PENTRONIC Skandinavia's leading manufacturer of industrial temperature sensors

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PENTRONIC NEWS

It's all about temperature!

TRACEABLE MEASUREMENT IS THE BASIS FOR AUTOMATIC QUALITY ASSURANCE AT ICU SCANDINAVIA

CONTINUED ON PAGE 2

Watch the temperature!

After a well-deserved summer holiday and some recovery time it's now full-speed ahead again here at Pentronic. The demand for our products and services has never been greater. While we regard this as proof of our efforts to supply first-class products, it can unfortunately impact our customers in the form of longer delivery times and a lower service level. To rectify this, we worked intensively this summer to increase our capacity via investments in new machinery and by hiring and training new employees.

In this issue of *Pentronic News* we focus on another of our strengths, expertise. Several of the articles discuss calibration and the importance of keeping a watchful eye on process parameters. In more and more sectors we are seeing increasing demands for traceability to internationally recognised standards. The main standard relevant to our work is ITS-90, the international temperature scale.

I hope you appreciate the temperature school that is included in each issue of *Pentronic News.*

Rikard Larsson
MANAGING DIRECTOR

TRACEABLE MEASUREMENT IS THE BASIS FOR AUTOMATIC QUALITY ASSURANCE

More measurements and measurements that are automatically traceable.

That is the result of apps and algorithms taking over previously manual monitoring tasks.

"In addition, temperature sensors and other sensors must also increasingly often be customised for their specific measurement task," says Per Hammargren of ICU Scandinavia.

ICU SCANDINAVIA is located just north of Sweden's capital, Stockholm. The letters ICU mean "I See You". The company develops, installs and maintains automatic systems for quality assurance. Originally it supplied alarm systems to small companies and did development work for manufacturers of medical devices.

"In 1998 we were commissioned by the Sahlgrenska University Hospital in Gothenburg and the University Hospital in Linköping to develop a wireless monitoring system for laboratories," Per says. "After the work was done they wanted to sign maintenance contracts."

That led the company to move from providing consultancy services to developing its own products. The original monitoring system has been developed into a sophisticated quality assurance system called Boomerang. Its customers are found around the world, with laboratories in medical premises and fertility clinics being the biggest sector.

"Temperature is one important quantity but we also measure and document carbon dioxide, air humidity, air-borne particulates, fluid levels and more," he adds.

The demand for traceable measurements is constantly increasing. ICU's system ensures that measurements are documented.

"Pentronic trains us in temperature measurement once a year so we can stay at the top in a field that's important to our customers," says Per Hammargren, ICU Scandinavia. Right: Michael Steiner of Pentronic.

The sensor, a special version made by Pentronic, supplies digital signals to nodes in the wireless temperature measurement system Boomerang.

This is important everywhere but not least in fertility clinics, where a lot of emotions are involved and the result is not always what a childless couple had hoped for. Then the laboratory must be able to prove it did everything right.

"In our turn we must take the correct measurements, and this places ever-higher demands on our sensors, especially for temperature," Per says.

ICU Scandinavia is a small company with complex products. That is why it has a network of specialists with cutting-edge expertise in their respective fields. Pentronic is ICU's partner for temperature and supplies not only customised temperature sensors but also knowledge.

"Pentronic gives a course for our entire organisation once a year so that we can keep our knowledge at a peak level and can discuss things that have arisen over the preceding twelve months."

Many customer-unique sensors have been developed for special tasks. One of them is a fully digital sensor that is connected to the wireless nodes with modular connectors. The signal is digital all the way, which means that no more errors can be added after the signal leaves the sensor.

"The sensors are calibrated at delivery. We also have our own routines for field calibration that we've developed together with Pentronic," Per says.

In addition to digital sensors, ICU Scandinavia also uses conventional temperature sensors when a larger measuring range or a different mechanical construction is required, and then Pt 100s are the main choice.

The other product from ICU Scandinavia is called Coolguard and is designed for large commercial kitchens. In terms of measurement technology it is not as complex as its counterpart for laboratories but the functions are all the more more advanced. The system logs temperatures in environments like fridges and freezers, warns if doors are left open and so on. It also sends alerts to whoever is on duty at a particular time. All the statistics are accessible in real time via a mobile app.

But it all begins with the measurements, and for that ICU Scandinavia chooses to partner with the specialists in the relevant fields.

