Calibration Procedure No. 2052H
17 September 1993

EG&G STANDARDS AND CALIBRATION LABORATORIES

CALIBRATION PROCEDURE
2052H

PROGRAMMABLE STANDARD

PLATINUM RESISTANCE THERMOMETERS

MANUFACTURER: HART SCIENTIFIC

MODEL: 5690 SERIES

17 SEPTEMBER 1993

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1.0 SUBJECT

A procedure for the calibration of Hart Scientific 5690 Series Programmable Standard Platinum Resistance Thermometers (PSPRT's) using various temperature standards as the working range of the Unit Under Test requires.

2.0 PURPOSE

To provide a set of instructions for the calibration of PSPRT's using various temperature standards as required.

3.0 GENERAL

The data taken during this test will be evaluated in accordance with the International Practical Temperature Scale of 1968 (IPTS-68). The PSPRT is capable of converting values to the International Temperature Scale of 1990 (ITS-90), but can accept only IPTS-68 coefficients for calibration. The range of temperatures will normally be:

TEMPERATURE FIXED POINT	DEGREES CELSIUS	
	IPTS-68	ITS-90
Freeze Point of Zinc	419.580	491.527
Freeze Point of Tin	231.968	231.928
Freeze Point of Water	0.0	0.0
Boiling Point of Liquid Nitrogen	-195.802	-195.794

3.1 The accuracy of the PSPRT's under test is ±.01°C for the Model 5690, ±.03°C for the Model 5691, and ±.1°C for the Model 5692 as assigned by the manufacturer. Evaluation of performance should be measured against manufacturer's specifications.

3.1.1 The temperature range of the PSPRT's under test is -183 to 500°C for the 5690 and -183 to 420°C for the 5691 and 5692.

3.2 The Hart 5690 Series PSPRT requires a personal computer for the user to read and/or gather data. PSPRT information is displayed on the monitor of the personal computer. Interface instructions are provided in the Hart Scientific 5690 Series Technical Manual.

3.3 Before beginning any actual calibration activities, read all of the procedures required to execute this calibration. There are various methods of obtaining the reference temperatures listed in step 3.0. Each standard has its own unique procedure to obtain the required parameters for the test.

3.4 PSPRT's must be handled with extreme care. Due to their construction, they are extremely fragile instruments. Any mishandling of the PSPRT's could result in measurement errors or possible irreparable damage to the instrument.

3.5 When reading/recording data, record the temperature and resistance values for the fixed point being used. Printing the computer screen to the local printer is helpful in recording data. This information will be used in determining the condition of PSPRT's.

4.0 TEST EQUIPMENT REQUIRED

4.1 All standards and test equipment/fixtures must bear current calibration labels, if required.

4.2 Recommended test equipment, or equivalent, with minimum specifications.

4.2.1

MANUFACTURER	MODEL NUMBER/NOMENCLATURE	ASSIGNED UNCERTAINTY
Hart Scientific	Zinc Freeze Point Cell	±.001mK
Hart Scientific	Tin Freeze Point Cell	±.001mK
Jarrett	Triple Point of Water Cell	±.0001mK
Leeds/Northrup	8163 Standard Platinum Resistance Thermometer	Must Have Traceability to NIST
Hart Scientific	9114 Programmable Furnace	Not Applicable
Measurements International Limited	6010A Automatic DC Resistance Bridge 4020A Multi Channel Scanner	±.12ppm
Guildline	9330-10 ohm Standard Resistor	±5.8ppm
Various	486 33MHz Personal Computer	Not Applicable

5.0 PRELIMINARY OPERATIONS

5.1 PSPRT's must be annealed prior to calibration. This is to relieve any strain on the platinum lattices that may have occurred before receipt by the Laboratory. PSPRT's should be annealed at approximately 400°C before testing. This may be done in an auxiliary furnace. No data is taken in this step. Refer to established procedure or the Manufacturer's Technical Manual for instructions.

