



Designation: E879 – 12

Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements¹

This standard is issued under the fixed designation E879; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the general requirements for Negative Temperature Coefficient (NTC) thermistor-type sensors intended to be used for laboratory temperature measurements or control, or both, within the range from -10 to 105°C .

1.2 This specification also covers the detailed requirements for ASTM designated sensors.

1.3 This specification also covers the requirements for general purpose, Negative Temperature Coefficient (NTC) thermistor-type sensors intended for use with Digital Contact Thermometers (also known as Digital Thermometers) within the range from -50 to $+150^{\circ}\text{C}$.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

[E344 Terminology Relating to Thermometry and Hydrometry](#)

[E563 Practice for Preparation and Use of an Ice-Point Bath as a Reference Temperature](#)

[F29 Specification for Dumet Wire for Glass-to-Metal Seal Applications](#)

3. Terminology

3.1 *Definitions*—The definitions given in Terminology [E344](#) shall apply to this specification.

3.2 *Definitions of Terms Specific to This Standard:*

¹ This specification is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.03 on Resistance Thermometers.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.1 *dissipation constant, δ , n*—the ratio of the change in energy dissipated per unit time (power) in a thermistor, $\Delta P = P_2 - P_1$, to the resultant temperature change of the thermistor, $\Delta T = T_2 - T_1$.

$$\delta = \frac{\Delta P}{\Delta T} \quad (1)$$

The dimensions of the dissipation constant are W/K. For this specification, T_1 is in the range from 20 to 38°C and $\Delta T = 10^{\circ}\text{C}$.

3.2.2 *dumet, n*—round, copper-coated 42 % nickel-iron wire intended primarily for sealing to soft glass. Also known as CuNiFe in some communities.

3.2.3 *insulation resistance, dc, n*—the resistance at a specified direct-current voltage between the insulated leads of a thermistor sensor and the metallic enclosure of the sensor, if such an enclosure is present, or else between the sensor leads and a conductive medium in which the sensor is immersed.

3.2.4 *qualification test, n*—a series of tests conducted by the procuring agency or an agent thereof to determine conformance of thermistor sensors to the requirements of a specification, normally for the development of a qualified products list under the specification.

3.2.5 *response time, n*—the time required for a sensor to change a specified percentage of the total difference between its initial and final temperatures as determined from zero-power resistances when the sensor is subjected to a step function change in temperature.

3.2.6 *time constant, n*—the 63.2 % response time of a sensor that exhibits a single-exponential response.

3.2.7 *zero-power resistance, n*—the dc resistance of a device, at a specified temperature, calculated for zero-power.

3.2.7.1 *Discussion*—Accurate zero-power resistance is obtained by extrapolating to zero-power the resistance values obtained from measurements at three or more levels of power with the sensor immersed in a constant temperature medium. For the purpose of this specification, this is obtained from measurements at a single power level adjusted such that the power is not greater than one-fifth the product of the dissipation constant specified in [Table 1](#) (see [3.2.1](#) and [7.3](#)) and the

