FLUKE®

Hart Scientific®

5608/5609

Platinum Resistance Thermometer User's Guide

Rev. 712601

Limited Warranty & Limitation of Liability

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To obtain warranty service, contact your nearest Hart authorized service center or send the product, with a description of the difficulty, postage, and insurance prepaid (FOB Destination), to the nearest Hart authorized service center. Hart assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If Hart determines that the failure was caused by misuse, alteration, accident or abnormal condition or operation or handling, Hart will provide an estimate or repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

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1 Before You Start

1.1 Symbols Used

Table 1 lists the International Electrical Symbols. Some or all of these symbols may be used on the instrument or in this manual.

Table 1 *International Electrical Symbols*

Symbol	Description
	AC (Alternating Current)
	AC-DC
	Battery
	CE Complies with European Union Directives
	DC
	Double Insulated
	Electric Shock
	Fuse
	PE Ground
	Hot Surface (Burn Hazard)
	Read the User's Manual (Important Information)
	Off
	On

Symbol	Description
	Canadian Standards Association
CAT II	OVERVOLTAGE (Installation) CATEGORY II, Pollution Degree 2 per IEC1010-1 refers to the level of Impulse Withstand Voltage protection provided. Equipment of OVERVOLTAGE CATEGORY II is energy-consuming equipment to be supplied from the fixed installation. Examples include household, office, and laboratory appliances.
	C-TIC Australian EMC Mark
	The European Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) mark.

1.2 Safety Information

Use this instrument only as specified in this manual. Otherwise, the protection provided by the instrument may be impaired.

The following definitions apply to the terms "Warning" and "Caution".

"Warning" identifies conditions and actions that may pose hazards to the user.

"Caution" identifies conditions and actions that may damage the instrument being used.

1.2.1 Warnings

To avoid personal injury, follow these guidelines.

- **DO NOT** use this instrument to measure the temperature of any hazardous live component.
- **DO NOT** use this unit for any application other than calibration work.
- **DO NOT** use this unit in environments other than those listed in the user's manual.
- Use of this instrument at high temperatures for extended periods of time can cause the handle to become hot.
- Follow all safety guidelines listed in the user's manual.
- Calibration Equipment should only be used by Trained Personnel.

1.2.2 Cautions

To avoid possible damage to the instrument, follow these guidelines.

- DO NOT remove the label from the handle. This cautions the user concerning the delicate nature of the instrument.
- DO NOT drop or bang the probe in any way. This will cause damage to the probe internally and affect its calibration.
- Read Section 5 entitled "PRT Care and Handling Guidelines" before removing the PRT from the shipping box or case. Incorrect handling can damage the PRT and void the warranty.
- Keep the shipping container in case it is necessary to ship the PRT. Incorrect packaging of the PRT for shipment can cause irreparable damage.

2 Introduction

2.1 General

The Hart Platinum Resistance Thermometers (PRT) models 5608 and 5609, are designed to be a secondary standard interpolating instrument converting temperature to resistance. The PRTs are used with a readout device to detect temperature changes or actual temperature.

2.2 Application

Hart 5608 and 5609 thermometers are classified as secondary standards. A secondary standard is used to transfer the ITS-90 from a standards laboratory to a customer's laboratory. Secondary standards are calibrated using a primary standard that has been calibrated in a primary calibration laboratory through a process called realizing the ITS-90.

2.3 Calibration

In order for any instrument to be used as a standard it must be calibrated. These instruments are sold uncalibrated unless calibration is requested at time of purchase. They are satisfactory as secondary standards and may be calibrated by comparison to primary standards.