5.2 Obtain a copy of the PSPRT Operating Program. A copy of this program is available on a hard copy disk maintained in the Temperature Standards Laboratory with the Manufacturer's Technical Manual. The current program is named "XCALL". Take the necessary steps to set the computer up in a usable configuration. Where appropriate, read established procedures or Manufacturer's Technical Manual. The program is written in GWBASIC. After reaching the GWBASIC mode, enter the command LOAD "XCALL".

The computer will return an OK prompt. Type in the command RUN. This will bring the user to a menu screen titled "XCALL PROGRAM MENU" (See Attachment 1). To establish a good interface, select Option F1 (See Attachment 1). A display titled "IDENTIFIED PROBES" will appear (See Attachment 2). Once effective communication has been established, select Option F10 (See Attachment 2). This will return the user to the main menu. Select Option F2 (See Attachment 1). This will offer a display titled "PROBE DATA DISPLAY" (See Attachment 3).

5.3 Obtain a copy of the SPRT Test Data Sheet (See Attachment 4). Record the results of the tests in the applicable space. Retain this work sheet for statistical analysis. See the example SPRT work sheet provided in the attachments.

Note: The SPRT Test Data Sheet has areas designated for bridge indication. Since the PSPRT's do not require a bridge for data display, the heading of bridge indication should be disregarded and computer displayed values placed where appropriate.

5.4 Ensure that all connectors, fixtures, and adapters necessary to perform the calibration are present.

6.0 CALIBRATION

Note: Tests should be executed in the order presented. This ensures the reliability of the PSPRT's under test. The sequence of fixed points shall be in the order of the highest temperature to the lowest with Water Triple Point checks made between each fixed point calibration. All readings viewed on the computer monitor should be printed and saved for data analysis.

6.1 Water Triple Point Test

6.1.1 Perform this test initially and then after every fixed point calibration. This action ensures the PSPRT's stability throughout the calibration. Major shifts (total of >.35mk) between the PSPRT's Water Triple Point and fixed point measurements may indicate a problem with the PSPRT's, or the PSPRT's may have been mishandled and require reannealing. The parameter of >.35mk shift should be addressed by observing the shifts between tests and by taking an average of all of the water triple point readings and comparing to the initial test.

6.1.2 Realize the Triple Point of Water per established procedure or the National Institute of Standards and Technology (NIST) Technical Note 1265, Guidelines for Realizing the International Temperature Scale of 1990 (ITS-90), Page 36, Step 3.2.3.

6.1.3 Proceed to Step 6.2 if initial Water Triple Point measurement.

6.1.4 For acceptable Water Triple Point verifications made after exposure to the fixed points, proceed to Step 6.3 during the Zinc Freeze Point calibration, Step 6.4 during the Tin Freeze Point calibration, or Step 6.4.10 during the Liquid Nitrogen Boiling Point test. If the observed shift in the value of the Freeze Point is greater than .35mk, proceed to the next step.

6.1.5 If the observed shift of the PSPRT's Water Triple Point measured after the present fixed point is greater than .35mk, go to step 5.1, perform the annealing process, and restart the calibration sequence from Step 6.1.

6.2 Zinc Freeze Point Test

6.2.1 Realize the Freeze Point of Zinc per established procedure or the National Institute of Standards and Technology (NIST) Technical Note 1265, Guidelines for Realizing the International Temperature Scale of 1990 (ITS-90), Page 52, Step 3.2.4.2.5.

6.2.2 Repeat Step 6.1

6.3 Tin Freeze Point Test

6.3.1 Realize the Freeze Point of Tim per established procedure or the National Institute of Standards and Technology (NIST) Technical Note 1265, Guidelines for Realizing the International Temperature Scale of 1990 (ITS-90), Page 51, Step 3.2.4.2.4.

