

Random NEWS

Vol.1 - Number 2
Summer 1995

An occasional
publication of

**HART
SCIENTIFIC**

Making the Heart Beat Faster



James C. Triplett,
Chairman, CEO

It's time again for Random News and it comes on the heels of our new 1995 Temperature Calibration Catalog.

Every time I help design and write a new catalog it reminds me of how much I like my job. This year's catalog is over 140 pages with literally hundreds of products designed and manufactured by Hart Scientific. Temperature calibration really is a combination of art and science. It's never dull, and it affords us many opportunities to produce new and interesting instruments.

In fact in this issue of Random News, we're introducing a new instrument we've almost named *The Black Stack*. It's a unique thermometer that combines cutting edge electronics, innovative software and 90's industrial design. This product represents some of the things I like best about Hart Scientific.

Truly new products are more than trivial improvements over another company's widgets. Temperature calibration product leaders should produce instruments that keep customers awake and excited with anticipation over what's next. Leaders should get the customer's attention and make their hearts beat faster. It's this endeavor that makes showing up for work rewarding.

See **Jim** on page 12

Producing the Highest Level of Accuracy from Standard Platinum Resistance Thermometers

by Xumo Li,
V.P. Technology Development
Director of Metrology,
Hart Scientific

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 resis-

See **SPRT** on page 2

SPRT from page 1

tance 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 1.1mK 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 7.5mK in temperature. On the other hand, the change in the resistance ratio,

$$W(961.78^{\circ}\text{C}) = R(961.78^{\circ}\text{C}) / R(0.01^{\circ}\text{C})$$

was within 1 PPM (a change of 2mK 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 1mK in temperature at 962°C (see Table 1).

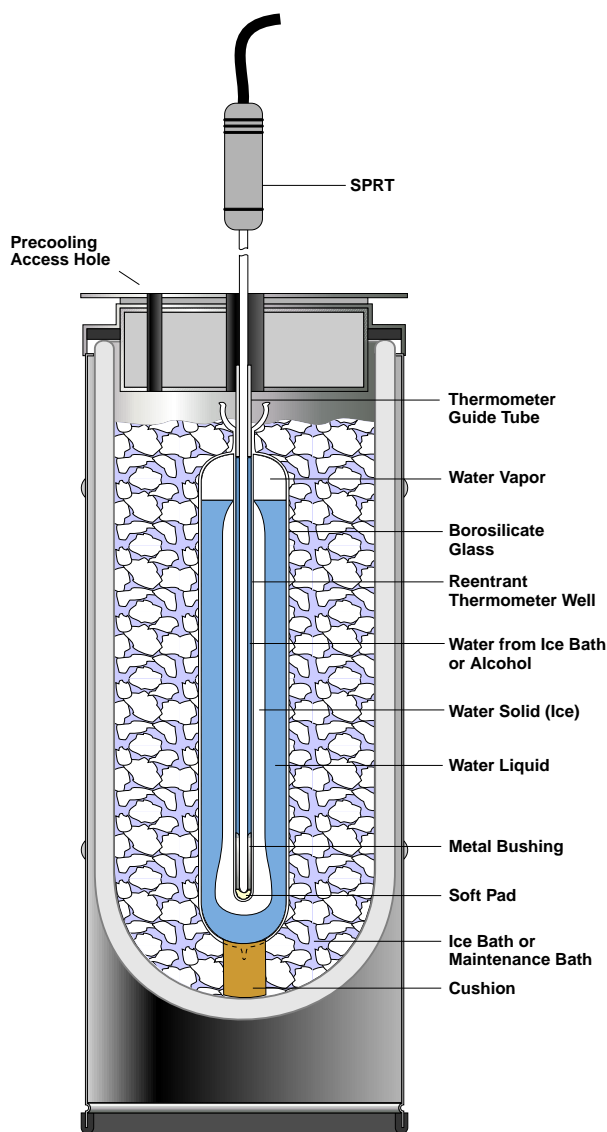


Table 1 The equivalent temperature error caused by an error in resistance measurement

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

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 uncertainty, the stability of the SPRT, the measuring temperature range and the working conditions. If the required uncertainty is 1mK or so, R_{tp} measurement should follow each R_t measurement. If accuracy requirements are 20mK 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 30mK.

