

FLUKE®

— **Hart Scientific**®

5681, 5683, 5684, 5685

*Standard Platinum
Resistance Thermometer
User's Guide*

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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
	AC-DC
	Battery
	CE
	DC
	Double Insulated
	Electric Shock
	Fuse
	PE Ground
	Hot Surface
	Read the User's Manual
	Off
	On

1.2 Safety Information

Use this instrument only as specified in this manual. Otherwise, the protection provided by the instrument may be impaired. Refer to the safety information in Warnings and Cautions.

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.



Warnings

To avoid possible electric shock or personal injury, follow these guidelines.

DO NOT use this instrument to measure the temperature of any hazardous live component.

DO NOT use this instrument for any application other than calibration work.

DO NOT use this instrument in environments other than those listed in the user's guide.

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 guide.

Calibration Equipment should only be used by Trained Personnel.



Cautions

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

DO NOT remove the label from the handle. The delicate nature of the instrument is described on the label.

Read Section 5 entitled, “Care and Handling Guidelines”, before removing the SPRT from the shipping box or case. Incorrect handling can damage the SPRT and void the warranty.

DO NOT subject the SPRT to mechanical shock.

Keep the shipping container in case it is necessary to ship the SPRT. Incorrect packaging of the SPRT for shipment can cause irreparable damage.

1.3 Verifying Probe Accuracy

Before using your probe, verify that its behavior has not changed significantly from the most recent calibration (as can sometimes occur from mechanical shock during shipping, for example). To verify your probe, check the probe at the triple point of water (0.01°C) or in a well-constructed ice bath, by following these steps:

1. Connect the probe to a calibrated readout and verify that the probe's coefficients have been correctly entered into the readout.

2. Properly prepare a triple point of water cell (TPW) or ice bath. (Contact Hart Customer Service if unsure how to do this.) A triple of water cell is preferred. Ice baths should use distilled water and crushed ice in a Dewar flask or thermos bottle. The ratio of ice-to-water should be such that the mixture is firm after prepared.
3. Set your readout to read in ohms rather than temperature. Place your probe in the TPW or ice bath and allow it to stabilize. (Remember a TPW is at 0.01°C and an ice bath is at 0°C.)
4. If using a TPW cell, compare the resistance value on your readout with the resistance value at TPW given on the probe's certificate. If using an ice bath, compare the resistance value on your readout with the resistance indicated on the certificate for 0°C. (You may have to use the probe's temperature versus resistance table and interpolate to get the probe's calibrated resistance value at 0°C.)
5. Considering the probe's uncertainty specification, determine whether or not it is within tolerance of the data on its most recent certificate of calibration. If it is, it may be placed in service. If not, double-check the probe coefficients in the readout. If they are correct, contact Hart Customer Service.

Hart recommends that a probe be periodically checked against a standard such as a triple point of water cell (or well-constructed ice bath if an ITS-90 fixed-point standard is not available). The verification interval depends on how the probe is handled, how and how much it is used, and your documented experience with it. Your probe should also be checked any time you suspect it may have received mechanical shock or whenever its accuracy appears suspect.

1.4 Authorized Service Centers

Please contact one of the following authorized Service Centers to coordinate service on your Hart product:

Fluke Corporation, Hart Scientific Division

799 E. Utah Valley Drive
American Fork, UT 84003-9775
USA

Phone: +1.801.763.1600
Telefax: +1.801.763.1010
E-mail: support@hartscientific.com

Fluke Nederland B.V.

Customer Support Services
Science Park Eindhoven 5108

5692 EC Son
NETHERLANDS

Phone: +31-402-675300
Telefax: +31-402-675321
E-mail: ServiceDesk@fluke.nl

Fluke Int'l Corporation

Service Center - Instrimpex
Room 2301 Sciteck Tower
22 Jianguomenwai Dajie
Chao Yang District
Beijing 100004, PRC
CHINA

Phone: +86-10-6-512-3436
Telefax: +86-10-6-512-3437
E-mail: xingye.han@fluke.com.cn

Fluke South East Asia Pte Ltd.

Fluke ASEAN Regional Office
Service Center
60 Alexandra Terrace #03-16
The Comtech (Lobby D)
118502
SINGAPORE

Phone: +65 6799-5588
Telefax: +65 6799-5588
E-mail: antng@singa.fluke.com

When contacting these Service Centers for support, please have the following information available:

- Model Number
- Serial Number
- Complete description of the problem

2 Introduction

2.1 General

The Hart Standard Platinum Resistance Thermometer (SPRT) is designed to be the best primary standard interpolating instrument converting temperature to resistance. Hart Scientific offers four models of SPRT probes (5681, 5683, 5684, and 5685). The Model 5681 fused silica sheathed SPRT covers the International Temperature Scale of 1990 (ITS-90) range from the Triple Point of Argon (-189°C) to the Freezing Point of Aluminum (660.323°C). The Model 5683 fused silica sheathed SPRT covers the ITS-90 range from the Triple Point of Argon (-189°C) to 450°C . The limited temperature range of the Model 5683 allows for unbeatable long-term stability typically less than 0.5mK after 100 hours at 450°C . The Models 5684 and 5685 cover high temperature ranges up to 1070°C and can be calibrated at the Freezing Point of Silver (961.78°C).

