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RDT Standard

PLATINUM RESISTANCE THERMOMETER

APRIL 1975

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Send copy and distribution inquiries to:

RDT Standards Office
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FOREWORD

This standard supersedes the March 1973 issue of RDT C 7-17T and incorporates those changes to that issue of the standard that were approved and published as Amendment 1 and those changes that were approved for publication in this revision. These changes are identified by the following marginal notations:

A1	Amendment 1, September 1974
C	Change approved April 1975

Editorial changes that were made during preparation of this revision are not identified.

PLATINUM RESISTANCE THERMOMETER

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PLATINUM RESISTANCE THERMOMETER

1. SCOPE

This standard covers the design, fabrication, and quality assurance requirements for sheathed alumina-insulated platinum resistance thermometers for continuous measurement of temperatures in the range of 0°C to 660°C (32 to 1220°F) in applications requiring high accuracy. These thermometers are for installation in thermowells and are not intended to form part of a pressure retaining boundary or to be exposed directly to reactors coolants or other process fluids. A1

1.1 Classification. Thermometers shall be one of the following types, as specified in the Ordering Data:

Type I Single-element thermometers.

Type II Dual-element thermometers.

1.2 Definitions. For purposes of this standard, the following definitions apply.

1.2.1 Single-Element Platinum Resistance Thermometer. An element provided with insulated leads to form the four-wire configuration and assembled into a sheath with the lead wires extending through the end seal to permit measurement of the electrical resistance of the element.

1.2.2 Dual-Element Platinum Resistance Thermometer. Two elements each provided with insulated leads to form the four-wire configuration and assembled into a sheath with the lead wires extending through the end seal to permit measurement of the electrical resistance of each element.

1.2.3 Element. A thermometer subassembly consisting of a length of platinum temperature-sensing wire mounted in electrical insulation with two platinum or 90 percent platinum/10 percent rhodium leads extending through the insulation, one from each end of the platinum temperature-sensing wire.

1.2.4 Callendar Equation. The mathematical relationship of the temperature of a platinum wire and its electrical resistance is given by Equation 1.

$$R_T = R_0 \left[1 + \alpha T - \alpha\delta \left(\frac{T}{100}\right) \left(\frac{T}{100} - 1\right)\right] \qquad (1)$$

where

R_T = the electrical resistance of the wire in ohms at temperature T (°C)

R_0 = the ice-point resistance is the electrical resistance in ohms of the wire at 0°C (32°F)

δ = a constant with value of approximately 1.5, as determined from calibrations performed in accordance with the requirements of 3.5.1

α = the average temperature coefficient of the platinum wire between 0°C and 100°C (32 and 212°F) and is expressed mathematically by Equation 2.

$$\alpha = \frac{(R \text{ in ohms at } 100°C) - Ro}{100R_0} \qquad (2)$$

Another useful form of Equation 1 is

$$R_T = R_0 \quad (1 + AT + BT^2) \qquad (3)$$

where

$$A = \alpha \left(1 + \frac{\delta}{100} \right)$$

$$B = - \frac{\alpha\delta}{10^4}$$

R_T, R_0, T, α, and δ are as defined for Equation 1.

Equation 3 is preferred for computations.

1.2.5 Sheath. A cylindrical metal tube with an end cap welded to the end in which the element is located.

1.2.6 End Cap. A metal disc welded to the element end of the sheath to form a hermetic seal.

1.2.7 End Seal. A hermetic seal at the end of the sheath opposite the end cap.

1.2.8 Four-Wire Configuration. The electrical circuit in which two connections are provided to each end of the element via two leads. (See Fig. 1.)

1.2.9 Sensitive Length. The distance from the external surface of the end cap to the point at which the connections are made to form the four-wire configuration, and, therefore, the maximum portion of the

