INSTRUCTION MANUAL
SERIES 162
STANDARD PLATINUM RESISTANCE THERMOMETERS
MODELS 162CE, 162CG, 162D, 162K

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1. INTRODUCTION

This manual provides information for installing, operating, and maintaining your series 162 Standard Platinum Resistance Thermometer (SPRT).

1.1 Description

The SPRT is the defining interpolating instrument on the International Temperature Scale of 1990 (ITS-90) from approximately -259°C to 962°C. This wide temperature range requires several thermometer types, which are included as part of the 162 series shown in Table 1.

Table 1. Series 162 SPRTs

Model	SPRT Type	Range
162CE	Long-stem, metal-sheath, R(0.01°C)=25.5 ohms	-200°C to 661°C
162CG	Long-stem, quartz-sheath, R(0.01°C)=25.5 ohms	-200°C to 661°C
162D	Capsule, metal-sheath, R(0.01°C)=25.5 ohms	-269°C to 250°C
162K	Long-stem, quartz-sheath, R(0.01°C)=0.25 ohms	0°C to 1100°C

The resistance-temperature characteristics are described in terms of the ratio of resistance R(t) at temperature t and the resistance R(0.01°C) at the triple point of water. The 162 SPRTs are constructed with pure, strain-free platinum and satisfy the ITS-90 criteria:

$$R(29.7646°C)/R(0.01°C) \geq 1.11807, \text{ and}$$
$$R(-38.8344°C)/R(0.01°C) \leq 0.844235.$$

The high temperature SPRT model 162K also satisfies the criterion:

$$R(961.78°C)/R(0.01°C) \geq 4.2844.$$

A more detailed description of your thermometer is included in the Specification Control Drawing (see Appendix A).

1.2 Calibration

A SPRT must be calibrated before it can be used for accurate temperature measurement. Rosemount Aerospace provides calibration services traceable to the National Institute of Standards and Technology (NIST) for all series 162 thermometers. Alternatively, the thermometer may be submitted directly to the NIST or other national standards laboratory. Additional information on calibration is provided in Section 4, Calibration.

1.3 Getting Started

Before using your thermometer, understand the capability of your SPRT and the equipment used with the thermometer. The following checklist includes important first steps to take towards achieving your accuracy and cost goals.

- ☑ The application temperature is within the SPRT specification (see Appendix A).
- ☑ The fluid is compatible with the thermometer (see 2.3).
- ☑ The installation has low vibration and adequate clearance (see 2.3).
- ☑ The thermometer is connected for a 4-wire measurement (see 3.1).
- ☑ The resistance measuring equipment is appropriate for uncertainty budget (see 3.2).
- ☑ The excitation current is selected to prevent appreciable self-heating error (see 3.2.1).
- ☑ The immersion depth is sufficient to minimize stem conduction errors (see 3.3).
- ☑ The thermometer has a valid calibration (see 4).

1.4 Technical Support

For technical assistance, contact our Metrology Products Group (phone: 651-681-8900, fax: 651-681-8909).

2. INSTALLATION

2.1 General

The calibration equipment used with the series 162 thermometers should be located in a laboratory environment conducive to precise measurements:

- Quiet, clean, and draft free
- Minimal vibration
- Low radio frequency, magnetic and electrical interference
- Stable temperature and humidity

2.2 Handling

The series 162 thermometers are delicate instruments that must be handled carefully to maintain calibration accuracy. Vibration or mechanical shock will strain the platinum sensing element causing the resistance to increase with time. Careful handling will prolong thermometer life and reduce the need for recalibration. When not in use, store the thermometer in its protective storage case.

The quartz sheath thermometers (162CG and 162K) require special attention. Besides being extremely fragile, surface contaminants will promote devetrification of the quartz at high temperatures. Never touch the sheath with bare hands. If handling is necessary, disposable plastic (powder-free) gloves or finger cots are recommended. As a precaution, wipe the sheath with alcohol to remove fingerprints and other debris before exposing it to elevated temperatures.

2.3 Mounting

The series 162 thermometers may be mounted for either horizontal or vertical installation. A typical installation is shown in Figure 1.

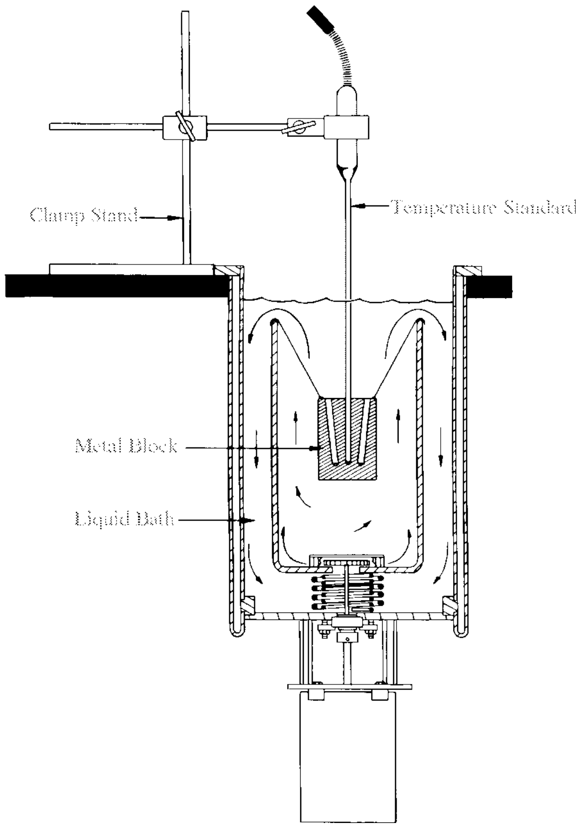


Figure 1. Long-stem SPRT Mounted in Stirred Liquid Bath

When used with a metal block or other rigid fixture, the clearance between the thermometer sheath and block should be sized to promote good thermal contact and allow easy insertion and removal. Recommended minimum well diameters are included in Table 2. For larger wells, thermal contact can be improved by using a bushing positioned over the sensing portion of the thermometer tip.

Table 2. Recommended Well Diameter

Model	Recommended Minimum Well Diameter
162CE, 162D	5.7 mm (0.226 inches)
162CG, 162K	7.75 mm (0.295 inches)

For the long-stem thermometers, the head and external lead wires are designed to remain near ambient conditions (see Appendix A for temperature limits). The thermometer head should not be submerged in liquid or chilled to form surface condensation since this could cause low insulation resistance between the lead wires. Additional mounting considerations for specific models are included below.

2.3.1 162CE

The model 162CE has a nickel-chromium alloy (Inconel X-750) sheath that is compatible with all common calibration media. A compression fitting may be installed on the 6.4 mm (0.250 inch) diameter portion of the sheath (see Appendix A) to allow use under pressures up to 13.8 MPa (2000 psia).

2.3.2 162D

The model 162D can be immersed directly in any nonconductive fluid compatible with the materials of construction. Wetted surfaces include nickel-chromium alloy (Inconel X-750), platinum, glass, and silver solder alloy.

Additional wire is often needed to extend the lead wire to the readout device. Copper wire, typically 26 gage or smaller, can be joined to the platinum wire with silver solder (BAg-7). The solder joint should be at least 18 mm (0.7 inch) from the glass seal. A Teflon or similar sleeving should be positioned over each lead wire to prevent a short circuit between lead wires or to ground.

CAUTION: DO NOT BEND OR OVERHEAT THE PINS AND PLATINUM LEAD WIRE ADJACENT TO THE HOUSING.

To minimize conduction errors, the thermometer and lead wire must be at approximately the same temperature. For cryostat applications, a small diameter extension wire is used and strapped to the calibration block as shown in Figure 2. This also provides strain relief for the delicate lead wires.

