Designation: E1137/E1137M – 08 (Reapproved 2014)

Standard Specification for Industrial Platinum Resistance Thermometers[1]

This standard is issued under the fixed designation E1137/E1137M; 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 requirements for metal-sheathed industrial platinum resistance thermometers (PRT's) suitable for direct immersion temperature measurement. It applies to PRT's with an average temperature coefficient of resistance between 0 and 100°C of 0.385 %/°C and nominal resistance at 0°C of 100 Ω or other specified value. This specification covers PRT's suitable for all or part of the temperature range −200 to 650°C. The resistance-temperature relationship and tolerances are specified as well as physical, performance, and testing requirements.

1.2 The values of temperature in this specification are based on the International Temperature Scale of 1990 (ITS-90).[2]

1.3 The values stated in inch-pound units or SI (metric) units may be regarded separately as standard. The values stated in each system are not exact equivalents, and each system shall be independent of the other.

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:*[3]

A269 Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

B167 Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696), Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617), and Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674) Seamless Pipe and Tube

E344 Terminology Relating to Thermometry and Hydrometry

E644 Test Methods for Testing Industrial Resistance Thermometers

E1652 Specification for Magnesium Oxide and Aluminum Oxide Powder and Crushable Insulators Used in the Manufacture of Base Metal Thermocouples, Metal-Sheathed Platinum Resistance Thermometers, and Noble Metal Thermocouples

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification see Terminology E344.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *connecting wire end closure, n*—moisture barrier at the connecting wire end of the sheath.

3.2.1.1 *Discussion*—The closure is intended to provide a seal sufficient to prevent the sensor's insulation resistance from dropping below the minimum requirements.

3.2.2 *connecting wires, n*—wires that run from the element through the connecting wire end closure and external to the sheath.

3.2.3 *excitation, n*—electrical current passing through the element.

3.2.4 *g-level, n*—acceleration of an object relative to the local acceleration of gravity.

3.2.4.1 *Discussion*—For example, a g-level of 5 is equivalent to an acceleration of approximately 5×9.8 m/s^2 = 49.0 m/s^2.

3.2.5 *minimum immersion length, n*—depth that a thermometer should be immersed, in a uniform temperature environment, such that further immersion does not produce a change in indicated temperature greater than the specified tolerance.

3.2.6 *PRT design, n*—generic term used to differentiate between different PRT construction details, such as element and connecting wire construction, insulation methods, sealing techniques, and mounting methods (for example, spring loaded or direct mounting).

[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.

Current edition approved Dec. 1, 2014. Published December 2014. Originally approved in 1987. Last previous edition approved in 2008 as E1137 – 08. DOI: 10.1520/E1137_E1137M-08R14.

[2] Preston-Thomas, H., "The International Temperature Scale of 1990 (ITS-90)," *Metrologia* , Vol 27, No. 1. 1990, pp 3– 10, *ibid*, Vol 27, No. 2, 1990, p107

[3] 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.

3.2.7 *self-heating, n*—change in temperature of the element caused by the heating effect of the excitation.

3.2.8 *sheath, n*—cylindrical metal tube with an integral welded closure at the end in which the element is located.

4. Significance and Use

4.1 This specification is written to provide common terminology, resistance versus temperature characteristics, accuracy classification, and inspection requirements for a specified configuration of a typical industrial platinum resistance thermometer (PRT).

4.2 This specification may be used as part of the documentation to support negotiations for the purchase and discussion of such thermometers.

5. Classification of Tolerances

5.1 The PRT shall conform to the resistance-temperature relation (see 9.2.1) within the following tolerances:

$$\text{Grade } A = \pm[0.13 + 0.0017|t|]^{\circ}C \quad (1)$$

$$\text{Grade } B = \pm[0.25 + 0.0042|t|]^{\circ}C \quad (2)$$

where:

$|t|$ = value of temperature without regard to sign, °C.