2.4 Recalibration

The recalibration of the 5608/5609 Secondary PRT should be scheduled according to the user's company Quality Assurance requirements. Normally, a PRT is recalibrated annually. Unless the PRT is used only over a limited range, calibration over the full range of the PRT is recommended. For information on calibration services for the 5608/5609, contact an Authorized Service Center for an RMA number and current pricing (see Section 1, Before You Start)

Depending on the user's Quality Assurance requirements, the PRT drift should be checked periodically at the Triple Point of Water (TPW). Section 8, Troubleshooting, provides information on drift with respect to mechanical shock and oxidation. If the R_{tp} cannot be restored after annealing to within calibration tolerances, a full recalibration should be scheduled.

3 Specifications

3.1 Specifications

Table 2 *Specifications*

Parameter	Value
Temperature range	5608: –200 °C to 500 °C 5609: –200 °C to 670 °C
Nominal resistance at 0.01 °C	100 Ω ± 0.5 Ω
Temperature coefficient	0.0039250 Ω/Ω/°C
Accuracy[1]	See footnote
Short-term repeatability[2]	± 0.01 °C at 0.010 °C ± 0.02 °C at max temp
Drift[3]	± 0.01 °C at 0.010 °C ± 0.02 °C at max temp
Hysteresis	± 0.01 °C maximum
Sensor length	30 mm ± 5 mm (1.2 in ± 0.2 in)
Sensor location	3 mm ± 1 mm from tip (0.1 in ± 0.1 in)
Sheath dimensions, length x diameter	5608-9: 229 x 3.18 mm (9 in x 0.125 in) 5608-12: 305 mm x 3.18 mm (12 in x 0.125 in) 5609-12: 12 in x 0.25 in 5609-15: 15 in x 0.25 in 5609-20: 20 in x 0.25 in 5609-300: 300 mm x 6 mm 5609-400: 400 mm x 6 mm 5609-500: 500 mm x 6 mm
Sheath diameter tolerance	5608: ± 0.1 mm (± 0.004 in) 5609-12: ± 0.006 in 5609-15: ± 0.006 in 5609-20: ± 0.006 in 5609-300: ± 0.1 mm 5609-400: ± 0.1 mm 5609-500: ± 0.1 mm
Sheath material	Inconel™ 600
Minimum insulation resistance	5608: 500 MΩ at 23 °C 5608: 20 MΩ at 500 °C 5609: 500 MΩ at 23 °C 5609: 10 MΩ at 670 °C
Transition junction temperature range[4]	–50 °C to 200 °C

Parameter	Value
Transition junction dimensions	71 mm x 12.5 mm (2.8 in x 0.49 in)
Minimum immersion length[5] (< 5 mK error)	5608: 80 mm (3.1 in) 5609: 100 mm (3.9 in)
Maximum immersion length	305 mm (12 in)
Response time[5]	5608: 9 seconds typical 5609: 12 seconds typical
Self heating (in 0 °C bath)	5608: 75 mW/°C 5609: 50 mW/°C
Lead-wire cable type	Teflon,™ 24 AWG
Lead-wire length	1.8 m (6 ft)
Lead-wire temperature range	–50 °C to 250 °C
Calibration	Calibration not included; NVLAP-accredited calibration optional, lab code 200348-0. Please see calibration uncertainty table and its explanation of changeable uncertainties.

[1]"Accuracy" is a difficult term when used to describe a resistance thermometer. The simplest way to derive basic "accuracy" is to combine the probe drift specification and calibration uncertainty with readout accuracy at a given temperature.
[2]Three thermal cycles from min to max temp, includes hysteresis, 99.9 % confidence
[3]After 100 hrs at max temp, 99.9 % confidence
[4]Temperatures outside this range will cause irreparable damage. For best performance, transition junction should not be too hot to touch.
[5]Per ASTM E 644

3.2 Electrical Circuit

The PRTs are provided with a terminal box handle. The two meter cable has four 24 AGW lead wires in a Teflon® jacket with a stainless steel spring strain relief.