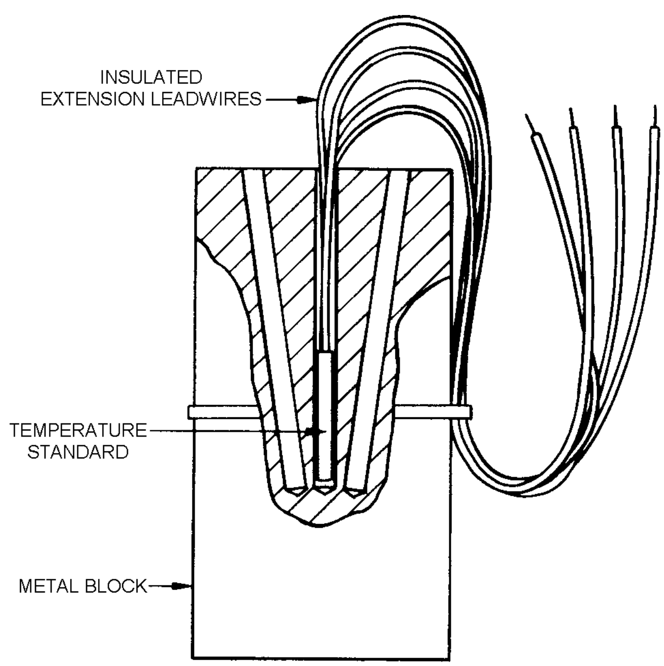


Figure 2. Cryogenic or Special Purpose Metal Block Installation-Model 162D

2.3.3 162CG and 162K

Models 162CG and 162K have fused quartz (SiO_2) sheaths that are compatible with most calibration fluids except for salts. Direct exposure to salt bath fluids will cause the sheath to spall and eventually lead to mechanical failure. For salt bath applications, the thermometer must be placed into a protective tube made of a corrosion resistant material such as 316 stainless steel.

At temperatures above approximately 600°C, fused quartz is not impervious to elements that can contaminate the platinum sensing element. The risk of contamination increases exponentially with temperature. When used in a furnace with exposed heating elements or other metal objects, the thermometer must be used with a dense protective tube compatible with quartz and platinum. Tubes made of platinum or more economical high purity aluminum oxide (99.8% min.) have proven to be effective diffusion barriers.

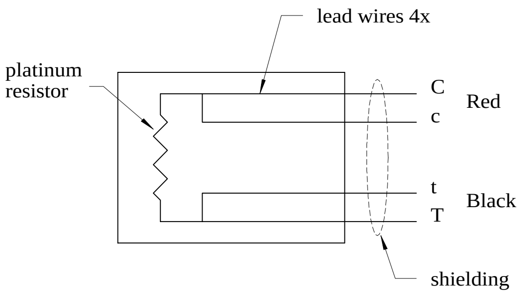
3. OPERATION

3.1 Thermometer Circuit

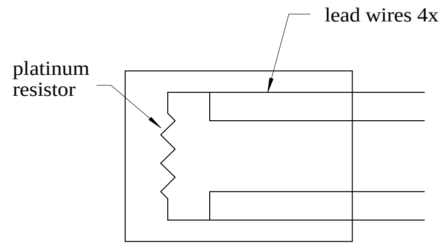
The series 162 thermometers include four lead wires so that lead resistances are effectively cancelled when used with a four-terminal resistance bridge or other readout instrument (see Figure 3). The model 162K also has a fifth lead wire that runs between the sensing element and housing. The fifth lead is positioned equidistant from the four element lead wires and is used to test insulation resistance.

The long-stem SPRTs include a molded strain relief on each spade lug, which is color coded black or red to identify common lead wires. The spade lugs are also stamped with the traditional designations "C" and "T" for the current carrying (source) leads and "c" and "t" for the potential (sense) leads. However, all the leads are identically constructed and matched within 0.005 ohms at the factory. Under most circumstances, it makes no difference which pair of leads is used for current and potential. Contact the factory if your application requires the lead resistances trimmed to a tighter tolerance.

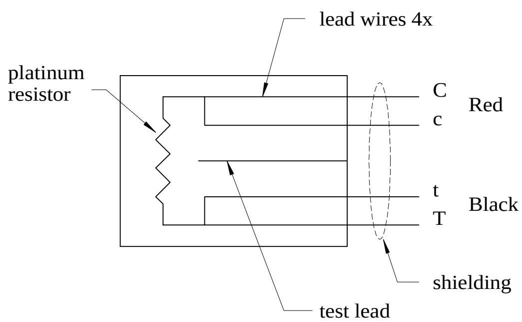
The external lead wire cable is fully shielded and isolated from the thermometer head. If needed, a guard wire can be attached to the shielding at the lug end of the cable by removing a small portion of the silicone rubber jacket.



Models 162CE and 162CG



Model 162D



Model 162K

Figure 3. Electrical Schematics

3.2 Resistance Measurement

The series 162 thermometers can be used with any AC or DC four-terminal resistance bridge, digital multimeter, or other readout instrument. Since the indicated temperature is determined from the measured resistance, the accuracy and resolution of the measurement equipment must be consistent with the desired uncertainty budget. The nominal resistance and sensitivity versus temperature for the 25.5 ohm and 0.25 ohm SPRTs are included in Table 3. This data can be used to convert resistance measurement uncertainty to equivalent units of temperature. For example, 0.1 mΩ at 500°C is equivalent to 1.2 m°C and 117.6 m°C for models 162CE and 162K respectively.

Table 3. Nominal Resistance versus Temperature

Temperature t (°C)	SPRT, R(0.01°C)=25.5 ohms		HTSPRT, R(0.01°C)=0.25 ohms		Sensitivity dR/dt∗1/R (%/°C)
	R (Ω)	dR/dt (mΩ/°C)	R (Ω)	dR/dt (mΩ/°C)	
-260	0.03	5.3			19.87
-250	0.17	27.1			15.54
-240	0.60	57.6			9.63
-230	1.31	82.7			6.33
-220	2.22	98.2			4.43
-210	3.25	106.2			3.27
-200	4.33	109.7			2.53
-150	9.83	108.4			1.10
-100	15.16	105.3			0.69
-50	20.37	103.3			0.51
0	25.50	101.7	0.2500	0.997	0.40
50	30.55	100.2	0.2995	0.982	0.33
100	35.52	98.6	0.3482	0.967	0.28
150	40.41	97.1	0.3962	0.952	0.24
200	45.23	95.6	0.4434	0.938	0.21
250	49.97	94.1	0.4899	0.923	0.19
300	54.64	92.7	0.5357	0.908	0.17
350	59.24	91.2	0.5808	0.894	0.15
400	63.76	89.7	0.6251	0.880	0.14
450	68.21	88.2	0.6687	0.865	0.13
500	72.58	86.7	0.7116	0.850	0.12
550	76.88	85.2	0.7537	0.835	0.11
600	81.10	83.6	0.7951	0.820	0.10
650	85.24	82.1	0.8357	0.804	0.10
700			0.8755	0.789	0.09
750			0.9146	0.773	0.08
800			0.9529	0.758	0.08
850			0.9904	0.743	0.08
900			1.0272	0.728	0.07
950			1.0632	0.714	0.07
1000			1.0985	0.700	0.06

3.2.1 Measuring Current

The resistance measurement requires an excitation current to be supplied to the SPRT. This current causes the sensing element to self-heat so that the indicated temperature is slightly higher than the actual medium temperature. The self-heating is proportional to the dissipated power and is minimized by using a low operating current. The self-heating is also influenced by the external heat transfer conditions. For example, a thermometer exposed to a stirred liquid bath produces a lower self-heating error compared to the same thermometer tested in still air.

The series 162 SPRTs exhibit minimal self-heating. Table 4 includes total self-heating errors at recommended current.

Table 4. Total Self Heating in Ice Bath or Triple Point of Water Cell

Model	Specification ($m°C/mA^2$)	Nominal Current (mA)	Typical Error (m°C)
162CE	<0.5	1	0.3
162CG	<0.6	1	0.4
162D	<0.6	1	0.3
162K	<0.3	10	2.0

The effect of self-heating can be evaluated by measuring the thermometer resistance at two current levels. When self-heating errors are significant, a "zero current" resistance measurement is used:

$$R_{zero} = R_1 - \frac{i_1^2 (R_2 - R_1)}{i_2^2 - i_1^2}$$

where
R_{zero}= resistance at zero current,
R_1= resistance at current i_1,
R_2= resistance at current i_2.

