - ISA S20.10A - Specification Form, Potentiometer Instruments
  - ISA S20.10B - Specification Form, Potentiometer Instruments (multiple)
  - ISA S20.11A - Specification Form, Temperature Instruments - Filled Systems
  - ISA S20.11B - Specification Form, Temperature Instruments - Filled Systems (multiple)
  - ISA S20.12A - Specification Form, Thermocouples & Thermowells
  - ISA S20.12B - Specification Form, Thermocouples & Thermowells (multiple)
  - ISA S20.13A - Specification Form, RTDs & Thermowells
  - ISA S20.13B - Specification Form, RTDs & Thermowells (multiple)
  - ISA S20.14A - Specification Form, Industrial Bimetal and Glass Thermometers
  - ISA S20.14B - Specification Form, Industrial Bimetal and Glass Thermometers (multiple)
3. Requirements

3.1 General

3.1.1 Data

3.1.1.1 A data set shall be provided for each temperature instrument.

3.1.1.2 The data set can be provided in editable electronic or hard copy format.

3.1.1.3 The minimum data set shall be in accordance with ISA S20.10, ISA S20.11, ISA S20.12, ISA S20.13, and ISA S20.14 Specification Forms.

3.1.1.4 Instruments shall be provided with the manufacturer’s data on the nameplate, which shall contain the instrument tag number as a minimum.

3.1.2 All equipment shall be rated for the specified electrical area classification.

3.2 Thermowells

For thermowell fabrication details, see PIP PCFTE100.

3.2.1 Thermowells that are installed without a permanent temperature element shall have a plug and chain.

3.2.2 Thermowell (TW) connection type (welded, screwed/threaded, or flanged) shall match the applicable piping specification.

Comment: If a screwed/threaded process connection is used, a warning tag shall be provided and affixed to the TW. For example, “Caution: threaded thermowell, back-up wrench required.”

3.2.3 TW material shall be 316 SS unless the process requires other material of construction.

Comment: Minute particles in gaseous oxygen service (22 to 100% O2 by volume) may heat up if they impinge at high velocity on obstructions in the pipe. Monel and/or Hastelloy materials of construction may be required depending on the pressure and temperature of the service. See CGA G-4.4 for more information.

3.2.4 A materials specialist shall be consulted for “weld-in” TWs on piping above 343°C (650°F).

3.2.5 All temperature sensors shall be installed in TWs with the following exceptions:

a. Temperature sensors in some services that are not hazardous may be installed without a TW (e.g., services such as ambient air, motor windings, bearing temperatures, and electronic equipment cabinets).

b. Temperature sensors in a process service that normally would be in a TW but require a faster response may be installed without a TW if the following safeguards are met:

1) Each installation shall be approved by owner.

2) Warning tags shall be placed on each installation.

3.2.6 Where ASME PTC 19.3 TW is applicable, frequency and stress calculations shall be performed for TWs.
3.2.7 TWs shall be constructed from solid bar stock unless otherwise approved by owner.

3.2.8 Standard TW bore sizes for temperature elements shall be 6.5 mm (0.260 inch) for TC and RTD or 9 mm (0.385 inch) for filled systems.

3.2.9 Tapered shank TW design is preferred.

3.2.10 For insulated pipe, lagging extension shall be provided to extend the temperature element connection point outside the insulation.

### 3.2.11 Installation

3.2.11.1 TWs shall be located a minimum of ten (10) diameters downstream of the mixing point for liquids.

3.2.11.2 TWs shall be located a minimum of twenty-five (25) diameters downstream of the mixing point for gases or desuperheaters.

3.2.11.3 See PIP PNF0200 for TW connections to piping.

3.2.11.4 See PIP PCITE200 for installation details.

### 3.3 Thermocouples

3.3.1 Standard thermocouples (TCs) shall be enclosed in a 6 mm (1/4-inch) outside diameter, type 316 SS protection sheath, with an epoxy sealed transition piece and TC extension wire to a weatherproof head.

Inconel sheath and high temperature insulation shall be used for temperature applications greater than 316°C (600°F).

3.3.2 TCs shall be fabricated with 18 gauge wire minimum.

3.3.3 TCs shall be in accordance with ASTM E230/E230M for TC types B, E, J, K, N, R, S, and T.

*Comment:* Type J TCs contain iron wire which is subject to corrosion in many locations.

3.3.4 The sheathed TC hot junction shall be grounded.

*Comment:* There are applications that may require ungrounded TCs such as differential, average temperature or special requirement of temperature receiver devices.