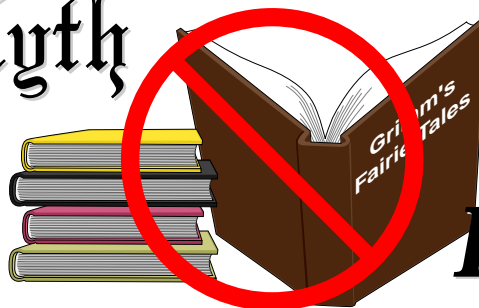
Can the R_{tp} given in the “NIST Calibration Report” be used to calculate the ratio?

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.

See SPRT on page 11



Myth



Busters

Myth: Metal Sheathed SPRTs are less delicate than Quartz Sheathed SPRTs.

Seems logical. Quartz breaks easily!

SPRTs are some of the finest measuring instruments in the world, and also some of the most delicate. An SPRT costs anywhere from \$2,900 to over \$6,000 and that's before it's calibrated. Calibration adds another \$1,200 to \$4,000 to the initial price of the instrument. With a total investment of \$10,000, it's easy to understand why durability is an issue.

When buying an SPRT, most customers face a choice between metal sheathed and quartz sheathed instruments. Quartz sheathed probes *look* delicate, metal sheathed probes do not. But as you might guess, looks can be deceiving.

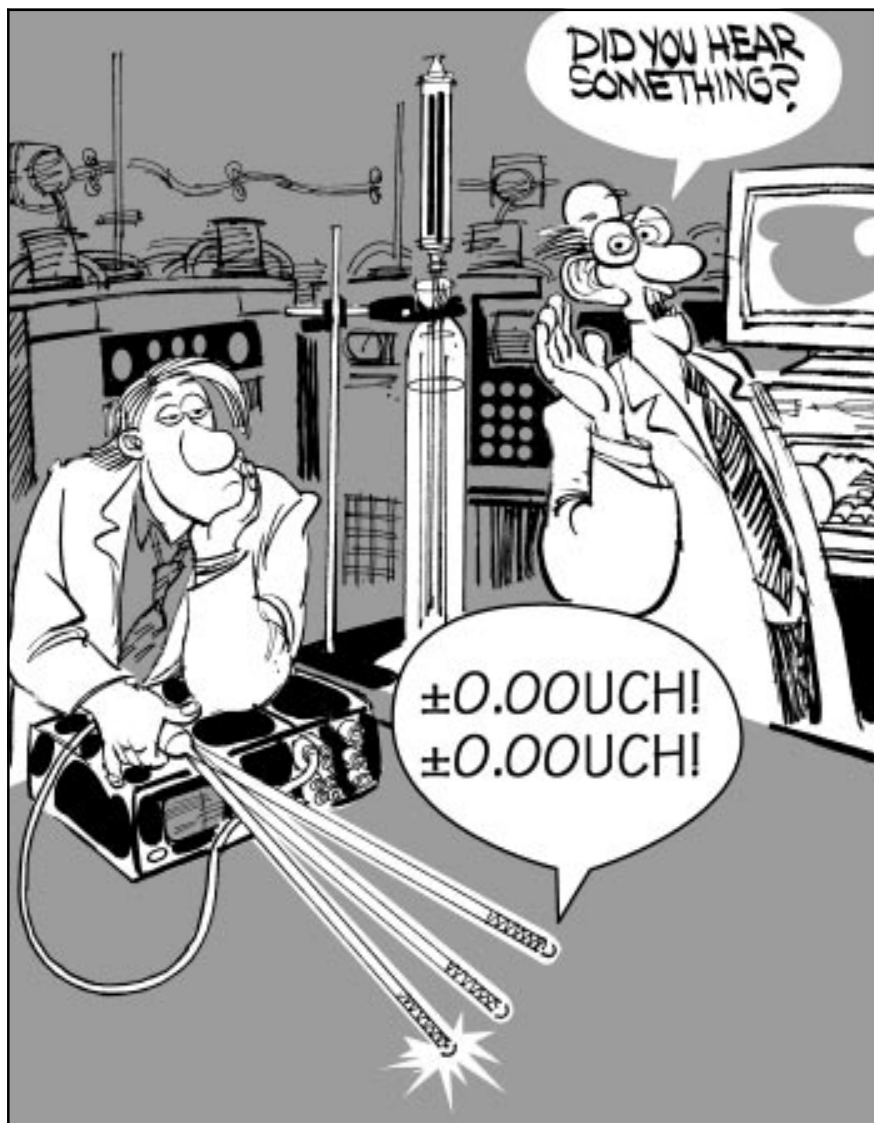
Most metrologists know SPRTs experience a change in calibration when subjected to mechanical shock. This potential for calibration change is the same in both quartz and metal sheathed probes. Simply put, you should never drop, tap, bang, vibrate or mechanically shock either type of probe for any reason. If you do, you automatically change the calibration of the probe in an indeterminate way.