3.2.2 Thermal emf

A thermal emf is generated any time an electrical circuit consisting of different materials passes through a temperature gradient. This voltage, although small, can corrupt the resistance measurement depending on the instrumentation used. The series 162 SPRTs exhibit minimal emf because the internal platinum lead wires are uniformly annealed and connections to the external copper lead wires are heat sinked. However, a resistance bridge or meter designed to reject thermal emf should always be used for accurate measurements. Common methods include AC excitation, DC excitation with current reversal, or DC offset compensation.

3.3 Immersion Depth

A long-stem SPRT requires a minimum depth of immersion to ensure the sensing element and medium are at the same temperature. Insufficient depth will cause an error due to conducted heat flow along the axis of the thermometer. This error depends on several factors, including the SPRT design, temperature gradient, and external heat transfer conditions.

The immersion characteristics are evaluated by measuring the thermometer resistance at different depths of immersion in an isothermal medium. Typical results for a stirred ice bath are shown in Figure 4. A significant difference between readings, as compared to the desired uncertainty budget, suggests further immersion is required. If this is not possible, the condition may improve by insulating the portion of the thermometer stem held at ambient temperature. For dry-well applications, reducing the air gap between the thermometer sheath and block with a metal bushing will promote thermal coupling and reduce stem conduction errors.

For precision measurements using fixed-point cells, a thermometer with adequate immersion will track the temperature gradient caused by the hydrostatic pressure effect of the liquid. The pressure coefficient is unique for each fixed-point material and does not exceed 7.1 m°C per meter of liquid for the ITS-90 fixed-points defined for the SPRT.

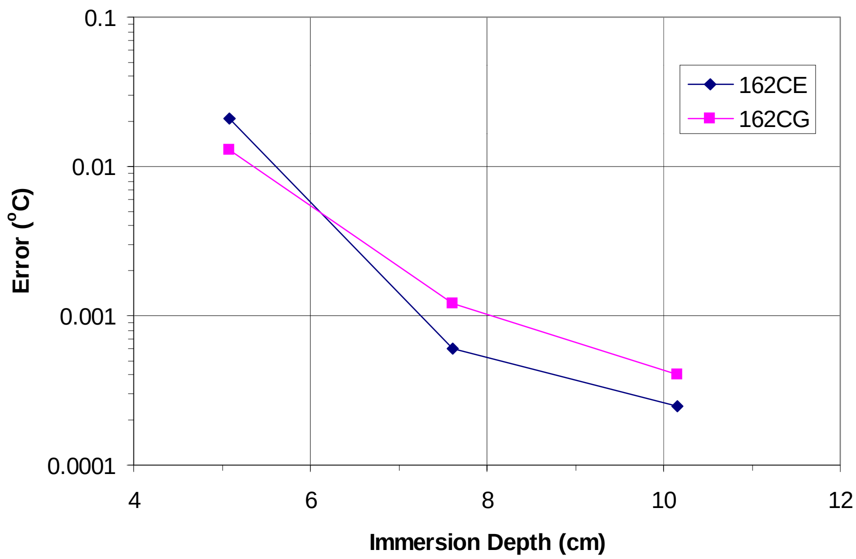


Figure 4. Typical Stem Conduction Error in Stirred Ice Bath

3.4 Cooling Rate

The series 162 SPRTs are designed to withstand thermal shocks over a specified temperature range. However, as temperature increases, the equilibrium concentrations of point defects in the platinum sensing element also increase. When rapidly cooled from temperatures above 600°C, some of these defects are frozen in the crystal structure, causing an increase in resistance. For example, the 162K cooled from 1100°C to room temperature in less than one minute will exhibit a shift in R(0.01°C) equivalent to 0.06°C. In comparison, the 162CE rapidly cooled from 661°C typically shifts less than 0.001°C. This effect is reversible and the original resistance can be recovered by subsequent annealing. However, this condition can be prevented by simply slow cooling the thermometer at a rate not exceeding 150°C per hour to 500°C before removing to room temperature.

3.5 Radiation

Radiation heat transfer is another source of error if the sensing element can see a surface appreciably hotter or colder than the measured medium. This is usually a concern with transparent glass sheath thermometers. However, the models 162CG and 162K feature a quartz sheath with a matte finish that essentially eliminates radiation light piping through the sheath wall. Radiation can also transmit through the medium. For example, room lights incident upon the top of an ice bath or triple point of water cell can produce an error up to 0.2 m°C. This error is eliminated by using an opaque cover over the bath.

4. CALIBRATION

4.1 General

The series 162 SPRT must be calibrated before it can be used for accurate temperature measurement. Calibration consists of measuring the thermometer resistance at a series of known temperatures and fitting the results with an interpolation equation. The calibration temperatures can be fixed points with assigned temperature values, such as reproducible freezing points, melting points, or triple points of pure materials. Alternatively, the thermometer can be calibrated by comparison against a SPRT with a known calibration. Prior to calibration, the SPRT must be fully annealed (see 5.1).

The ITS-90 prescribes calibration points and interpolation formula for specific temperature ranges. Approximations of the ITS-90, such as using fewer or different calibration points, are commonly used to balance cost and accuracy constraints. The laboratory performing the calibration is responsible for providing a description of the test method and statement of uncertainty.

4.2 Resistance Ratio

The SPRT is calibrated in terms of resistance ratio. The ITS-90 defines the resistance ratio W(t) as the ratio of resistance R(t) at temperature t and the resistance R(0.01°C) at the triple point of water:

$$W(t)=R(t)/R(0.01°C)$$

Using resistance ratio reduces system level errors and simplifies the calibration. For example, the W(t) is essentially independent of the ohm value if both R(t) and R(0.01°C) are measured with the same resistance bridge. This minimizes errors caused by differences in equipment and ohm value maintained by the user and calibration laboratory. In addition, metallurgical changes of the platinum wire affect the R(t) more than W(t). The superior stability of W(t) improves accuracy and extends the time interval between calibrations. Finally, SPRTs exhibit similar W(t) characteristics. The deviations between two thermometers or a reference function can be described with a simple equation; the basis for the ITS-90 interpolation formula.

4.3 Triple Point of Water

The triple point of water (TPW) is a state where ice, water, and water vapor coexist in thermal equilibrium. The TPW is a defining fixed point on the ITS-90 and has an assigned temperature value of 0.01°C. The R(0.01°C) is an important measurement for determining the resistance ratio W(t) and is a common benchmark for tracking the SPRT stability. Measuring the R(0.01°C) locally is the only way to take full advantage of a W(t) calibration and also provides a useful check for validating measurements.

The best way to determine R(0.01°C) is with a TPW cell. These cells are commercially available and typically have uncertainty less than 0.2 m°C. Alternatively, the R(0.01°C) may be approximated from the ice-point:

$$R(0.01\ ^{o}C) \cong R(0\ ^{o}C)/0.99996$$

However, it is difficult to prepare and use an ice bath with uncertainty better than 2 m°C.

4.4 Interval

SPRTs are typically calibrated on intervals between six months and two years, depending on uncertainty budget and conditions of use. Thermometers used at temperatures above 500°C or subjected to rough treatment are more susceptible to drift and usually require more frequent recalibrations than other applications. Although a fixed calibration interval is convenient, it is generally more cost effective to evaluate and define an interval that meets the user's cost and accuracy goals. Using historic calibration data provides rationale for establishing the calibration interval.

Periodically measuring the thermometer resistance at a fixed-point, such as the triple point of water, allows the condition of the thermometer to be monitored. When the change in resistance exceeds a predetermined tolerance, the thermometer is recalibrated. Preferably, the check-point resistance tolerance is established based on historic calibration data for the unit under test. For reference only, an approximate relationship between the maximum change in resistance ratio W(t) and shift in R(0.01°C) is shown in Figure 5. This relationship assumes the most recent R(0.01°C) is used to compute W(t).