5.1.1 The tolerances are given in Table 1 for a PRT with a nominal resistance of 100 Ω at 0°C.

6. Ordering Information

6.1 The purchase order documents shall specify the following information to ensure that the PRT is adequately described:

6.1.1 The number of this specification,

6.1.2 Sheath diameter and overall length (see Fig. 1),

6.1.3 Sheath material,

6.1.4 Minimum and maximum sensed temperature,

6.1.5 Maximum and minimum temperature at connecting wire end closure,

6.1.6 Connection configuration; 2-Wire, 3-Wire, 4-Wire (potentiometric), and compensating loop (4-Wire) (see Fig. 2),

6.1.7 Tolerance, (Grade A, or Grade B),

6.1.8 Nominal resistance at 0°C (100 Ω unless otherwise specified), and

TABLE 1 Classification Tolerances[A, B]

Temperature, *t*, °C	Grade A		Grade B	
	°C	Ω	°C	Ω
– 200	0.47	0.20	1.1	0.47
– 100	0.30	0.12	0.67	0.27
0	0.13	0.05	0.25	0.10
100	0.30	0.11	0.67	0.25
200	0.47	0.17	1.1	0.40
300	0.64	0.23	1.5	0.53
400	0.81	0.28	1.9	0.66
500	0.98	0.33	2.4	0.78
600	1.15	0.37	2.8	0.89
650	1.24	0.40	3.0	0.94

[A] The table represents values for 3-wire and 4-wire PRT's. Caution must be exercised with 2-wire PRT's because of possible errors caused by connecting wires.

[B] Tabulated values are based on elements of 100.0 Ω (nominal) at 0°C.

6.1.9 Serial Number identification requirement (mandatory if an individual calibration or test record will be maintained).

7. Materials and Manufacture

7.1 All materials used shall be in accordance with the following requirements:

7.1.1 *Sheath Materials*—For temperatures not exceeding 480°C, austenitic stainless steel tubing, conforming to Specification A269. For temperatures not exceeding 650°C, high-nickel alloy tubing, conforming to Specification B167.

7.1.2 *Sensing Element*—Sensing element shall be platinum.

7.1.3 *Insulation*—The insulating material within the PRT shall be compatible with the temperature range −200 to 650°C or as specified in 6.1.4. Magnesium oxide (MgO) and aluminum oxide ($Al_2 O_3$) powders and crushable insulators conforming to Specification E1652 satisfy this requirement.

7.1.4 *Connecting Wire End Closure Materials*—Closure materials shall provide a barrier against water and other liquids and generally prevent the penetration of water vapor. Any material used shall be compatible with the ambient temperatures specified for the application (see 6.1.5).

7.1.4.1 Typically, epoxy materials are used for ambient temperatures less than 200°C and moisture impervious ceramic adhesives are used over 200°C, but the connecting wire end closure shall not be limited to these materials if the end closure meets all other requirements of this specification.

7.1.5 *Connecting Wires*—Typically, materials of connecting wires are: nickel plated copper, nickel, platinum, constantan, or manganin. Individual connecting wires may be comprised of two or more different materials and sizes over their length to accommodate different requirements internal and external to the sensor sheath. Where different materials are used, care must be exercised in their selection to minimize thermoelectrically induced measurement error (see 9.6). Any material used in joining the connecting wires to the PRT element must withstand the maximum operating temperature of the PRT.

8. Other Requirements

8.1 *Pressure*—The PRT shall withstand an external pressure of 21 MPa (3000 psig) and shall be tested in accordance with Test Methods E644 pressure test. The PRT shall remain within the tolerance specified in 5.1.

8.2 *Vibration:*

8.2.1 The PRT shall withstand vibration testing as described in Test Methods E644 using the test parameters in Table 2.

8.2.2 The PRT shall be mounted by installation in the thermowell or by threaded connection to simulate normal mounting procedure as limited by Table 2.

8.2.3 The PRT shall be continuously energized with an oscilloscope-monitored 1.0-mA dc excitation. There shall be no discontinuity of the monitored trace during the test.

8.2.4 After the PRT is tested for vibration the insulation resistance of the PRT shall remain within the tolerance of Table 3 and the resistance at 0°C within the tolerance specified in 5.1.

8.3 *Mechanical Shock:*

8.3.1 The PRT shall withstand mechanical shock testing as described in Test Methods E644. The half-sine pulse shall have a peak g-level of 50 and duration of 11 ms.