In most instances, a blow to an SPRT sufficient to change its measurement accuracy is not a significant enough blow to break a quartz sheath. So is a quartz sheath more delicate than a metal sheath? In a strict sense, of course it is. But in the practical sense, because a quartz sheath looks more delicate than a metal sheath, it's often treated with more respect, care and attention. In reality quartz probes actually get bumped less often than metal probes. The quartz is a visible reminder of how much caution is necessary when handling SPRTs.

In specific applications such as use in the metal blocks of dry-wells, metal stem probes are easier to insert and remove than quartz probes. Quartz scratches and can't endure any torquing without cracking, so it has its disadvantages.

When an SPRT is going to be handled by more than one person, the quartz vulnerability is actually its strength. It serves as a constant reminder of both the precision and delicacy of the instrument.

End



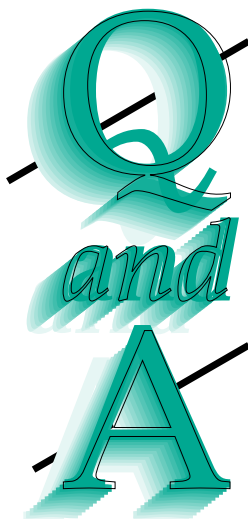
To the Point:

This new feature will keep you posted on current developments in Hart's research and manufacturing of fixed point cells and other primary standards.

The Gallium Melting Point cell is now in regular production in our Pleasant Grove facility. Lab tests confirm that a melting plateau of one week is possible while using a Hart 7012 bath to maintain the cell at the correct temperature. Other commercial cells and apparatus normally provide a plateau of only a few hours. Hart's significant increase in plateau stability provides convenience and saves hours in SPRT calibration time. Call us for more details on this cell and the bath needed to maintain it.

End

Hart Scientific
P.O. Box 460
Pleasant Grove, UT 84062
1-800-GET-HART
1-800-438-4278



IEEE-488 vs. RS-232. Which do I use?

The most common way computers connect to external devices is through an RS-232 connector. They're generally referred to as serial ports and are used to connect mice, modems or other devices to a PC.

However, in the world of instruments, and especially with automation, an RS-232 is only one of two popular communication options. The other is the IEEE-488 (GPIB) port. Both create communication links to PCs, but each

has its strengths and weaknesses. In this Q & A section of Random News, Bryan Cowley, Hart's customer service specialist answers some of the most common questions we get regarding IEEE-488 and RS-232 ports.

1. *How many instruments can I control from a single PC with each type of port?*

A normally-configured PC almost always comes with two serial (RS-232) communication ports. Each RS-232 port controls only one instrument, so you'll need one port per device. However, you can add additional RS-232 boards to any PC with open slots.