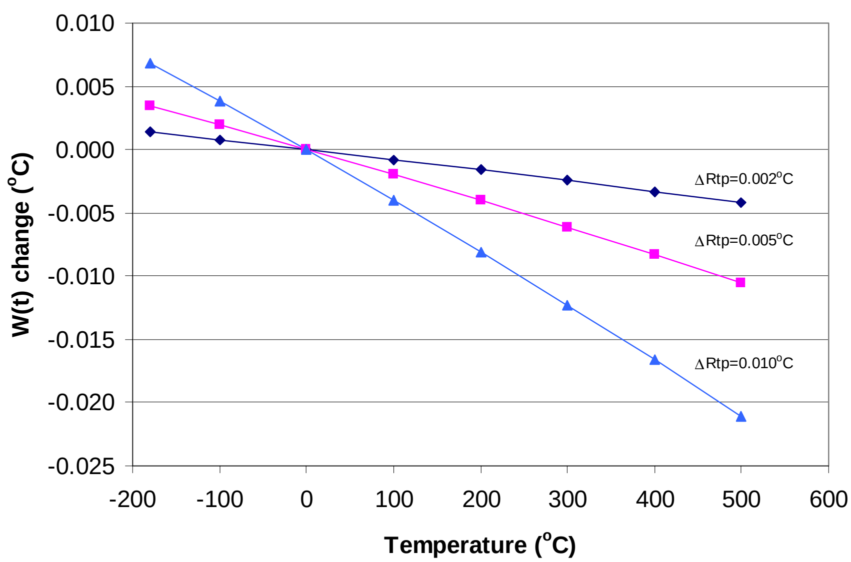


Figure 5. Approximate Change in W(t) for Shift in R(0.01°C) Equivalent to 0.002°C, 0.005°C, and 0.010°C

4.5 Schedules

The thermometer is suitable for calibration over all or part of the specified temperature range. Rosemount Aerospace offers several fixed-point and comparison calibration schedules traceable to the NIST (see Price List P2710). Alternatively, the thermometer may be submitted directly to the NIST or similar standards laboratory.

5. MAINTENANCE

5.1 Annealing

The SPRT is calibrated with the sensing element fully annealed. During transportation and handling, the platinum wire can become strained, causing R(0.01°C) and resistance ratio W(t) to change (see Figure 5). Subjecting the thermometer to elevated temperatures restores the platinum to a stable, strain-free state.

The annealing procedure requires a high temperature furnace and a method of checking the thermometer resistance at a fixed temperature between heat treatments. The triple point of water or ice-point are common check temperatures. The procedure is summarized below.

- Measure resistance at check-point temperature.
- Heat soak thermometer at recommended annealing temperature in Table 5 (see 2.3.3 for precautions related to quartz sheath thermometers).
- Slow cool thermometer if applicable (see 3.4).
- Measure resistance at check-point temperature.
- Repeat procedure until the thermometer reaches desired stability and continues to exhibit recovery (decreasing resistance).

The required annealing time varies depending on the condition of the thermometer. Limit the initial soak to 2 to 4 hours to assess the recovery rate. Subsequent heat soak times can be extended but should not exceed 24 hours between check-point measurements.

CAUTION: PROLONGED HEATING AT MAXIMUM SPECIFIED TEMPERATURE MAY SHORTEN THE LIFE OF THE THERMOMETER. THE ANNEALING TIME SHOULD BE BASED ON ACHIEVING STABILITY, NOT A PREVIOUSLY ANNEALED RESISTANCE VALUE. USUALLY ONLY A PORTION OF THE RESISTANCE SHIFT IS RECOVERED SINCE STRAIN CAN CAUSE A PERMANENT DIMENSIONAL CHANGE IN THE WIRE.

Because of the limited temperature capability of the capsule SPRT, the model 162D is usually not annealed before recalibrating. However, a severely strained element will exhibit some recovery at maximum temperature of 250°C.

Table 5. Recommended Annealing Temperature

Model	Annealing Temperature
162CE	500°C or maximum application temperature not exceeding 661°C
162CG	
162D	250°C
162K	500°C or maximum application temperature not exceeding 1100°C

5.2 Lead Wire Problems

The external lead wires may fail after several years of service due to repeated flexing and handling. Open or shorted lead wires will result in erroneous readings. Use an ohmmeter to periodically check lead wire continuity and insulation resistance between each lead wire and case (see 3.1). If a problem exists, remove the thermometer housing and examine the lead wire connections.

The model 162CE and 162K housings are threaded onto the sensor body. Remove the 162CG housing by unscrewing the knurled retainer. Make sure the exposed lead wires are not touching each other or the inside of the housing. Check the lead wire continuity from the hermetically sealed pins inside the housing.

If needed, the external cable can be replaced. Failures that occur internal to the thermometer are usually nonrepairable. However, return the thermometer to Rosemount Aerospace for evaluation.

5.3 Low Insulation Resistance

The room temperature insulation resistance between the lead wire and case typically measures greater than 1000 megohms. Low insulation resistance may indicate moisture within the thermometer or on the hermetically sealed pins inside the housing. Eliminate external moisture by removing the thermometer housing, carefully cleaning the pins with isopropyl alcohol, and blowing them dry. A leak in the enclosure may allow moisture to enter the thermometer and cause instability. If these symptoms persist, return the thermometer to Rosemount Aerospace for evaluation and possible repair.

6. RETURN OF HARDWARE

The thermometer should be shipped in its protective storage case and wood crate. The storage case should be surrounded by 8 to 10 cm (3 to 4 inches) of soft insulation to cushion the thermometer against mechanical shock. The cover of the crate should be attached with screws; a nailed cover is not acceptable.

Thermometers returned for recalibration or repair, whether in or out of warranty, should be shipped prepaid to:

ISOTECH

Isotech North America
158 Brentwood Drive, Unit 4
Colchester, VT 05446
Phone: (802) 863-8050
Fax: (802) 863-8125

A letter that contains the following information should accompany the thermometer:

- Company name and address
- Buyer's name and phone number
- Technical contact name and phone number
- Description of problem or calibration service requested
- A purchase order for non-warranty service
- Return shipping instructions

7. SUGGESTED READING

The following publications contain useful information on SPRTs and related calibrations.

- H. Preston-Thomas, "The International Temperature Scale of 1990 (ITS-90)," *Metrologia*, Vol. 27, pp. 3-10, (1990). For errata see ibid., Vol. 27, p. 107, (1990).
- B. W. Mangum and G. T. Furukawa, "Guidelines for Realizing the International Temperature Scale of 1990 (ITS-90)," NIST Technical Note 1265, (1990).
- H. Preston-Thomas, P. Bloembergen, and T. J. Quin, *Supplementary Information for the International Temperature Scale of 1990*, Bureau International des Poids et Measures, (1990).
- G. F. Strouse and W. L. Tew, "Assessment of Uncertainties of Calibration of Resistance Thermometers at the National Institute of Standards and Technology," NISTIR 5319, (1994)
- J. L. Riddle, G. T. Furukawa, and H. H. Plumb, "Platinum Resistance Thermometry," NBS Monograph 126, (1973).
- *Temperature: Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., Vol. 6, American Institute of Physics, New York, (1992).
- *Temperature: Its Measurement and Control in Science and Industry*, J. F. Schooley, ed., Vol. 5, American Institute of Physics, New York, (1982).
- Standard Guide for Use of Water Triple Point Cells, E 1750, Annual Book of ASTM Standards, Vol. 14.03
- Standard Guide for Use of Freezing-Point Cells for Reference Temperatures, E 1502, Annual Book of ASTM Standards, Vol. 14.03
- Standard Practice for Preparation and Use of an Ice-Point Bath as a Reference Temperature, E 563, Annual Book of ASTM Standards, Vol. 14.03

APPENDIX A

Specification Control Drawing

REVISIONS (ALL SHEETS ARE SAME REV)					
ZONE	REV	DESCRIPTION	DWG NO	APPD	DATE
—	E	REDRAWN WITH CHANGES REV ALL SPEC. NOTES	A6248	RWP JPZ	971114
—	F	REV'D NOTES 1.0, 2.9	A101093	RWP TJM	010922

SPECIFICATIONS

1.0 SCOPE. THE MODEL 162CE IS A LONG STEM STANDARD PLATINUM RESISTANCE THERMOMETER (SPRT) DESIGNED TO MEET THE REQUIREMENTS OF THE INTERNATIONAL TEMPERATURE SCALE OF 1990 (ITS-90) FROM THE TRIPLE POINT OF ARGON (-189.3442°C) TO THE FREEZING POINT OF ALUMINUM (660.323°C). THE SENSING ELEMENT IS MADE FROM PURE, STRAIN-FREE PLATINUM AND IS HERMETICALLY SEALED IN AN INCONEL X-750 SHEATH CONTAINING A HELIUM/OXYGEN GAS MIXTURE.