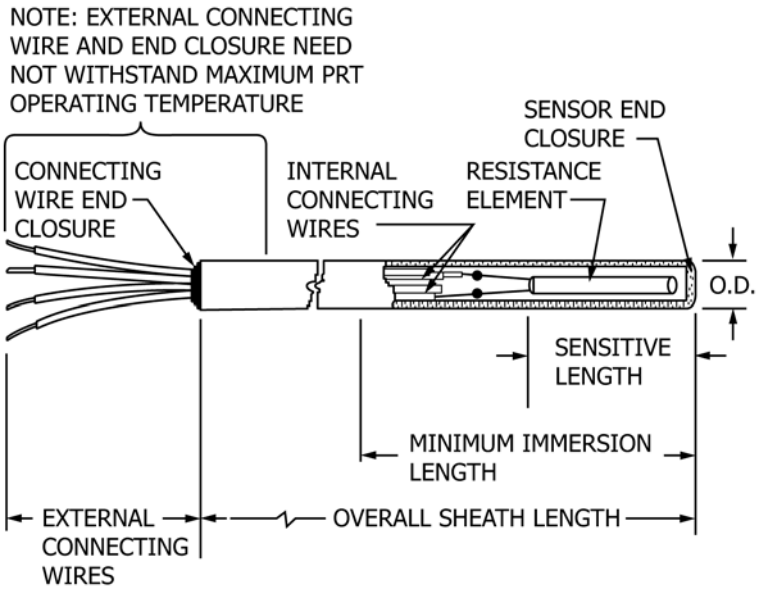

FIG. 1 Typical Industrial Platinum Resistance Thermometer

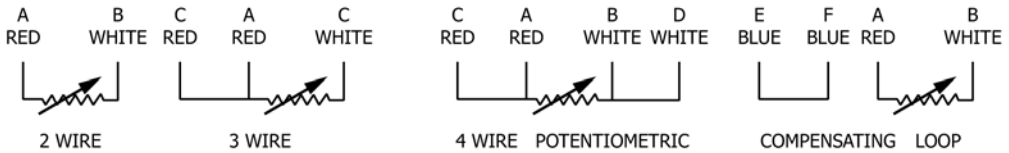

FIG. 2 Connection Configurations

TABLE 2 Vibration Test Parameters

NOTE 1— The values in Table 2 apply to a PRT mounted in a thermowell with nominal diametral clearance of less than 0.25 mm (0.01 in.). If the PRT is not mounted in a thermowell, the values in Table 2 apply to a PRT with an unsupported stem length less than 100 mm (4 in.).

Frequency	5 to 500 Hz
Test Level	1.27-mm (0.05-in.) double amplitude displacement or peak g-level of 3, whichever is less
Resonant Dwell Time	30 min for each resonant point
Cycling Time	3 h per axis less the time spent at resonant dwells at the axis.
Mounting	As normally mounted including the mating thermowell, if applicable.

TABLE 3 Insulation Resistance

Applied dc Voltage, Volts dc		Minimum Insulation Resistance	
min	max	°C	MΩ
10	50	25 ± 5	100
10	50	300 ± 10	10
10	50	650 ± 15	2

8.3.2 The PRT shall be continuously energized with an oscilloscope-monitored 1.0-mA dc excitation. There shall be no discontinuity of the monitored trace during the test.

8.3.3 After the PRT is tested for mechanical shock, the insulation resistance of the PRT shall remain within the tolerance of Table 3 and the resistance at 0°C within the tolerance in 5.1.

8.4 *Thermal:*

8.4.1 The PRT shall be capable of continuous operation over the specified temperature range (see 6.1).

8.4.2 The connecting wire end closure and external connecting wires need not withstand the entire PRT operating temperature range. As a minimum, these materials must withstand the ambient temperature limits specified for the application (see 6.1.5).

9. Performance

9.1 *Excitation:*

9.1.1 The PRT must be constructed such that it is usable in ac or dc measurement systems. In ac measuring systems, reactance effects shall be considered.

9.1.2 The PRT shall be capable of operating with continuous excitation of 10 mA. However, excitation of 1 mA or less is recommended to minimize measurement errors associated with self-heating (see 9.4).

9.2 *Resistance versus Temperature Relation:*

9.2.1 *Resistance-Temperature Equations*—Within the specified tolerances (see 5.1), the PRT shall have resistance-temperature characteristics defined as follows:

for the range $-200°C \le t < 0°C$:

$$R_t = R_o\left[1 + At + Bt^2 + C(t - 100)t^3\right]\ \Omega \quad (3)$$

for the range $0°C \le t \le 650°C$:

$$R_t = R_o\left[1 + At + Bt^2\right]\ \Omega \quad (4)$$

where:

t = temperature (ITS-90), °C,

R_t = resistance at temperature (t),
R_o = resistance at 0°C,
A = 3.9083×10^{-3}°C^{-1},
B = -5.775×10^{-7}°C^{-2}, and
C = -4.183×10^{-12}°C^{-4} .