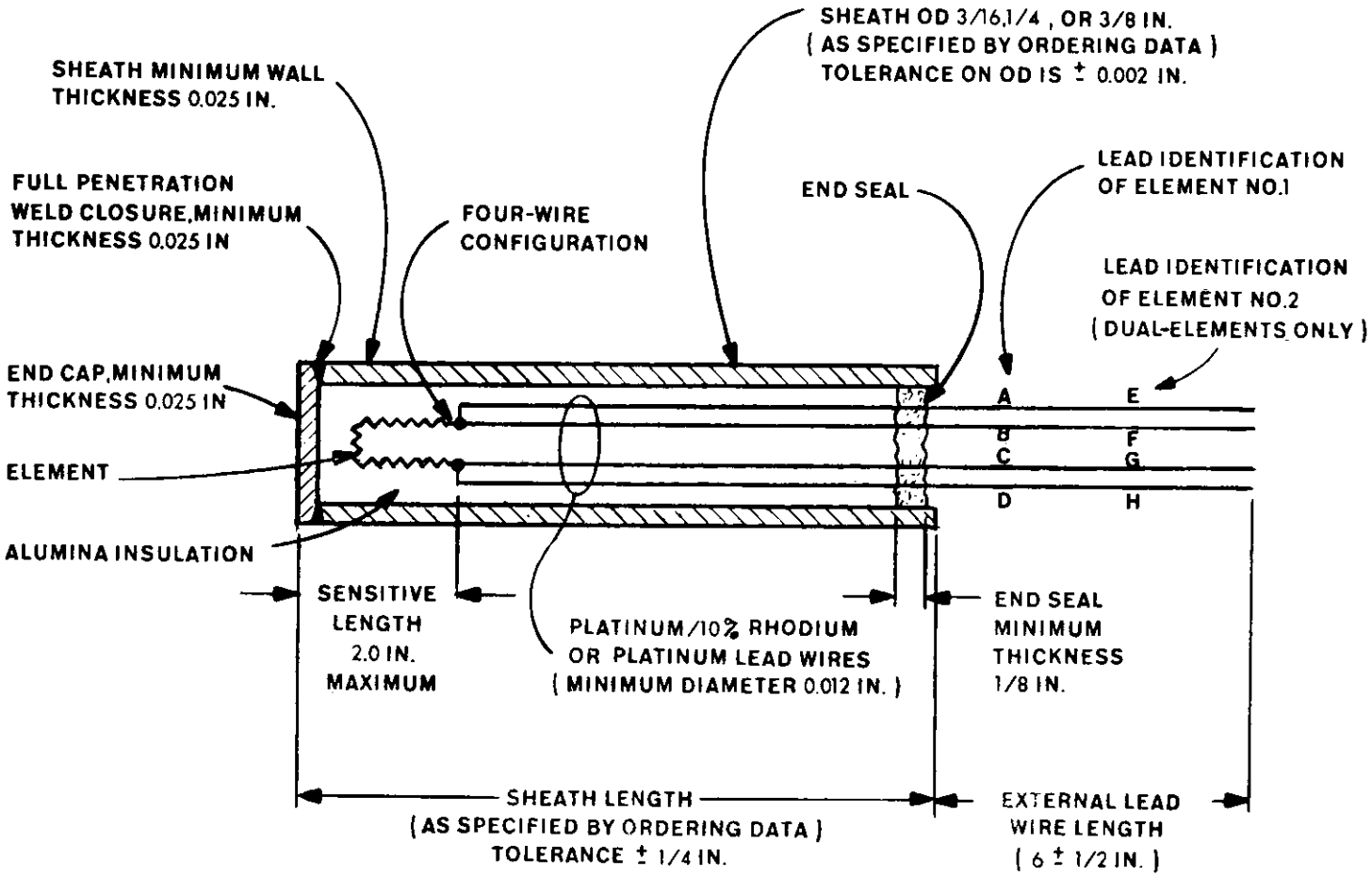

Fig. 1. Thermometer Construction Features and Standard Dimension Requirements.

sheath length whose temperature is indicated by the measured resistance of the element.

1.2.10 Lead Wires. The four wires which run from each element, through the end seal, and external to the sheath.

2. APPLICABLE DOCUMENTS

The following documents are a part of this standard to the extent specified in Sections 3 through 5. The issue of a document in effect on the date of invitation to bid, including any amendments or other published changes also in effect shall apply unless otherwise specified. Where this standard appears to conflict with the requirements of a referenced document, such conflict shall be brought to the attention of the purchaser for resolution.