TABLE 1 Specification for ASTM Clinical Laboratory Thermistor Sensors

| ASTM No. | E879 S B1N | E879 E B1N | E879 S B2N | E879 E B2N |
|---|---|---|---|---|
| Description | Silicone Rubber Coated Glass Probe | Epoxy Coated Glass Probe | Silicone Rubber Coated Glass Probe | Epoxy Coated Glass Probe |
| Major Application | General Purpose Clinical Laboratory Temperature Measurement | General Purpose Clinical Laboratory Temperature Measurement | General Purpose Clinical Laboratory Temperature Measurement | General Purpose Clinical Laboratory Temperature Measurement |
| Operating Temperature Range | -10 to 60°C | -10 to 60°C | -10 to 60°C | -10 to 60°C |
| Accuracy Class | 1 (±0.01°C) | 1 (±0.01°C) | 2 (±0.02°C) | 2 (±0.02°C) |
| Temperatures for Accuracy Class | -10 to 60°C | -10 to 60°C | -10 to 60°C | -10 to 60°C |
| Accuracies for other Temperatures Within Specified Temperature Range | | | | |
| Calibration Type | Non-interchangeable | Non-interchangeable | Non-interchangeable | Non-interchangeable |
| Nominal <i>R-T</i> Characteristic | | | | |
| $R = \exp[A_0 + A_1/T + A_2/T^2 + A_3/T^3]$ (<i>T</i> in kelvins) | | | | |
| $T(°C) = [a_0 + a_1 \ln R + a_2 (\ln R)^2 + a_3 (\ln R)^3]^{-1} - 273.15$ | | | | |
| <i>A</i> ₀ | -4.4495078 | -4.4495078 | -4.4495078 | -4.4495078 |
| <i>A</i> ₁ | 3614.7764 | 3614.7764 | 3614.7764 | 3614.7764 |
| <i>A</i> ₂ | 88190.906 | 88190.906 | 88190.906 | 88190.906 |
| <i>A</i> ₃ | -22328247 | -22328247 | -22328247 | -22328247 |
| <i>a</i> ₀ | 0.11766716 × 10 ⁻² | 0.11766716 × 10 ⁻² | 0.11766716 × 10 ⁻² | 0.11766716 × 10 ⁻² |
| <i>a</i> ₁ | 0.28173082 × 10 ⁻³ | 0.28173082 × 10 ⁻³ | 0.28173082 × 10 ⁻³ | 0.28173082 × 10 ⁻³ |
| <i>a</i> ₂ | -0.23285292 × 10 ⁻⁵ | -0.23285292 × 10 ⁻⁵ | -0.23285292 × 10 ⁻⁵ | -0.23285292 × 10 ⁻⁵ |
| <i>a</i> ₃ | 0.24131652 × 10 ⁻⁶ | 0.24131652 × 10 ⁻⁶ | 0.24131652 × 10 ⁻⁶ | 0.24131652 × 10 ⁻⁶ |
| Type of Immersion Fluid | water, air | water, oil, air | water, air | water, oil, air |
| Nominal <i>R</i> ₀ at 25°C | 2.5 κΩ | 2.5 κΩ | 2.5κΩ | 2.5 κΩ |
| Dissipation Constant | 3.5 ± 0.9 mW/K | 5.0 ± 1.2 mW/K | 3.5± 0.9 mW/K | 5.0 ± 1.2 mW/K |
| 63.2 % Response Time | 0.55 ± 0.16 s | 0.45 ± 0.11 s | 0.55 ± 0.16 s | 0.45 ± 0.11 s |
| Ratio of 95 % to 63.2 % Response Times | 2.5 ± 0.6 | 2.1 ± 0.5 | 2.5 ± 0.6 | 2.1 ± 0.5 |
| Design and Construction | Fig. 2 | Fig. 3 | Fig. 2 | Fig. 3 |