2.0 PERFORMANCE AND DESIGN

2.1 TEMPERATURE RANGE. THE THERMOMETER CAN BE USED FROM -200°C TO 561°C. MAXIMUM TEMPERATURE FOR HEAD IS 200°C.

2.2 PRESSURE RANGE. 0 TO 2000 PSIA.

2.3 ELECTRICAL CIRCUIT. FOUR-WIRE (SEE SCHEMATIC DIAGRAM).

2.4 RESISTANCE-TEMPERATURE CHARACTERISTICS.
- R(.01°C)=25.5± .4 OHMS
- R(29.7646°C)/R(.01°C) $\geq$ 1.11807
- R(-38.8344°C)/R(.01°C) $\leq$ .844235

2.5 REPEATABILITY. WHEN CYCLED OVER THE SPECIFIED TEMPERATURE RANGE, THE R(.01°C) SHALL REPEAT WITHIN THE EQUIVALENT OF .001°C.

2.6 SELF HEATING. THE SELF HEATING SHALL BE $\leq$ .0005°C/mA² WHEN MEASURED AT THE TRIPLE POINT OF WATER (.01°C).

2.7 INSULATION RESISTANCE. THE RESISTANCE BETWEEN LEAD AND CASE SHALL BE GREATER THAN 1000 MEGOHMS AT 25°C WITH 100 Vdc APPLIED.

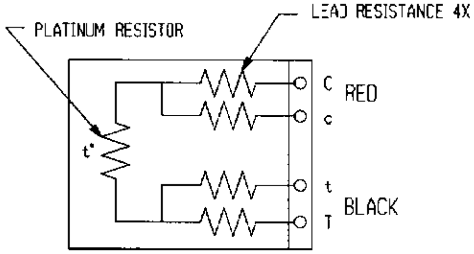
2.8 MATERIALS OF CONSTRUCTION.

ELEMENT:	PLATINUM, 99.999% MIN
INTERNAL LEADS:	4-CONDUCTOR, PLATINUM
SHEATH:	INCONEL X-750
HEAD:	300 SERIES SST
GAS FILLING:	HELIUM + OXYGEN
CABLE:	4-CONDUCTOR (20AWG-7X15/40 SILVER PLATED COPPER), FEP INSULATED, TWISTED, SILVER PLATED COPPER BRAIDED SHIELD, SILICONE RUBBER JACKET, GOLD PLATED COPPER SPADE LUG WITH PVC MOLDED STRAIN RELIEF.

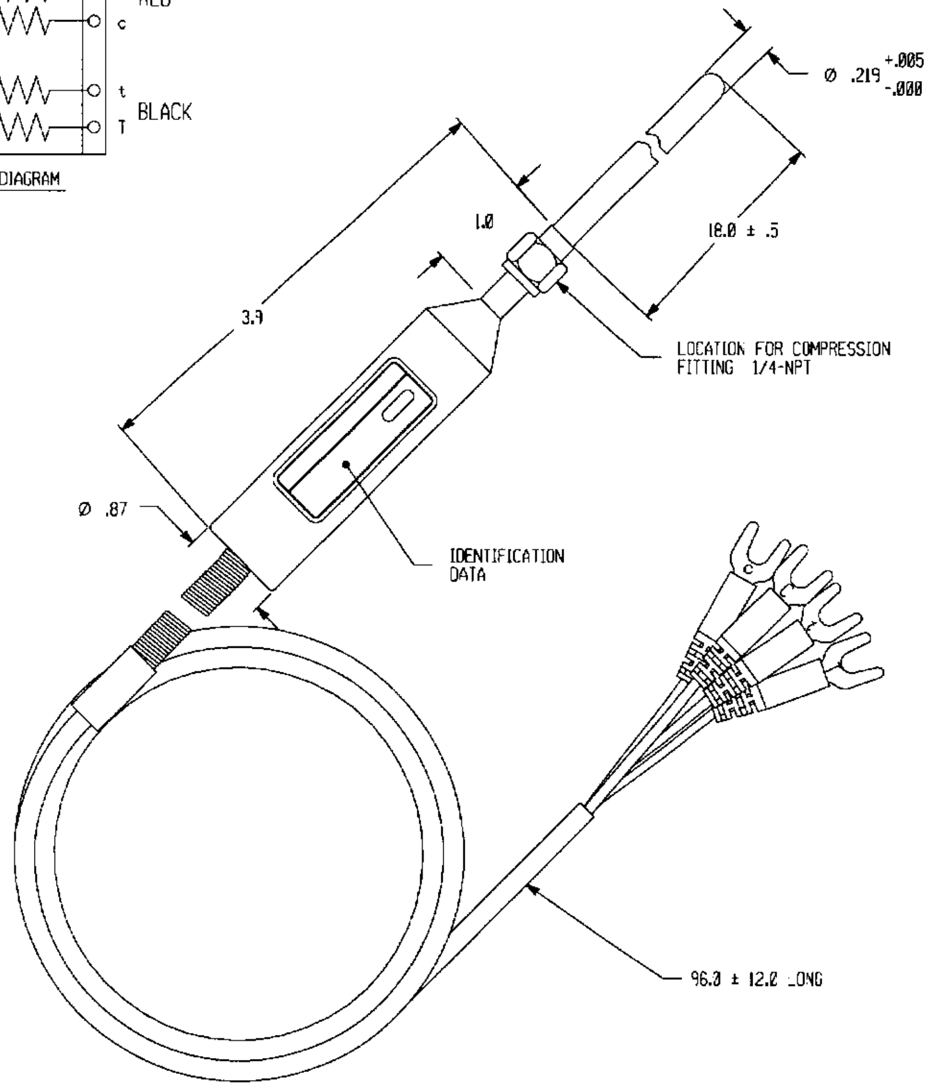
2.9 IDENTIFICATION. THE THERMOMETER AND STORAGE CASE SHALL BE LABELED WITH THE FOLLOWING INFORMATION:

ROSEMOUNT AEROSPACE INC.
STANDARD PLATINUM RESISTANCE THERMOMETER
MODEL 162CE
SERIAL NUMBER ______

3.0 CALIBRATION (OPTIONAL). THE THERMOMETER IS SUITABLE FOR CALIBRATION OVER ALL OR PART OF THE RANGE -200°C TO 661°C. REFER TO ROSEMOUNT AEROSPACE CALIBRATION PRICE LIST FOR AVAILABLE SCHEDULES AND CALIBRATION UNCERTAINTY.



SCHEMATIC DIAGRAM



SPECIFICATION DRAWING

NOTES: DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.

CAD MAINTAINED. CHANGES SHALL BE INCORPORATED BY THE DESIGN ACTIVITY.