4 Installation

4.1 Environmental Issues

Ideally, temperature calibration equipment should be used in a calibration laboratory or other facility specifically designed for this purpose. Environmental requirements include:

- Stable temperature and relative humidity <80%
- Clean, draft-free area
- Low noise level: low radio frequency, magnetic or electrical interference
- Low vibration levels

4.2 Mounting

Most often temperature standards, primary and secondary, are used to calibrate other temperature-sensitive equipment. The PRT must be mounted carefully to avoid any damage to the sheath or sensor. If the fluid bath used does not have a lid designed for PRT insertion, clamps should be used to ensure the handle and cable are not immersed. **Do not screw the clamps too tight. Over tightening will damage the sheath.** If metal comparison blocks are used in the bath, maintain a close fit between the thermometer sheath and the well in the comparison block. However, allow for the thermal expansion of the thermometer sheath when determining block well tolerances.

4.3 Lead Wire Identification

The 5608 and 5609 PRTs are equipped with a four-wire cable. The same circuit schematic applies to both PRTs (see Figure 1). Four lead wires are used to cancel lead wire resistance. For best results, the readout device should be equipped to handle four-terminal resistors.

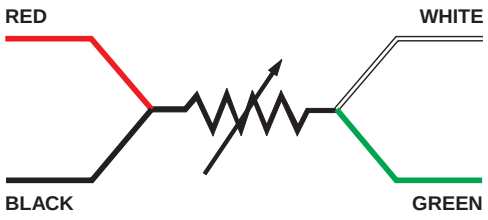

Figure 1 *PRT Schematic*

The lead wires are four different colors. Lead wire pairs attached to each end of the sensor are identified as shown in Figure 1.

5 PRT Care and Handling Guidelines

5.1 PRT Care

CAUTION: READ THIS SECTION BEFORE REMOVING THE PRT FROM THE SHIPPING BOX OR CASE

The 5608 and 5609 Platinum Resistance Thermometers (PRTs) are delicate instruments. Care must be taken in handling the PRTs to maintain calibration accuracy. The stress free design of the PRT sensor reduces the effects of mechanical shock. In addition, contamination problems of the sensor at high temperature have been eliminated. However, care should still be used when handling the PRT even though the Inconel sheath is durable and provides good protection for the sensor. Correct handling of the PRT will prolong the life expectancy. When not in use, the PRT should be stored in the protective case.

Note: *The PRT sheath changes color after use at high temperatures. The PRT may arrive with a brown tint to the sheath due to calibration at high temperatures.*

The handle is not designed to be immersed. The temperature limits of the handle are: –50°C to 200°C. Temperatures outside these limits can damage the sealed portion of the handle and the connectors.

5.2 PRT Handling Guidelines

- **DO** anneal the thermometer after shipment. Shipping the thermometer can cause mechanical shocks that effect the accuracy of the thermometer. Therefore, if possible, we advise that the thermometer be annealed before use. The 5608 thermometer should be annealed at 500°C for four hours. The 5609 at 660°C for four hours.
- **DO** keep the thermometer as clean as possible. Always remove any fluid from the sheath immediately after taking the thermometer from a bath.
- **DO** immerse the thermometer in the appropriate liquid for the temperature range. If a dry block is used, the well diameter should allow the PRT to comfortably slip in and out without excess movement. For best results, immerse the thermometer as deep as possible to avoid "stem effect" (the temperature error caused by the conduction of heat away from the sensor). Do not submerge the handles.

- **DO** allow sufficient time for the thermometer to stabilize before making measurements. This allows for the best accuracy.
- **DO** use the correct drive current with the thermometer to prevent error in temperature or resistance. Hart Scientific recommends 1mA.
- **DO** anneal the 5608 thermometer at 500°C and the 5609 thermometer at 600 to 661°C for 12 hours if they become oxidized.
- **DO** use the protective shipping box or case provided or other protection when the thermometer is not in use.
- **DO NOT** subject the thermometer to any physical shock or vibration.
- **DO NOT** use pliers or other devices to squeeze the sheath. This action can permanently damage the PRT.
- **DO NOT** subject the thermometer to temperatures above the highest specified operating temperature.
- **DO NOT** expose the thermometer's handle or cables to extreme temperatures. The temperature limits of the handle are: –50°C to 200°C
- **DO NOT** submerge the handle or cable in liquids.
- **DO NOT** screw a clamp down so tight that it dents the sheath. This can permanently damage the PRT.