| ASTM No. | E879 S A2N | E879 E A2N | E879 G B1N | E879 H B1N |
| Description | Silicone Rubber Coated Glass Probe | Epoxy Coated Glass Probe | 5κΩ -4-Wire Non-interchangeable Sensor in S.S. Housing | 5κΩ -2-Wire Non-interchangeable Sensor in S.S. Housing |
| Major Application | General Purpose Clinical Laboratory Temperature Measurement | General Purpose Clinical Laboratory Temperature Measurement | General Purpose Clinical Laboratory Temperature Measurement | General Purpose Clinical Laboratory Temperature Measurement |
| Operating Temperature Range | -10 to 105°C | -10 to 105°C | -10 to 60°C | -10 to 60°C |
| Accuracy Class | 2 (±0.02°C) | 2 (±0.02°C) | 1 (±0.01°C) | 1 (±0.01°C) |
| Temperatures for Accuracy Class | -10 to 105°C | -10 to 105°C | -10 to 60°C | -10 to 60°C |
| Accuracies for other Temperatures Within Specified Temperature Range | | | | |
| Calibration Type | Non-interchangeable | Non-interchangeable | Non-interchangeable | Non-interchangeable |
| Nominal <i>R-T</i> Characteristic | | | | |
| $R = \exp[A_0 + A_1/T + A_2/T^2 + A_3/T^3]$ | | | | |
| $T(°C) = [a_0 + a_1 \ln R + a_2 (\ln R)^2 + a_3 (\ln R)^3]^{-1} - 273.15$ | | | | |
| <i>A</i> ₀ | -4.3332974 | -4.3332947 | -3.7563605 | -3.7563605 |
| <i>A</i> ₁ | 4440.1603 | 4440.1603 | 3614.7764 | 3614.7764 |
| <i>A</i> ₂ | -104525.78 | -104525.78 | 88190.906 | 88190.906 |
| <i>A</i> ₃ | -4581329.78 | -4581329.78 | -22328247 | -22328247 |
| <i>a</i> ₀ | 0.98667965 × 10 ⁻³ | 0.98667965 × 10 ⁻³ | 0.98019160 × 10 ⁻³ | 0.98019160 × 10 ⁻³ |
| <i>a</i> ₁ | 0.24329879 × 10 ⁻³ | 0.24329879 × 10 ⁻³ | 0.28530667 × 10 ⁻³ | 0.28530667 × 10 ⁻³ |
| <i>a</i> ₂ | -0.59584872 × 10 ⁻⁶ | -0.59584872 × 10 ⁻⁶ | -0.28303328 × 10 ⁻⁵ | -0.28303328 × 10 ⁻⁵ |
| <i>a</i> ₃ | 0.97166167 × 10 ⁻⁷ | 0.97166167 × 10 ⁻⁷ | 0.24131652 × 10 ⁻⁶ | 0.24131652 × 10 ⁻⁶ |
| Type of Immersion Fluid | water, air | water, air | all fluids compatible with Type 304 S.S. | all fluids compatible with Type 304 S.S. |
| <i>R</i> ₀ at 25°C | 10κΩ | 10 κΩ | 5 κΩ | 5 κΩ |
| Dissipation Constant | 3.5 ± 0.9 mW/K | 5.0 ± 1.2 mW/K | 4.8± 1.2 mW/K | 4.8 ± 1.2 mW/K |
| 63.2 % Response Time | 0.55 ± 0.16 s | 0.45 ± 0.11 s | 4.5 ± 1.1 s | 4.5 ± 1.1 s |
| Ratio of 95 % to 63.2 % Response Times | 2.5 ± 0.6 | 2.1 ± 0.5 | 2.6 ± 0.3 | 2.6 ± 0.3 |
| Design and Construction | Fig. 2 | Fig. 3 | Fig. 4 | Fig. 5 |