RMTAERO PROPRIETARY & PRIVATE / RMTAERO PROPRIETARY / RMTAERO PRIVATE / RMTAERO PROPRIETARY / NO RESTRICTIVE MARKINGS X

NEXT ASSY | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES REMOVE ALL BURRS AND SHARP EDGES. MACHINE SURFACE FINISH 125

-TOLERANCES-
DECIMALS: .X ± .1; .XX ± .02; .XXX ± .010
FRACTIONS ± 1/32
ANGLES ± 2°

DO NOT SCALE PRINT

CONTRACT NO

DR	C. NYBO	970717
CHKD	R. PHILLIPS	971114
APPD	J. ZWAK	971114

THIRD ANGLE PROJECTION

Rosemount Aerospace Inc. BURNSVILLE, MINNESOTA USA

TITLE TEMPERATURE SENSOR ASSY STANDARD

SIZE C | CAGE CODE 60678 | DRAWING NO 0162CE

SCALE: NONE | SHEET 1 OF 1

DWG NO 0162CE SH 1

MICROSTATION

REVISIONS (ALL SHEETS ARE SAME REV)					
ZONE	REV	DESCRIPTION	CHG NO	APPD	DATE
—	A	NEW RELEASE	A7336	RWP JPZ	971210
—	B	REV'D NOTES 1.0, 2.8	A101093	RWP TJM	010922
C1		Ø.28 WAS Ø.276			

SPECIFICATIONS

1.0 SCOPE. THE MODEL 162CG IS A LONG STEM STANDARD PLATINUM RESISTANCE THERMOMETER (SPRT) DESIGNED TO MEET THE REQUIREMENTS OF THE INTERNATIONAL TEMPERATURE SCALE OF 1990 (ITS-90) FROM THE TRIPLE POINT OF ARGON (-189.3442°C) TO THE FREEZING POINT OF ALUMINUM (660.323°C). THE SENSING ELEMENT IS MADE FROM PURE, STRAIN-FREE PLATINUM AND IS HERMETICALLY SEALED IN A QUARTZ SHEATH CONTAINING A NITROGEN/OXYGEN GAS MIXTURE.

2.0 PERFORMANCE AND DESIGN

2.1 TEMPERATURE RANGE. THE THERMOMETER CAN BE USED FROM -200°C TO 675°C. MAXIMUM TEMPERATURE FOR HEAD AND CABLING IS 125°C.

2.2 ELECTRICAL CIRCUIT. FOUR-WIRE (SEE SCHEMATIC DIAGRAM).

2.3 RESISTANCE-TEMPERATURE CHARACTERISTICS.
- R(.01°C)=25.5± .5 OHMS
- R(29.7646°C)/R(.01°C) ≥ 1.11807
- R(-38.8344°C)/R(.01°C) ≤ .844235

2.4 REPEATABILITY. WHEN CYCLED OVER THE SPECIFIED TEMPERATURE RANGE, THE R(.01°C) SHALL REPEAT WITHIN THE EQUIVALENT OF .001°C.

2.5 SELF HEATING. THE SELF HEATING SHALL BE ≤ .0006°C/mA² WHEN MEASURED AT THE TRIPLE POINT OF WATER (.01°C).

2.6 INSULATION RESISTANCE. THE RESISTANCE BETWEEN LEAD AND CASE SHALL BE GREATER THAN 1000 MEGOHMS AT 25°C WITH 100 Vdc APPLIED.

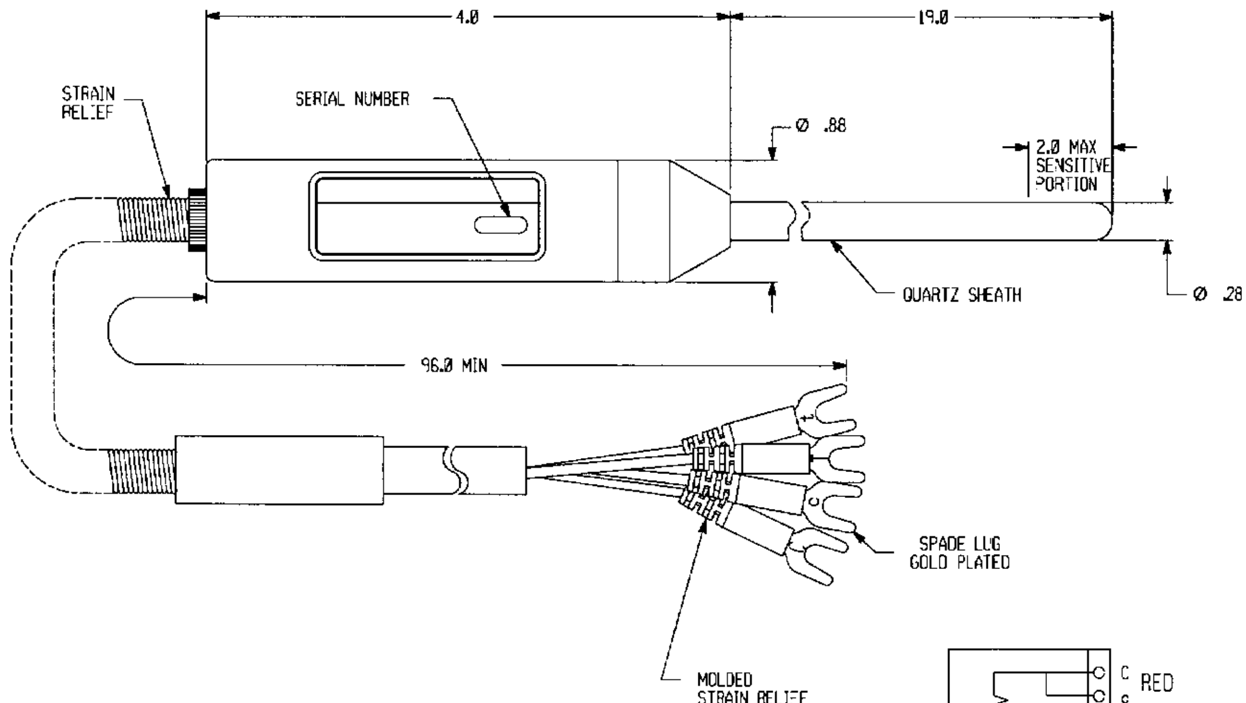
2.7 MATERIALS OF CONSTRUCTION.

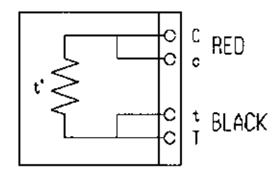
ELEMENT:	PLATINUM, 99.999% MIN
INTERNAL LEADS:	4-CONDUCTOR, PLATINUM
SHEATH:	FUSED QUARTZ
HEAD:	POLYETHERIMIDE WITH ANODIZED ALUMINUM COVER.
GAS FILLING:	NITROGEN + OXYGEN
CABLE:	4-CONDUCTOR (20AWG-7X15/40 SILVER PLATED COPPER), FEP INSULATED, TWISTED, SILVER PLATED COPPER BRAIDED SHIELD, SILICONE RUBBER JACKET, GOLD PLATED COPPER SPADE LUG WITH PVC MOLDED STRAIN RELIEF.

2.8 IDENTIFICATION. THE THERMOMETER AND STORAGE CASE SHALL BE LABELED WITH THE FOLLOWING INFORMATION:

ROSEMOUNT AEROSPACE INC.
STANDARD PLATINUM RESISTANCE THERMOMETER
MODEL 162CG
SERIAL NUMBER ______

3.0 CALIBRATION (OPTIONAL). THE THERMOMETER IS SUITABLE FOR CALIBRATION OVER ALL OR PART OF THE RANGE -200°C TO 661°C. REFER TO ROSEMOUNT AEROSPACE CALIBRATION PRICE LIST FOR AVAILABLE SCHEDULES AND CALIBRATION UNCERTAINTY.





SCHEMATIC DIAGRAM

SPECIFICATION DRAWING

CAD MAINTAINED. CHANGES SHALL BE INCORPORATED BY THE DESIGN ACTIVITY.