"The demand for traceable measurements and for minimising human errors is constantly increasing, and thereby so is the need for our products. That's why we see a positive future for us here at ICU Scandinavia – both in Scandinavia and in the rest of the world," Per concludes.

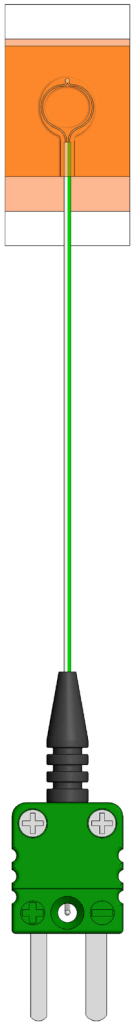
PRODUCT INFORMATION

www.pentronic.se

SURFACE TEMPERATURE SENSOR WITH SELF-ADHESIVE FOIL

Pentronic presents a thermocouple for measuring surface temperature with a measuring tip equipped with self-adhesive polyimide foil. The application is temporary or permanent temperature measurements made on flat surfaces or pipes. Common applications are research and development. The flat measuring tip and the thin 0.25 mm wire give a very rapid response time – fractions of seconds. The new sensor model has been developed to be more flexible and to better meet customers' needs for a choice of cable length and connector. The maximum temperature is 180 °C.

If you require a higher temperature resistance for surface temperature sensors with self-adhesive foil, contact Pentronic.



Model 6206000, Built on order

TWO ROUTES TO TRACEABLE CALIBRATION

Measuring a temperature without knowing what measurement uncertainty you have is basically worthless. The technique of linking the measurement uncertainty of an individual sensor to ITS-90 (the international temperature scale) is called traceable calibration. So how can you ensure that each individual sensor is traceably calibrated?

THERE ARE TWO ALTERNATIVES: Do the job yourself with some support from an accredited laboratory or use Pentronic's accredited calibration laboratories to supply the entire traceability.

The traditional method is to do the work yourself but to first have an accredited laboratory calibrate one or more reference sensors. You then use the reference sensor to check your own sensors by using calibration furnaces and baths.

"Previously our main job was to calibrate reference sensors," explains Lars Grönlund, manager of Pentronic's accredited calibration laboratory. "A number of our customers with their own expertise and calibration resources still work this way. But more and more are choosing to contract out the entire calibration process."

This is because the process involves many steps and uncertainties, which must all be documented when you are ensuring traceability yourself. It is not enough just to use a calibrated reference sensor. You must also include in your calculations your own equipment, additional errors in the measurement chain, the measurement environment, and other factors in order to ensure a final measurement uncertainty that is within the desired limits.

If you decide to use Pentronic, you will have the help of laboratories that have long been accredited for doing calibrations in the field. The accreditation means that the laboratory operations are monitored by a Swedish government authority, Swedac, which audits them on a recurring basis. Pentronic has been accredited without a break since 1988 and now has laboratories located in Västervik and Karlstad.

Pentronic's accredited calibration laboratories are increasingly working on site for customers. From left: Andreas Holm, Karoline Haneck, Morgan Norring and Lars Grönlund.

You can find information about the methods, measuring ranges and best measurement ability at the authority's website, swedac.se.

With field calibration, we have basically the same possibilities as in our laboratories, although with greater measurement uncertainty. The measuring range is -80 till +1200 °C.

"The performance depends on where and how the measurements are done. We do measurement uncertainty calculations for every job," Lars points out.

A sensor's true measurement performance will often become optimised when the calibration is done under conditions equivalent to those of the final measuring process. That is why Pentronic often makes customised reference sensors for every job. This gives greater certainty and closer margins than when using standard reference sensors.

The purpose of the calibration is to confine the error within specific margins. At the same time, the calibration means that the measurement performance is improved. Without traceable calibration, the standard for the sensor type is what applies. As an example, according to the standard, the tolerance limit is ±1.5 °C for a type K thermocouple at 300 °C.

"By doing calibration on site at the customer's we can get that down to ± 0.3 °C," Lars says.

In either case, the result is that each individual sensor becomes traceably documented in a way that will satisfy every quality auditor.

Whichever option you choose for traceable calibration, Pentronic is at your service.

"But if you want help with field calibration it's always important to contact us in plenty of time so that we can accept the job," Lars Grönlund concludes.

