Number 4
Spring 1998

random NEWS

An occasional publication of
HART SCIENTIFIC

James C. Triplett, Chairman, CEO

Was it Random News—or Phantom News?

We said we were going to publish an issue of Random News every time the mood came upon us, but after the mood seemed to disappear for about eighteen months I think we should rename the newsletter *Phantom News* instead of *Random News*!

Several times during those long winter months of hibernation, one or more of us got an urge to do an issue of *Random News*, but we were shouted down by others in our group who thought we needed to concentrate our attention on one of our other pressing projects like finishing our new tradeshow booth or publishing Hart's 1998 catalog, which was supposed to be published in 1997. We had so much new stuff to put in the 1997 catalog, 1997 came and went before we finally got the catalog to the printer in 1998. With that done *Random News* was reborn.

see JIM on page 12

New! Easier to Use, Less Expensive Fixed Points

by Thomas Wiandt
Manager, Metrology Services
Hart Scientific, Inc.

Fixed-points are an integral part of the International Temperature Scale of 1990 (ITS-90). They embody dual phase (solid-liquid) or triple phase (solid-liquid-vapor) transition points of high purity materials. The temperature at which this phase transition takes place is a known precise temperature and is an excellent temperature reference for precision calibration of thermometers.

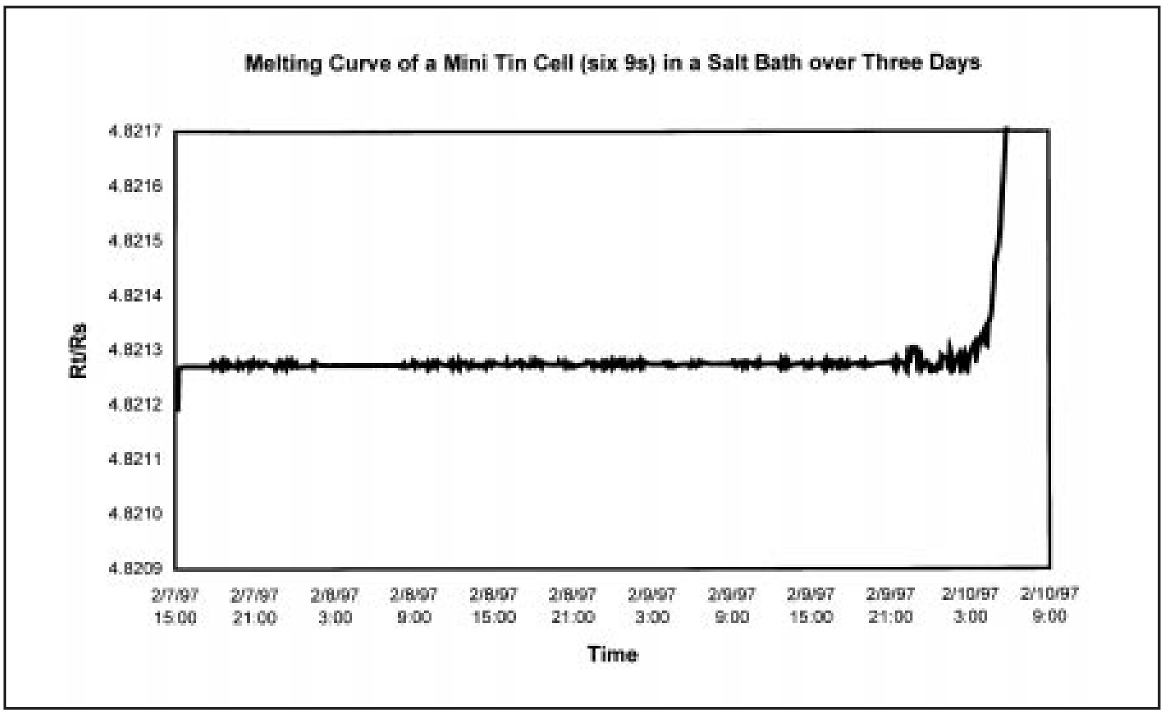
The drawback, of course, is the cells are expensive, require costly equipment to maintain them, and need precise technique to get accurate, repeatable measurements. As a result, they are generally used for calibration of primary temperature standards such as SPRTs and types R, S, and gold-platinum thermocouples. The calibration of secondary standards and industrial sensors with fixed-point cells has been economically prohibitive until now!