All four SPRTs are hand constructed at Hart by experts with years of SPRT manufacturing experience. Each SPRT is carefully annealed at the appropriate temperatures and precisely tested for stability. Convection prevention discs are used to reduce stem errors caused by thermal radiation. For Models 5681, 5683, and 5685 the sensing elements are fabricated using high purity platinum wire wound in a strain free design on a fused silica cross frame. For Model 5684, the sensing element is formed from high-purity platinum wire wound bi-



Figure 1 Model 5681 Standard Platinum Resistance Thermometer

filarily around a fused silica support. The fused silica sheaths are pressure sealed with a special argon/oxygen mixed gas and fit with a terminal box handle with a strain relieved connection to the four wire cable. Gold plated spade lugs terminate the wires.

2.2 Application

Hart 5680 series thermometers are classified as primary standards. A primary standard is defined in terms of transfer of the ITS-90 from a standards laboratory to a customer's laboratory. Primary standards are calibrated in a standards lab using known intrinsic values. The SPRTs are designed to meet the National Voluntary Laboratory Accreditation's (NVLAP) Level I Accuracy Class.

2.3 Calibration

In order for any instrument to be used as a standard it must be calibrated. The SPRTs may be purchased calibrated or non-calibrated. Hart Scientific's National Voluntary Laboratory Accreditation Program (NVLAP) has the capability of performing fixed point of comparison calibrations traceable to NIST. The 5681 can be economically calibrated using the comparison method or any one of several fixed point calibrations matching ITS-90 subranges. Fixed point calibration is recommended for the 5683, 5684, and 5685.

2.3.1 Calibration Options

In order for the thermometers to make accurate temperature measurements, they must be calibrated. Calibration can be attained through any recognized primary standard laboratory designed to perform temperature calibrations. Hart Scientific can provide either comparison calibration or fixed-point calibrations as shown in Table 2.

2.4 Recalibration

The recalibration of the SPRTs should be scheduled according to the user's company Quality Assurance requirements. Normally, an SPRT is recalibrated annually. Unless the SPRT is used only over a limited range, calibration over the full range of the SPRT (-189°C to 661°C for the 5681, -189°C to 480°C for the 5683, and 0°C to 962°C for the 5684 and 5685) is recommended. For information on recalibrating your SPRT, contact Hart Scientific's Customer Service department for an RMA number and current pricing (see Section 1, Before You Start).

2.5 Return Procedure

Note: Call Hart Scientific's Customer Service or visit our support page on the world wide web for an RMA number before shipping.

Table 2 Fixed Point and Comparison Calibrations

SPRT Calibration by ITS-90 Fixed Point			
All calibrations in this section include the following: (1) calibration at two levels of current and extrapolation to zero power, (2) ITS-90 deviation function coefficients and interpolation tables for the nominal current calibration and the zero-power calibration, and (3) analysis for compliance to ITS-90 criteria for a standard interpolating instrument of the ITS-90.			
Order No.	Temperature	ITS-90 Subranges	Fixed Points Used
1910-4	-200°C to 0°C	4	comp at NBPLN ₂ , TPHg, TPW
1910-4-11	-200°C to 30°C	4, 11	comp at NBPLN ₂ , TPHg, TPW, MPGa
1910-4-10	-200°C to 157°C	4, 10	comp at NBPLN ₂ , TPHg, TPW, FPIIn
1910-4-9	-200°C to 232°C	4, 9	comp at NBPLN ₂ , TPHg, TPW, FPIIn, FPSn
1910-4-8	-200°C to 420°C	4, 8	comp at NBPLN ₂ , TPHg, TPW, FPSn, FPZn
1910-4-7	-200°C to 660°C	4, 7	comp at NBPLN ₂ , TPHg, TPW, FPSn, FPZn, FPAI
1910-5-10	-40°C to 157°C	5, 10	TPHg, TPW, MPGa, FPIIn
1910-5-9	-40°C to 232°C	5, 9	TPHg, TPW, MPGa, FPIIn, FPSn
1910-5-8	-40°C to 420°C	5, 8	TPHg, TPW, MPGa, FPSn, FPZn
1910-5-7	-40°C to 660°C	5, 7	TPHg, TPW, MPGa, FPSn, FPZn, FPAI
1910-11	0°C to 30°C	11	TPW, MPGa
1910-10	0°C to 157°C	10	TPW, FPIIn
1910-9	0°C to 232°C	9	TPW, FPIIn, FPSn
1910-8	0°C to 420°C	8	TPW, FPSn, FPZn
1910-7	0°C to 660°C	7	TPW, FPSn, FPZn, FPAI
1910-6	0°C to 962°C	6	TPW, FPSn, FPZn, FPAI, FPAg