2.1 RDT Standards.

RDT C 18-1T Ceramic Electrical Insulators

RDT F 2-4T Quality Verification Program Requirements

RDT F 7-2T Preparations for Sealing, Packaging, Packing, and Marking of Components for Shipment and Storage A1

2.2 American National Standards (ANSI).

ANSI B 46.1 Surface Texture

2.3 American Society for Testing and Materials (ASTM) Publications.

ASTM A 632 Seamless and Welded Austenitic Stainless Steel Tubing (Small Diameter) for General Service

ASTM B 163 Seamless Nickel and Nickel Alloy Condenser and Heat-Exchanger Tubes

ASTM B 166 Nickel-Chromium-Iron Alloy Rod and Bar A1

ASTM B 167 Nickel-Chromium-Iron Alloy Seamless Pipe and Tube

ASTM E 94 Radiographic Testing

ASTM E 142 Controlling Quality of Radiographic Testing

2.4 American Welding Society (AWS) Specifications.

AWS A5.14 Nickel and Nickel-Alloy Bare Welding Rods and Electrodes A1

2.5 International Committee of Weights and Measures.

Metrologia, International Journal of Scientific Metrology, Vol. 5, No. 2 April 1969, pp 35-44.

3. TECHNICAL REQUIREMENTS

The thermometers shall be of the configuration and construction shown in Fig. 1. The option of single- or dual-element thermometers (Type I or II) will be specified in the Ordering Data.

3.1 Materials.

3.1.1 Element Wire. The temperature-sensing wire element shall consist of round, smooth, clean platinum wire free of any drawing lubricant or other detrimental agent and shall have a minimum α of 0.00384/°C. The element leads shall also be clean and free of any detrimental agent and shall meet the requirements of 3.1.5.

3.1.2 Element Insulation. The element insulation powder shall be aluminum oxide conforming to the RDT C 18-1 requirements for high purity alumina (99.5 percent minimum aluminum oxide). The rods, beads, and mandrels shall consist of aluminum oxide conforming to the RDT C 18-1 requirements for high purity alumina for rods, beads, and mandrels (99.0 percent minimum aluminum oxide). A1

3.1.3 Sheath Assembly. Unless otherwise specified in the Ordering Data, the sheath, end cap, any integrally attached fittings for mounting in a thermowell (3.6), and weld material that comprise the sheath assembly shall be nickel-chromium-iron alloy conforming to the requirements of ASTM B 163, ASTM B 166, ASTM B 167, or AWS A5.14 as applicable to the product form, or to the requirements of equivalent material standards approved by the purchaser. A1

3.1.4 End Seal. The end seal shall consist of a minimum thickness of 1/8 inch of fused glass bonded to the inside surface of the sheath and wires. The glass shall have a coefficient of thermal expansion compatible with that of the sheath and wires. The glass shall be suitable for use as a hermetic seal for continuous operation at the temperature and radiation environmental conditions specified in 3.4.

A prefabricated glass-to-metal or ceramic-to-metal end seal of the general hollow pin feed-through type that meets the foregoing requirements may also be acceptable. A supplier who proposes to supply this type end seal shall submit the design and fabrication details with the bid for purchaser approval.

3.1.5 Lead Wires. The lead wires shall be solid, 99.99 percent minimum purity platinum or 90 percent platinum/10 percent rhodium, one type exclusively in any thermometer. The 90 percent platinum/10 percent

rhodium wire shall be manufactured from 99.99 percent minimum purity platinum and 99.9 percent minimum purity rhodium. A1

3.2 Fabrication.

3.2.1 Preparation. The sheath material shall be cleaned to the "thermocouple clean" condition as defined by ASTM A 632, except the solvent used shall not be acetone and no discoloration is permitted on the final dry swatch. The sheath and end cap shall be free of foreign material which would impair the electrical resistance of the insulation, the electrical resistance-temperature relationship of the element, or the corrosion resistance of the sheath.

The element insulation in the completed thermometer shall be free of moisture and contaminants. Care shall be taken at all times to prevent the absorption of moisture by the aluminum oxide rods, beads, coil forms (mandrels), and powder. The interior of the assembled thermometer shall be thoroughly dried at the time of end seal application.

3.2.2 Insulation. The insulation shall be installed in the sheath so that the element and lead wires are not free to move relative to the sheath during mechanical vibration.