To solve this problem we have developed new fixed-point cells in a compact "mini" size that are easy to use, low cost, and very accurate for the calibration of secondary standards and industrial sensors. Here are some interesting facts about them:

- High Efficiency - many thermometers can be calibrated in one run.
- High Accuracy - uncertainties approach traditional fixed-point calibrations and surpass typical comparison calibrations (2 to 4 mK below 420°C, 10 mK at 660°C, and 30 mK at 1000°C).
- High Stability - mini-cells are stable with no recalibration required.
- Ease of Use - mini-cells are easier to use than traditional fixed-point cells.
- Immersion Depth - mini-cells are usable with thermometers as short as 230 mm (9 inches).
- Low Cost - mini-cells cost 40% to 70% less than primary fixed-point cells.

The Mini-Fixed-Point Cell

The secondary level fixed-point cell (mini-cell) is similar in design and construction to the primary fixed-point cell. The difference is size. Mini-cells are 30% shorter and 10% smaller in diameter. The smaller size reduces the amount of primary metal in the cell by 50%. The metal is available in two levels of purity, 99.9999+%, just like in primary cells, and 99.999% for use in less stringent applications.



Realization Methods

Achieving the highest level of accuracy is the most important consideration for work in a primary thermometry laboratory. The standards, instruments and techniques are established with this goal in mind. Ease of use and efficiency are only considered when the accuracy goal is met. In secondary and industrial applications, however, accuracy is only one consideration among many. In most cases, cost and ease of use are as important as accuracy.

To meet the criteria of easy-to-use and low cost, not only does the cell need to be less expensive to make, it has to be easier to use, too. To solve this portion of the puzzle, we looked at the melting point of the mini-cell rather than its freezing point. Not only are melting points much easier to achieve, melting-point plateaus last a long time. Melting plateaus of 24 hours or more are easily obtainable, so many calibrations can be done during one plateau.

With a freezing curve, the metal in the cell is transitioning from a molten state to a solid state, losing energy as its phase change progresses. Each introduction of a test thermometer accelerates this transition by absorbing energy as the thermometer heats up, thus reducing the length of the freeze plateau. Preheating the test thermometers helps, but it does not solve the problem.

Melting curves, on the other hand, take advantage of the phase transition in the other direction. Energy is being absorbed by the metal in the mini-cell as it melts. Thus, the introduction of test thermometers causes a release of energy to heat the thermometers, thereby prolonging the plateau. Preheating is employed to shorten the equilibration time. When several fixed-points are used in this manner (for example aluminum, zinc, and tin for the ITS-90 range of 0 to 660°C), several thermometers can be completely calibrated in one day.

These are Hart's new models 9210 and 9260 furnaces for maintaining the small Triple Point of Water cells and mini fixed-point cells.

Equipment

Melting plateaus can be achieved using a variety of heat sources, including inexpensive ones. For the highest levels of accuracy, mini-cells should be used in traditional fixed-point furnaces in the same manner as primary fixed-point cells. For less accurate work, special holding fixtures used in high-stability temperature calibration baths are excellent for achieving long melting plateaus. Finally, for the optimal mix of cost and ease of use, new automated mini-cell furnaces are unbeatable.

The furnaces for mini-cells were designed specifically for maintaining the small cells. There are two models available (one for the triple point of water and one for metal cells) which cover the range of 0 to 670°C. These furnaces provide the best combination of stability, ease of use, cell plateau duration and cost. The apparatus are fast and semi-automatic so the cells can be in use in less than 30 minutes after initiation with very little intervention on the part of the operator. Using mini-cells and their special maintenance furnaces takes very little training. The small units don't eat up lab space, and their combined cost is close to the cost of one primary fixed-point cell alone.

Conclusion

Mini-cells are the lowest-cost, easiest-to-use tool for high accuracy calibrations of secondary standards and industrial sensors. Nothing else comes close!

End

Example of prices and uncertainties at the aluminum point (660.323°C)

Traditional large cell	$9,450
Traditional metrology furnace	$17,500
Total Cost	$26,950
Expanded Uncertainty	2.5 mk
New mini-cell	$4,200
Traditional metrology furnace	$17,500
Total Cost	$21,700
Expanded Uncertainty	4.0 mk
New mini-cell	$4,200
New mini-cell maintenance furnace	$6,995
Total Cost	$11,195
Expanded Uncertainty	10.0 mk

Myth: Thermistors Don't Make Good Temperature Standards.

by J. Randall Owen
President, COO

Thermistors don't make good temperature standards? Yes they do. You've probably seen sensor comparison charts published by magazines and probe manufacturers. They're typically found in articles and application notes intended to help you select the correct sensor for various applications. In thermistor charts I regularly find the authors listing poor linearity and poor long-term stability as disadvantages. These are the reasons I most often hear repeated when someone believes a thermistor isn't a good thermometry standard.