The IEEE-488 interface is a parallel communication system which allows multiple devices

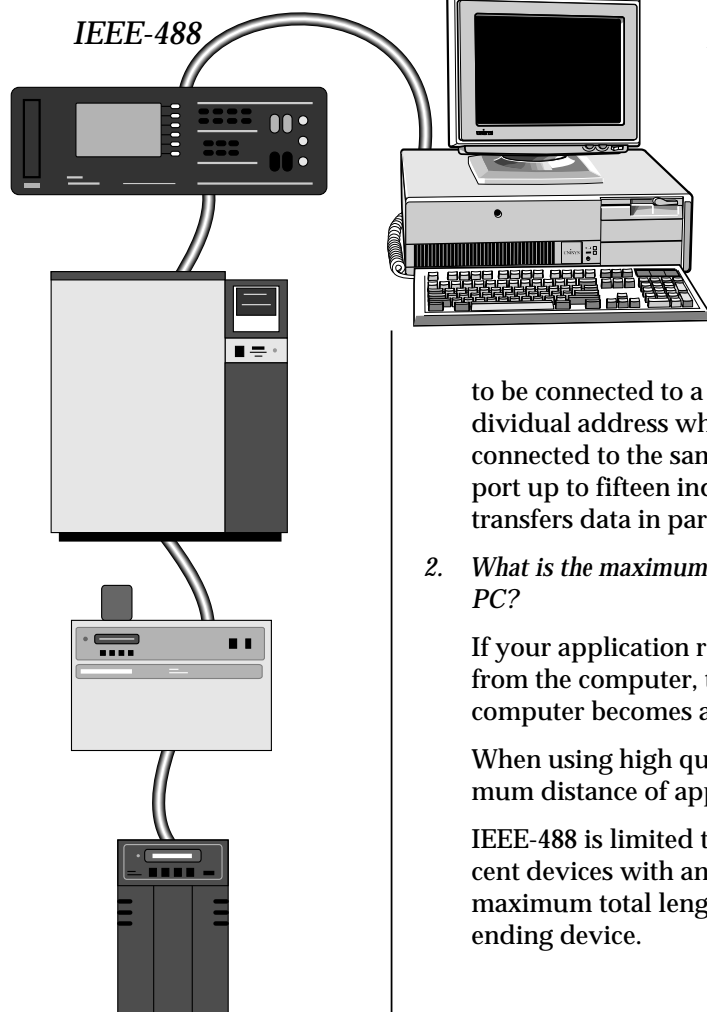
to be connected to a single port and cable. Each device is given an individual address which separates it from all the other instruments connected to the same port. Typically, a single IEEE-488 port can support up to fifteen individual devices. Also note that since IEEE-488 transfers data in parallel, the system is much faster.

2. *What is the maximum distance that the equipment can be operated from the PC?*

If your application requires the equipment to be out of arm's reach from the computer, the total distance between the instrument and the computer becomes a factor in the communication process.

When using high quality cables, RS-232 ports are effective for a maximum distance of approximately 50 feet.

IEEE-488 is limited to approximately 12 feet between any two adjacent devices with an average separation of approximately 6 feet and a maximum total length of approximately 60 feet from beginning to ending device.

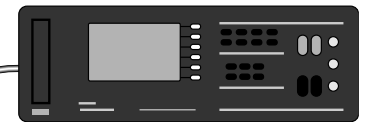
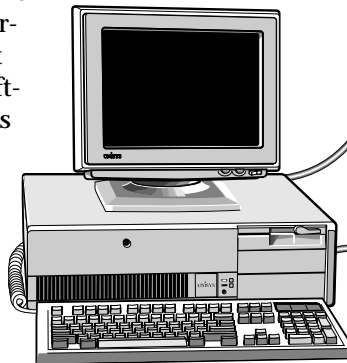


3. *What software can be used to control the equipment?*

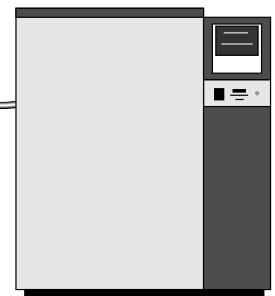
Serial communication software comes in many forms and may already be installed on your computer. For example, Windows™ comes with a serial communications package included. Since the RS-232 protocol has been standardized, it is simple to switch between serial communications software if needed. Windows, however, only provides the basic communication instructions between a device and an RS-232 port. Most instruments require additional software code to provide the specific communication needed to automate it.