SPRT Calibration by Comparison		
All calibrations in this section include the following: (1) ITS-90 deviation function coefficients for the nominal current calibration, (2) bound interpolation table in 1-degree increments in terms of resistance vs. T_{90} for the nominal current calibration, and (3) analysis for compliance to ITS-90 criteria for a standard interpolating instrument of the ITS-90.		
Order No.	Temperature	Comparison Points Used
1920-4-9	-200°C to 232°C	-197.0°C, -38.8°C, 0.01°C, 156.6°C, 231.9°C
1920-4-8	-200°C to 420°C	-197.0°C, -38.8°C, 0.01°C, 231.9°C, 419.5°C
1920-4-7	-200°C to 660°C	-197.0°C, -38.8°C, 0.01°C, 231.9°C, 419.5°C, 660.3°C
1920-D-9	-100°C to 232°C	-100°C, -38.8°C, 0.01°C, 156.6°C, 231.9°C
1920-D-8	-100°C to 420°C	-100°C, -38.8°C, 0.01°C, 231.9°C, 419.5°C
1920-D-7	-100°C to 660°C	-100°C, -38.8°C, 0.01°C, 231.9°C, 419.5°C, 660.3°C
1920-5-9	-40°C to 232°C	-38.8°C, 0.01°C, 156.6°C, 231.9°C
1920-5-8	-40°C to 420°C	-38.8°C, 0.01°C, 231.9°C, 419.5°C
1920-10	0°C to 157°C	0.01°C, 156.6°C
1920-9	0°C to 232°C	0.01°C, 156.6°C, 231.9°C
1920-8	0°C to 420°C	0.01°C, 231.9°C, 419.5°C
1920-7	0°C to 660°C	0.01°C, 231.9°C, 419.5°C, 660.3°C

Extreme care must be taken in shipping an SPRT. Place the thermometer in the factory provided protective storage case. Be sure the case is latched securely. Place the protective case in the original manufacturer's wooden shipping crate or wooden crate with similar dimensions (44 ½ in. x 11 ¾ in. x 11 ¾ in.). Place soft insulation on all sides of the crate to cushion the SPRT against mechanical shocks. The cover of the crate should be attached with screws. We recommend that you label the crate as extremely fragile. Whether the thermometer is returned for repair or warranty, please include a letter containing the following information

- Description of the faulty operation and circumstances of failure.
- Complete shipping instructions for the return of the thermometer to the customer.

3 Specifications

3.1 Specifications

	5681	5683	5684	5685
Measuring Temperature Range	-200°C to 661°C	-200°C to 480°C	0°C to 1070°C [†]	0°C to 1070°C [†]
Nominal R_{TPW}	25.5Ω		0.25Ω	2.5Ω
Specified Current	1 mA		14.14 mA	5 mA
Resistance Ratio	W(302.9146 K) ≥ 1.11807 and W(234.3156 K) ≤ 0.844235		W(302.9146 K) ≥ 1.11807 and W(1234.93 K) ≥ 4.2844	
Sensitivity	0.1Ω/°C		0.001Ω/°C	0.01Ω/°C
Drift Rate	< 0.002°C/100 hours at 661°C (typically < 0.001°C)	< 0.001°C/100 hours at 480°C (0.0005°C typical)	< 0.003°C/100 hours at 1070°C (typically < 0.001°C)	
Sensor Support	Quartz glass cross		Quartz glass strip with notches	Quartz glass cross
Diameter of Sensor Pt Wire	0.003" (0.07 mm)		0.016" (0.4 mm)	0.008" (0.2 mm)
Protective Sheath	Quartz glass Diameter: 0.28" (7 mm) Length: 20.5" (520 mm)		Quartz glass Diameter: 0.28" (7 mm) Length: 26.8" (680 mm)	

[†]The official maximum temperature of an SPRT as a defining interpolation instrument of the ITS-90 is 961.78°C, but these types of SPRTs were found to be stable up to at least 1070°C. The annealing temperature during the stability test was 1085°C. The lower temperature limit of these types of SPRTs can be as low as -200°C. In general, it is suggested that a 25-ohm SPRT be used below 0°C.

3.2 Construction

Construction of the 5681, 5683, 5684, and 5685 SPRT is shown in Figure 2 and explained below.

Model 5681 covers the range from -189°C to 661°C. The 25.5Ω sensor element is crafted using high purity platinum wire wound in a strain free design on a fused silica cross frame. The 5681 has a sensitivity of 0.1Ω/°C.

Model 5683 covers the range from -189°C to 480°C. The 25.5Ω sensor element is crafted using high purity platinum wire wound in a strain free design on a fused silica cross frame. The Model 5683 has a sensitivity of 0.1Ω/°C. The Model 5683 is different from the Model 5681 in the filling gas and manufacture procedure. The drift rate of the Model 5683 can be decreased to about half of that of the Model 5681.

Model 5684 covers the range from 0°C to 1070°C. The 0.25Ω High Temperature Platinum Resistance Thermometer (HTPRT) sensor uses a high purity plat-