Let's look at non-linearity first. With today's powerful microprocessor-based readouts, non-linearity isn't really an issue. As long as the resistance vs. temperature curve of the sensor is very predictable, or repeatable, the sensor can make accurate measurements when used with a readout designed to deal with the non-linearity. The Steinhart-Hart equation or resistance look-up tables are commonly used by instruments to accurately convert resistance to temperature.

Poor long term stability has been the main concern about thermistors. Changes in the physical composition of the semiconductor can result in either an increase or a decrease in the resistance of the thermistor. Oxidation of the semiconductor materials contributes to this change. For example, a common additive in thermistors is copper oxide which has poor stability in the presence of oxygen. Problems with changing contact resistance sometimes result from thermal stress or insufficient strain relief between the thermistor body and its leads.

While these potential problems occasionally occur in the lower-cost thermistor devices, they are not common in thermistors which are hermetically sealed in glass. Sealing the thermistor eliminates oxygen transfer to the semiconductor and prevents resistance shifts. The rate at which the resistivity of a thermistor will change in the presence of oxygen increases with increasing temperature. Consequently, the use of a hermetic seal permits operation of the bead at higher temperatures. The glass seal also provides an adequate strain relief for the lead-to-ceramic contact on many thermistor styles.

Between 1974 and 1976 the National Bureau of Standards conducted a study on the stability of thermistors. The results demonstrated *no significant drift* for bead-in-glass thermistors. Non-glass-sealed disk type thermistors showed definite drift which increased as the test temperature increased. Later, J.A. Wise of the National Institute of Standards and Technology conducted another investigation that was published at the Seventh International Temperature Symposium in Toronto. Her study included newer, glass-sealed disk thermistors as well as bead-in-glass thermistors. This

Hart's Model 1504 Tweener reads thermistors accurately to ±0.003°C.

time, the disk type faired nearly as well as the bead type.

These extensive studies conclude that a super-stable glass-sealed thermistor will typically drift only 0.001°C to 0.002°C per year. This level of stability is comparable and in fact better than some SPRTs on the market today. However, a *calibrated* reference probe made with this type of thermistor costs between $500 and $1400 depending on its range and stability. An *uncalibrated* SPRT costs about $3,000. The thermistor probe is priced at the same level as a secondary PRT probe while delivering 10 to 20 times better annual stability.

Though many applications may not require high stability performance and many thermistors may not be suitable for standards thermometry, this does not mean *all* thermistors are not suitable. The same is true for platinum resistance thermometers. Most industrial RTDs are not suitable for standards work. This doesn't mean that a properly constructed PRT or SPRT is a bad standard.

Another interesting point is the fragility of the sensor. Sometimes thermistors are criticized as being too fragile. While a bare bead thermistor is fairly delicate, a properly constructed stainless steel-sheathed probe is surprisingly rugged when compared to a PRT or SPRT. The platinum resistance element in an SPRT or PRT is far more susceptible to mechanical shock than its thermistor counterpart. While the bumps and taps of everyday handling can impact the strain relief and contact resistance of the PRT, the same level of mechanical shock will not change the base resistance in a thermistor probe. The thermistor is recommended where frequent handling is expected.

The only real limitation of thermistors in metrology applications is temperature range. Currently, the most common ranges for super-stable thermistors suitable for metrology lie between 0°C and 110°C. Of course, a large percentage of all measurement applications fall between these two temperatures. An excellent strategy is to use a thermistor for work in this range and a PRT for work beyond that range. This reduces the handling of the PRT and the likelihood that a shift in base resistance will occur.

Thermistors typically have larger base resistance and resistance change-per-degree than PRTs. This makes it easier to read their resistance precisely. It also contributes to a thermistor's ability to provide better resolution than a PRT. It is common to get meaningful and repeatable readings of temperature change to 5 places past the decimal.

See MYTH on page 12

References:

1) Wood, S.D., Mangum, B. W., An Investigation of the Stability of Thermistors, Journal of Research, National Bureau of Standards, 83, 3, (1978).

2) Wise, J.A., Stability of Glass-Encapsulated Disc-Type Thermistors, Temperature: Its Measurement and Control in Science and Industry, Vol. 6 (American Institute of Physics, New York, 1992), part 1, p. 481.

3) Siwek, W.R., Sapoff, M., Stability of NTC Thermistors, Temperature: Its Measurement and Control in Science and Industry, Vol. 6 (American Institute of Physics, New York, 1992), part 1, p. 497.

