TPW maintenance bath

- Maintains TPW cells for up to two months
- Optional immersion freezer for simple cell freezing
- Independent cutout circuit protects cells from breaking

For frequent use of traditional-size triple point of water cells, nothing helps save you time and hassle like a good maintenance bath. The 7312 Triple Point of Water Maintenance Bath keeps your cells up and running reliably for weeks at a time—even during heavy usage—and comes at a price you'll love.

The 7312 accommodates two TPW cells and includes three pre-cool wells for properly cooling probes prior to measurements within the cells. Stability and uniformity are each better than ± 0.006 °C, so your cells stay usable for up to eight weeks. Whatever method you use for building your ice mantles, you can be assured they'll last in a 7312 bath.

An independent safety circuit protects your water cells from freezing and breaking by monitoring the temperature of the bath and shutting down its refrigeration system should the bath controller fail. Noise-reduction techniques in the manufacturing process ensure your bath doesn't add excessive noise to your lab.

With a temperature range from –5 °C to 110 °C, this bath can also be used for comparison calibrations—particularly of long-stem probes—or maintenance of gallium cells. An optional gallium cell holding fixture fits two cells, which, in a 7312 bath, can maintain their melting plateaus for up to two weeks.

In fact, the 7312 is available with a time-saving 2031A "Quick Stick" Immersion Freezer so you can build your ice mantles quickly and hands-free. Just fill the 2031A's condensing reservoir with dry-ice and alcohol, insert it into the cell, and get some other work done while your ice mantle forms in less than an hour. (Alternatively, LN_2 may be used.)

If you're using traditional-size TPW cells, don't take the time to create an ice mantle only to watch it melt quickly as it sits in a bucket of ice. Maintain your cells the right way in a Hart 7312 TPW Maintenance Bath.

Specifications

Range	–5 °C to 110 °C
Stability	± 0.001 °C at 0 °C (alcohol-water mix) ± 0.004 °C at 30 °C (alcohol-water mix)
Uniformity	± 0.003 °C at 0 °C (alcohol-water mix) ± 0.006 °C at 30 °C (alcohol-water mix)
TPW Duration	Six weeks, typical (assumes correctly formed ice mantle)
Set-Point Accuracy	± 0.05 °C at 0 °C
Set-Point Repeatability	± 0.01 °C
Display Resolution	± 0.01 °C
Set-Point Resolution	± 0.002 °C; 0.00003 °C in high-resolution mode
Access Opening	121 x 97 mm (4.75 x 3.8 in)
Immersion Depth	496 mm (19.5 in)
Volume	19 liters (5 gallons)
Communications	RS-232 included
Power	115 V ac (± 10 %), 60 Hz or 230 V ac (± 10 %), 50 Hz, specify
Size (HxWxD)	819 x 305 x 622 mm (12 x 24.5 x 32.25 in)
Weight	34 kg (75 lb)

Ordering Information

7312	TPW Maintenance Bath (includes TPW Holding Fixture, MPGa Holding Fixture, and RS-232 Interface)
2001-IEEE	Interface, IEEE-488
2031A	"Quick Stick" Immersion Freezer

Hart's 2031A "Quick Stick" Immersion Freezer offers unmatched convenience and simplicity in forming the triple point of water ice mantle.

Use TPW and ratio method to improve SPRT stability and accuracy

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Introduction

The Standard Platinum Resistance Thermometer (SPRT) is the most accurate thermometer in the extended temperature range from –259 °C to 962 °C. The uncertainty of an SPRT can be as low as a few tenths of a millikelvin (mK).

More and more metrologists are using SPRTs as reference standards to calibrate other types of thermometers or to achieve a high level of accuracy for any reason. However, the handling and use of an SPRT is as important to achieving a high level of accuracy as the design and performance of the SPRT itself. Several types of errors can corrupt SPRT measurements.

Sometimes absolute resistance is used to calculate temperature instead of the resistance ratio. When absolute resistance is substituted for the resistance ratio, errors of more than 10 mK at 660 °C are common. In addition, even when the correct measurement and calculations are made, the resistance of the SPRT in the triple point of water should be determined immediately after a high accuracy measurement is made with the thermometer.

The triple point of water measurement is often overlooked but is vital to accuracy. The relationship of the triple point of water measurement to SPRT accuracy is explained with a few key points.

