

Establishment of a Primary Standards Laboratory

Application Note



Customer Background

As developing countries begin to establish a metrology base infrastructure or join international organizations (for example, the EU), they have a need to establish National Metrology Institutes (NMIs) for primary temperature standard measurement. These NMIs typically provide the traceable link to all lower-level laboratories in the associated country. In addition to providing traceability, the NMIs often consult and recommend solutions to other labs in their country.

The temperature facility within such an NMI would typically include a primary standards laboratory realizing the International Temperature Scale (ITS-90) by fixed points. The laboratory would operate strictly to the requirements of the International Standard ISO 17025:2005, General Requirements for the Competence of Calibration and Testing Laboratories.

Primary Standards Laboratory for the Realization of the International Temperature Scale of 1990 (ITS-90) from -196°C to 962°C

The construction of a primary temperature standards laboratory for an NMI requires a capability similar to the Hart laboratories in Utah, USA and Norwich, UK. A primary laboratory needs to realize the ITS-90 and provide calibration for Standard Platinum Resistance Thermometers

A visit to our working primary and secondary laboratories is strongly recommended where all aspects of building and commissioning a temperature facility can be discussed in depth with our metrologists. Topics to include ITS-90, uncertainties, laboratory management (ISO-17025), all elements of construction, HVAC, fume extraction, and health and safety issues.

(SPRTs) over the temperature range of -196°C to 962°C.

ITS-90 is the internationally recognized standard for maintaining worldwide temperature compatibility. Laboratories realizing the ITS-90 reproduce a series of intrinsic temperatures using fixed-point cells and associated maintenance baths and furnaces to maintain phase transition plateaus at the points listed in Table 1.

Each cell needs a dedicated SPRT check standard to monitor its performance at every realization. And a realization SPRT is also needed to enable the cells to be brought to plateau. An annealing furnace is required when working at temperatures above 500°C to prevent damage to all SPRTs. The resistance of the SPRTs is measured by a 0.1-ppm DC bridge balanced against a 10-ohm standard resistor maintained in an oil bath. Software is very helpful in providing for the calculation of coefficients and interpolation tables.

When performing thermocouple calibrations, a high performance Digital Multimeter (DMM) is used to measure the voltage output of thermocouples. Ice-making equipment provides an ice point for thermocouple reference junctions.

Variance in environmental conditions can impact measurement results. The laboratory temperature and humidity is monitored and recorded using a high-precision thermo-hygrometer.

The suggested equipment (Table 4) is intended to provide a range of uncertainty (k=2) approaching that of the Hart primary level laboratories (Table 2 and Table 3). This will of course be finally dependent on the establishment of the laboratory practices and procedures. Hart can advise on this process.

Table 1 ITS-90 Fixed Points

Fixed Point	Temperature
Boiling Point of Liquid Nitrogen (BPLN ₂) [†]	-196°C
Triple Point of Mercury (TPHg)	-38.8344°C
Triple Point of Water (TPH ₂ O) [†]	0.01°C
Melting Point of Gallium (MPGa)	29.7646°C
Freezing Point of Indium (FPIn)	156.5985°C
Freezing Point of Tin (FPSn)	231.928°C
Freezing Point of Zinc (FPZn)	419.527°C
Freezing Point of Aluminum (FPAl)	660.32°C
Freezing Point of Silver (FPAg)	961.78°C
[†] This is a comparison point used by virtually all laboratories to avoid the complexity and expense of realizing the Triple Point of Argon (TPAr at -189.3442°C). The BPLN ₂ requires an SRT traceable to a national standard at the TPAr. [‡] The fundamental reference point of the ITS-90.	

Table 2 Hart Scientific Metrology Laboratory Capabilities - SPRT uncertainty levels

Hart Scientific Metrology Laboratory Capabilities			
Type	Temperature	Uncertainty	Technique
SPRT (Fixed Point)	-196°C	2.0 mK	Comparison at NBPLN2
	-38.834°C	2.0 mK	Calibration at TPHg
	0.010°C	2.0 mK	Calibration at TPW
	29.7646°C	2.0 mK	Calibration at MPGa
	156.5985°C	3.0 mK	Calibration at FPIn
	231.928°C	4.0 mK	Calibration at FPSn
	419.527°C	6.0 mK	Calibration at FPZn
	660.323°C	8.0 mK	Calibration at FPAl
	961.78°C	10.0 mK	Calibration at FPAg

Thermocouple potential is shown in the following table:

Table 3 Hart Scientific Metrology Laboratory Capabilities - thermocouple uncertainty levels

Hart Scientific Metrology Laboratory Capabilities			
Type	Temperature	Uncertainty	Technique
Noble Metal Thermocouple Au/Pt Type S-R	0°C to 1000°C	0.02°C extrapolated to 0.025°C	Calibration at FPSn, FPZn, FPAl, and FPAg.
	0°C to 1450°C	0.15°C extrapolated to 2°C	

Table 4 Equipment needed

Item No.	Qty.	Description	Model No.	Remarks
1	1	LN ₂ Comparison Calibrator (-196°C)	7196-4	
2	1	Triple Point of Mercury	5900	
3	2	Triple Point of Water (TPW)	5901D-Q	
4	1	Melting Point of Gallium (Ga)	5943	
5	1	Freezing Point of Indium (In)	5904	
6	1	Freezing Point of Tin (Sn)	5905	
7	1	Freezing Point of Zinc (Zn)	5906	
8	1	Freezing Point of Aluminium (Al)	5907	
9	1	Freezing Point of Silver (Ag)	5908	
10	1	Mercury Maintenance Bath	7341 2027-DCBM	
11	1	TPW Maintenance Bath	7312	Maintains two TPW cells
12	1	Gallium Maintenance Apparatus	9230	
13	4	Freeze Point Furnace	9114	For In, Sn, Zn, Al
14	1	Freeze Point Furnace	9115	For Ag
15	6	Standard Platinum Resistance Thermometer (SPRT)	5683-S	-200°C to 480°C
16	2	Standard Platinum Resistance Thermometer (SPRT)	5681-S	-200°C to 661°C
17	2	Standard Platinum Resistance Thermometer (SPRT)	5685-S	0°C to 1070°C
18	3	Working Standard SPRT	5698-25	
19	2	Type S Thermocouple Standard or Type R Thermocouple Standard	5650-20CS 5649-20CS	With reference junction
20	1	Gold-Platinum Thermocouple	5629-B	
21	1	Primary Standard Automatic Resistance Bridge 10 channel scanner Software IEEE Interface	5581 5313-002 5313-004 5313-003	
22	1	Resistance Standard	5430-10	10 ohm
23	1	Resistor Maintenance Bath	7108	
24	1	Annealing Furnace	9117	
25	1	Thermo/Hygrometer	1621-S	
26	1	Crushed Ice System	Scottsman AC55 Crushman 360 (crusher) QL3-4H (filter)	Thermocouple reference
27	1	Dry Ice Maker	Polyfoam 460	Liquid carbon dioxide required or use liquid nitrogen
28	1	Dewar Flask	2028	Ice reference
29	1	Digital Multimeter	8508A	
		Training and Commissioning		

¹All items to be supplied with accredited/traceable certificates to national standards where appropriate.

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