Thermometer Readouts

Model	ASL F250	Hart 1504 Tweener	Hart 1560 Black Stack	ASL F700	Hart 1575 Super-Thermometer	Hart 1590 Super-Thermometer	ASL F18
Thermistors?	No†	Yes	Yes	No†	Yes	Yes	No†
Meter Accuracy at 25°C	±0.01°C	±0.003°C	±0.0013°C	±0.001°C	±0.00025°C	±0.000125°C	±0.0001°C
Resolution	0.001°C	0.0001°C	0.0001°C	0.00025°C	0.000075°C	0.00005°C	0.0001°C
Price	$3,275	$1,295	$3,390	≈ $20,000	$9,995	$13,995	≈ $45,000

†We realize this chart compares apples to oranges. That's because our competitors don't make thermistor readouts. So to be fair we've shown the best published specs from the closest competition. All their specs assume a 25Ω or 100Ω platinum resistance thermometer.

Q and A

What are Stem Conduction Errors and How Can They Create Errors in Calibration?

by Michael Hirst
Vice President, Technology and Design

Stem conduction is heat conduction along the length of a thermometer. When the heat source temperature and the handle, or cable end, of the thermometer are at different temperatures, stem conduction happens. This difference produces a sensor reading that's different from the actual heat source temperature. Two thermometers side by side in the same heat source with stems made of different materials may read two different temperatures.

The following chart illustrates the stem conduction effect. Five different, but high quality thermometers were tested in a liquid bath at 80°C. The test was performed by immersing each of the thermometers to a specific depth. Since each thermometer or probe had design differences including the length of sensor and the diameter, the immersion was adjusted for those variables.

Immersion Depth = Sensor Length + X Diameters

Temperatures were normalized at *SL + 20 Diameters*.

Temperature Error at 80°C Due To Stem Conduction, Degrees C

Depth	Probe 1 SPRT, Inconel Sheath, 5.5 mm Dia 50 mm SL	Probe 2 SPRT, Quartz Sheath, 7 mm Dia 29 mm SL	Probe 3 SPRT, Inconel Sheath, 6.3 mm Dia. 29 mm SL	Probe 4 Secondary, Inconel Sheath, 6.3 mm Dia. 41mm SL	Probe 5 Secondary, Inconel Sheath, 6.3 mm Dia. 38 mm SL
SL+20D	0	0	0	0	0
SL+17.5D	0	0	–0.001	–0.002	–0.002
SL+15D	0	0	–0.005	–0.003	–0.003
SL+12.5D	–0.002	–0.002	–0.010	–0.005	–0.005
SL+10D	–0.002	–0.001	–0.015	–0.010	–0.050
SL+7.5D	–0.004	–0.003	–0.020	–0.050	–0.100
SL+5D	–0.007	–0.005	–0.050	–0.130	–0.430

The results show that thermometers 1 and 2 read nearly the same temperature values for each depth, while thermometers 3, 4, and 5 read very different temperatures with less immersion depth. This illustrates stem conduction effects. This simple test has many implications for the work you do. How much immersion depth do you need for your sensors?

Factors That Impact Stem Conduction Error

Remember the heat conduction formula: *Q = (K x A x Delta T)/d*

Q = heat, *K* = thermal conductance factor, *A* = cross sectional area, *Delta T* is the temperature difference between the sensor and ambient, and *d* is the immersion depth. Knowing that an increase of *Q* will increase the error of the measurement, consider each of the components of this equation.