TPW and accuracy

In general, SPRTs have excellent stability; however, a small drift in resistance might happen now and then, especially after transportation, thermal cycling, or accidental rough handling. A change as low as 1 ppm in resistance at about 660 °C (the freezing point of aluminum) will be equivalent to a change of 1.1 mk in temperature. The stability required of a high-quality standard resistor is about 1 ppm. The working and environmental conditions normally associated with a standard resistor are much better than the conditions usually found when working with an SPRT. So a few ppm of stability might be the best we can expect for most SPRTs.

The ratio of two resistances of an SPRT based on two temperatures is much more stable than the stability expected when an absolute resistance at a single fixed temperature is used. For example, using only the freezing point of silver as a reference point over a six year time frame, an SPRT exhibited a change of 5 ppm in its resistance [1]; this is equivalent to a change of 7.5 mk in temperature. On the other hand, the change in the resistance ratio,

$$W(961.78\ °C) = R(961.78\ °C)/R(0.01\ °C)$$

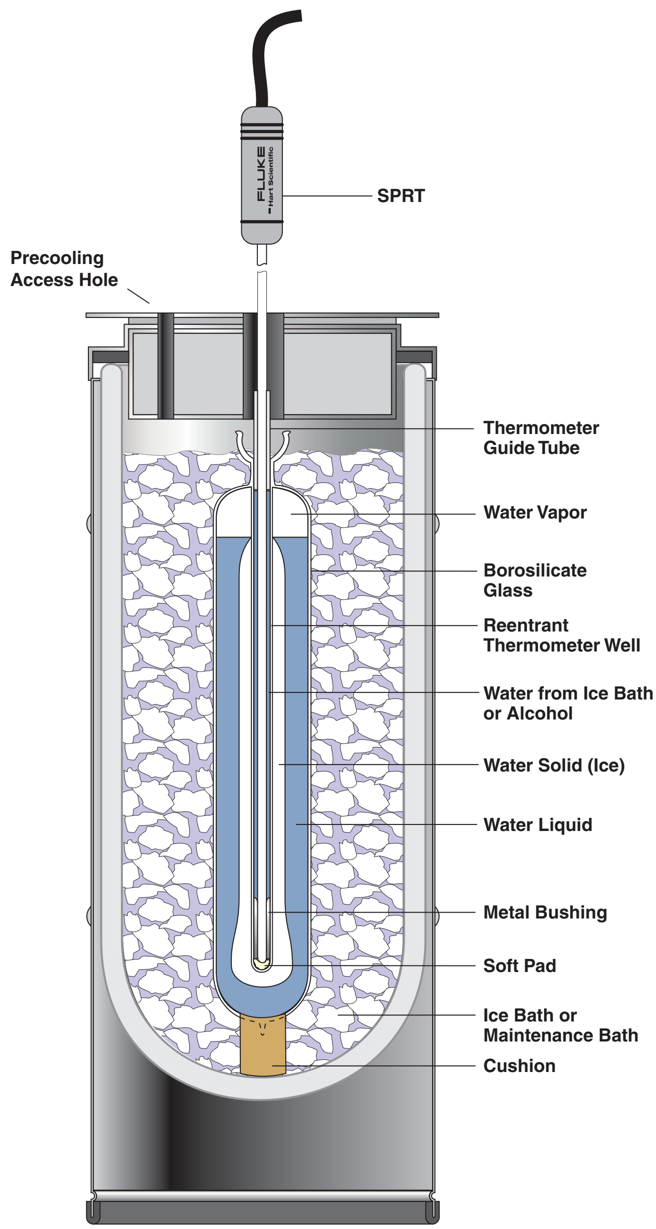
was within 1 ppm (a change of 2 mk in temperature) across the same six-year period. This explains why the resistance ratio W(t) is specified by the International Temperature Scales since 1960 instead of the absolute resistance R(t).

The best method for accomplishing this ratio is to use the Triple Point of Water as the second temperature because of its excellent stability and simplicity. It has been specified as a reference point for SPRTs since 1960 [2]. Thus, the highest SPRT accuracy possible is achieved when the resistance of an SPRT at the triple point of water (R_{tp}) is made immediately after a measurement at any other temperature.

Use of the ratio method also reduces system error introduced by any electronic readout. This reduction in system error is important because as little as 0.7 PPM of error in resistance will cause an error of 1 mk in temperature at 962 °C (see table below).