6.3.2 Repeat Step 6.1

6.3.3 Exit the PSPRT Measurement Program

6.4 Boiling Point of Liquid Nitrogen Test

Caution: Liquid Nitrogen boils at the temperature of -195.8°C. Contact with this material may cause severe injury. Extreme caution must be taken during this test. **Cryogenic gloves should be used to minimize Liquid Nitrogen contact with the hands.** When transferring Liquid Nitrogen between holding containers, care must be taken due to the boiling which takes place. Liquid Nitrogen has a tendency to splatter until the holding vessel temperature stabilizes. Feet should be protected due to extreme cold. Floors may also be damaged if not protected.

6.4.1 Secure a comparison SPRT with traceability to NIST and a copy of its NIST Calibration Test Report. The numbers in this report are the reference figures for the comparison test the Boiling Point of Liquid Nitrogen.

6.4.2 The DC Automatic Resistance Bridge is required for this test. See the Manufacturer's Technical Manual for the use of this item if necessary. Connect the comparison SPRT to the bridge and ensure the Bridge/SPRT system is functioning correctly. Prompt the personal computer used to interface with PSPRT's under test to gather the reference data from the Bridge/System. Refer to established procedure or Manufacturer's Technical Manual.

6.4.3 Secure the necessary test fixtures to perform the test. These include a containing device for the Liquid Nitrogen, a fixture for the placement of the thermometers to be compared and tested, a few containers for the transportation and storage of Liquid Nitrogen and a small sheet of metal to act as a base for the test fixtures and as a protective area when the Liquid Nitrogen boils over onto the floor. This test fixture configuration is setup, readily available, and stored in the Temperature Standards Laboratory.

6.4.4 Secure a supply of Liquid Nitrogen and necessary transfer containers. Transfer the Liquid Nitrogen to the test fixture. Slowly pour the Liquid Nitrogen into the test fixture. The Liquid Nitrogen will begin to boil violently. This is normal and will cease once the test fixtures have reached equilibrium temperature. Equilibrium temperature will be evidenced by a large boil-over and then a simmering of the Liquid Nitrogen.

Monitor the level of Liquid Nitrogen present in the test fixture. The test fixture currently in use has a red marker to indicate the minimum level of Liquid Nitrogen required for the test. If the level should reach this marker, provide additional Liquid Nitrogen as required to reach the desired level.

6.4.5 Carefully insert the PSPRT's under test and the comparison SPRT into the test fixture, allow an ample period of time for the thermometers to reach equilibrium temperature (about 5-10 minutes). This will be position one of the test.

Note: This will be a two position test. This is to ensure the temperature gradients in the test fixture will not cause erroneous indications.

6.4.6 Gather the data as required by the SPRT Data Sheet. Once the reference data has been recorded on the SPRT work sheet, prompt the computer to change back to the PSPRT Program XCALL. Repeat Step 5.2 to reenter the PSPRT Measurement Program. This program was exited from in Step 6.3.3.

6.4.7 Record the data displayed on the computer monitor on the SPRT work sheet in the space provided.

6.4.8 Reposition the PSPRT's under test and the comparison SPRT so they are directly across from their location in position one. Repeat Steps 6.4.4 through 6.4.7. In this case, the data taken will be recorded as position two.

6.4.9 Remove the thermometers from the text fixture. Repeat Step 6.1.

6.4.10 Secure the excess quantity of Liquid Nitrogen remaining in the test fixture. Use the following sequence:>

6.4.10.1 Refer to Step 6.4 for safety related information.

6.4.10.2 Remove the thermometer holding device from the container used during the test. Ensure that all of the Liquid Nitrogen is emptied from the thermometer holder by inverting the holder and draining the Liquid Nitrogen from thermometer wells. Place the thermometer holder in a suitable storage area where moisture is not a concern.

6.4.10.3 Place one of the containers used to transport the Liquid Nitrogen close to the Liquid Nitrogen holder used during the test. Use a metal funnel to empty the excess Liquid Nitrogen from the test holding device back to the transport container. Dispose of the excess Liquid Nitrogen properly. Place the empty holding container in an area where moisture is not a concern.