3.2.2 Welding Techniques. The sheath weld closure shall be made using the inert gas tungsten-arc welding process. Metallic surfaces shall be throughly cleaned before welding. The joining of all metallic components, including the element, shall be made by the direct fusion method without addition of filler metal. The use of brazing fluxes is prohibited in the construction of the thermometer. The welding and fusion procedures shall be submitted for approval before fabrication. Welding shall not be permitted along the lengths of the lead wires, i.e., the leads shall be solid conductors from the point at which the leads form the four-wire configuration to the ends of the leads external to the sheath.

3.3 Mechanical Requirements.

3.3.1 Dimensions.

3.3.1.1 Sheath Length. The sheath length shall be as specified in the Ordering Data. The tolerance on the sheath length shall be ±1/4 inch or as specified in the Ordering Data.

3.3.1.2 Sheath Outside Diameter. The nominal sheath outside diameter shall be 3/16, 1/4, or 3/8 inch as specified in the Ordering Data. The tolerance on the sheath outside diameter shall be ± 0.002 inch.

3.3.1.3 Sheath Wall Thickness. The sheath wall thickness shall be at least 0.025 inch.

3.3.1.4 Sheath Straightness. The sheath shall be reasonably straight and free from bends or kinks. Special straightness requirements shall be as specified in the Ordering Data.

3.3.1.5 End Cap and Weld Closure Thickness. The end cap and weld closure shall be at least 0.025 inch thick.

3.3.1.6 End Seal Thickness. The end seal shall be at least 1/8 inch thick.

3.3.1.7 External Lead Wire Length. Unless otherwise specified in the Ordering Data, the external lead wire length shall be 6 ± 1/2 inch.

3.3.1.8 Lead Wire Diameter. The diameter of each lead wire shall be at least 0.012 inch (AWG 28).

3.3.1.9 Sensitive Length. The sensitive length shall not exceed 2.0 inches as determined by radiographic examination in accordance with 4.7.1.3.

3.3.2 Surface Finish. The outside surface of the thermometer shall be bright, clean, and free of oxide. The surface finish shall not exceed a 63 microinch arithmetic average maximum roughness when inspected using the procedure in ANSI B46.1. There shall be no gouges, scratches, dents, or other defects greater than 0.002 inch in depth.

3.4 Environmental Conditions. The environmental conditions to which the thermometers will be subject are as follows, or as specified in the Ordering Data:

1.	Ambient temperature	0°C to 660°C (32 to 1220°F) except for the end seal
2.	End seal ambient temperature	0°C to 260°C (32 to 500°F)
3.	Maximum gamma radiation dose rate	10^5R/hr
4.	Maximum integrated gamma radiation dose	2 x 10^{10} rads
5.	Maximum pressure	10 psig
6.	Maximum vibration	0.5 g in the range of 10 to 40 Hz

3.5 Electrical Requirements.

3.5.1 Resistance-Temperature Relationship and Calibration. The element resistance of each thermometer at 0°C (32°F) shall be 100 ± 0.1

ohms. All data and calibration tables shall be based on the International Practical Temperature Scale of 1968 (IPTS-68) as defined in Metrologia. (See 2.5.)

The element resistance-temperature relationship of any thermometer in the range 0 to 660°C (32 to 1220°F) shall not deviate more than 0.56°C (1°F) from the Callendar equation (see 1.2.4) relationship (modified to conform to the IPTS-68) applied to that particular element.

The constants R_0, α, δ, A, and B, in Equations 1, 2, and 3 shall be determined from the calibrations performed at 0°C, 100°C, and 660°C (32°F, 212°F, and 1220°F) and shall be supplied with the thermometer at the time of shipment.

When required by the Ordering Data, a calibration table (in °C or in °F as specified by the Ordering Data), relating the element resistance and temperature of each particular thermometer at specified temperature intervals from 0 to 660°C (32 to 1220°F) shall be furnished. The tables shall be generated for each particular thermometer with the Callendar equation (modified to conform to IPTS-68) and the constants R_0, A, and B derived from the 0°, 100°C, and 660°C (32°F, 212°F, and 1220°F) calibrations.

3.5.2 Insulation Resistance. Each thermometer element-to-sheath insulation resistance shall be equal to or greater than the values listed in Table 1. This requirement applies to each element of dual-element thermometers. In addition, the element-to-element resistance of dual-element thermometers shall meet the requirements of Table 1.