6 Operation

6.1 General

For best results, be familiar with the operation of the heat source and the readout instrument. Be sure to follow the manufacturer's instructions for the readout instrument and the heat source.

6.2 Comparison Calibration of Other Instruments

The uniformity and stability of the heat source and the degree of accuracy required determine the number of temperature measurements necessary. However, to follow "good" practice procedures, always measure the triple point of water (R_{tp}) after each temperature measurement. The following equation provides the most accurate measurement of the ratio:

$$W_t = \frac{R_t}{R_{tp}}$$

All PRTs experience errors caused by self-heating of the element. Self-heating is a combination of two factors, heat dissipation and heat sink. Self-heating error can be reduced to have a negligible effect if the PRT is used with the same excitation current and medium in which it was calibrated.

6.3 Immersion Requirements

Stem effect can cause measurement errors for any thermometer. Errors produced by not following the immersion depth guidelines are due to heat lost or gained by the sensing element through the thermometer stem. In addition, heat losses occur due to radiation losses from the sensing element to the housing.

The immersion depth for standards is dependent on several factors including accuracy requirements and type of liquid. Therefore, we recommend minimum immersion depths as stated in the preceding paragraph and in the specifications. However, remember the handle limitations. The handle is not designed to be immersed. The temperature limits of the handle are –50°C to 200°C. Temperatures outside these limits can damage the handle. Convection of heat from the heat source must be kept within the handle limits.

The exact immersion depth required can be determined by performing a gradient test taking measurements approximately every 1.27 cm (.5 inches) until there is a significant difference in readings. Allow the thermometer to stabilize at each new depth. Plot the results to see the stem effect.

6.4 Thermal EMF

Two factors contribute to thermal EMF, chemical consistency and physical consistency. Variations in chemical structure due to impurities can contribute to thermal EMF. Also discrepancies in crystal structure can contribute to thermal EMF. These factors are minimized by annealing the full length of wire before construction of the PRT.

Likewise, connection to extension lead wires and readout instruments can be a source of thermal EMF. The thermal EMF is caused by a difference in temperature between two connections. If the two connections are the same temperature, there will be little or no thermal EMF effects. However, if there is a substantial temperature difference between connections, the thermal EMF effects will be significant. Therefore, cover or insulate any exposed bridge or galvanometer terminals to lessen the source of error. The effects of thermal EMF can be canceled by using an AC bridge or a DC bridge with reversible current.

6.5 Transition Junction

Exceeding the temperature range of the transition junction will cause a breach in the seal of the instrument. Maintaining the seal is critical to preventing moisture from entering the device. If moisture penetrates the seal, the PRT's short term repeatability, hysteresis, and insulation resistance may be adversely affected. Insulation resistance also decreases rapidly as the transition junction temperature increases, even if the seal is not broken. When the insulation resistance becomes sufficiently low, performance suffers. A good rule of thumb is that the transition junction is too hot when it is hot enough to burn your thumb.

7 Accessories

7.1 Case Options

The 5608/5609 PRT comes in a rigid case appropriate for the length of the probe.

- Model 2601 protective case for thermometer probes 12 inches in length or shorter.
- Model 2609 protective case for thermometer probes 15 inches in length or longer.