3.3.5 The TC metal sheath shall be connected to the ground connection terminal strip in the TC head by way of the extension wire shield in the sealed transition piece. Crimped connections shall not be permitted.

3.3.6 Grounding of the shield at more than one location shall be avoided.

3.3.7 TC heads shall have the following characteristics:

a. Cast aluminum or owner approved alternative

b. Compression type terminal block with brass terminals and an extra terminal for attaching the extension wire shield connection

*Comment:* Duplex TCs require either four or six terminals.

c. Two FNPT connections
3.4 **Resistance Temperature Detectors**

3.4.1 Resistance Temperature Detectors (RTDs) shall use a 100 ohm platinum element (resistance measured at 0°C), hermetically sealed and manufactured in accordance with IEC 60751, Class B.

3.4.2 RTDs shall be in accordance with IEC 60751 (equivalent to DIN 43760) temperature coefficient of 0.00385 ohms per ohm per degree Celsius.

3.4.3 Standard RTDs shall be enclosed in a 6 mm (1/4-inch) outside diameter, type 316 SS protection sheath. An Inconel sheath and high temperature insulation shall be used for temperature applications greater than 316°C (600°F).

    *Comment:* Smaller diameters may be used for special applications requiring faster response times.

3.4.4 RTDs shall use insulated nickel or nickel alloy wire from a platinum element to an epoxy sealed transition piece where the copper wires shall be attached by welding or soldering. Crimped connections shall not be permitted.

3.4.5 RTDs shall be fabricated with 18 gauge wire minimum. Duplex design MgO sheathed may not fit standard sheath or require smaller gauge wire.

3.4.6 RTDs shall have the 3 lead wire design.

    *Comment:* Four-wire RTDs may be required for certain applications.

3.4.7 RTD heads shall have the following characteristics:

a. Cast aluminum or owner approved alternative

b. Compression type terminal block with an extra screw provided for attaching the wire shield

    *Comment:* Duplex RTDs require 6 or 8 terminals.

c. Two FNPT connections

3.5 **Temperature Transmitters**

3.5.1 Temperature transmitters shall be smart electronic with an input from a TC or RTD sensor.

3.5.2 Electronic temperature transmitters shall have the following characteristics:

a. Accuracy, including the combined effects of linearity, hysteresis and repeatability, equal to or better than plus or minus 1°C / 1.8°F

b. Span, TC/RTD input type, etc., shall be configurable.

3.5.3 Transmitters having a TC input shall also provide:

a. Input/output isolation

b. Cold junction compensation

c. Automatic TC burnout detection with selectable upscale or downscale failure mode. Transmitter burnout shall be configured.

d. Built-in temperature linearization capability for output signal

3.5.4 Transmitters having RTD input shall also provide input/output isolation.
3.6 **Stand-Alone Electronic Indicators**

3.6.1 Stand-alone electronic indicators (indicators that receive a temperature element as a direct input) shall have the following characteristics:

a. Receive either TC or RTD signals
b. Direct readout in degrees Fahrenheit or degrees Celsius
c. Circuitry that provides a linearized readout

3.6.2 Stand-alone electronic indicators with TC input(s) shall incorporate cold junction compensation and automatic TC burnout detection.

3.7 **Indicating Thermometers**

3.7.1 Mercury-filled thermometers shall not be permitted.

3.7.2 Thermometers shall have a minimum accuracy of plus or minus 1.0% of the scale span.

3.7.3 Indicating thermometers shall be designed to install into a TW with a 0.25 mm (0.01 inch) clearance between the thermometer stem and the TW inside diameter.

3.7.4 The stem length of thermometers shall be selected to bottom out in the TW in which they are to be installed.

3.7.5 Bimetallic thermometers shall have the following characteristics:

a. Helix measuring element
b. Minimum 75 mm (5-inch) diameter dial face with a nonglare white finish and black or contrasting color markings
c. Stainless steel, every angle weatherproof case with bezel ring
d. 6 mm (1/4-inch) outside diameter protection tube
e. Hexagonal head or wrench flats
f. Display temperature units (°C and/or °F)

3.7.6 Thermometers indicating range shall be selected such that the normal operating temperature falls between 30 and 70 percent of the scale range, while the maximum and minimum temperature can still be read.

3.8 **Filled and Mechanical Thermal Systems**

Filled and mechanical thermal systems shall only be used for local indication or self-actuated temperature devices with owner’s approval.