TABLE 1 (continued)

| ASTM No. | E879 G B1N | E879 H B1N | E879 G A2N | E879 H A2N |
|---|---|---|---|---|
| Description | 10 κΩ 4-Wire Non-interchangeable Sensor in S.S. Housing | 10 κΩ 2-Wire Non-interchangeable Sensor in S.S. Housing | 10 κΩ 4-Wire Non-interchangeable Sensor in S.S. Housing | 10 κΩ 2-Wire Non-interchangeable Sensor in S.S. Housing |
| Major Application | General Purpose Clinical Laboratory Temperature Measurement | General Purpose Clinical Laboratory Temperature Measurement | General Purpose Clinical Laboratory Temperature Measurement | General Purpose Clinical Laboratory Temperature Measurement |
| Operating Temperature Range | -10 to 60°C | -10 to 60°C | -10 to 105°C | -10 to 105°C |
| Accuracy Class | 1 (±0.01°C) | 1 (±0.01°C) | 2 (±0.02°C) | 2 (±0.02°C) |
| Temperatures for Accuracy Class | -10 to 60°C | -10 to 60°C | -10 to 105°C | -10 to 105°C |
| Accuracies for other Temperatures | | | | |
| Within Specified Temperature Range | | | | |
| Calibration Type | Non-interchangeable | Non-interchangeable | Non-interchangeable | Non-interchangeable |
| Nominal <i>R-T</i> Characteristic | | | | |
| $R = \exp[A_0 + A_1/T + A_2/T^2 + A_3/T^3]$ | | | | |
| $T(°C) = [a_0 + a_1 \ln R + a_2 (\ln R)^2 + a_3 (\ln R)^3]^{-1} - 273.15$ | | | | |
| <i>A</i> ₀ | -3.5684919 | -3.5684919 | -3.7191520 | -3.7191520 |
| <i>A</i> ₁ | 3907.7065 | 3907.7065 | 4045.1666 | 4045.1666 |
| <i>A</i> ₂ | 33480.382 | 33480.382 | -8181.7100 | -8181.7100 |
| <i>A</i> ₃ | -18666997 | -18666997 | -14472122 | -14472122 |
| <i>a</i> ₀ | 0.86972495 × 10 ⁻³ | 0.86972495 × 10 ⁻³ | 0.89898144 × 10 ⁻³ | 0.89898144 × 10 ⁻³ |
| <i>a</i> ₁ | 0.27135335 × 10 ⁻³ | 0.27135335 × 10 ⁻³ | 0.26152805 × 10 ⁻³ | 0.26152805 × 10 ⁻³ |
| <i>a</i> ₂ | -0.20689100 × 10 ⁻⁵ | -0.20689100 × 10 ⁻⁵ | -0.97537969 × 10 ⁻⁶ | -0.97537969 × 10 ⁻⁶ |
| <i>a</i> ₃ | 0.20547429 × 10 ⁻⁶ | 0.20547429 × 10 ⁻⁶ | 0.16613292 × 10 ⁻⁶ | 0.16613292 × 10 ⁻⁶ |
| Type of Immersion Fluid | all fluids compatible with Type 304 S.S. | all fluids compatible with Type 304 S.S. | all fluids compatible with Type 304 S.S. | all fluids compatible with Type 304 S.S. |
| Nominal <i>R</i> ₀ at 25 °C | 10 κΩ | 10κΩ | 10 κΩ | 10 κΩ |
| Dissipation Constant | 4.8 ± 1.2 mW/K | 4.8 ± 1.2 mW/K | 4.8± 1.2 mW/K | 4.8 ± 1.2 mW/K |
| 63.2 % Response Time | 4.5 ± 1.1 s | 4.5 ± 1.1 s | 4.5± 1.1 s | 4.5 ± 1.1 s |
| Ratio of 95 % to 63.2 % Response Times | 2.6 ± 0.3 | 2.6 ± 0.3 | 2.6 ± 0.3 | 2.6 ± 0.3 |
| Design and Construction | Fig. 4 | Fig. 5 | Fig. 4 | Fig. 5 |
| ASTM No. | E879 V B3I | E879 W B3N | | |
| Description | Interchangeable Sensor Enclosed in 1.17 mm Plastic Tube | Non-interchangeable Sensor Enclosed in 0.92 mm Plastic Tube | | |
| Major Application | Cuvette Thermometry | Cuvette Thermometry | | |
| Operating Temperature Range | -10 to 60°C | -10 to 60°C | | |
| Accuracy Class | 3 (±0.05°C) | 3 (±0.05°C) | | |
| Temperatures for Accuracy Class | 24 to 45°C | -10 to 60°C | | |
| Accuracies for other Temperatures | -10 to 24°C: ±0.1°C 45 to 60°C: ±0.1°C | | | |
| Within Specified Temperature Range | | | | |
| Calibration Type | Interchangeable | Non-interchangeable | | |
| Nominal <i>R-T</i> Characteristic | | | | |
| $R = \exp[A_0 + A_1/T + A_2/T^2 + A_3/T^3]$ | | | | |
| $T(°C) = [a_0 + a_1 \ln R + a_2 (\ln R)^2 + a_3 (\ln R)^3]^{-1} - 273.15$ | | | | |
| <i>A</i> ₀ | -3.1645305 | -3.0612396 | | |
| <i>A</i> ₁ | 3763.4399 | 3613.0051 | | |
| <i>A</i> ₂ | 47816.278 | 88718.122 | | |
| <i>A</i> ₃ | -18332303 | -22380305 | | |
| <i>a</i> ₀ | 0.78686094 × 10 ⁻³ | 0.78069589 × 10 ⁻³ | | |
| <i>a</i> ₁ | 0.28128740 × 10 ⁻³ | 0.28967541 × 10 ⁻³ | | |
| <i>a</i> ₂ | -0.25226292 × 10 ⁻⁵ | -0.38427027 × 10 ⁻⁵ | | |
| <i>a</i> ₃ | 0.20852922 × 10 ⁻⁶ | 0.24169639 × 10 ⁻⁶ | | |
| Type of Immersion Fluid | water | water | | |
| Nominal <i>R</i> ₀ at 25°C | 11 κΩ | 10 κΩ | | |
| Dissipation Constant | 1.1 ± 0.3 mW/K | 0.8 ± 0.2 mW/K | | |
| 63.2 % Response Time | 0.5 ± 0.12 s | 0.26 ± 0.06 s | | |
| Ratio of 95 % to 63.2 % Response Times | 3.0 ± 0.3 | 3 ± 0.3 | | |
| Design and Construction | Fig. 6 | Fig. 7 | | |

TABLE 2 Equivalent Temperature Tolerances for Different Class Sensors (See 4.1 and 4.4)

| Accuracy Class | Temperature Tolerance, °C |
|----------------|---------------------------|
| 1 | ±0.02 |
| 2 | ±0.03 |
| 3 | ±0.05 |
| 4 | ±0.1 |

appropriate tolerance requirement of Table 2. When making stability measurements, the power shall be kept constant.