9.2.2 *Resistance Table*—Resistance values of the PRT versus temperature using the equations of 9.2.1 and R_o of 100 Ω are given in Table 4.

9.2.3 Inverse equations that may be used to compute values of temperature (°C) as a function of resistance are given in Appendix X1.

9.3 *Insulation Resistance*—The insulation resistance between each connecting wire and the sheath shall meet the requirements of Table 3 when tested in accordance with Test Methods E644. The PRT shall be tested with at least the minimum immersion length exposed to the temperature environment.

9.4 *Self-Heating*—A power of at least 33 mW shall be required to produce a self-heating of 1°C when the PRT is tested in water in accordance with Test Methods E644.

9.5 *Thermal Response Time*—The 63.2 % response time shall not exceed the values in Table 5 when determined in accordance with Test Methods E644. The step change in temperature shall be from 20 ± 5°C air to 77 ± 5°C water flowing at 0.9 ± 0.09 m/s (3.0 ± 0.3 ft/s).

9.6 *Thermoelectric Effect*— When tested in accordance with Test Methods E644 at the upper operating temperature, the PRT shall remain within the tolerances specified in 5.1 with an excitation current of 1-mA dc ± 15 %, regardless of polarity.

NOTE 1—Internal and external connecting wire composition, wire inhomogeneity, and temperature gradients within the PRT can be sources for generation of thermoelectric EMF. Some resistance determination error can result from this EMF. The magnitude and sense of this thermoelectric effect error depends on the excitation current, temperature distribution, and construction of the PRT. For a given PRT, the thermoelectric effect can be minimized by using an alternating polarity excitation with a suitable measurement circuitry.

9.7 *Stability*—When tested in accordance with Test Methods E644, the PRT shall remain within the tolerances specified in 5.1 for a four-week test. During this test, the resistance at 0°C shall be checked at regular intervals (two times per week).

9.8 *Minimum Immersion Length*—When determined in accordance with Test Methods E644, the PRT minimum immersion length shall be less than 51 mm (2 in.). The limit of uncertainty shall be 0.13 and 0.25°C for Grade A and Grade B PRT's respectively.

9.9 *End Seal Integrity*—When tested in accordance with Test Methods E644, the PRT shall meet the minimum insulation resistance value at 25 ± 5°C as specified in Table 3.

10. Dimensions, Mass, and Permissible Variations

10.1 A PRT without a process fitting or other means of attachment is shown in Fig. 1.

10.2 PRT's manufactured in accordance with this specification shall be able to pass through the straightness ring gauge with the gauge sizes listed in Table 6.

11. Required Tests

11.1 *Qualification Tests*—The PRT shall be subjected to the tests outlined in Table 7 to demonstrate conformance to this specification. The manufacturer shall perform these tests at least one time to qualify the PRT design. Thereafter, it is recommended these tests be used on a periodic basis to verify process control.

11.1.1 *Qualification Test Report*—The manufacturer shall prepare and retain a qualification test report applicable to the PRT design that documents the model number, test procedure (by reference to Test Methods E644 and this specification), and the results obtained.

11.2 *Acceptance Tests*—The manufacturer shall verify that the PRT to be delivered satisfies the following minimum test requirements: resistance at 0°C (see 5.1), room temperature insulation resistance (see 9.3), and dimensions (see 10.2).

NOTE 2—The purchaser may perform any of the tests included in Table 7 as a basis for acceptance or rejection.

12. Declaration of Conformity

12.1 The manufacturer shall provide a document to the purchaser that states the PRT satisfies the requirements of this specification.

13. Product Marking

13.1 Each PRT shall carry a permanent identification marking, which includes, as a minimum, the PRT serial number or date code. A serial number is required if the PRT will be subjected to calibration or testing that requires an individual test record (see 6.1.9). Additional identification including the PRT producer, grade, and this ASTM designation shall be present on the PRT, on a tag attached to the PRT, or on the PRT packaging.

14. Packaging

14.1 Each PRT shall be packaged to adequately protect it against handling shock and vibration in transportation and storage.