RMTAERO PROPRIETARY / PRIVATE / RMTAERO PROPRIETARY / RMTAERO PRIVATE / RMTAERO PROPRIETARY / NO RESTRICTIVE MARKINGS X	NEXT ASSY / USED ON / APPLICATION	UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES REMOVE ALL BURRS AND SHARP EDGES. MACHINE SURFACE FINISH 125 -TOLERANCES- DECIMALS: X ± .1, XX ± .02, XXX ± .010 FRACTIONS ± 1/32, ANGLES ± 2° DO NOT SCALE PRINT	CONTRACT NO DR C. NYBO 970717 CHKD R. PHILLIPS 971210 APPD JOHN ZWAK 971211 THIRD ANGLE PROJECTION

Rosemount Aerospace Inc.	BURNSVILLE, MINNESOTA USA
TITLE	TEMPERATURE SENSOR ASSEMBLY
SIZE C · CAGE CODE 60678	DRAWING NO 0162CG
SCALE: NONE	SHEET 1 OF 1

NOTES: DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.

DWG NO 0162CG SH 1

MICROSTATION

		REVISIONS (ALL SHEETS ARE SAME REV)			
ZONE	REV	DESCRIPTION	CHG NO	APPD	DATE
—	P	REDRAWN ; REVISED TEXT	A4948	RWP/SW	970721
—	R	REV'D SPEC NOTES 1.0, 2.9	A101093	RWP-TJM	010922

SPECIFICATIONS

1.0 SCOPE. THE MODEL 162D IS A CAPSULE-TYPE STANDARD PLATINUM RESISTANCE THERMOMETER (SPRT) DESIGNED TO MEET THE REQUIREMENTS OF THE INTERNATIONAL TEMPERATURE SCALE OF 1990 (ITS-90) FROM 13.8 K TO 523 K. THE SENSING ELEMENT IS MADE FROM PURE, STRAIN-FREE PLATINUM AND IS HERMETICALLY SEALED IN A METAL SHEATH CONTAINING HELIUM GAS.

2.0 PERFORMANCE AND DESIGN.

2.1 TEMPERATURE RANGE. 4 TO 523 K.

2.2 PRESSURE RANGE. 0 TO 6.89 MPa.

2.3 ELECTRICAL CIRCUIT. FOUR-WIRE (SEE SCHEMATIC DIAGRAM).

2.4 RESISTANCE-TEMPERATURE CHARACTERISTICS.
R(273.16 K) = 25.5 ± .1 OHMS
R(302.9146 K)/R(273.16 K) ≥ 1.11807
R(234.3156 K)/R(273.16 K) ≤ 0.844235

2.5 REPEATABILITY. WHEN CYCLED OVER THE TEMPERATURE RANGE 13.8 K TO 523 K, THE R(273.16 K) SHALL REPEAT WITHIN THE EQUIVALENT OF 1 mK.

2.6 SELF HEATING. THE SELF HEATING SHALL BE ≤ .6 mK/mA² WHEN MEASURED AT THE TRIPLE POINT OF WATER (273.16 K).

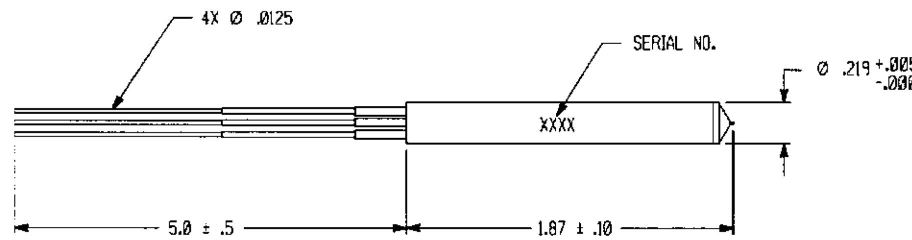
2.7 INSULATION RESISTANCE. THE RESISTANCE BETWEEN LEAD AND CASE SHALL BE GREATER THAN 1000 MEGOHMS AT 295 K AND 50 MEGOHMS AT 523 K WITH 100 Vdc APPLIED.

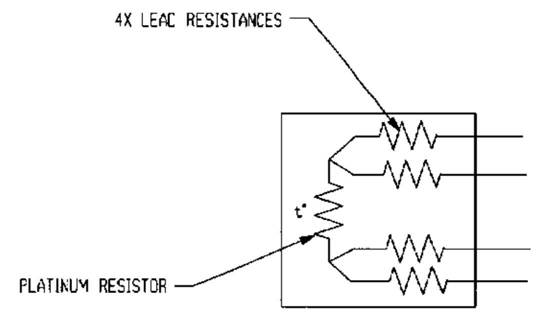
2.8 MATERIALS OF CONSTRUCTION.
ELEMENT: Pt, 99.999%
LEAD WIRE: Pt, 99.999%
SHEATH: INCONEL X-750
GAS FILLING: He

2.9 IDENTIFICATION. THE STORAGE CASE SHALL BE LABELED WITH MODEL AND SERIAL NUMBER. THE THERMOMETER SHALL BE ENGRAVED WITH THE INFORMATION BELOW.

MODEL	THERMOMETER IDENTIFICATION
162D	SERIAL NUMBER
162DI	SERIAL NUMBER + CUSTOMER P/N

3.0 CALIBRATION (OPTIONAL). THE THERMOMETER IS SUITABLE FOR CALIBRATION OVER ALL OR PART OF THE RANGE 13.8 K TO 523 K. REFER TO ROSEMOUNT AEROSPACE CALIBRATION PRICE LIST FOR AVAILABLE SCHEDULES AND CALIBRATION UNCERTAINTY.





SCHEMATIC DIAGRAM

NOTES:
1 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.

CAD MAINTAINED. CHANGES SHALL BE INCORPORATED BY THE DESIGN ACTIVITY.

SPECIFICATION DRAWING

RMTAERO PROPRIETARY & PRIVATE / RMTAERO PROPRIETARY / RMTAERO PRIVATE / RMTAERO PROPRIETARY / NO RESTRICTIVE MARKINGS X

NEXT ASSY | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES REMOVE ALL BURRS AND SHARP EDGES. MACHINE SURFACE FINISH 125
-TOLERANCES-
DECIMALS .X ± .1, .XX ± .02, .XXX ± .010
FRACTIONS ± 1/32
ANGLES ± 2°
DO NOT SCALE PRINT

CONTRACT NO

DR	C. NYBO	970610
CHKD	R. PHILLIPS	970721
APPD	S. WEERES	970727

THIRD ANGLE PROJECTION

Rosemount Aerospace Inc. BURNSVILLE, MINNESOTA USA

TITLE TEMPERATURE STANDARD PLATINUM RESISTANCE TYPE

SIZE C | CAGE CODE 60678 | DRAWING NO 0162D

SCALE: NONE | SHEET 1 OF 1

DWG NO 0162D SH 1

MICROSTATION

REVISIONS (ALL SHEETS ARE SAME REV)					
ZONE	REV	DESCRIPTION	CHG NO	APPD	DATE
	G	REDRAWN TO CAD PER NEW CONFIGURATION	A10955	RWP SML	981013
	H	REV'D NOTES 1.0, 2.10	A101093	RWP TJH	010922

SPECIFICATIONS

1.0 SCOPE. THE MODEL 162K IS A HIGH TEMPERATURE STANDARD PLATINUM RESISTANCE THERMOMETER (HTSPRT) DESIGNED TO MEET THE REQUIREMENTS OF THE INTERNATIONAL TEMPERATURE SCALE OF 1990 (ITS-90) FROM THE ICE POINT (0°C) TO THE FREEZING POINT OF SILVER (961.78°C). THE SENSING ELEMENT IS MADE FROM PURE, STRAIN-FREE PLATINUM AND IS HERMETICALLY SEALED IN A QUARTZ SHEATH CONTAINING AN ARGON/OXYGEN GAS MIXTURE.

2.0 PERFORMANCE AND DESIGN

2.1 TEMPERATURE RANGE. THE THERMOMETER CAN BE USED FROM 0°C TO 1100°C. MAXIMUM TEMPERATURE FOR HEAD AND CABLING IS 125°C.

2.2 ELECTRICAL CIRCUIT. FOUR-WIRE RESISTANCE ELEMENT WITH A FIFTH LEAD FOR INSULATION RESISTANCE MEASUREMENT (SEE SCHEMATIC DIAGRAM).