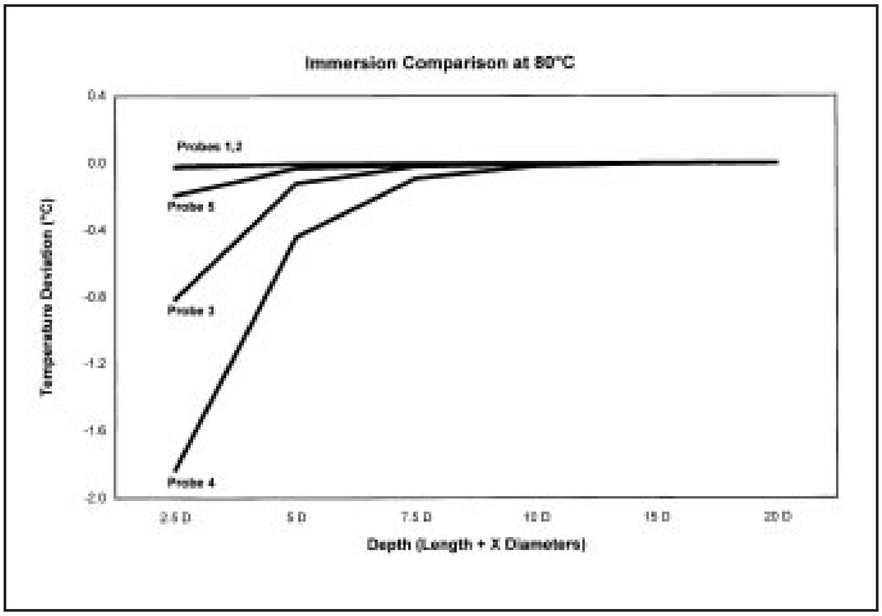
Thermal Conductance Factor

A high thermal resistance (hence low conductance value) helps to isolate the temperature sensor against the conduction of heat to the ambient air (or vice-versa). The material type and diameter of lead wires, the sheath thickness and materials of construction all factor into this. The copper lead of a type T thermocouple is clearly a high thermal conductor for a given diameter of wire and may need to be compensated for in some way.

Probe 5 in our test had a heavy walled sheath. The effect of the heat conducted along this sheath contributed to the errors. A related factor for quartz sheaths is light piping.

Cross Sectional Area

Whatever the heat conduction coefficient of the stem material, the bigger the cross-sectional area of the stem, the more heat conduction and the greater the error. Using the diameter to determine immersion depth helps compensate for this. However, a calibration comparison of two thermometers of vastly different stem diameters may actually require the smaller one to be placed at the same depth as the larger one so both sensors are at the same temperature. Labs calibrating short, large diameter sensors find it very difficult to obtain a high accuracy calibration because of the dominating effect of stem conduction.



Delta T

Delta T refers to the temperature difference between the heat source and the ambient temperature. Calibrations are usually made over wide temperature ranges. Stem conduction errors increase directly with this temperature difference as our equation suggests.

Depth

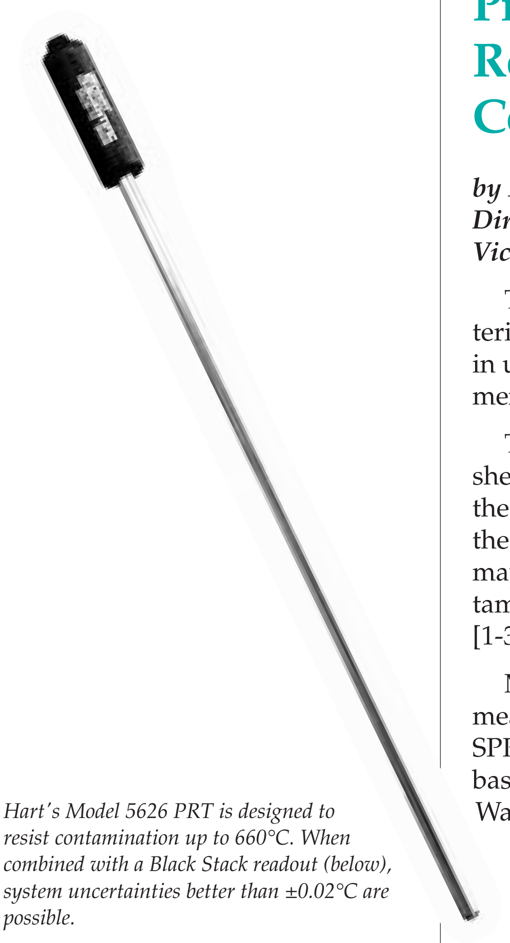
Many factors influence the errors related to stem conduction but few are as easy to control as depth. The equation shows that the other effects can be reduced by increasing the value of immersion depth. Immerse the thermometer as far as possible while still keeping all the test and reference sensors as close together as practical. Remember not to cook the connection or handle end of the thermometer.

In our example, we used a liquid bath for our heat source. If you're using a dry-well or furnace, stem conduction errors are greater and more difficult to manage.

The formula given in this brief, simple discussion of stem conduction error can be used as a general rule-of-thumb for figuring immersion depth. You should do some similar experiments with your own sensors to establish their stem conduction errors. Thermometers with low stem conduction errors make good references for checking the uniformity of heat sources. *End*

Protection of Standard Platinum Resistance Thermometers From Metallic Contamination

by Xumo Li
Director of Metrology
Vice President, Technology Development



Hart's Model 5626 PRT is designed to resist contamination up to 660°C. When combined with a Black Stack readout (below), system uncertainties better than ±0.02°C are possible.

The platinum sensing element in an SPRT changes its resistance characteristics when exposed to mechanical shocks. This is one of the problems in using an SPRT. However, other risk factors also threaten the measurement performance of an SPRT.