15. Keywords

15.1 ITS-90; metal sheath; platinum resistance thermometer; PRT

TABLE 4 Resistance versus Temperature[A, B]

ITS-90°C	0	–1	–2	–3	–4	–5	–6	–7	–8	–9	–10
–200	18.52										
–190	22.83	22.40	21.97	21.54	21.11	20.68	20.25	19.82	19.38	18.95	18.52
–180	27.10	26.67	26.24	25.82	25.39	24.97	24.54	24.11	23.68	23.25	22.83
–170	31.34	30.91	30.49	30.07	29.64	29.22	28.80	28.37	27.95	27.52	27.10
–160	35.54	35.12	34.70	34.28	33.86	33.44	33.02	32.60	32.18	31.76	31.34
–150	39.72	39.31	38.89	38.47	38.05	37.64	37.22	36.80	36.38	35.96	35.54
–140	43.88	43.46	43.05	42.63	42.22	41.80	41.39	40.97	40.56	40.14	39.72
–130	48.00	47.59	47.18	46.77	46.36	45.94	45.53	45.12	44.70	44.29	43.88
–120	52.11	51.70	51.29	50.88	50.47	50.06	49.65	49.24	48.83	48.42	48.00
–110	56.19	55.79	55.38	54.97	54.56	54.15	53.75	53.34	52.93	52.52	52.11
–100	60.26	59.85	59.44	59.04	58.63	58.23	57.82	57.41	57.01	56.60	56.19
–90	64.30	63.90	63.49	63.09	62.68	62.28	61.88	61.47	61.07	60.66	60.26
–80	68.33	67.92	67.52	67.12	66.72	66.31	65.91	65.51	65.11	64.70	64.30
–70	72.33	71.93	71.53	71.13	70.73	70.33	69.93	69.53	69.13	68.73	68.33
–60	76.33	75.93	75.53	75.13	74.73	74.33	73.93	73.53	73.13	72.73	72.33
–50	80.31	79.91	79.51	79.11	78.72	78.32	77.92	77.52	77.12	76.73	76.33
–40	84.27	83.87	83.48	83.08	82.69	82.29	81.89	81.50	81.10	80.70	80.31
–30	88.22	87.83	87.43	87.04	86.64	86.25	85.85	85.46	85.06	84.67	84.27
–20	92.16	91.77	91.37	90.98	90.59	90.19	89.80	89.40	89.01	88.62	88.22
–10	96.09	95.69	95.30	94.91	94.52	94.12	93.73	93.34	92.95	92.55	92.16
0	100.00	99.61	99.22	98.83	98.44	98.04	97.65	97.26	96.87	96.48	96.09
ITS-90°C	0	1	2	3	4	5	6	7	8	9	10
0	100.00	100.39	100.78	101.17	101.56	101.95	102.34	102.73	103.12	103.51	103.90
10	103.90	104.29	104.68	105.07	105.46	105.85	106.24	106.63	107.02	107.40	107.79
20	107.79	108.18	108.57	108.96	109.35	109.73	110.12	110.51	110.90	111.29	111.67
30	111.67	112.06	112.45	112.83	113.22	113.61	114.00	114.38	114.77	115.15	115.54
40	115.54	115.93	116.31	116.70	117.08	117.47	117.86	118.24	118.63	119.01	119.40
50	119.40	119.78	120.17	120.55	120.94	121.32	121.71	122.09	122.47	122.86	123.24
60	123.24	123.63	124.01	124.39	124.78	125.16	125.54	125.93	126.31	126.69	127.08
70	127.08	127.46	127.84	128.22	128.61	128.99	129.37	129.75	130.13	130.52	130.90
80	130.90	131.28	131.66	132.04	132.42	132.80	133.18	133.57	133.95	134.33	134.71
90	134.71	135.09	135.47	135.85	136.23	136.61	136.99	137.37	137.75	138.13	138.51
100	138.51	138.88	139.26	139.64	140.02	140.40	140.78	141.16	141.54	141.91	142.29
110	142.29	142.67	143.05	143.43	143.80	144.18	144.56	144.94	145.31	145.69	146.07
120	146.07	146.44	146.82	147.20	147.57	147.95	148.33	148.70	149.08	149.46	149.83
130	149.83	150.21	150.58	150.96	151.33	151.71	152.08	152.46	152.83	153.21	153.58
140	153.58	153.96	154.33	154.71	155.08	155.46	155.83	156.20	156.58	156.95	157.33
150	157.33	157.70	158.07	158.45	158.82	159.19	159.56	159.94	160.31	160.68	161.05
160	161.05	161.43	161.80	162.17	162.54	162.91	163.29	163.66	164.03	164.40	164.77
170	164.77	165.14	165.51	165.89	166.26	166.63	167.00	167.37	167.74	168.11	168.48
180	168.48	168.85	169.22	169.59	169.96	170.33	170.70	171.07	171.43	171.80	172.17
190	172.17	172.54	172.91	173.28	173.65	174.02	174.38	174.75	175.12	175.49	175.86
200	175.86	176.22	176.59	176.96	177.33	177.69	178.06	178.43	178.79	179.16	179.53
210	179.53	179.89	180.26	180.63	180.99	181.36	181.72	182.09	182.46	182.82	183.19
220	183.19	183.55	183.92	184.28	184.65	185.01	185.38	185.74	186.11	186.47	186.84
230	186.84	187.20	187.56	187.93	188.29	188.66	189.02	189.38	189.75	190.11	190.47
240	190.47	190.84	191.20	191.56	191.92	192.29	192.65	193.01	193.37	193.74	194.10
250	194.10	194.46	194.82	195.18	195.55	195.91	196.27	196.63	196.99	197.35	197.71
260	197.71	198.07	198.43	198.79	199.15	199.51	199.87	200.23	200.59	200.95	201.31
270	201.31	201.67	202.03	202.39	202.75	203.11	203.47	203.83	204.19	204.55	204.90
280	204.90	205.26	205.62	205.98	206.34	206.70	207.05	207.41	207.77	208.13	208.48
290	208.48	208.84	209.20	209.56	209.91	210.27	210.63	210.98	211.34	211.70	212.05
300	212.05	212.41	212.76	213.12	213.48	213.83	214.19	214.54	214.90	215.25	215.61
310	215.61	215.96	216.32	216.67	217.03	217.38	217.74	218.09	218.44	218.80	219.15
320	219.15	219.51	219.86	220.21	220.57	220.92	221.27	221.63	221.98	222.33	222.68
330	222.68	223.04	223.39	223.74	224.09	224.45	224.80	225.15	225.50	225.85	226.21
340	226.21	226.56	226.91	227.26	227.61	227.96	228.31	228.66	229.02	229.37	229.72
350	229.72	230.07	230.42	230.77	231.12	231.47	231.82	232.17	232.52	232.87	233.21
360	233.21	233.56	233.91	234.26	234.61	234.96	235.31	235.66	236.00	236.35	236.70
370	236.70	237.05	237.40	237.74	238.09	238.44	238.79	239.13	239.48	239.83	240.18
380	240.18	240.52	240.87	241.22	241.56	241.91	242.26	242.60	242.95	243.29	243.64
390	243.64	243.99	244.33	244.68	245.02	245.37	245.71	246.06	246.40	246.75	247.09
400	247.09	247.44	247.78	248.13	248.47	248.81	249.16	249.50	249.85	250.19	250.53
410	250.53	250.88	251.22	251.56	251.91	252.25	252.59	252.93	253.28	253.62	253.96
420	253.96	254.30	254.65	254.99	255.33	255.67	256.01	256.35	256.70	257.04	257.38
430	257.38	257.72	258.06	258.40	258.74	259.08	259.42	259.76	260.10	260.44	260.78
440	260.78	261.12	261.46	261.80	262.14	262.48	262.82	263.16	263.50	263.84	264.18
450	264.18	264.52	264.86	265.20	265.53	265.87	266.21	266.55	266.89	267.22	267.56
460	267.56	267.90	268.24	268.57	268.91	269.25	269.59	269.92	270.26	270.60	270.93
470	270.93	271.27	271.61	271.94	272.28	272.61	272.95	273.29	273.62	273.96	274.29
ITS-90°C	0	1	2	3	4	5	6	7	8	9	10