STRAIGHT FROM THE LAB

A KNOWLEDGE ENGINE FOR PENTRONIC'S CUSTOMERS

Traceability is not the only thing coming out of Pentronic's accredited calibration laboratory. The lab is also a source of expertise within the company.

"The laboratory is an important knowledge engine for all of Pentronic," explains Michael Steiner, a sales engineer at the company who used to work at the lab.

ORGANISATIONALLY, the laboratory is a separate unit directly under Pentronic's managing director. In terms of technology, the lab's operations come under Sweden's national accreditation body, Swedac.

Although temperature might seem to be a simple form of kinetic energy that is by its very nature simple to measure, a constant development process is occurring towards more accurate and certain methods of measurement. An accredited laboratory must keep up to date with the continual flow of new standards and research.

Three of the employees in the sales department began their career with Pentronic in the laboratory. It is also the source of much of the information that the company passes on at its temperature measurement courses.

This top-level quality assurance knowledge means that a customer has competent personnel to discuss any questions with. There is a constant exchange of information between the sales engineers, development and production departments, and laboratories about the customer's application and measurement situation.

SWEDAC ACKREDITERING
0076
ISO/IEC 17025

For Pentronic there are clear advantages of having an in-house accredited laboratory. Perhaps the most important is the temperature knowledge that is spread throughout the company.

The benefits also flow in the other direction. Pentronic adapts its temperature sensors to its customers' measurement needs, which sometimes results in designs that are at the leading edge of technology. This gives the laboratory first-hand information about how the market and measurement technology are developing.

At the same time, customers also become linked up with this continual build-up of knowledge, whether they order calibration services or measurement equipment. The prerequisite for correct measurement is a supplier who is expert in the field and has a deep understanding of the customer's measurement situation.

MEASURING THE OUTDOOR TEMPERATURE

QUESTION ? ANSWER

Questions should be of general interest and be about temperature measurement techniques and/or heat transfer.

QUESTION: We measure the outdoor temperature using a sheathed thermocouple with a diameter of 2 mm and the tip is located 20 mm out from the house wall. Will the air velocity have any influence on the measurement result? When the wind blows it feels a lot colder than when the air is still.

Per J

ANSWER: Here we must distinguish between the act of measuring the outdoor temperature using a passive sensor (the thermocouple) and the body's experience of the same temperature.

If we start with the thermocouple, it measures its own temperature and nothing else. The heat exchange with the air occurs via convection. Heat exchange also occurs between the thermocouple and its surroundings via radiation if the thermocouple and its surroundings (the house, ground, sky etc.) have different temperatures. For example, during the cold months of the year, the outer wall of the house has a surface temperature that is slightly higher than the air temperature. A well-insulated house has a lower surface temperature than a poorly insulated house. This also means that some heat transfer can occur from the house to the sensor via conduction in the sheathed thermocouple.