6.5 Temporarily secure the test equipment and PSPRT's under test while reducing test data to obtain the coefficients necessary for reprogramming the PSPRt's under test.

6.6 Go to Step 7.0 at this time.

6.7 With the coefficients generated in step 7.1.4. Reprogram the PSPRT's under test as directed by the Manufacturer's Technical Manual.

6.8 Determine if the PSPRT's under test are within manufacturer's specifications at this time. Make note of this for later use.

6.8.1 Reverify the Water Triple Point test as outlined in Step 6.1. (Treat this as an initial test). Record this data for use in developing a Report of Test.

6.8.2 Reverify the Tin Freeze Point test as outlined in Step 6.3. Record this data for use in developing a Report of Test.

6.9 Turn off and secure all equipment where applicable. Proceed to Step 7.2.

7.0 DATA REDUCTION

7.1 Verify the completed SPRT work sheet for accuracy of data.

7.1.1 Access the Scientific Network and select the following options from their respective menus.

7.1.2 Select Option "C" from the Main Network Menu.

7.1.2.1 Select Option "E" from the Scientific Network Main Menu

7.1.2.2 Select Option "D" from the Standards Calibration Menu

7.1.2.3 Select Option "C" from the Mechanical Standards Menu

7.1.2.4 Select Option "A" from the Temperature Standards Menu

7.1.3 Enter the information required.

7.1.4 Generate a test report to obtain the required ratios and coefficients. Print this report for future reference and for use in developing a Report of Test.

7.1.4.1 Generate an IPTS-68 Test Report to obtain the required ratios and coefficients (See Attachment 5).

7.1.4.2 The test report will indicate the PSPRT under test has failed. This is normal and should be disregarded.

7.1.4.3 Refer back to Step 6.7 to reprogram the PSPRT with the new coefficients generated in Step 7.1.4.1.

7.2 Report of Test Generation

7.2.1 Generate a Report of Test in accordance with Metrology Laboratory Operating Procedure (MLOP) 17 See Attachment 6). Follow all directions as outlined in MLOP 17 to complete the Report of Test generation process.

8.0 REFERENCES

8.1 United States Department of Commerce. National Institute of Standards and Technology. NIST Technical Note 1265, Guidelines for Realizing the International Temperature Scale of 1990 (ITS-90). Washington: GPO, 1990.

8.2 United States Department of Commerce. National Bureau of Standards. NBS Monograph 126, Platinum Resistance Thermometry. Washington: GPO, 1973.

8.3 Hart Instructional Manual for Models 5690, 5691, and 5692. Printed January 1991.

Hart Scientific
P. O. Box 435
220 N. 1300 West
Pleasant Grove, UT 84062

Attachment 1

```
*****************************************
***         XCALL PROGRAM MENU          ***
***                                     ***
*****************************************
```

<F1> - IDENTIFY ALL PROBES AT 9600 BAUD, ADDRESSES: 00 TO 09

<F2> - - - - - - DISPLAY PROBE(S) TEMPERATURE AND RESISTANCE

<F3> - - - - - - - PLOT PROBE TEMPERATURE IN DEGREES CELSIUS

<F4> - - - - - - - - - - - - - - PLOT PROBE RESISTANCE IN OHMS

<F5> - - - DISPLAY PROBE(S) DATA FILES FROM DISK IN DRIVE A:

<F6> - - - - - - - - PROBE TEMPERATURE RECALIBRATION PROGRAM

<F7> - - - - - - - - DISPLAY AND CHANGE PROBE CONFIGURATION

<F9> - - - - - EXIT THIS PROGRAM ---> GO TO GWBASIC PROMPT

<F10> - - - - - - - EXIT THIS PROGRAM ---> GO TO DOS PROMPT

Attachment 2

F1

****
* IDENTIFIED PROBES *
****

UNIT #	ADDRESS	BAUD RATE	IDENTIFY	LABEL
1	0 1	9600	X2001V3.E	030/60-110433

HIGHEST SEARCHED ADDRESS: 0.9

PRESS <F1> TO REPEAT THIS PROGRAM

**** PRESS <F10> TO RETURN TO MENU ***

Attachment 3

F2

```
*****************************************
*          PROBE DATA DISPLAY           *
*****************************************
07-14-1993                                          13:52:55
```