4. Classification

4.1 Thermistor sensors covered by this specification shall be classified with a type designation code that includes the ASTM detailed specification number followed by a descriptive code. See Fig. 1.

4.2 *ASTM Specification Number*—The ASTM specification number specifies uniquely the design and construction of the sensor including the type designation if more than one type appears in the same specification.

4.2.1 *Type Designation*—The type designation shall be a letter symbol to indicate the design and construction of the thermistor sensor.

4.2.1.1 *Type S*—Silicone rubber-coated glass probe with tinned Dumet extension leads (see Fig. 2).

4.2.1.2 *Type E*—Epoxy-coated glass probe with silver-plated copper extension leads (see Fig. 3).

4.2.1.3 *Type G*—General purpose four wire sensor in stainless steel housing (see Fig. 4).

4.2.1.4 *Type H*—General purpose two-wire sensor in stainless steel housing (see Fig. 5).

4.2.1.5 *Type V*—Interchangeable sensor enclosed in 1.2-mm vinyl tube (see Fig. 6).

4.2.1.6 *Type W*—Non-interchangeable sensor enclosed in 0.9-mm vinyl tube (see Fig. 7).

4.3 *Operating Temperature Range*—The operating temperature range shall be designated by a letter symbol (see Table 3).

4.4 *Accuracy Class*—The accuracy class shall be designated by a single-digit number (see Table 2).

4.5 *Calibration Type*—The type of calibration required for each unit shall be designated by a letter symbol. The letter *I* shall be used to denote units that are interchangeable with respect to a single resistance-temperature relationship. The letter *N* shall be used to denote non-interchangeable units for which resistance-temperature information must be furnished

for each unit. For Calibration Type *N* sensors, serial number identification must be provided.

5. Requirements

5.1 *Specifications*—Sensors shall comply with the general requirements specified herein as well as with the applicable detailed specifications of Table 1. In the event of conflict between this requirement paragraph and the detailed specification of Table 1, Figs. 2-7 the latter shall govern.

5.2 *Zero-Power Resistance versus Temperature Relationship*—The zero-power resistance versus temperature relationship shall be presented in a form such that any temperature within the specified operating temperature range can be obtained from that relationship and have an uncertainty no greater than one-tenth the specified tolerance in Table 2. When tested in accordance with 7.2, the zero-power resistance versus temperature relationship for interchangeable parts shall comply to within the tolerance specified in Table 2. The manufacturer of the sensor shall, for non-interchangeable parts, supply this relationship with each part shipped.

5.2.1 *Accuracy*—The resistance-temperature relationship, provided in Table 1, or with the sensor, or both, shall not differ from that obtained from measurements made in accordance with 7.2 by more than the tolerances specified in Table 2 for the applicable intervals specified in Table 1.

5.3 *Thermal Requirements:*

5.3.1 *Dissipation Constant*—When tested in accordance with 7.3, the dissipation constant shall be as specified in the detailed specification.

5.3.2 *Response Time*—When tested in accordance with 7.4, the response time or time constant, or both, shall be as specified in the detailed specification.

5.4 *Environmental Requirements:*

5.4.1 *Operating Temperature Range*—The operating temperature range shall be as specified in the type designation code (see 4.1 and 4.3).

5.4.2 *Storage Temperature Range*—Sensors shall be capable of meeting all requirements specified herein as well as those listed in the applicable detailed specification after storage at any temperature (or combination thereof) in the range from -40 to 60°C for a period of 1 year.

5.4.3 *Humidity Requirement*—Sensors shall be capable of being operated or stored at relative humidity from 0 to 95 % without condensation.