Typically, the platinum sensor in an SPRT is sealed in a fused-silica sheath with a mixture of gases including oxygen. This sheath separates the platinum sensor from its surroundings to help protect it. However, if the SPRT is used near a base metal (or its alloy) at a high temperature, it may exchange free-floating metal ions with the base metal causing contamination, thus changing its base resistance and affecting its accuracy. [1-3]

Marcarino [2] has shown that nickel, chromium and iron ions can permeate fused silica at temperatures above 960°C. In one experiment, an SPRT was annealed at 1070°C for 200 hours in a nickel block (nickel is a base metal). This altered the accuracy of the SPRT at the Triple Point of Water (0.01°C) by 0.04°C.

At our own laboratory in Utah, we have shown that an SPRT annealed for hundreds of hours in an aluminum-bronze block can be contaminated at temperatures as low as 660°C. Little is known about contamination of SPRTs at temperatures below 960°C, so we are currently working to quantify the magnitude of the problem at 660°C.

The question is how can you protect your SPRT at high temperatures? First and foremost, eliminate base metals from the surrounding environment (bath or furnace) in which the SPRT is being used. If that cannot be done completely, enclose the SPRT in a platinum sheath. Platinum is the most effective metal for keeping free-floating ions from penetrating the SPRT.

High-purity, high-density graphite can be used as a substitute, but because it oxidizes easily at high temperatures, it should be enclosed in a fused silica vessel with an argon atmosphere.

Next time you buy an SPRT ask how the sensor is protected against contamination.

References

1. Li, Xumo et al, A New High-Temperature Platinum Resistance Thermometer, Metrologia, 18, 203, 1982.

2. Marcarino, P. et al, Contamination of Platinum Resistance Thermometers at High Temperature through Their Silica Sheaths, Metrologia, 26, 175, 1989.

3. BIPM, Supplementary Information for the International Temperature Scale of 1990, 88, 1990.

End

Calibration Uncertainty Problem

Here's an uncertainty problem for you to think about. Our data give the individual uncertainty components present in a typical PRT comparison calibration procedure. The procedure uses a secondary PRT and a readout device (with an internal standard resistor) as the reference instruments. The readout is used to measure both the reference thermometer and the unit under test. This is repeated 5 times and the average is taken. Some of the uncertainty components have been evaluated statistically, others have not.

Source Uncertainty

Reference readout 0.002 °C (instrument spec)

Reference PRT 0.0150 °C (calibration uncertainty)

Calibration bath stability 0.0035 °C (standard deviation)

Calibration bath uniformity 0.0025 °C (standard deviation)

Can you:

1) Categorize the source uncertainty as type A or B according to current ISO methods,

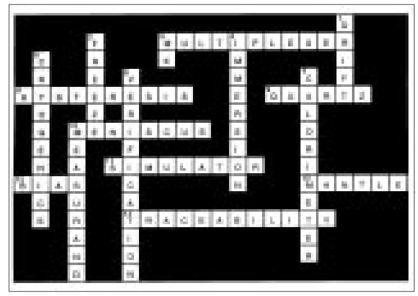
2) Combine the type A's and then the type B's properly,

3) Combine the type A's with the type B's for a combined standard uncertainty, and

4) Determine expanded uncertainty using a coverage factor of 2?

Solution on page 11

They were having a sale on the 10-karat fixed-point, so I got you one.



Solution to previous Random News' crossword puzzle which was published in issue number three in 1921.

New Fast Start Cooler Now Available

Refrigerated calibration baths can now reach their extreme low temperatures up to five times faster. Hart's new Fast-Start Cooler easily connects to your LN_2 source and fits into your Hart bath lid's fill hole to speed up your temperature changes and increase your productivity. We've even added a "silencer" to keep your lab quiet while the Fast-Start Cooler runs.

Everyone knows Hart makes the world's most stable calibration baths. We also provide the tools you need to maximize your efficiency. Call us and find out how a Fast-Start Cooler can help improve your work.

