FLUKE®

Hart Scientific®

5686/5695

Glass Capsule Standard Platinum Resistance Thermometer User's Guide

Rev. 622202

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Tables and Figures

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 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.

1.2.2 ⚠ 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 thermometer to any physical shock or vibration.
- Keep the shipping container in case it is necessary to ship the SPRT. Incorrect packaging of the SPRT for shipment can cause irreparable damage.
- **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.
- **DO NOT** submerge the handle or cable in liquids.

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 (TPW) (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 TPW cell or ice bath. Contact a Hart Authorized Service Center (see Section 1.4) for assistance. A TPW 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 an Authorized Hart Scientific Service Center (see Section 1.4).

   Hart Scientific recommends that a probe be periodically checked against a standard such as a TPW 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 Divsion

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 Scientific Standard Platinum Resistance Thermometer (SPRT) is designed to be the best primary standard interpolating instrument converting temperature to resistance. Hart Scientific Model 5686/5695 glass capsule SPRTs are a branch of the whole Hart Scientific SPRT family (Fig. 1). Model 5686/5695 SPRTs are mainly designed for the following two applications: used in low temperature range down to 13K (- 260°C), or used where a totally immersed probe is prefered to minimize the heat flow from or to the sensor. Long stem SPRTs are not suitable for some applications where the probe should be encased into a vessel completely. The Model 5686 SPRT covers the range from 13K (–260°C) to 505 K (232°C), and Model 5695 SPRT covers the range from –200°C (73 K) to 500°C (773 K). The 5695 SPRT is the first and unique capsule SPRT above 232°C.

Model 5696/5695 SPRTs are hand constructed at Hart Scientific by experts with years of SPRT manufacturing experience. Each SPRT is carefully annealed at the appropriate temperatures and precisely tested for stability. Their sensing elements are fabricated using high purity platinum wire wound in a strain free design on a fused silica cross frame. The special glass capsule is pressure sealed with 5N pure helium for the 5686, and with a special argon/oxygen mixed gas for the 5695.

Figure 1 *5686/5695 Standard Platinum Resistance Thermometer*

2.2 Application

Model 5686/5695 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 Calibration Laboratory has the capability of performing fixed point calibration, or comparison calibrations traceable to NIST.

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. Hart Scientific's Calibration Laboratory has the capability of performing fixed point calibration, or comparison calibrations traceable to NIST.

2.5 Return Procedure

NOTE: *Call the nearest Authorized Service Center (see Section 1.4) for assistance before shipping.*

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. 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

	5686	5695
Temperature range	13 K to 505 K	–200°C to 500°C
Nominal R_{tp}	25.5 ohms	
Resistance ratio	W(302.9146K) ≥ 1.11807, W(234.3156K) ≤ 0.844235	
Drift rate over the entire range	< 0.01°C per year	
Drift rate over a range of 100°C	Typically 0.001°C per year	
Filling gas	Pure helium (99.999%)	Mixture of argon and oxygen
Lead wires	Four platinum wires, 3 cm long	
Diameter (mm)	5.5 ±0.3	
Length (mm)	56	68

3.2 Construction

Construction of the 5686 and 5695 SPRT is shown in Figure 2 and explained below.

Model 5686 covers the range from 13 K to 505 K. The 25.5Ω sensor element is crafted using high purity platinum wire wound in a strain free design on a fused silica cross frame.

Model 5695 covers the range from –200°C to 500°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.

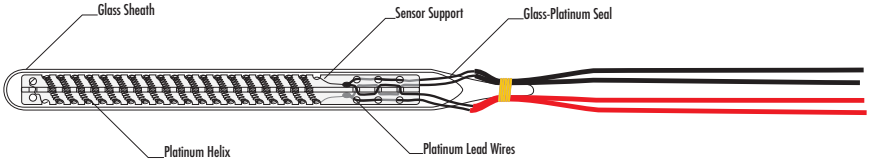

Figure 2 *The construction of 5686/5695 SPRT*

3.3 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 valid-

ity 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 ???, 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 Hart Scientific Authorized Service Center (see Section 1.4) for authorization. The Service Center assumes NO risk for in-transit damage.

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

Capsule-type SPRTs are usually used “totally immersed”, meaning that they are generally inserted into a well in a copper block. The connections are made to long fine copper wires insulated with varnish or a similar coating, and these are thermally anchored to the block and to at least one other point within the cryostat so as to reduce or eliminate heat flow into or from the thermometer. For applications above 100°C, the user should decide how to mount the capsule in his apparatus according to the conditions.

4.3 Electrical Circuit

Model 5686/5695 SPRTs are equipped with four platinum wires with Teflon sleeves. Four lead wires are used to cancel lead wire resistance. For best results, the readout device should be equipped to handle four-terminal resistors.

The lead wire colors are red and black. Two red color leads are from one end of the sensor resistance, and two black leads are from another end (See Figure 2 on page 9 for details).

5 Care and Handling Guidelines

Caution: *Read before removing the SPRT from the case.*

5.1 SPRT Care

The 5686/5695 capsule 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 can cause a change in Rtpw as high as 1 mK. The glass capsule 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

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.

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.

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.

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.

DO use the protective 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 subject the thermometer to temperatures above the highest specified operating temperature.

DO NOT expose the thermometer's cables to extreme temperatures.

6 Operation

6.1 General

For best results, be familiar with the operation of the cryostat, calibration bath or furnace and the read-out instrument. Be sure to follow the manufacturer's instructions for the read-out instrument, cryostat, 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 resistance (R_{tpw}) after each temperature measurement. This provides the most accurate measurement of the resistance ratio $W(t) = \frac{R(t)}{R_{tpw}}$

6.3 Measuring Current

The recommended current for 5686/5695 is 1 mA for most situations. The resistance sensitivity with temperature becomes lower at lower temperatures. To compensate for the loss of sensitivity, measuring currents below 24.5 K are generally increased from 1 mA usually used above that temperature, up to about 5 mA at 13.8 K..

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 5686 measurements are made at 1 mA and 1.41 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:

Where:

R0 = Zero current resistance

R1 = Resistance measured at current i1

R2 = Resistance measured at current i2

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.

6.4 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.