While most PCs come equipped with at least one serial port, IEEE-488 interface cards must be purchased separately. All IEEE-488 cards require driver software, and driver software varies with the manufacturer of the interface card. IEEE driver software does not have a standard protocol like RS-232 software. This raises compatibility questions between IEEE drivers and operating software packages. Sometimes this is not an easy problem to resolve.

In addition, because IEEE-488 is a more complex system, changing between different IEEE-488 systems from different companies requires a learning curve that may not be pleasant.



Serial RS-232



4. *Who will be responsible for maintaining the communications system?*

Most companies have people with RS-232 and IEEE communication expertise. Unfortunately those people may not be responsible for maintaining your system. You should choose your system according to your ability, the number of instruments you need to automate, the number of computers you have available and your tolerance for complexity. RS-232 communications seem to be more straight forward and easier to learn and maintain. When problems occur, or when a piece of equipment is added or changed, customers with RS-232 based systems seem to have an easier time tracking down problems or bringing the new piece of equipment on line.

Those customers that use and like IEEE-488 devices have taken the time to learn their particular system. However, troubleshooting and making changes on these systems can be time consuming, even for these users.

5. *Isn't there a lot more to this than you've explained here?*

You bet there is. Both of these standards are constantly changing. RS-232 is moving closer to IEEE capabilities every year, and new IEEE tools are making it easier to custom program applications, even for novices. However, if you're aware of these new developments and understand them, you could have skipped this Q&A because you already know that nothing in life is ever this simple. *End*

Hart Model 1560—*The Black Stack*

If you need a thermometer that's flexible and changes to meet your needs, we've got one for you.

It reads PRTs, SPRTs, thermocouples, thermistors and more. It supports up to 99 channels and completely replaces a thermometer and DMM combination. It's innovative, easy to use, fast, programmable and re-configurable when your needs change.

If you want a moderately priced reference thermometer to read a calibrated PRT, you simply buy the basic unit and the 2 channel PRT module. The LCD screen will guide you through the thermometer's functions and provide you with all the data you need to an accuracy of 0.005°C with a resolution of 0.001°C .

Over time, of course, your needs are going to change. But what if you've already invested in *The Black Stack*? You've spent your money and your time learning to use it; should you just start over with a completely new instrument? You would have to if you had bought a thermometer from someone else, but the engineers at Hart designed *The Black Stack* to change when your needs change. It's as easy as plugging in a new module. You won't have to take anything apart, change any chips or jumpers or even reprogram your unit. When you plug in your new module, the 1560 automatically reads it, configures itself and changes its LCD information display to the new thermometer you've just created.

Each module is calibrated individually and stores its own parameters and calibration information independently, but all the data is readable from the 1560's display. The unit features a proprietary digital bus which links the units together and requires no calibration of the base unit itself.

Start with a 2-channel PRT/SPRT basic unit for a reference thermometer, and then add more modules to read more reference probes or to read the sensors you're calibrating. If you'd like, stack in the 12-channel thermocouple unit that reads any type of TC and provides its own cold junction compensation, or add a 10-channel PRT module or a thermistor module. Create exactly the type of thermometer you need without having to learn a new instrument, write software or buy multiple pieces of unrelated equipment to get your job done.

The IEEE or RS-232 port connects *The Black Stack* to your computer for complete automation of your calibration work. Why buy a DMM, a scanner and a reference thermometer when one *Stack* does it all? (Compare Figure 1 and Figure 2.)