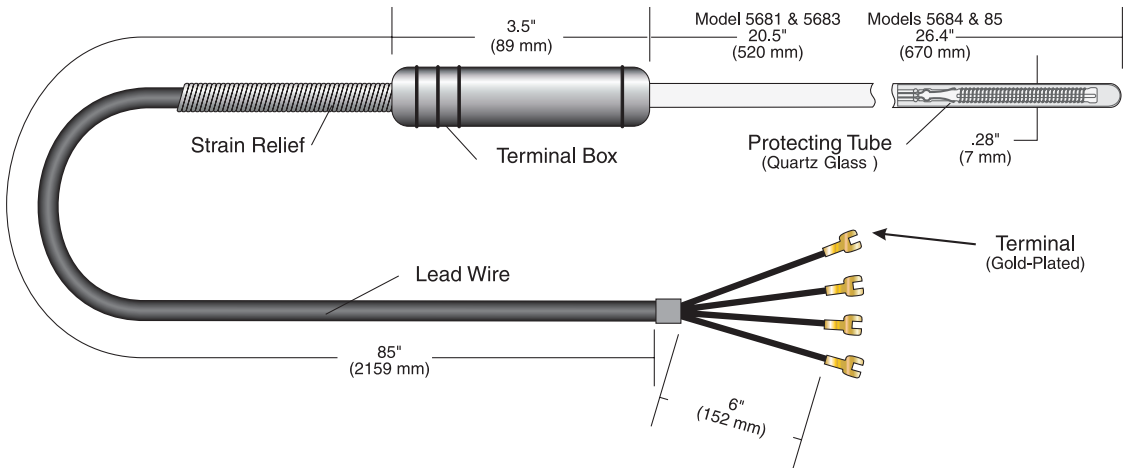


Figure 2 Standard Dimensions

inum wire with a strip-shaped support made from high purity fused silica. The 5684 demonstrates a typical sensitivity of $0.001\Omega/^{\circ}\text{C}$.

Model 5685 covers the range from 0°C to 1070°C . The 2.5Ω High Temperature Platinum Resistance Thermometer (HTPRT) sensor is constructed of high purity platinum wire bifilarly wound around a fused silica cross frame. The 5685 has a sensitivity of $0.01\Omega/^{\circ}\text{C}$.

3.3 Electrical Circuit

All four SPRTs are provided with a terminal box handle. The eight-foot cable has four Teflon-coated wires enclosed in a silicon rubber jacket with a stainless steel spring strain relief. Gold plated spade lugs terminate the wires.

3.4 Warranty

Fluke Corporation, Hart Scientific Division (Hart) warrants this product to be free from defects in material and workmanship under normal use and service for a period as stated in our current product catalog from the date of shipment. If your probe thermometer was calibrated by Hart, Hart also warrants the validity of the data on the certificate of calibration accompanying your probe. However, because probes are subject to change from mishandling, vibration, and other forms of mechanical shock, Hart does not warrant the behavior of your probe once it has left Hart's control. (See Section 1.3, Verifying Probe Accuracy, for procedures for initially checking your probe upon receipt at your facility.) This warranty extends only to the original purchaser and shall not apply to any product which, in Hart's sole opinion, has been subject to misuse, alteration, abuse or abnormal conditions of operation or handling.

Software is warranted to operate in accordance with its programmed instructions on appropriate Hart products. It is not warranted to be error free.

Hart's obligation under this warranty is limited to repair or replacement of a product which is returned to Hart within the warranty period and is determined, upon examination by Hart, to be defective. If Hart determines that the defect or malfunction has been caused by misuse, alteration, abuse or abnormal conditions or operation or handling, Hart will repair the product and bill the purchaser for the reasonable cost of repair.

To exercise this warranty, the purchaser must forward the product after calling or writing an Authorized Service Center for authorization. Service Centers assume NO risk for in-transit damage.

For service or assistance, please contact and Authorized Service Center

THE FOREGOING WARRANTY IS PURCHASER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR MERCHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE. HART SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSS WHETHER IN CONTRACT, TORT, OR OTHERWISE.

4 Installation

4.1 Environmental Issues

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

- Stable temperature and humidity.
- 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. Three representative applications are shown in the following figures.

- Figure 3 Liquid Bath Installation
- Figure 4 Water Triple Point Cell in an Ice Bath Dewar
- Figure 5 Hart 9114 Metrology Furnace with SPRT in Fixed Point Cell

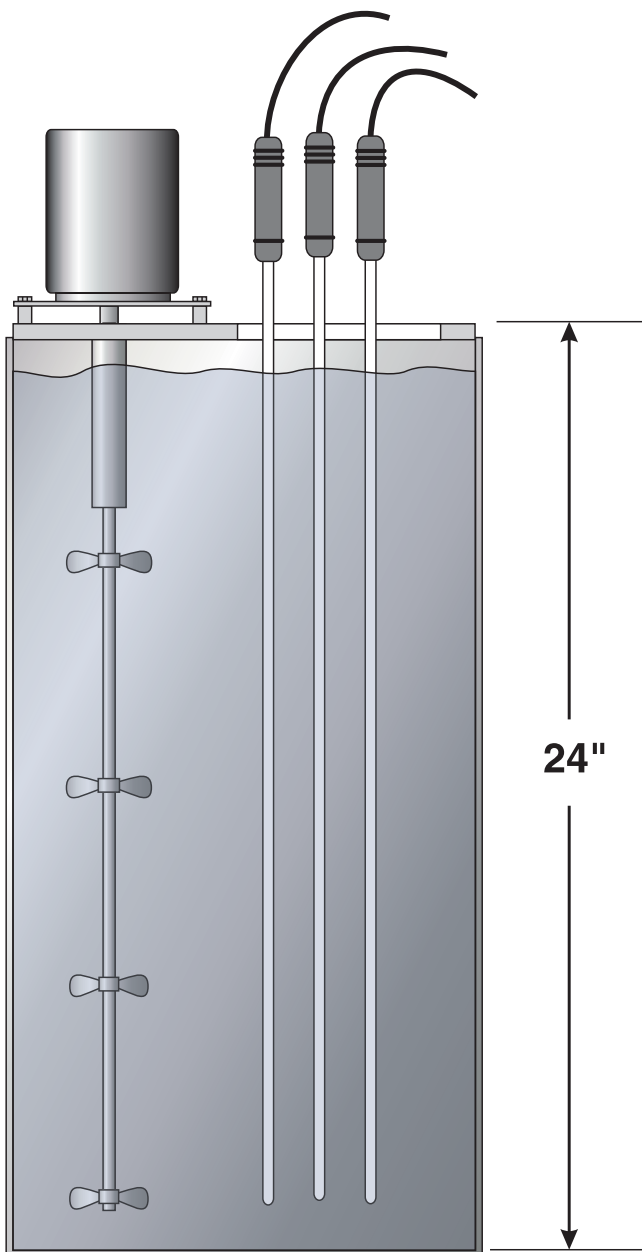
The SPRT must be mounted carefully to avoid any damage to the sheath or sensor. If the fluid bath used does not have a lid designed for SPRT insertion, clamps should be used to ensure the handle and cable are not immersed. If metal comparison blocks are used in the bath, maintain a close fit between 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.