Table 1. Insulation Resistance

Applied D. C. Voltage (Direct and Reversed) Minimum	Required Minimum Insulation Resistance, ohms	
	25°C (75°F)	660°C (1220°F)[a]
100 V	100,000	50,000

[a]The entire thermometer sheath length shall be held at this t temperature except in the region of the end seal, where the end seal rated temperature shall not be exceeded.

3.5.3 Time Response. The time response of each element shall conform to the following requirements when subjected to the test described in Appendix B and required by 4.7.2.10.

a. The repeatability of the three consecutive tests of the thermometer time response shall be within 5 percent.

b. The average of the three measured time response values shall conform to Table 2.

Table 2. Time Response Requirements

Nominal Sheath Outside Diameter, inch	Maximum Time to Respond to 63 percent of the Temperature Change, seconds
3/16	5.0
1/4	8.0
3/8	20.0

3.5.4 Self-Heating. The element resistance with 10 mA excitation current through the element shall be no more than 0.08 ohms greater than that with 1 mA excitation current (the equivalent of 50 mW/°C or 28 mW/°F), when subjected to the test described in 4.7.2.11.

3.5.5 Thermal Voltages. Each thermal voltage in the thermometers shall be no greater than 10 μV when measured in the test described in 4.7.2.12.

3.5.6 End Seal. The end seal shall have good bonding to the wires and sheath and shall have no cracks or chips. Bubbles in limited numbers may be tolerated provided their diameter is less than 0.005 inch and they are so located that the seal or the bonding of the glass to either the wires or sheath is not weakened. Any thermometer which fails these end seal requirements shall be reported to the purchaser; repair of end seals is not permitted without the approval of the purchaser.

3.5.7 Performance Verification. Each thermometer shall meet the requirements of Table 3 when subjected to the tests described in 4.7.2.1 through 4.7.2.9.

3.6 Special Requirements. Special requirements imposed by application considerations such as additional calibrations, increased accuracy, or mating of the thermometer to a thermowell shall be as specified in the Ordering Data and shown in required detail on drawings or tables included in the Ordering Data. Special physical considerations such as sheath roundness or unusual tolerances shall be as specified in the Ordering Data.

4. QUALITY ASSURANCE REQUIREMENTS

4.1 Quality Verification Program. A quality verification program shall be provided and maintained for thermometers produced to this

Table 3. Performance Verification Requirements

Requirement	Refer to Paragraph	Acceptance Criteria
Lead resistance	4.7.2.1	The data shall be recorded.
Aging at temperature	4.7.2.2	The measured R_0 value shall differ from the original R_0 value by 0.1 ohm or less for each test.
Thermal cycling	4.7.2.3	
Vibration test	4.7.2.4	
End seal, weld closure, and sheath integrity	4.7.2.5	Insulation resistance at 25°C (75°F) shall meet Table 1 requirements and be at least 90 percent of that measured in 4.7.1.2.
Insulation resistance retest	4.7.2.6	
Recalibration	4.7.2.7	1. Conform to 3.5.1. 2. The R_0 value shall differ from the original R_0 value measured in 4.7.1.1 by 0.1 ohm or less. 3. The value of derived constants A and B shall be within ± 2 percent of the inital value measured in 4.7.1.1.
Lead resistance retest	4.7.2.8	The resistance of each pair of leads shall differ from the original value measured in 4.7.1.1 by 0.1 ohm or less when corrected for temperature between initial and repeated tests.
End seal retest	4.7.2.9	Conform to 3.5.6 upon repeating test of 4.7.1.4.

standard. Manufacturing and testing procedures and the quality verification program shall meet the requirements of RDT F 2-4 and shall have the purchaser's approval before the start of fabrication. The verification program shall include, but is not limited to, these items:

1. Quality verification program. This document describes the manner in which the work is to be done to meet RDT F 2-4.

2. Manufacturing procedures and checklists. This document describes the routines of work for thermometer manufacturing and testing.

3. Test data. The results of tests and checks required in both this standard and the Ordering Data.

4. Material certification specified by RDT F 2-4.

5. Certification that thermometers delivered meet the requirements of this standard and the Ordering Data.

4.2 Responsibility. The supplier (manufacturer) shall be re responsible for the quality of all thermometers bought to this standard, as well as for the quality of all materials and tools used in fabrication and testing.