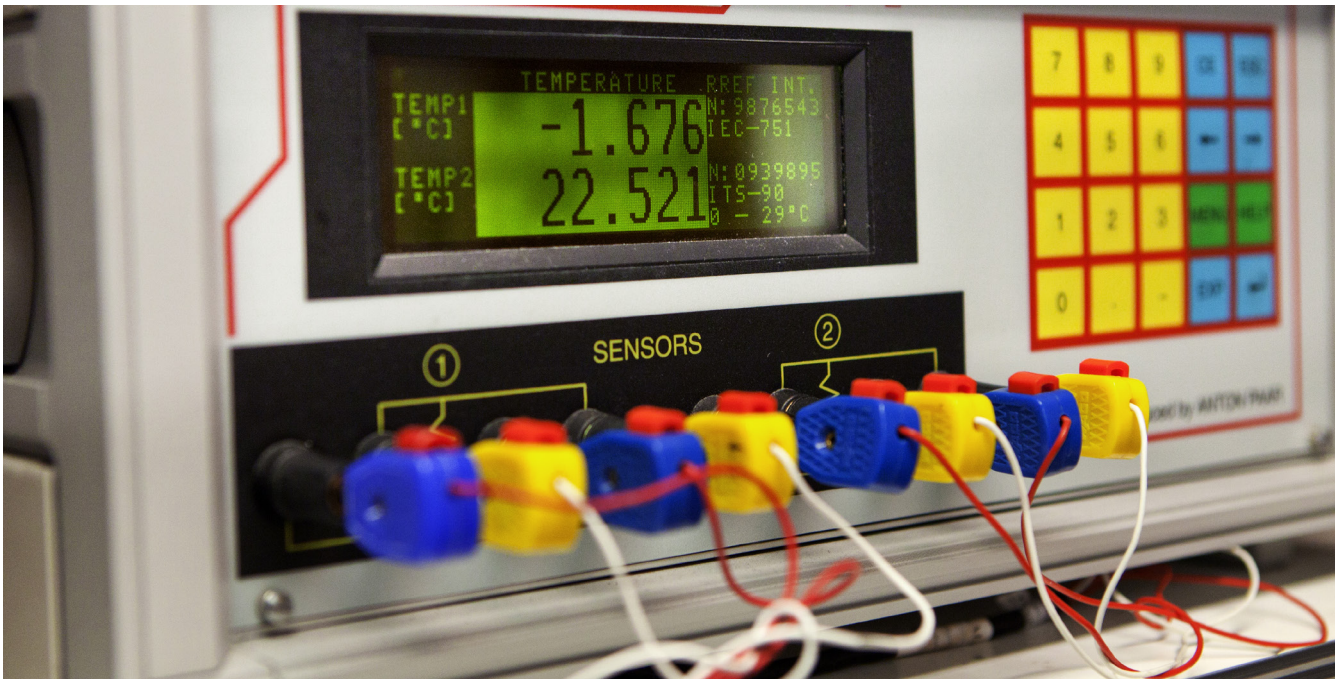
The dominant heat transfer mechanism is convection, and in normal cases the influence of the heat conduction and radiation on the measurement result is very small. The difference between the air temperature and the measured temperature is therefore also very small. If the wind is blowing, the influence of the convection increases and the small temperature deviation that might occur between the air and the sensor becomes even smaller. If you believe that the ambient temperature, e.g. the sky temperature, is deviating from the air temperature, you should first equip the thermocouple with a radiation shield if you want to increase the accuracy. The heat conduction in the thermocouple can be reduced by increasing the distance between the wall and the sensor.

Unlike the thermocouple, the body is an active sensor. Heat is produced in the body and the heat transfer system is complicated. The heat transfer from an unprotected area of skin to colder surroundings occurs via convection and radiation. Corresponding to this heat flow is a heat flow of equal size from inside the body out to the skin's surface, and the heat transfer is controlled by a complex regulating system. When the wind blows, the influence of the convection increases and consequently the heat transfer increases. The air does not become colder when there is a wind, but the increased heat flow makes the body's surface temperature fall and we feel that it has become colder. Moisture transport to and from the body also influences the cooling process and thereby the sensation of cold. Ref 1.

In summary, in normal cases the deviation between the air temperature and the measured temperature is very small. Any deviation caused by radiation and heat conduction is reduced if the wind is blowing.

Ref 1: www.pentronic.se > News > Technical Information > Examples of heat transfer > Does the air get colder when the wind blows? (Pentronic News 2013 #1)

If you have questions or comments, contact Professor Dan Loyd, LiU, dan.loyd@liu.se



After a historical review and the basic theory of heat transfer, it is time to start measuring temperature in Lesson 3.

LESSON 3 TRACEABLE TEMPERATURE MEASUREMENT

In order to be able to measure a temperature you must also know what measurement uncertainty you have. Without that, the temperature measurement is basically worthless.