The competition has to sell you multiple instruments be-

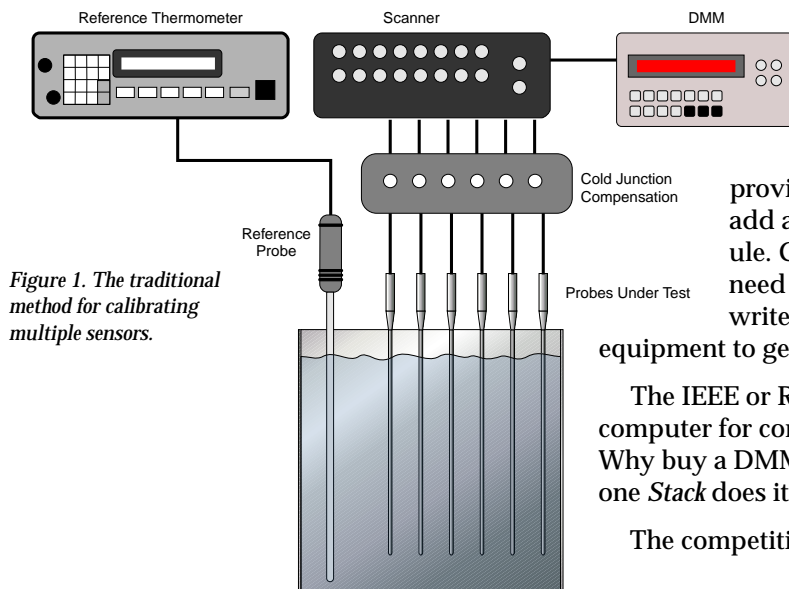


Figure 1. The traditional method for calibrating multiple sensors.

cause they don't know how to build one like *The Black Stack*. Try it, and you'll understand why Hart Scientific is the leader in temperature calibration products.

Call us for more information on shipping dates and pricing. You'll be surprised to learn that you can own *The Black Stack* for less than \$3,500.

End

Name-that-Tune Contest

Did you read about *The Black Stack*? It's an interesting product, so we wanted to give it an interesting name. Can you think of a better name than *The Black Stack*? Want to try?

If you can come up with a better name than *The Black Stack* and we decide to use it, we'll give you the 1560 thermometer as your prize, only it won't be called *The Black Stack* anymore. And we'll put a brass plaque on it giving you credit for the new name. Follow a few simple rules and you can win.

Rules you have to follow to win.

Rule 1. We pick the winner.

Rule 2. No matter what your mother told you, winning is the only thing that counts; second place doesn't get you anything in this contest.

Rule 3. All the submitted names become our property. You can't take them back, copyright them, get paid for them or receive anything else that resembles compensation other than the thermometer we promised you, if and only if, you win. However, you can show your names to your family, brag about them to fellow employees or whine about not winning if you want to.

Rule 4. If you're an employee of Hart Scientific or an affiliated company, we keep the instrument and give you the brass plaque.

Rule 5. Rules 1-4 are really important, so read them one more time and then follow them.

The Black Stack is described on page 8 of this newsletter. Study those features, contemplate the shape and create the new name. You have until October 1, 1995 to get your entries in, but don't wait because if we choose a name that's been submitted by more than one person, we're going to award the prize to the first entry we received having the winning name.

All entries must be sent to us in writing. We can't accept entries by phone, unless of course it's a fax which is a phone entry in writing. (Boy, this is tricky stuff.) You can enter as many times as you like, but you must submit a separate entry for every 100 names you send in. We get tired of reading after every 100 names or so.

Don't delay—take a week off and get started now.