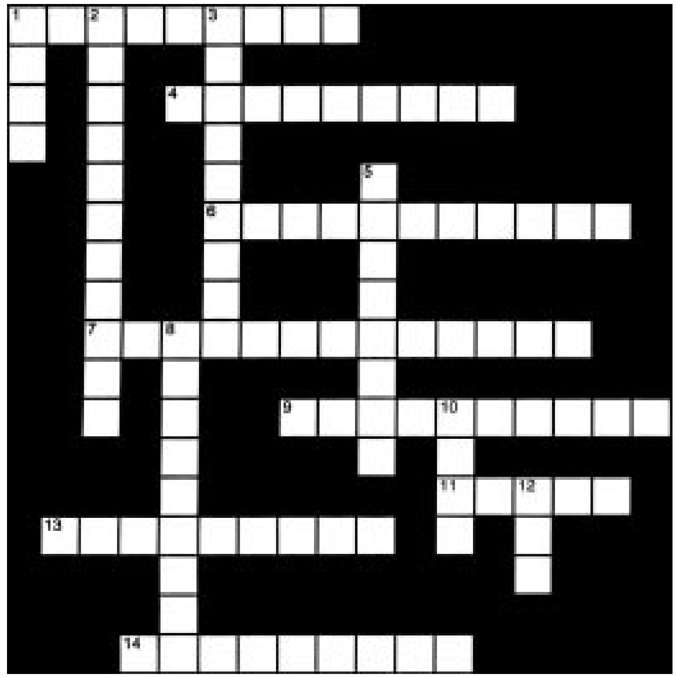
Crossword Puzzle

Across

1. The temperature depression below the freezing point of a reference material in the supercooled state (or wearing your pocket protector on the golf course).
4. The ideal source of thermal radiant power having a spectral distribution described by the Planck equation.
6. The probability of performing without failure a specified function under normal conditions for a period of time.
7. The selection of the nearest graduation when a measurement lies between.
9. A device that produces a measurable output as a function of temperature.
11. Temperature coefficient of resistance of a PRT over the range of 0 to 100°C.
13. Any constant, with variable values, used as a referent for determining other values.
14. Science of weights and measures.

Down

1. Home of the finest primary standards equipment available and also home of one of the nine quietest places in the world.
2. A gradual impairment in ability to perform.
3. To determine the indication or output of a measuring device with respect to that of a standard.
5. Error caused by apparent shifting of objects when viewing position is changed.
8. The limits of the range of values that apply to a properly functioning measuring instrument.
10. The algebraic difference between the upper and lower range values of an instrument.
12. Convenient expression of small fractions and percentages.



Temperature Calibration Training Courses

Hart Scientific now offers four different training courses at our manufacturing facility located next to the luge run for the 2002 Olympic Games. Each course is offered twice a year and each of them has lots of demonstrations, hands-on work, and instruction in temperature calibration theory. Each course is designed for a different level of calibration work. The four classes cover the spectrum from industrial calibrations to ITS-90 fixed-point work with SPRTs and noble-metal thermocouples.

Tom, Rick, Mike, Xumo and Randy. Can you ask them a question at one of our seminars they can't answer? If you can, we'll pay you $50. No one has stumped this band so far.

Our staff of instructors includes some of the most knowledgeable and experienced people in the industry. They have managed temperature labs, consulted with national metrologists around the world, performed cutting-edge research, and published articles in respected journals. They also design some of the finest calibration equipment in the world.

At our ITS-90 seminar you have a chance to win $50 cash if you can stump these guys with a difficult calibration question. Nobody has done it yet! But you're welcome to try. Call us today for a schedule of upcoming seminars. Register early—all of our previous classes have been filled long before the class date. *End*

Calibrate-*it* Software Review

Would you like software that actually automates the complete calibration process?

Hart's new Calibrate-*it* software will calibrate your temperature sensors unattended. It works evenings, holidays, weekends—anytime. It doesn't care if you're sleeping, sun-bathing or having a beer.

This software reads any of Hart's thermometer readouts (such as the Black Stack or Super Thermometers) and talks to virtually any combination of our temperature sources.

Calibrate-*it* will calibrate SPRTs, RTDs, thermistors and any type of thermocouples—up to 96 in any combination—simultaneously. All it requires is a few minutes of your time to tell it exactly what you'd like done. With a menu-driven, Windows™ interface, it's fast and easy.

Calibrate-*it* automatically creates calibration reports that conform to the requirements of ANSI/NCSL Z540-1. With optional Generate-*it* software you can automate the calculation of sensor coefficients for ITS-90, IPTS-68, Callendar-Van Dusen or polynomial equations.

Check out some of the comments we've received recently from Calibrate-*it* users. If you're still not sure, call us. We'll send you a demo disk and you can decide for yourself! *End*

"We use the software at a test stand to calibrate RTDs in batches from 1 to about 8. It works well to set the temperatures with the software and test various probes simultaneously and automatically. It helps make our work more accurate." *Frank Steinberg*

"It has improved our work immensely. Before this we were manual. It controls our baths and our Black Stack so we can test multiple probes at the same time. We would definitely recommend it." *Paul Sisson*

"It's easy to install and operate. I'm happy with it. It definitely has the competition beat." *Wayne Hutchinson*

Temperature Calibration Professionals and Calibrate-*it* users.

To the Point

News on fixed-points and primary standards development

Do you think 0.00025°C is accurate? What about inexpensive and easy to obtain? Hart's new Super Thermometer II gives you 1-ppm accuracy and great software features that are easy to use for 60% less than the cost of a bridge.