Frequency of R_{tp} measurement

When accuracy requirements don't extend to the highest levels, R_{tp} may need measuring only once a day, every few days, or at some other suitable interval. How frequently R_{tp} needs measuring depends on several factors, such as acceptable



Use TPW and ratio method to improve SPRT stability and accuracy

uncertainty, the stability of the SPRT, the measuring temperature range, and the working conditions. If the required uncertainty is 1 mk or so, R_{tp} measurement should follow each R_t measurement. If accuracy requirements are 20 mk or more in a temperature range lower than 420 °C and the SPRT used is quite stable, the R_{tp} might be measured once a week. The stability over time of each SPRT must be measured, even when using SPRTs manufactured in the same lot from the same supplier.

When temperature measurements are higher than 800 °C, it is better to measure the R_{tp} as soon as the SPRT cools down to room temperature. Whenever possible, an SPRT should cool down to at least 500 °C with a low cooling rate (about 100 °C per hour). Otherwise, the SPRT should be annealed before making a measurement at the triple point of water.

A suitable annealing procedure is a two-hour anneal at 700 °C at the end of which the SPRT is allowed to cool to 450 °C over a period of about two and one half hours. After this initial cooling period, the SPRT can cool quickly to room temperature. Fast cooling from high temperatures above 500 °C may cause significant increases in R_{tp} because of the quenching-in effect on lattice defects found in platinum wire. This increase of R_{tp} could be as large as 30 mk.

Can the R_{tp} given in the "NIST Calibration Report" be used to calculate the ratio?

Some metrologists may feel the R_{tp} measured by NIST is more accurate than that measured in their own lab, so they prefer to use the value for R_{tp} given in the "NIST Calibration Report" to calculate the resistance ratio in the interpolation equation. While it's true that the accuracy of NIST's measurements are generally much better than those done in other labs, the R_{tp} of your SPRT may have changed during transportation, so it should be measured again in your own lab. Furthermore, the R_{tp} should be measured using the same instrument and time frame as the R_t to reduce system error with the readout included in the measuring procedure. It is important to always use the same readout instrument to measure both R_t and R_{tp}.

Avoiding mechanical strain and the annealing procedure

An SPRT is a delicate instrument. Shock, vibration, or any other form of acceleration may cause strains that change its temperature-resistance characteristics. Even a light tap, which can easily happen when an SPRT is put into or taken out of a furnace or a triple point of water cell, may cause a change in R_{tp} as high as 1 mk. Careless handling of an SPRT over the course of a year has resulted in R_{tp} increases equivalent to 0.1 °C.

Annealing at 660 °C for an hour will relieve most of the strains caused by minor shocks and nearly restore the R_{tp} to its original value. If the maximum temperature limit for an SPRT is lower than 660 °C, it should be annealed at its maximum temperature. Such an annealing procedure is always advisable after any type of transportation.

The annealing furnace should be very clean and free of metals, such as copper, iron, and nickel. SPRTs are contaminated when they are annealed in furnaces containing a nickel block, even when the SPRTs were separated from the nickel block by quartz sheaths [3]. Well designed, clean annealing furnaces are important for quality measurements with SPRTs.

Conclusions

SPRTs are among the finest temperature measuring devices known. However, high accuracy comes at a price and not just in terms of money. Patience, care and proper procedures are major factors in producing high quality measurements.

Support instruments such as triple point of water cells are inexpensive and simple to use. Annealing is a well understood process. Uncompromised measurements are possible in almost every laboratory situation.

References

1, Li, Xumo et al, Realization of the International Temperature Scale of 1990 between 0 °C and 961.78 °C at NIM, "Temperature, Its Measurement and Control in Science and Industry," Volume 6, Part 1, p. 193 (1992).

2, CGPM (1960): Comptes Rendus des Seances de la Onzieme Conference Generale des Poids et Mesures, pp. 124-133.

3, Li, Xumo et al, A New Type of High Temperature Platinum Resistance Thermometer, Metrologie, 18 (1982), p. 203.

Temperature (°C)	The temperature error caused by an error of 1 PPM in resistance measurement (mK)	The resistance error equivalent to an error of 1 mK in temperature (PPM)
–200	0.04	25.4
–100	0.14	6.9
0.01	0.25	4.0
232	0.51	2.0
420	0.74	1.4
660	1.1	0.9
962	1.5	0.7