End

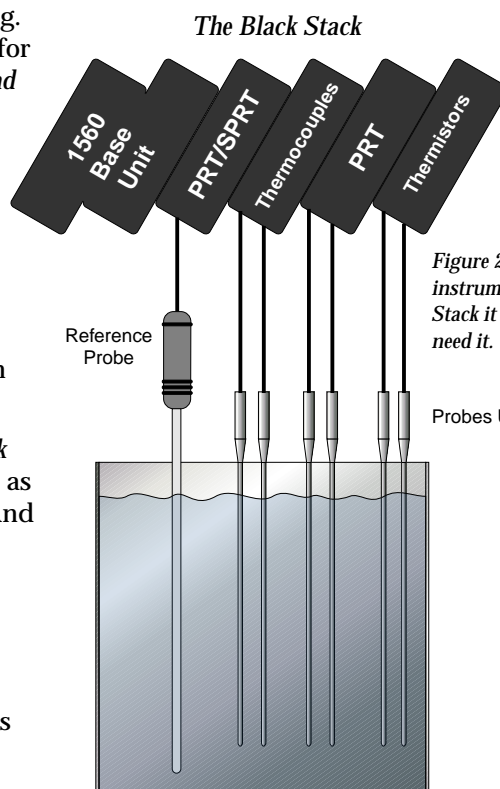


Figure 2. One instrument does it all. Stack it the way you need it.

Probes Under Test

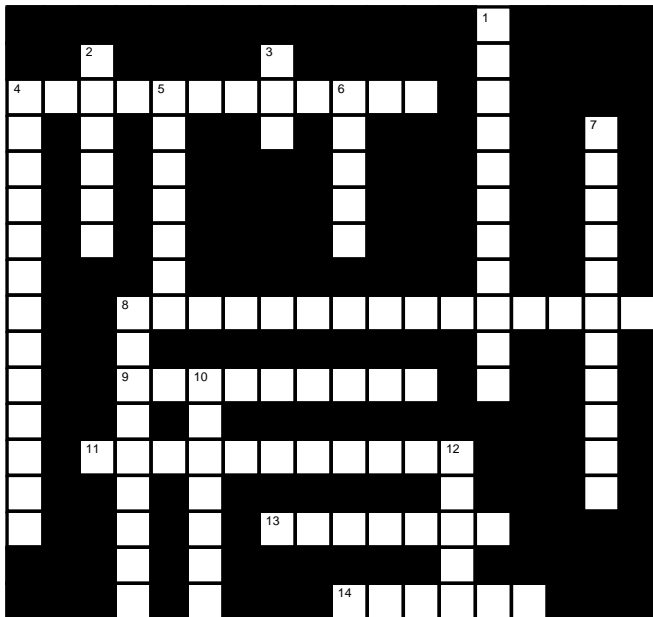
Crossword Puzzle

Across

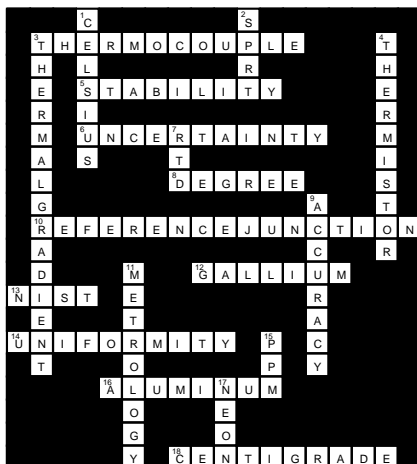
4. Factors used in linearization of an RTD
8. Decomposition of glass and quartz materials
9. Property of resistance to flow in a fluid
11. Comparison of a known to a lesser unknown
13. Portable temperature calibration source
14. High temperature standard platinum resistance thermometer

Down

1. Document associated with a calibration
2. International temperature unit starting at -273.15°C
3. Liquid in glass thermometer
4. Introduction of impurities to an SPRT
5. High temperature calibration source
6. European accreditation agency (UK)
7. The measurement of temperature
8. Departure from a known value
10. Violently _____ fluid bath
12. US accreditation agency



Solution to last issue's crossword puzzle.



New Faces

Mike Jerman recently joined Hart as Manager, International Product Sales. He has 7 years of international experience as an applications engineer in the process instrument industry. His educational background includes a BS in mechanical engineering and an MBA. If you're one of our many customers outside the U.S., contact Mike anytime to discuss your calibration needs.



*Mike Jerman, Manager,
International Product Sales*

New Places



We're still working on the building. It's going a little slower than we had hoped; however, some people are in a hurry to move in. Everybody wants a window!