4.3 Basis of Acceptance. Acceptance of the thermometers shall be dependent on meeting the requirements of this standard and the purchase documents.

4.4 Inspection and Sampling Rates. Inspection and sampling rates for the opitional tests and requirements shall be as stated in the Ordering Data.

4.5 Production Schedule. A monthly production schedule and progress report shall be required. Three weeks advance notice shall be given the purchaser of any scheduled tests so that the purchaser's inspector may witness all tests. Problems affecting delivery, performance, or nonconformance shall be reported in writing to the purchaser as soon as such problems arise.

4.6 Component Material Samples. When specified in the Ordering Data, samples of the thermometer component materials shall be packaged to prevent damage and contamination, properly identified, and forwarded to the purchaser. The required amount of each sample to be supplied shall be as specified in the Ordering Data.

4.7 Tests. The mandatory tests shown in Table 4 shall be performed. In addition, any of the optional tests listed in Table 5 and required by the Ordering Data shall be performed. The data from each test shall be documented.

Table 4. Mandatory Tests

	Test	Refer to Paragraph
1.	Calibration	4.7.1.1
2.	Insulation resistance	4.7.1.2
3.	Radiographic examination	4.7.1.3
4.	End seal	4.7.1.4

Table 5. Optional Tests

	Test	Refer to Paragraph
1.	Lead resistance	4.7.2.1
2.	Aging at temperature	4.7.2.2
3.	Thermal cycling	4.7.2.3
4.	Vibration test	4.7.2.4
5.	End seal, weld closure, and sheath integrity	4.7.2.5
6.	Insulation resistance retest	4.7.2.6
7.	Recalibration	4.7.2.7
8.	Lead resistance retest	4.7.2.8
9.	End seal retest	4.7.2.9
10.	Time response	4.7.2.10
11.	Self-heating	4.7.2.11
12.	Thermal voltages	4.7.2.12

4.7.1 Mandatory Tests, Calibrations, and Requirements. The mandatory tests listed in this section shall be performed before any other testing on the completed thermometers.

4.7.1.1 Calibration of Each Thermometer. Each thermometer shall be calibrated at 0°C, 100°C, and 660°C (32°F, 212°F, and 1220°F). The requirements for calibration shall be in accordance with in 3.5.1.

4.7.1.2 Insulation Resistance. The thermometer insulation resistance shall be measured between the sheath and the element (via one or more of the lead wires) at nominal temperatures of 25°C and 660°C (75°F and 1220°F). The measurements shall be made both with the sheath connected first to the positive voltage terminal and then to the negative voltage terminal of a 100 V (minimum) dc source. The voltage shall be applied for at least one minute before the resistance value is read. In addition, the insulation resistance shall be measured between the two elements of dual element thermometers at nominal temperature of 25°C and 660°C (75°F and 1220°F). The measurements shall be made first with one element connected to the positive voltage terminal and then to the negative voltage terminal of a nominal 100 V dc source. The voltage shall be applied for at least 1 minute before the resistance value is read. The requirements for both single and dual element thermometers shall be in accordance with 3.5.2.

4.7.1.3 Radiographic Examination. A radiographic examination shall be made of the entire thermometer length (except for the external lead wires) in accordance with Appendix A. The radiographs shall be examined visually for compliance with 3.3.1.9 and as specified in the Ordering Data.

4.7.1.4 End Seal. The end seal shall be examined visually at a magnification of 10X. The requirements shall be in accordance with 3.5.6.

4.7.2 Optional Tests for Performance Verification. Any of the tests in 4.7.2.1 through 4.7.2.9 specified in the Ordering Data shall be performed in ascending numerical sequence. The basis of acceptance in the tests of 4.7.2.1 through 4.7.2.9 shall be in accordance with 3.5.7.

4.7.2.1 Lead Resistance. The resistance of each pair of leads (A-B and C-D for single-element thermometers, A-B, C-D, E-F, and G-H for dual-element thermometers, see Fig. 1) shall be measured at room temperature. The resistance and temperature shall be recorded.