Read temperature directly in degrees C, F or K, or take readings in ohms or resistance ratios. Store sensor characterizations in memory for easy recall, or see the stability of your standards on a full-color LCD display that tilts to your favorite viewing angle. Connect and disconnect your sensors or resistors quickly with Hart's DWF connectors (patent pending) instead of hassling with binding posts. Read up to 50 sensors at a time with additional multiplexers.

Best of all—because it's a Super Thermometer II—nothing else anywhere in the world is this accurate and this easy to use for this price. Nothing! Call us today for more information—1-800-438-4278.

Solution

1) Type A's:
Calibration bath stability
Calibration bath uniformity
Type B's:
Reference readout
Reference PRT

2) Type A's use RSS method of combination

$$= \sqrt{0.0035^2 + 0.0025^2} = 0.0043$$

Type B's assume rectangular distribution then combine using RSS method (the reference readout is used twice).

$$= \sqrt{\left(0.002/\sqrt{3}\right)^2 + \left(0.002/\sqrt{3}\right)^2 + \left(0.0150/\sqrt{3}\right)^2} = 0.0088$$

3) Combine using RSS method

$$= \sqrt{0.0043^2 + 0.0088^2} = 0.0098$$

4) Simply multiply the combined standard uncertainty by the coverage factor

$$= 0.0098 \times 2 = 0.0196$$

Calendar of Events

Hart Scientific Seminar
Temperature Metrology — *May 13-15*

Sensors Expo
San Jose Convention Center — *May 19-21*

Hart Scientific Seminar
Industrial Temperature Calibration — *June 8-10*

NCSL
Albuquerque Convention Center — *July 19-22*

Hart Scientific Seminar
ITS-90 Realization Workshop — *Aug.10-13*

Hart Scientific Seminar
Realizing ITS-90 — *Sept.14-16*

Sensors Expo
Chicago Rosemont Convention Center — *Oct.6-8*

ISA Expo
Houston Astrodome — *Oct.19-22*

Hart Scientific Seminar
Temperature Metrology — *Nov.16-18*

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JIM *continued from page 1*

Like all of our previous issues (which are now considered collectors' items) this one is filled with interesting information about temperature calibration, a new crossword puzzle, a new myth busters column, a temperature calibration cartoon and one mindless article, specifically this one.

Every time we write an issue of Random News we really enjoy it, and we hope you like reading it as much as we liked writing it. Perhaps next time an urge comes upon some of us to do the next edition of our calibration rag, we won't let someone else talk us into waiting until we're done with something else. After all, we do have subscribers which implies they have something to subscribe to. (Subscriptions are free, however.)

By the time you've read this, you should have gotten our new 1998 catalog that was supposed to have been published in 1997. It's filled with new products, new articles and a variety of other items to catch your attention. It's the best catalog we've ever done. Not only is it a convenient way of buying from us directly, it contains a variety of reference information you'll want to keep.

So with the new trade show booth done, *Random News* published, and the catalog finished, what's left to do? How about fixing our web site? Yes, we've got a new web site. Right after we had finished drawing a temperature calibration cartoon for *Random News*, we put our crayolas away and started talking management stuff. One topic of conversation was the fact that every company in the entire world was working on a web site, so naturally we started working on one too!

Now as you might expect, the first web site we did really sucked. But that didn't deter us from our quest of having the absolute best web site in the world. And we're getting closer. We have our new web pages up and running now. So get ready for the best cyber version of temperature calibration around.

It sure looks like we're going to have a lot of free time on our hands by the beginning of July. *End*

MYTH *continued from page 5*

The size of a thermistor bead is also considerably smaller than the size of a PRT. In a stainless steel sheath, the thermistor is much less affected by stem-conduction than a PRT. In many applications a large PRT probe is simply too large. For example, the testing or calibration of biomedical devices and analytical instruments frequently requires a sensor smaller than even the bare PRT element, not to mention its tubular packaging. Off-the-shelf thermistor standards are available in diameters of only 0.07" with small gauge leads. Tremendous flexibility is possible in custom packaging thermistors for surface, air and liquid measurements.

While Hart manufactures reference PRTs and SPRTs, we do not make thermistors. Still, we feel it's important to promote their virtues because their unique advantages can contribute significantly to metrology and calibration work. For this reason, each of Hart's thermometer readouts is available with the ability to read thermistors. When you're considering the purchase of a readout, check into the possibility of reading thermistors. If the salesman tells you a thermistor isn't a good standard, you've just had a good indication of the company's credibility. *End*