5.5 *Stability:*

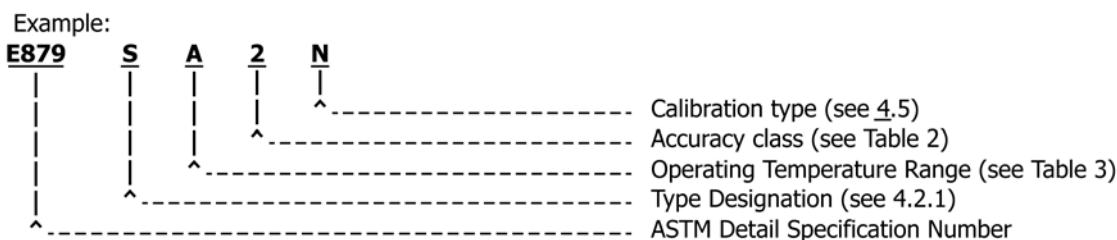
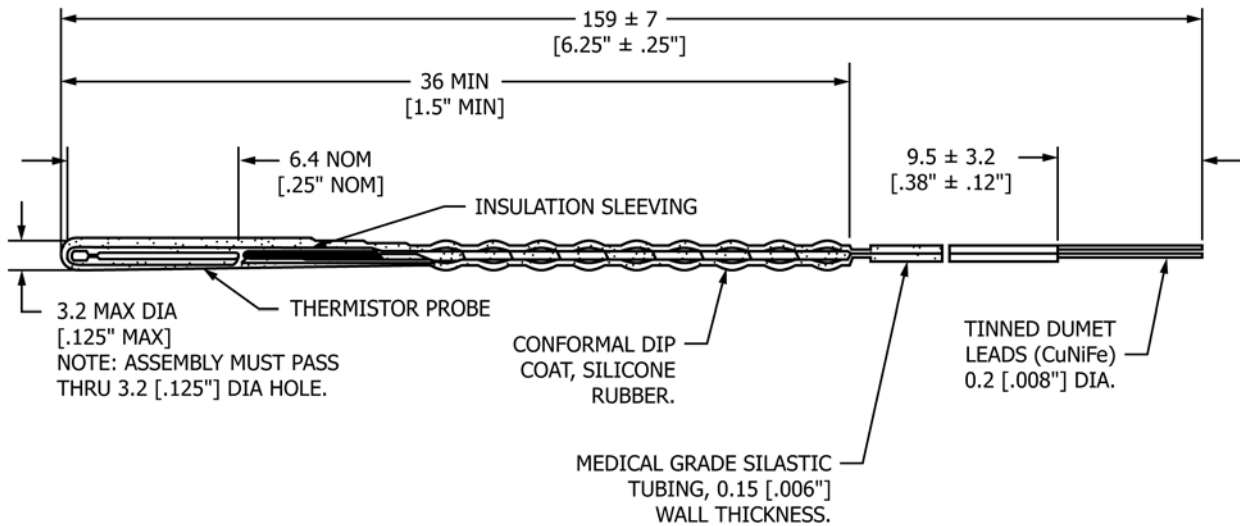
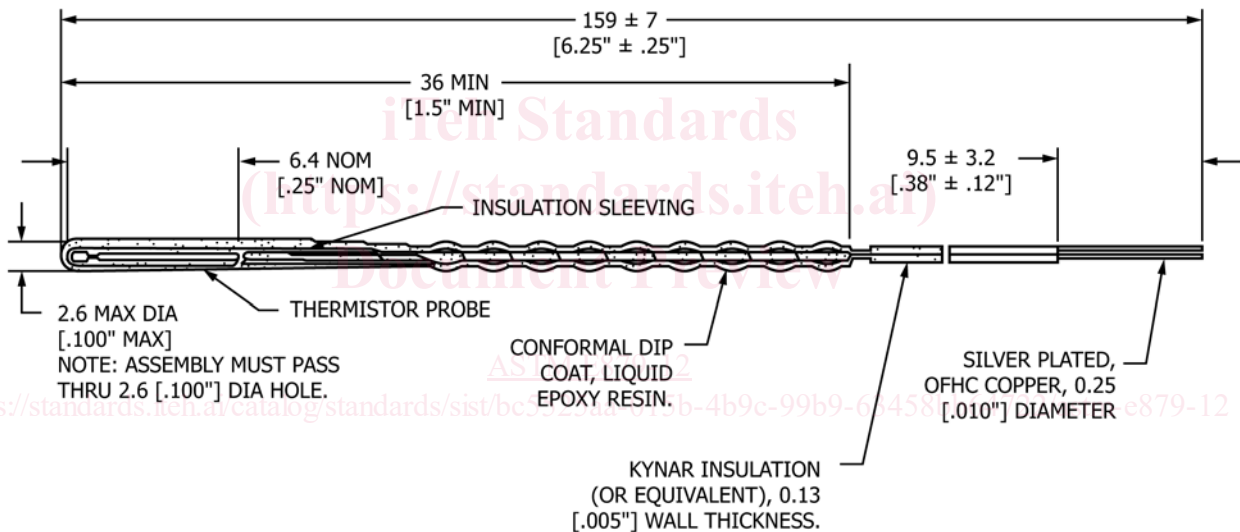