7.2 PRT Termination

The 5608/5609 PRT can be terminated in three ways (Figure 2) depending on the user's requirements:

- Gold Plated Spade Lug
- Bare Wire
- 5–Pin Din Connector

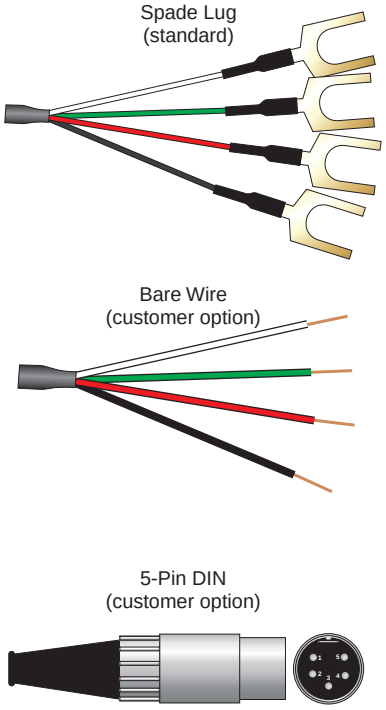

Figure 2 *Probe Termination Examples*

8 Troubleshooting

8.1 Troubleshooting

In the event that the probe appears to function abnormally, this section may be of use in solving the problem. Several possible problem conditions are described along with likely causes and solutions. If a problem arises, please read this section carefully and attempt to understand and solve the problem. If the probe seems faulty or the problem cannot otherwise be solved, contact an Authorized Service Center for assistance. Be sure to have the model number and serial number of your probe available.

Problem	Causes and Solutions
Data changes greater than 0.1°C are observed	• Mechanical shock can cause temperature errors as great as 0.5°C. If this is observed, first measure and record the $R_{tp.}$ Next anneal the 5608 PRT at 500°C and the 5609 PRT at 660°C overnight. Measure the R_{tp} again. The annealing should decrease the R_{tp}. If the R_{tp} is stable, recalibrate the PRT.
Data changes less than 0.1°C	• Slight mechanical shock can cause temperature errors less than 0.1°C. If this is observed, first measure and record the $R_{tp.}$ Next anneal the 5608 PRT at 500°C and the 5609 PRT at 660°C overnight. Measure the R_{tp} again. The annealing should decrease the R_{tp}. Repeat the annealing, R_{tp} measurement cycle several times. When the R_{tp} is stable, recalibrate the PRT. If the R_{tp} does not stabilize, contact an Authorized Service Center (see Section 1.3). • Oxidation of the platinum sensor may occur after prolonged use between 200 and 450°C. This oxidation will demonstrate itself by an increase in R_{tp} of less than 0.1°C. To reduce the effects of oxidation, anneal the 5608 PRT at 500°C and the 5609 PRT at 600 to 661°C overnight (12 hr.). Measure the R_{tp} again. Repeat the annealing, R_{tp} measurement cycle several times This annealing process should return R_{tp} to within calibration tolerances. If the R_{tp} is within calibration tolerance, the PRT is usable. If the R_{tp} is not within calibration tolerance, but it is stable, recalibrate the PRT.
Data unstable	• If the data is unstable at the Triple Point of Water (TPW), check the connector. If the connector is correct, contact an Authorized Service Center (see Section 1.3). The PRT may be damaged and need repair. • If the data is unstable at high temperatures, it may be due to electrical noise in the system. Reduce the temperature and observe the data. If it is stable, electrical noise is interfering with the measurements at high temperatures. Check the grounding of the readout device and the heat source. A faulty ground on either device could interfere with high temperature measurements. A ground wire attached to the metal sheath of the PRT may help to reduce electrical noise interference.

Problem	Causes and Solutions
Temperature readout different than expected, e.g. the heat source is set at 300°C, the PRT measures 275°C.	• Measure the PRT resistance at TPW. • If the resistance of the PRT is less than the rated resistance, e.g. 70Ω for the 5608/5609, there may be a short in the sensor. Contact an Authorized Service Center. • If the resistance of the PRT is only a few ohms, there may be a short in the four lead–wires. Contact an Authorized Service Center. • If the PRT is open, the resistance will be "Out of Limits" or in the kilohm or megohm range. Contact an Authorized Service Center.