For applications where the fluid in the bath is not compatible with the SPRT (salt), the SPRT can be slid into a thin walled metal sheath for protection. The gap between the protective sheath and the SPRT should not be any larger than 0.003 in. (0.08 mm).

At high temperatures, the SPRT is subject to metal ion contamination. If a metal equilibration block is used in a furnace above 600°C, protective shielding such as thin wall platinum tubing or high purity ceramic is advised.

4.3 Lead Wire Identification

All Hart 5680 Series SPRTs are equipped with a four-wire cable. The same circuit schematic applies to all three SPRTs (See Figure 7). Four lead wires are used to cancel lead wire resistance. For best results, the readout device should be equipped to handle four-terminal resistors.



7007 Tank with Long Stem SPRTs

Figure 3 Liquid Bath Installation

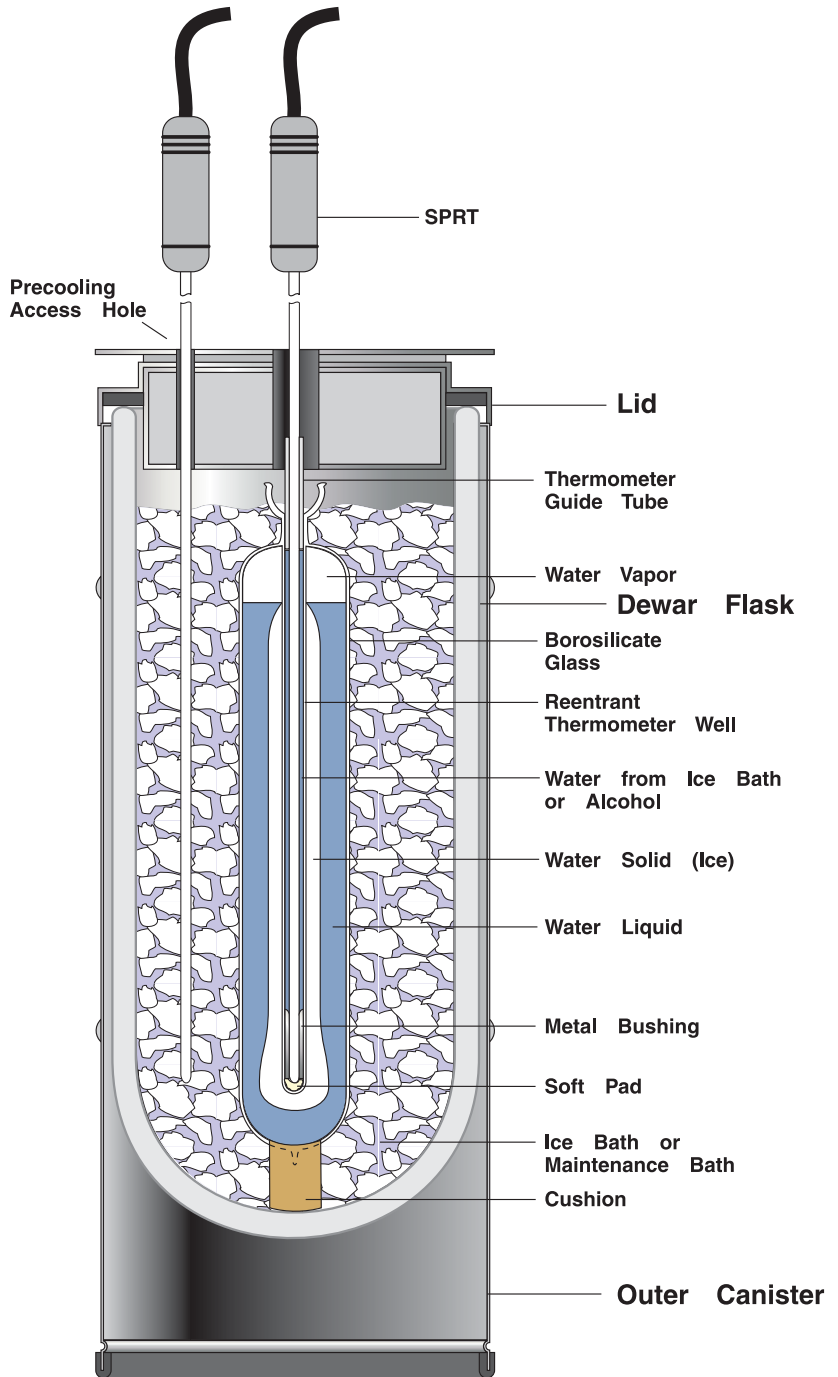


Figure 4 Water Triple Point Cell in an Ice Bath Dewar

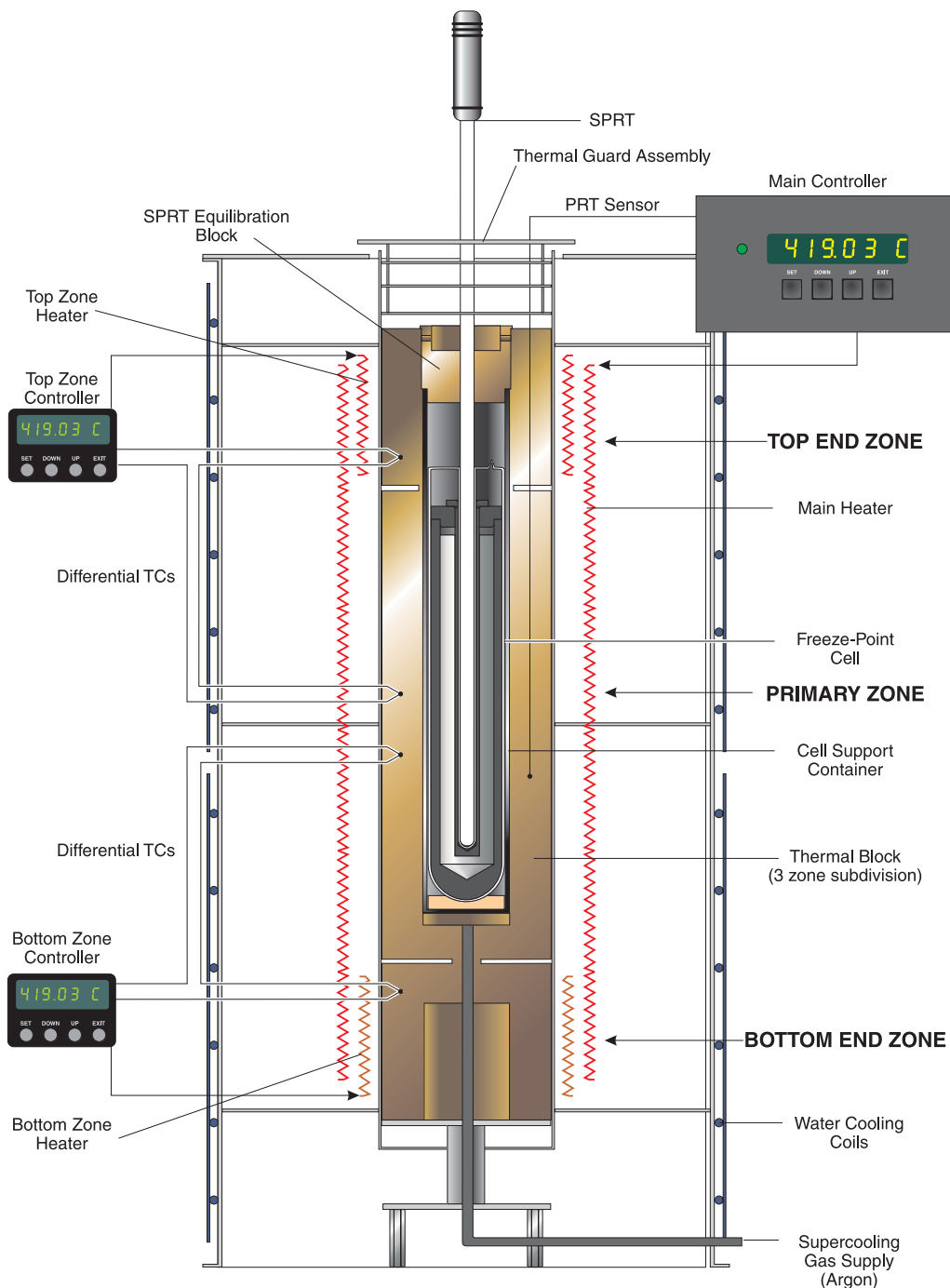


Figure 5 Hart 9114 Metrology Furnace with SPRT in Fixed Point Cell

The lead wire colors are red, black, white, and blue. Lead wire pairs attached to each end of the sensor are identified by heat shrink tubing. Red and black wires have red heat shrink tubing. Blue and white wires have black heat shrink tubing. (See Figure 6 for details).

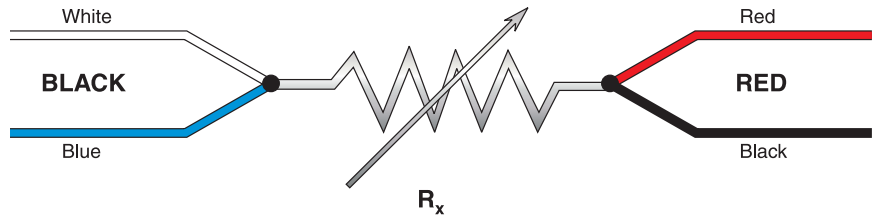


Figure 6 SPRT Circuit Schematic

5 Care and Handling Guidelines



Caution: Read before removing the SPRT from the case.