UNIT #	PROBE ADDRESS	LABEL (13 CHARACTERS)	PROBE TEMPERATURE (°C)	(°F)	RESISTANCE (OHMS)
1	0 1	030/60-110433	+23.810	+74.859	218.482

```
[Press to record Probe data on Drive A]      Setup     Plot     Data      To
DAT1   DAT2   DAT3   DAT4   DAT5   DAT6      Probe      °C     Files    MENU
<F1>   <F2>   <F3>   <F4>   <F5>   <F6>      <F7>      <F8>    <F9>    <F10>
```

TEST DATA SHEET

17 September 1993

TEST REPORT NUMBER: 4.

INSTRUMENT: Platinum Resistance Thermometer IPTS-68/ITS-90		MAKER	
MODEL		SUBMITTED BY	
METROLOGY NUMBER	ACCURACY: see Test Report	SERIAL NUMBER	
TEST DATE	CALIBRATION CYCLE / DUE DATE	TESTED BY	LAB TEMP. : °C REL. HUMIDITY: % ATM PRESSURE : InHg

STANDARDS USED	MAKER	METROLOGY NUMBER	Test Report No.
6010A Automatic DC Resistance Bridge/Scanner	Measurement International	M62361, M63262	4.62361.
Triple Point of Water / Fixed Point Cells	Jarrett + Hart/Isotech	M060857,58,59,60	4.608 . /see below
Standard Resistor(s)	Guildline		

Thermometer Range: _____ to _____. All recorded Bridge indications are resistance in units of "ohms".

Triple Point of Water with correction to Ice Point

	Initial	After Zinc	After Tin	After $^{PB}LN_2$ (Final)	Comments
Bridge Indication: (Rtpw)					
Ice Point Correction:					
Ice Point Resistance: (Ro)					

Temperature Fixed Points

Fixed Point:	ZINC Freeze Point	TIN Freeze Point	MERCURY Triple Point	GALLIUM Melt Point	INDIUM Freeze Point
Metro No./Test Report No.	Z07328 4.07328.	M62477 4.62477.	M62253 4.62253.	M60636 4.60636.	M63400 4.63400.
Bridge Indication:	(R_{Zn})	(R_{Sn})	(R_{Hg})	(R_{Ga})	(R_{In})

LN2 Boiling Point

(Comparison measurement with Standard PRT Metrology Number: _____ /Test Report No. _____)

	Position #1 Standard	Position #1 Item Under Test	Position #2 Standard	Position #2 Item Under Test	
Bridge Indication:					
Standard Value:		xxxxxxxxxxxxxx		xxxxxxxxxxxxxx	
Std Error/IUT Correction					
Postion Value	xxxxxxxxxxxxxx		xxxxxxxxxxxxxxx		
Average of IUT Position #1 & #2 Values:	($R^{PB}LN_2$)				

High Temperature Fixed Points

Fixed Point:	Aluminium Freeze Point	Silver Freeze Point	
Metrology No./Test Report No.			
Bridge Indication:	(R_{Al})	(R_{Ag})	

ONLY those tests required by IPTS-68/ITS-90 for the temperature range of the thermometer are performed, all others are "Not Applicable".

IPS90BR TCB

17 September 1993

4.08782.03 User: BOC300

The above identified item was tested with reference to standards maintained in the KSC Reference Standards Laboratory. The units maintained by the standards are directly traceable to the National Institute of Standards & Technology "NIST", formerly the National Bureau of Standards "NBS".
The temperature during the test was 23 ±1 degrees Celsius.