480	274.29	274.63	274.96	275.30	275.63	275.97	276.30	276.64	276.97	277.31	277.64
490	277.64	277.98	278.31	278.64	278.98	279.31	279.64	279.98	280.31	280.64	280.98
500	280.98	281.31	281.64	281.98	282.31	282.64	282.97	283.31	283.64	283.97	284.30
510	284.30	284.63	284.97	285.30	285.63	285.96	286.29	286.62	286.95	287.29	287.62
520	287.62	287.95	288.28	288.61	288.94	289.27	289.60	289.93	290.26	290.59	290.92
530	290.92	291.25	291.58	291.91	292.24	292.56	292.89	293.22	293.55	293.88	294.21
540	294.21	294.54	294.86	295.19	295.52	295.85	296.18	296.50	296.83	297.16	297.49
550	297.49	297.81	298.14	298.47	298.80	299.12	299.45	299.78	300.10	300.43	300.75
560	300.75	301.08	301.41	301.73	302.06	302.38	302.71	303.03	303.36	303.69	304.01
570	304.01	304.34	304.66	304.98	305.31	305.63	305.96	306.28	306.61	306.93	307.25
580	307.25	307.58	307.90	308.23	308.55	308.87	309.20	309.52	309.84	310.16	310.49
590	310.49	310.81	311.13	311.45	311.78	312.10	312.42	312.74	313.06	313.39	313.71
600	313.71	314.03	314.35	314.67	314.99	315.31	315.64	315.96	316.28	316.60	316.92
610	316.92	317.24	317.56	317.88	318.20	318.52	318.84	319.16	319.48	319.80	320.12
620	320.12	320.43	320.75	321.07	321.39	321.71	322.03	322.35	322.67	322.98	323.30
630	323.30	323.62	323.94	324.26	324.57	324.89	325.21	325.53	325.84	326.16	326.48
640	326.48	326.79	327.11	327.43	327.74	328.06	328.38	328.69	329.01	329.32	329.64
650	329.64										