SPRT, *from page 3*

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 1mK. 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. *End*

Our Cupboard is Bear of Puns

These two entries in the Hart bear pun contest each received five dollars. If you missed out, here's another chance.



Enter Hart's new bear pun contest. If we use your pun in the newsletter we'll send you \$5. Here's three puns to start your thinking:

Is this a bear thermistor probe?

This SPRT's going to be a bear to calibrate.

I'll bet this one bearily works.

Our two entries:

The **Bear** facts on fixed point cells is the **Hart** of temperature calibration.

Richard Doke, Wyle Labs

Don't try to calibrate that SPRT. Just dig a hole and **beary** it!

Ken Hawblitz, Upjohn

(Okay, Ken, this is pushing the definition of a pun but we're sending you \$5 anyway.)

If we publish your pun in the next newsletter we'll send you five bucks too! *End*

Inside

Heart Beat.....	1
SPRT Accuracy	1
Myth Busters.....	4
To the Point.....	5
Q&A	6
New Product	8
"Name that Tune".....	9
Crossword Puzzle.....	10
New Faces, New Places..	10
The "Bear" Facts.....	11

Solve Our Calibration Cost Problem!

In our last newsletter we printed the following "cost of inaccurate temperature measurement" problem submitted by Burns Engineering:

Inaccurate sensors—their surprising cost!			
Given		Determine the correct answer.	
Process Fluid	water	The approximate annual cost of energy per degree Fahrenheit of error. (select one)	1. \$13 annually
Flow Rate	100 GPM		2. \$56 annually
Control Temp	100°F		3. \$423 annually
Energy Cost	2.9¢ per KW-HR		4. \$3693 annually

Burns Engineering has submitted the following solution to the problem:

1. Calculate the flow rate in pounds per year:

$$\frac{100 \text{ Gal}}{\text{Min}} \times \frac{1 \text{ ft}^3}{7.481 \text{ gal}} \times \frac{61.9 \text{ lb}}{\text{ft}^3} \times \frac{60 \text{ min}}{\text{Hr}} \times \frac{24 \text{ Hr}}{\text{day}} \times \frac{365 \text{ days}}{\text{year}} = \frac{434,896,939 \text{ lb}}{\text{year}}$$

2. Calculate the energy used to raise this mass one degree Fahrenheit:

$$\frac{434,896,939 \text{ lb}}{\text{Yr}} \times \frac{1 \text{ BTU}}{\text{lb-}^\circ\text{F}} \times \frac{1 \text{ KWH}}{3412 \text{ BTU}} = 127,461 \frac{\text{KWH}}{\text{Yr-}^\circ\text{F}}$$

3. Determine cost of energy:

$$127,461 \frac{\text{KWH}}{\text{Yr-}^\circ\text{F}} \times \frac{\$.029}{\text{KWH}} \approx \$3,696 \text{ per year per } ^\circ\text{F} \quad \text{End}$$

Jim, from page 1

I never want Hart Scientific to become a company that simply copies other people's instruments. I don't want us to copy their products, their catalogs or their newsletters. At Hart we strive to create meaningful value in everything we do—and meaningful value goes beyond simple specs. It means designing and developing instruments that do the job in an efficient, effective and productive way. It means saving you time and frustration while producing the best possible measurements. Too many companies forget that it's the overall customer experience that counts, and not just the advertised specs.

Innovation takes courage, skill and a sense of humor. So when companies fail to innovate, I always wonder what's missing. Maybe it's their sense of humor.

We'll keep working on new products that hopefully keep your hearts beating faster—along with ours.

Jim

P.S. Don't forget to play our new "Name-that-Tune" contest. Beat us at our own game and we'll give you a great prize sure to let everyone in your organization know how creative you are. End

Random News is published at
random intervals by
Hart Scientific, Inc.
All correspondence should be
addressed to:

Hart Scientific
P.O. Box 460
Pleasant Grove, UT 84062

Tel: 801-785-1600
Fax: 801-785-7118