4.7.2.2 Aging at Temperature. The thermometer (the first 4 inches at the sensing end, minimum) shall be aged for a minimum time of 250 hours at 650 ± 10°C (1200 ± 20°F). The value of R_0 (both elements of dual-element thermometers) shall be measured and recorded.

4.7.2.3 Thermal Cycling. The thermometer (the first 4 inches at the sensing end, minimum) shall be subjected to at least 30 thermal cycles between nominal upper and lower temperatures of 650°C and 95°C (1200°F and 200°F), respectively. The rate of change of element temperature shall be between 1 to 8°C/sec (2 to 15°F/sec) on both the heating and cooling portion of each thermal cycle. The thermal cycling upper and lower temperatures and rates shall be determined by monitoring the element resistance (both elements of dual-element thermometers) during the test. The value of R_0 (both elements of dual-element thermometers) shall then be measured and recorded.

4.7.2.4 Vibration Test. The thermometer shall be subjected to sinusoidal vibration in the range of 25 to 30 g (800 to 960 ft/sec^2) rms applied in each of three mutually perpendicular axes (the axis parallel to the sheath and two axes perpendicular to the sheath and to each other) for at least 15 minutes. The vibration frequency shall be in the range of 80 to 100 Hz. The value of R_0 (both elements of dual-element thermometers) shall then be measured and recorded.

4.7.2.5 End Seal, Weld Closure, and Sheath Integrity. The thermometer, including the end seal, shall be submerged in boiling water for a minimum time of 1 hour. The thermometer shall be removed from the boiling water and immediately submerged (including the end seal) into ambient temperature [approximately 25°C (75°F)] water for a minimum time of 30 minutes.

4.7.2.6 Insulation Resistance Retest. The insulation resistance test specified in 4.7.1.2 shall be repeated and the 25°C (75°F) nominal test in 4.7.1.2 shall be repeated first.

4.7.2.7 Recalibration. The calibrations required in 4.7.1.1 shall be repeated.

4.7.2.8 Lead Resistance Retest. The measurements specified in 4.7.2.1 shall be repeated.

4.7.2.9 End Seal Retest. The test specified in 4.7.1.4 shall be repeated.

4.7.2.10 Time Response. Three consecutive measurements shall be made of the thermometer time response in accordance with the method described in Appendix B. The basis for acceptance is that the test results conform to the requirements of 3.5.3.

4.7.2.11 Self-Heating. The element electrical resistance shall be measured with the thermometer inserted 6 inches into an ice bath at 0°C (32°F), with 1 mA and 10 mA excitation current through the element. Each measurement shall be made after thermal equilibrium has been established for at least 5 minutes as indicated by monitoring the element resistance. Each element of dual-element thermometers shall be subjected to this test with zero excitation current in the other element.

The basis for acceptance is that the test results conform to the requirements of 3.5.4.

4.7.2.12 Thermal Voltages. The thermal voltages shall be measured with no excitation current in the element while the thermometer is instanteously inserted from thermal equilibrium at room temperature to a depth of 8 ± 1/2 inches in boiling water. The thermal voltages are defined as the voltages across leads A and B, C and D, and A and D (refer to Fig. 1 for lead identification) of single-element thermometers and the voltages across leads A and B, C and D, A and D, E and F, G and H, and E and H of dual-element thermometers. Each voltage measurement shall be made during a time interval equal to at least five time constants of the thermometer and beginning at the instant the thermometer in inserted into the water. The basis for acceptance is given in 3.5.5.

5. PREPARATION FOR DELIVERY

5.1 Cleanliness. Before packing, all external surfaces of the thermometer shall be wiped clean with alcohol used as the solvent. The external surfaces of the thermometer and lead wires shall be free of oils and other residues.

5.2 Identification. Each thermometer and its leads shall be identified as follows.

5.2.1 Each thermometer shall bear a unique number which shall be electroetched on the sheath. This number shall relate the thermometer to all of its component material lots, examination, calibration, test and certification records.

5.2.2 Each lead shall be labelled or tagged in accordance with the scheme shown in Fig. 1.

5.3 Packing. Packing shall be in accordance with the supplier's commerical practice which will ensure maintenance of the cleanliness of the thermometer until delivered and accepted at its destination. The method of packing shall be in accordance with the general requirements given in RDT F 7-2.