FIG. 1 Classification Code



NOTE: METRIC [ENGLISH] ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE INDICATED.

FIG. 2 Silicone Rubber Coated Glass Probe



NOTE: METRIC [ENGLISH] ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE INDICATED.

FIG. 3 Epoxy Coated Glass Probe

5.5.1 *Short-Term Stability* (10 days)—When tested in accordance with 7.5.1, the equivalent temperature shift shall be no greater than 10 % of the tolerance shown in Table 2 for the accuracy class specified.

5.5.2 *Long-Term Stability* (120 days)—When tested in accordance with 7.5.2, the equivalent temperature shift shall be no greater than 25 % of the tolerance shown in Table 2 for the accuracy class specified.

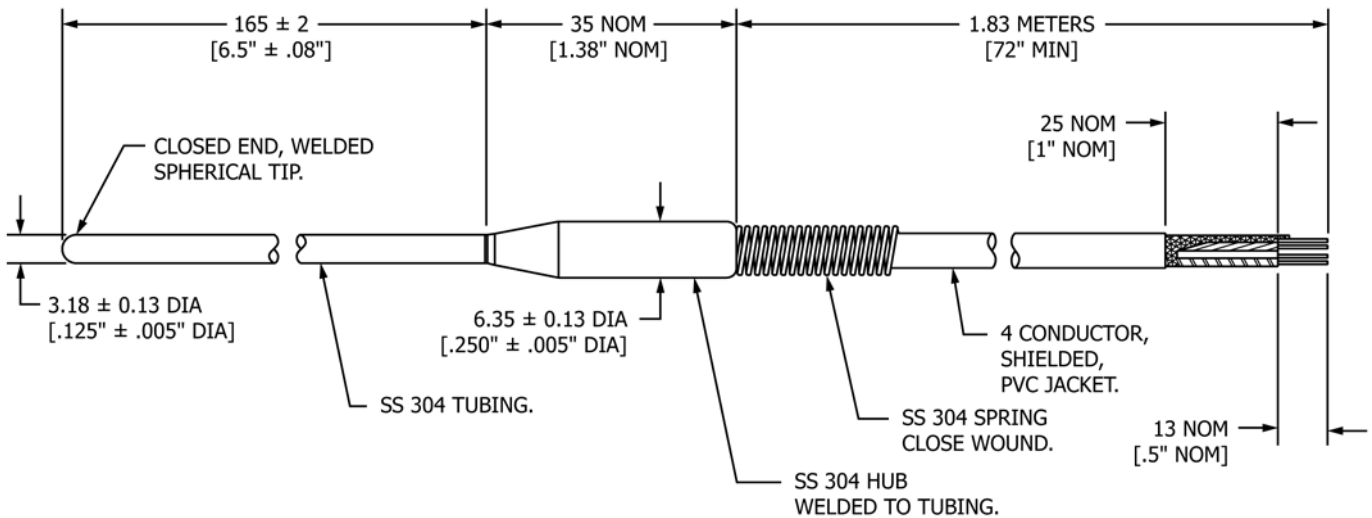
5.6 *Low-Temperature Storage*—When tested in accordance with 7.6, there shall be no evidence of mechanical damage and the sensor shall comply with the accuracy requirements of 5.2.

5.7 *Thermal Shock*—When tested in accordance with 7.7, there shall be no evidence of mechanical damage and the sensor shall comply with the accuracy requirements of 5.2.