5.1 SPRT Care

The 5680 series Standard Platinum Resistance Thermometers (SPRTs) are extremely delicate instruments. Great care must be taken in handling the SPRTs to maintain calibration accuracy. Vibration or shock may cause the resistance to increase. A slight tap to the SPRT tip as it is removed from an instrument can cause a change in R_{tp} as high as 1 mK. At high temperatures, the SPRT may become contaminated if inserted into metal blocks. This contamination can effect the accuracy of the sensor if the contamination invades the sensor changing the purity of the platinum wire. The fused silica sheath is very fragile and susceptible to contamination. Once a SPRT is contaminated, it can contaminate other standards equipment. (Copper contamination shows as red smudged on the sheath.) Any contamination can cause devitrification of the sheath at high temperatures. The fused silica sheath should not be handled with bare hands. Cotton gloves or other suitable methods should be used in handling the SPRT. **The sheath should always be wiped down with 200 proof Ethyl Alcohol or other suitable solvent before exposure to high temperatures.** Correct handling of the SPRT will prolong the life expectancy. When not in use, the SPRT should be stored in the protective case provided by Hart.

5.2 SPRT Handling Guidelines

1. **DO** keep the thermometer as clean as possible. Always remove any fluid from the sheath immediately after taking the thermometer from a bath. To remove any possible contaminants, always wipe the sheath with ethyl alcohol or other solvent before submitting the SPRT to high temperatures.
2. **DO** immerse the thermometer in the appropriate liquid for the temperature range. If a dry block is used, the well diameter should allow the SPRT 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.
3. **DO** allow sufficient time for the thermometer to stabilize before making measurements. This allows for the best accuracy.
4. **DO** use the correct drive current with the thermometer to prevent error in temperature or resistance.
5. **DO** anneal the thermometer at a temperature slightly higher than the maximum temperature at which the thermometer will be used when it has been subjected to mechanical or temperature shock. The SPRT should also be annealed

before calibration. If the thermometer is annealed in a furnace above 660°C, the furnace should be base metal free.

6. **DO** use the protective case provided or other protection when the thermometer is not in use.
7. **DON'T** subject the thermometer to any physical shock or vibration.
8. **DON'T** subject the thermometer to temperatures above the highest specified operating temperature.
9. **DON'T** expose the thermometer's handle or cables to extreme temperatures.
10. **DON'T** submerge the handle or cable in liquids.

5.3 Metal Ion Contamination of SPRTs

Since the acceptance of ITS-90, information has been accumulating about contamination of SPRTs. ITS-90 extended the range of the SPRT as an interpolation device and new problems manifested themselves. Metal ion contamination is one of the new problems and can start at approximately 700°C.

At high temperatures the lattice structure of most metals becomes quite loose. This allows some of the metal ions to come off the surface analogous to steam rising from hot water. Since the molecular activity increases with temperature, so does the amount of ion loss and the risk of contamination. Ion transfer occurs at different temperatures for different metals. Copper, nickel, iron, and manganese are metals that have been attributed to causing contamination. In addition the quartz lattice structure also becomes quite loose at these high temperatures. This allows the quartz to become transparent to these metal ions permitting the transfer of these ions to the pure platinum wire of the SPRT sensor. The new alloy formed has a different alpha (α) curve than the pure platinum meaning a loss of calibration.

Contamination can be spread by an "infected" SPRT to other primary standards analogous to a virus. Therefore, it is very important to avoid contamination as much as possible to ensure the longevity of the SPRT itself and to decrease the spread to other standards.

Isolation of sensitive materials can prevent contamination. Pure platinum foil is being used by some experts to absorb the ions before they reach the SPRT sensor. Silicon carbide is also used by some experts to shield the SPRT sensor because it is less expensive. Information on contamination effects and prevention is still being gathered by experts in the field.

5.4 Devitrification of Quartz Glass (Fused Silica)

Devitrification is a natural process with quartz materials. The quartz is utilized in a glass (fused silica) state. The most stable state for quartz is crystalline. Therefore, devitrification is the tendency of the quartz to return to its most stable state. If the quartz is kept extremely clean and free of contamination,

devitrification will occur only at high temperatures. The process occurs more rapidly and at lower temperatures when the glass has become contaminated by alkaline metals (Na, K, Mg, and Ca). The alkalis found in normal tap water can cause the process to start. There is conflicting opinion among the experts as to whether the process can be stopped. Some say that once the process starts it does not stop. Others indicate that once the alkali is removed, the process will stop.

Removal of the devitrification is not practical as it requires drastic measures and is potentially dangerous to the instrument and/or the user.

Devitrification starts with a dulling or opacity of the quartz. It develops into a rough and crumbling surface. Devitrification ultimately weakens the glass/quartz until it breaks or is otherwise no longer useful.

The best cure for contamination and devitrification is prevention. Being aware of the causes and signs of contamination can help the user take the steps necessary to control contamination of the SPRT. Keep your SPRT clean and avoid contact with metals at temperatures above 600°C.

6 Operation

6.1 General

For best results, be familiar with the operation of the calibration bath or furnace and the read-out instrument. Be sure to follow the manufacturer's instructions for the read-out instrument and the calibration bath or furnace.