2.3 RESISTANCE-TEMPERATURE CHARACTERISTICS.

R(.01°C)=.20 TO .25 OHMS
R(29.7646°C)/R(.01°C) ≥ 1.11807
R(961.78°C)/R(.01°C) ≥ 4.2844

2.4 REPEATABILITY. THE R(.01°C) SHALL REPEAT WITHIN THE EQUIVALENT OF .002°C WHEN CYCLED OVER THE SPECIFIED TEMPERATURE RANGE AND SLOW COOLED (2.6).

2.5 STABILITY. THE R(.01°C) DRIFT RATE SHALL NOT EXCEED THE EQUIVALENT OF .01°C PER 100 HOURS WHEN SUBJECTED TO THE MAXIMUM SPECIFIED TEMPERATURE IN A CLEAN OXIDIZING ENVIRONMENT AND SLOW COOLED (2.6).

2.6 COOLING. THE THERMOMETER SHALL SURVIVE RAPID WITHDRAWL FROM ELEVATED TEMPERATURE. HOWEVER, THE SPECIFIED REPEATABILITY AND STABILITY ARE ACHIEVED BY SLOW COOLING 150°C PER HOUR TO 500°C BEFORE REMOVING TO AMBIENT CONDITIONS.

2.7 SELF HEATING. THE SELF HEATING SHALL NOT EXCEED .003°C AT 10mA WHEN MEASURED AT THE TRIPLE POINT OF WATER (.01°C).

2.8 INSULATION RESISTANCE. THE RESISTANCE BETWEEN LEAD AND CASE (FIFTH WIRE) SHALL BE GREATER THAN 1000 MEGOHMS AT 25°C WITH 100 Vdc APPLIED AND GREATER THAN 1 MEGOHM AT 1063°C WITH 1 Vdc APPLIED.

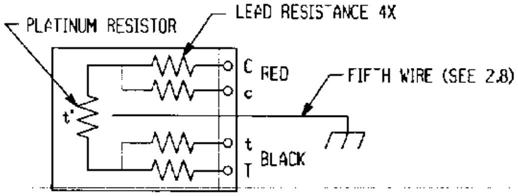
2.9 MATERIALS OF CONSTRUCTION.

ELEMENT:	PLATINUM, 99.999% MIN
INTERNAL LEADS:	4-CONDUCTOR, PLATINUM
SHEATH:	FUSED QUARTZ
GAS FILLING:	ARGON + OXYGEN
CABLE:	4-CONDUCTOR (28AWG-7X15/40 SILVER PLATED COPPER), FEP INSULATED, TWISTED, SILVER PLATED COPPER BRAIDED SHIELD, SILICONE RUBBER JACKET, GOLD PLATED COPPER SPADE LUG WITH PVC MOLDED STRAIN RELIEF.

2.10 IDENTIFICATION. THE THERMOMETER AND STORAGE CASE SHALL BE LABELED WITH THE FOLLOWING INFORMATION:

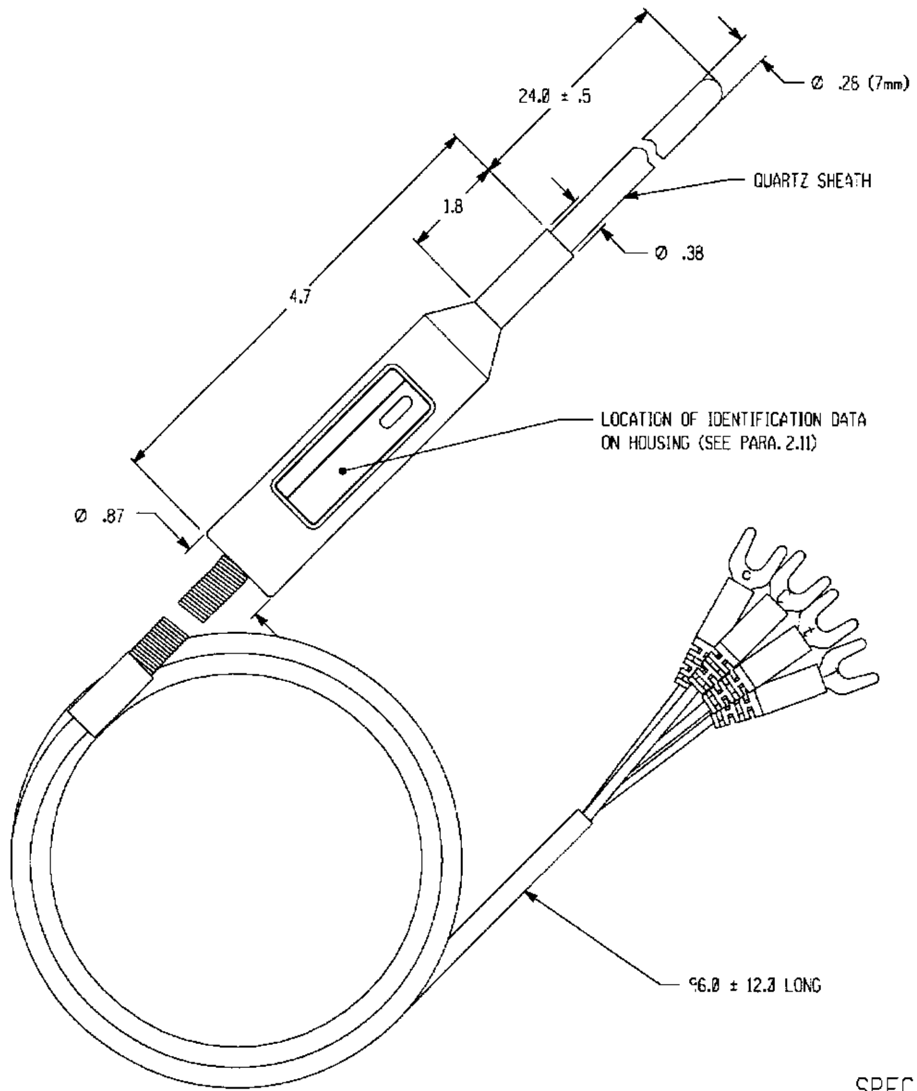
ROSEMOUNT AEROSPACE INC.
STANDARD PLATINUM RESISTANCE THERMOMETER
MODEL 162K
SERIAL NUMBER ______

3.0 CALIBRATION (OPTIONAL). THE THERMOMETER IS SUITABLE FOR CALIBRATION OVER ALL OR PART OF THE RANGE 0°C TO 1100°C. REFER TO ROSEMOUNT AEROSPACE CALIBRATION PRICE LIST FOR AVAILABLE SCHEDULES AND CALIBRATION UNCERTAINTY.



SCHEMATIC DIAGRAM

NOTES: DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.



SPECIFICATION DRAWING

CAD MAINTAINED. CHANGES SHALL BE INCORPORATED BY THE DESIGN ACTIVITY.

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES REMOVE ALL BURRS AND SHARP EDGES. MACHINE SURFACE FINISH 125	CONTRACT NO	Rosemount Aerospace Inc.	BURNSVILLE, MINNESOTA USA
-TOLERANCES- DECIMALS .X ± .1 .XX ± .02 .XXX ± .010 FRACTIONS ± 1/32 ANGLES ± 2°	DR D CARLSON 981008; CHKD R PHILLIPS 981013; APPD S M LENERTZ 981013	TITLE: TEMPERATURE STANDARD PLATINUM RESISTANCE TYPE	
NEXT ASSY / USED ON — APPLICATION	THIRD ANGLE PROJECTION	SIZE C; CAGE CODE 60678; DRAWING NO 0162K	
DO NOT SCALE PRINT		SCALE: NONE	SHEET 1 OF 1

RMTAERO PROPRIETARY & PRIVATE / RMTAERO PROPRIETARY / RMTAERO PRIVATE / RMTAERO PROPRIETARY / NO RESTRICTIVE MARKINGS

DWG NO 0162K SH 1

MICROSTATION