[A] This table is based on the equations of 9.2.1 and R_o of 100 Ω. For PRT's with R_o values other than 100 Ω, the resistance-temperature characteristics can be calculated using the equations of 9.2.1 or by multiplying the tabulated values of resistance by the ratio R_o/100.
[B] Temperature is expressed in degrees Celsius (ITS-90). To determine the temperature corresponding to a tabulated value of resistance, first locate the decade temperature left of the resistance value. To this temperature, add the temperature increment located above the resistance value. For example, the resistance values of 84.67, 187.56, and 253.96 Ω correspond to temperatures of – 39, 232, and 420°C respectively.

TABLE 5 Thermal Response Time

Nominal Sheath Outside Diameter		63.2 % Step Response Time
mm	in.	s
3.0	0.125	3
6.0	0.250	8

TABLE 6 Dimensions and Tolerances of PRT Sensors and Inspection Devices

Sheath Sizes				Straightness Ring Gauge			
Nominal Diameter		Tolerance		Length (min)		Inside Diameter	
mm	in.	±mm	±in.	mm	in.	mm	in.
3 to 12	0.125 to 0.500	0.1	0.004	10× nominal diameter		nominal diameter +0.15	nominal diameter +0.006

TABLE 7 Required Tests

Test	Test Methods E644, Section	Acceptance Criteria, Specification E1137, Paragraph
Insulation Resistance	5	9.3
Resistance versus Temperature	6	9.2
Minimum Immersion Length	7	9.8
Pressure	8	8.1
Thermal Response Time	9	9.5
Vibration	10	8.2
Self-Heating	12	9.4
Stability	13	9.7
Thermoelectric Effect	14	9.6
Mechanical Shock	11	8.3
Dimensional	N/A	10.2
End Seal Integrity	18	9.9

APPENDIX

(Nonmandatory Information)

X1. TEMPERATURE VERSUS RESISTANCE EQUATIONS

X1.1 The following inverse equations may be used to compute values of temperature (°C) as a function of resistance over the range of – 200 to 650°C. The computed values of temperature will be within the tolerances of 5.1 plus the error, if any, associated with the inverse equation.

For $R_t/R_o < 1$ (t < 0°C), an approximate inverse of Eq 3 within ±0.002°C is:

$$t = \sum_{i=1}^{4} D_i \left(R_t/R_o - 1\right)^i \quad \text{(X1.1)}$$

For $R_t/R_o \geq 1$ (t ≥ 0°C), the inverse of Eq 4 is:

$$t = \frac{\sqrt{A^2 - 4B\left(1 - R_t/R_o\right)} - A}{2B} \quad \text{(X1.2)}$$

where:

t = temperature ITS–90, °C
R_t = resistance at temperature t, Ω,
R_o = resistance at 0°C, Ω,
A = 3.9083×10^{-3}°C^{-1},
B = -5.775×10^{-7}°C^{-2},
D_1 = 255.819°C,
D_2 = 9.14550°C,
D_3 = −2.92363°C, and
D_4 = 1.79090°C.