	Temperature (Degrees C)	Resistance (Ohms)	Resistance Ratio (Rx/Ro)
H2o Freezing Point :	0.00000	199.92800	1.00000
Tin Freezing Point :	231.96800	375.03300	1.87584
Zinc Freezing Point :	419.58000	507.61100	2.53897
Nitrogen Boiling Point:	-195.80000	40.55400	.20284

Alpha:	3.852574E-03
Delta:	1.500107E+00
A4:	-7.339291E-05
C4:	1.635914E-13
A:	3.910367E-03
B:	-5.779274E-07

1: W[T]=W*[T]+A4[T]+C4(T^3)(T-100) between -182.96 and 0 degrees C.
2: W[T]=1+A[T']+B[T'^2] between 0 and 630.74 degrees C.
3: T'=T-.045(T/100)(T/100-1)(T/419.58-1)(T/630.74-1)

W(T)* is the resistance ratio given by the reference function WCCT.68 "T68" for Platinum Resistance Thermometers for the range of 13.81 to 273.15 Kelvin.

The ratio of Rt(100)/Rt(0) equals: 1.385257
This Thermometer is 'NOT SATISFACTORY' as a defining Standard in accordance with the text of the IPTS-68. The estimated uncertainty of calibration on the IPTS-68 is ±2mk at the freezing point of Water, Tin, Zinc, and.
±3mk at the Nitrogen point.

Tested By: **C. PIEHOTA**

Physical Standards

Approved By: **B.D. Bryan**
Branch Manager

EG&G FLORIDA
EG&G FLORIDA, INC., P.O. BOX 21267 KENNEDY SPACE CENTER, FLORIDA 32815

REPORT OF TEST

Item Tested: Hart Thermometer Resistance Standard
Model No: 5691
Metrology No: M08782
Test Report No: 4.08782.03

The above identified item was tested with reference to standards maintained in the KSC Reference Standards Laboratory. The units maintained by the Laboratory are derived from naturally occurring physical constants. The Laboratory temperature during the test was 23.0 degrees Celsius.

The Unit Under Test (UUT) consists of a Standard Platinum Resistance Thermometer (SPRT). A personal computer was used as a peripheral device to communicate with the SPRT and to display data.

Upon receipt, the UUT was verified by using temperature fixed points as defined by the IPTS-68 temperature scale. The results of the initial test follow:

Temperature Fixed Point	IPTS-68	Resistance (ohms)	Probe Temperature	Resistance Ratio RX/RO
Boiling Point of Nitrogen:	-195.8 C	40.554	-195.81 C	.20284
Freeze Point of Water:	0.0 C	199.928	.023 C	1.00000
Freeze Point of Tin:	231.97 C	375.033	231.981 C	1.87584
Freeze Point of Zinc:	419.58 C	507.611	419.592 C	2.53897

IPTS-68 Coefficients Determined During The Test:

Alpha:	3.852574E-03
Delta:	1.500107E+00
A4:	-7.339291E-05
C4:	1.635914E-13
A:	3.910367E-03
B:	-5.779274E-07

The above coefficients were loaded into the UUT's non-volatile memory to provide optimum measurement accuracy. After loading the above coefficients into the UUT's non-volatile memory, the UUT was given a partial reverification to ensure the accuracy of the initial test and the coefficients it had yielded. The results of the reverification follow:

Item Tested: Hart Thermometer Resistance Standard
Model No: 5691
Metrology No: M08782
Test Report No: 4.08782.03

Temperature Fixed Point	IPTS-68	Resistance	Probe Temperature
Freeze Point of Water:	0.0	199.928	0.000
Freeze Point of Tin:	231.97	375.034	231.970

The UUT As Received met the manufacturer's stated specifications of ±.03°C on all of the IPTS-68 defining points.

Test Completed: 16 April 1993
Submitted by: BOC-300

Tested by: C. M. Piehota

C. M. Piehota, Lead
Electronic Laboratories

Approved by: P B Pokorny

P. B. Pokorny
Branch Manager