6.2 Comparison Calibration of Other Instruments

The uniformity and stability of the bath 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. This provides the most accurate measurement of the ratio:

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

6.3 Measuring Current

Each SPRT has a specified drive current depending upon the particular sensor. The recommended currents are listed in the specifications for each thermometer and in the following table:

Model	Resistance	Drive Current
5681/5683	25Ω	1 mA
5684	0.25Ω	10 mA
5685	2.5Ω	3 mA

Errors caused by self-heating of the element need to be minimized. Allowing sufficient time for the SPRT to stabilize and the heat to be dispersed into the surrounding medium will provide the most accurate results.

The Hart testing or calibration certificates provided with the SPRT represent data that has been extrapolated. For example, on Model 5681 measurements are made at 1 mA and 1.4 mA. These measurements are then extrapolated to zero current. This can be done graphically by plotting i^2 vs. R and extrapolating to zero power or by using the following equation:

$$R_0 = R_1 - \frac{i_1^2(R_2 - R_1)}{i_2^2 - i_1^2}$$

where:

R₀ = Zero current resistance

R_1 = Resistance measured at current i_1

R_2 = Resistance measured at current i_2

6.4 Immersion Requirements

Stem effect can cause measurement errors for any thermometer not immersed in the fluid at least six inches. This error is 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 sand-blasted finish on the quartz sheath is designed to depreciate losses due to radiation piping. Convection prevention discs provide multiple radiation shields along the lead wires. Convection discs and quartz insulation on lead wires causes some shunt resistance at very high temperatures. However, the effect of the shunt resistance is insignificant. Full immersion is recommended in a furnace or freeze point cell.

The immersion depth for primary standards is dependent on several factors including accuracy requirements and type of liquid. Therefore, we recommend an 8 inch minimum immersion depth.

The exact immersion depth required can be determined by performing a gradient test taking measurements approximately every 1/2 inch (1.27 cm) 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.

6.5 Thermal EMF

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

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.

6.6 Cooling Rates at High Temperatures

The equilibrium concentration of point defects in the pure platinum wire increase exponentially to the increase in temperature. If a high cooling rate (i.e., removing a SPRT from a high temperature and cooling it to room temperature in less than a minute) occurs above 500°C, some of the point defects in the platinum wire become trapped in the crystalline structure causing a slight in-

crease in resistance. This slight increase in resistance can be reversed by annealing the SPRT. To avoid this problem, slowly cool the SPRT at a rate of roughly 150°C/hour above 500°C before removing to room temperature.

The SPRT can be safely removed from an instrument at 500°C or less and cooled to room temperature without concern for the cooling rate.

7 Accessories

7.1 Case

The SPRTS are shipped in a protective case. The SPRT should be stored in this case when not in use. The SPRT should be shipped in this case when returning (see Section 2.5, Return Procedure).

7.2 SPRT Termination

The 5680 series SPRTs are terminated with gold plated lugs.

8 Troubleshooting

8.1 Troubleshooting

In the event that the probe appears to function abnormally, this section may help to find and solve 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 Hart Scientific Customer Service for assistance (1-801-763-1600). Be sure to have the model number and serial number of your probe available.

Problem	Solution
Data changes	<p>Slight mechanical shock can cause temperature errors as much as 2mK. If this is observed, first measure and record the R_{tp}. Next anneal the SPRT at 661°C (5681 only), 480°C (5683), or 975°C (5684 and 5685) overnight (12 hours). 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 SPRT. If the R_{tp} does not stabilize, contact Hart Scientific Customer Service.</p> <p>Severe mechanical shock can permanently damage the SPRT. If annealing the SPRT does not resolve the data change, contact Hart Scientific Customer Service.</p> <p>Oxidation of the platinum sensor may occur after prolonged use between 200 – 450°C. R_{tp} will show an increase. To reduce the effects of oxidation, anneal the SPRT at the appropriate temperature as described above. 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 SPRT is usable. If the R_{tp} is not within calibration tolerance, but it is stable, recalibrate the SPRT.</p>
Data unstable	<p>Connection may not be made. If the data is unstable at the Triple Point of Water (TPW), check the connection first. If this action does not fix the problem contact Hart Scientific Customer Service. The SPRT may be damaged and need re-pair.</p> <p>Electrical noise in the system. 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 lead wire (the fifth wire) of the SPRT may help to reduce electrical noise interference. Be sure the ground lead wire is connected to an appropriate ground on the readout device.</p>

Problem	Solution
Temperature readout different than expected, e.g. the heat source is set at 300°C, the SPRT measures 275°C	<p data-bbox="575 210 897 232">Measure the SPRT resistance at TPW.</p> <ul data-bbox="575 239 1208 461" style="list-style-type: none"><li data-bbox="575 239 1208 309">• If the resistance of the SPRT is less than the rated resistance, there may be a short in the sensor. Contact Hart Scientific Customer Service.<li data-bbox="575 315 1208 385">• If the resistance of the SPRT is only a few ohms, there may be a short in the four lead-wires. Contact Hart Scientific Customer Service.<li data-bbox="575 392 1208 461">• If the SPRT is open, the resistance will be “Out of Limits” or in the kilo-ohm or mega-ohm range. Contact Hart Scientific Customer Service.