6. NOTES AND ORDERING DATA CHECKLIST

6.1 Ordering Data. The following technical and procurement data will be furnished by the purchaser. Any necessary data not furnished with the purchase document shall be requested from the purchaser before submitting a bid.

Item	Refer to Paragraph
1. Quantity of thermometers	-
2. Type I or II thermometers	3.1
3. Alternate materials for sheath assembly	3.1.3

	Item	Refer to Paragraph
4.	Sheath length and tolerance	3.3.1.1
5.	Sheath outside diameter	3.3.1.2
6.	Sheath straightness	3.3.1.4
7.	External lead wire length	3.3.1.7
8.	Alternate environmental conditions	3.4
9.	Calibration table requirements	3.5.1
10.	Special requirements	3.6
11.	Basis or acceptance	4.3
12.	Inspection and sampling rates	4.4
13.	Component material samples	4.6
14.	Radiographic examination	4.7.1.3
15.	Optional tests	4.7.2 and Table 5

6.2 Information to be Submitted with Bid.

	Item	Refer to Paragraph
1.	End seal design and fabrication details	3.1.5

APPENDIX A

Radiographic Examination

A minimum of two radiographs separated by 90 degrees on the sheath circumference shall be made of the entire thermometer sheath length. The radiographs shall be made perpendicular to the thermometer axis. The radiography shall be performed in accordance with the following requirements:

1. The radiography shall be performed in accordance with ASTM E 94 at a sensitivity level of 2-1T.

2. The design of the penetrameter shall be as specified in ASTM E 142, Fig. 1.

The penetrameter shall be 0.005 inch thick. The 1T, 2T, and 4T hole diameters shall be 0.010 inch, 0.020 inch, and 0.040 inch, respectively. The images of the penetrameter identification number, outline, and 1T hole shall be visible on the radiograph. The penetrameter shall be mounted on a block (shim) of material which is the same nominal composition as the thermometer sheath and equal in thickness to twice the nominal sheath wall thickness. The block or shim shall be at least 1/4 inch wider and longer than the penetrameter, which shall be centered on the block. The penetrameter/block shall be elevated so as to be the same distance from the film as the top of the thermometer sheath. The placement of the block and the penetrameter shall be normal to the radiation beam and on the source side of the film. The block shall be no closer than 1/2 inch to the nearest thermometer sheath. C

3. The density of the individual films shall be in the range of 2.0 to 3.0 in the area being examined as measured by a densitometer. The film density at the penetrameter shall be -15, +30 percent of the density at an appropriate point on the thermometer image. (The term "density" is defined in ASTM E 94.)

4. All lengths of wire inside the thermometer sheath shall be clearly visible in the radiograph (when viewed with optical magnification as necessary).

5. The radiograph shall be supplied to the purchaser with appropriate means to identify the thermometer with its radiograph.

APPENDIX B

Time Response Measurement

The thermometer time response shall be measured in accordance with the procedure listed below.

1. The thermometer is inserted at least 3 inches into an ice bath at 0°C (32°F) until thermal equilibrium is attained, at which time a zero reference is established on the recording instrumentation. The recording instrumentation shall be accurate to within ±3 percent of the voltage and time spans used.

2. The thermometer is inserted no more than 3 inches into ambient temperature water [approximately 25°C (75°F)] flowing at a maximum rate of 3 ft/sec. When thermal equilibrium is reached, a 100 percent response reference is established on the recording instrumentation.

3. The thermometer is reinserted at least 3 inches into the ice bath until thermal equilibrium is reached, at which time the thermometer is manually transferred from the ice bath to the flowing water in conformance with these requirements:

   a. The time required to remove the thermometer from the ice bath and place it in a final position at no more than 3 inches insertion into the water shall not exceed 2 seconds.

   b. The thermometer shall be inserted into the water in a continous motion, i.e., there shall be no withdrawal of the thermometer from the water at any time while data is being recorded.

   c. The instant at which the thermometer sheath touches the water shall be recorded with accurancy of ±50 milliseconds to provide the zero (starting point) time reference.

   d. The electrical resistance of the element is recorded as the temperature of the sensitive length changes to the temperature of the water.

   e. The graph of the element resistance as a function of time in the test shall be supplied to the purchaser.