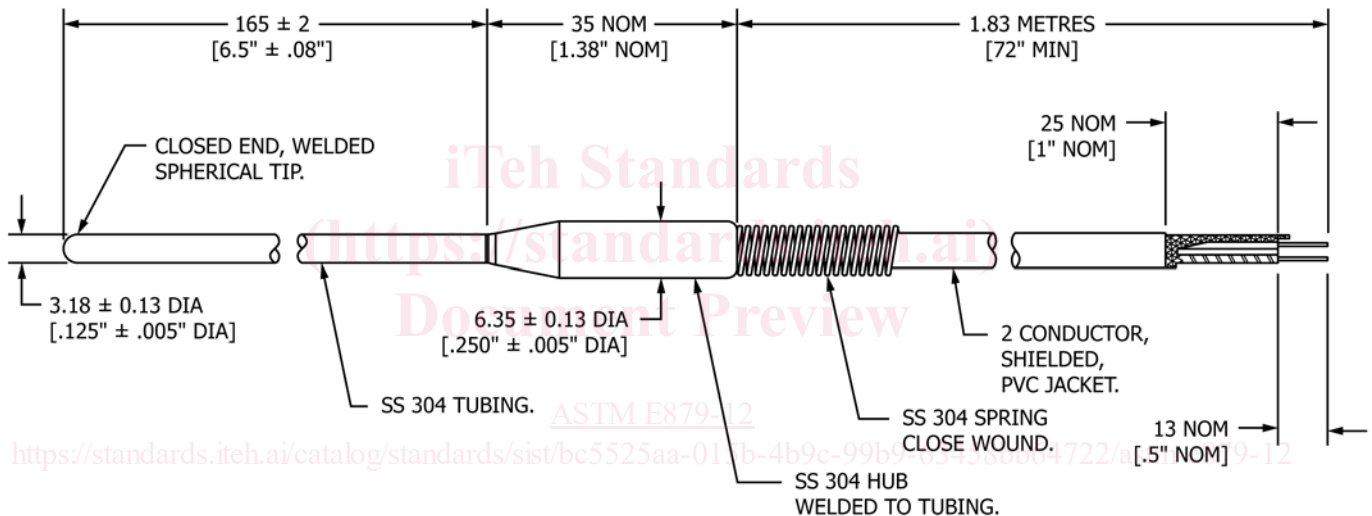
5.8 *Insulation Resistance:*

5.8.1 *Dry Test*—This requirement shall apply to sensors that have exposed metallic surfaces, but are not designed for immersion in conductive fluids. When tested in accordance with 7.8.1, there shall be no evidence of mechanical damage and the insulation resistance shall be sufficiently high that its shunting effect will not prevent the unit from complying with the accuracy requirement of Table 2. In no case shall the insulation resistance be less than 10^8 ohms.

5.8.2 *Wet Test*—This requirement shall apply to sensors that are designed for use in conductive solutions. When tested in accordance with 7.8.2, there shall be no evidence of mechanical damage and the insulation resistance shall be sufficiently high that its shunting effect will not prevent the unit from



NOTE 1—Metric (English) All dimensions in millimetres unless otherwise indicated.
FIG. 4 General Purpose Four-Wire Sensor in Stainless Steel Housing



NOTE 1—Metric (English) All dimensions in millimetres unless otherwise indicated.
FIG. 5 General Purpose Two-Wire Sensor in Stainless Steel Housing

complying with the accuracy requirement of **Table 2**. In no case shall the insulation resistance be less than 10^8 ohms.

6. Quality Assurance Provisions

6.1 *General*—The methods of examination and tests contained in Section 7 are to be used to determine the conformance of sensors to the requirements of this specification. Each manufacturer or distributor who represents his products as conforming to this specification may, as agreed upon between the purchaser and seller, use statistically based sampling plans that are appropriate for each inspection lot. Records shall be kept as necessary to document the claim that all of the requirements of this specification are met. The tests specified in this section are intended as minimum requirements. Additional

sampling and testing of the product, as may be agreed upon between the purchaser and the seller, are not precluded by this section.

6.2 Classification of Inspection:

6.2.1 *Qualification Tests*—Qualification tests shall be performed for each basic design manufactured in accordance with this specification. The sample size required for the tests conducted shall be in accordance with **Table 4**. In order for a design to qualify, there shall be no failures resulting from any of the tests.

6.2.2 *Responsibility for Qualification Testing*—The manufacturer shall perform qualification testing, at least once, for each basic design for which this specification applies. If a basic