THE TRACEABILITY CHAIN FOR TEMPERATURE

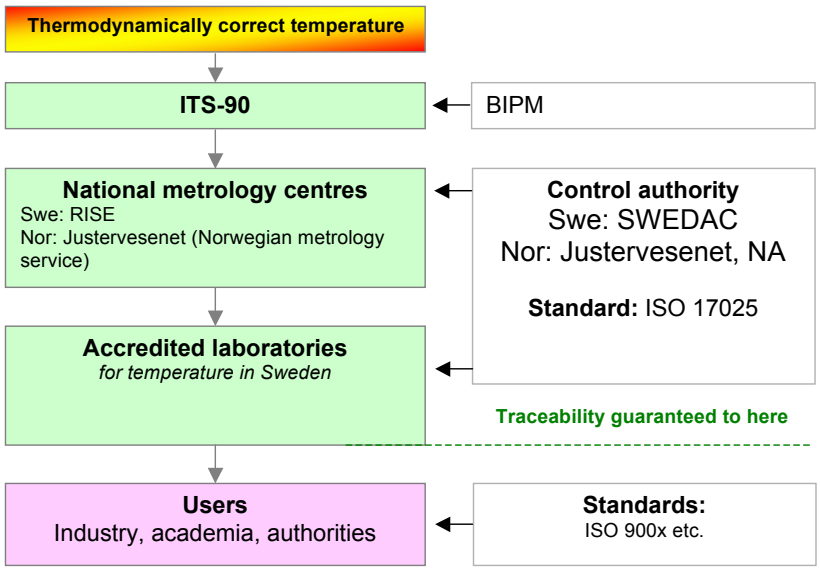
The start of an unbroken chain to the correct temperature begins with ITS-90 (the international temperature scale, set in 1990 by the International Bureau of Weights and Measures, BIPM). In Sweden, RISE (formerly SP) is the national metrology centre for temperature. There accredited laboratories can get their equipment calibrated. The national accreditation body for Sweden, Swedac, ensures that the right equipment, routines and skills exist to maintain the accreditation.

The user then decides how to ensure the traceability to the sensors being used.

GLOSSARY:

Calibration: is a comparison of two measurements made by sensors or measurement systems. One of them has a known uncertainty and the other (made by the sensor or measurement system you want to calibrate) has an unknown uncertainty. Adjusting the sensor or measurement system is not part of the calibration process.

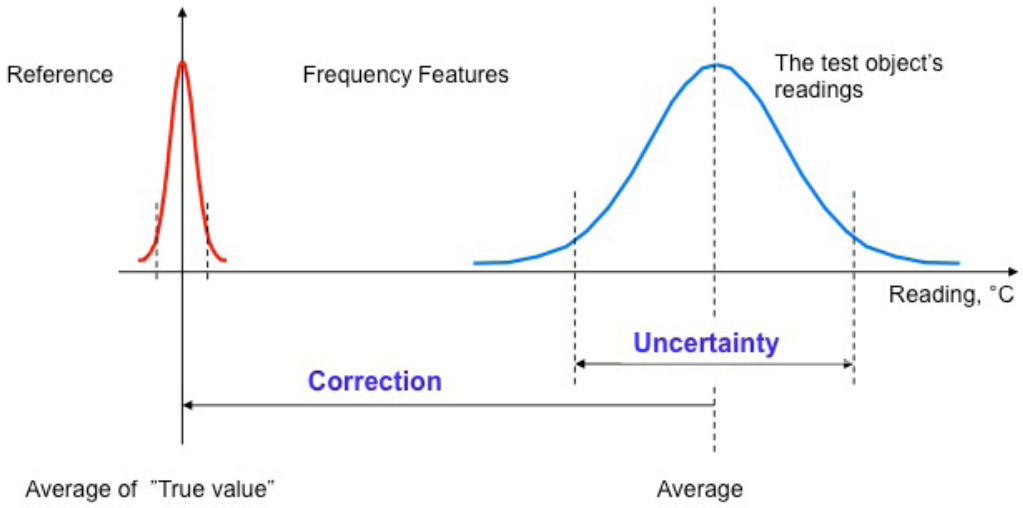
Traceability: means that the measurement result can be traced back to a known temperature via an unbroken chain of comparisons, all with known uncertainties.



This figure shows how temperature is made traceable to ITS-90 via various calibration bodies. The link to the thermodynamic temperature is via BIPM's research project.

REQUIREMENTS FOR TRACEABILITY AND MEASUREMENT UNCERTAINTY

When doing accredited work in accordance with ISO 17025, the demands for traceability and for the accounting of measurement uncertainty are absolute requirements. ISO 9001 and 9002 require a calibration chain to recognised standards, and that the measurement capability is sufficient. The latter means in practice that the measurement uncertainty must be both known and small in order for the accuracy of the measurements to be sufficiently good for the



The figure shows the concepts of correction and measurement uncertainty in a comparative calibration. You obtain the spread around the mean values by repeating the readings a large number of times. The spread is caused by the chance measurement errors that are introduced with every reading.

measurement task. Thus ISO 9001 and 9002 do not make any specified demands on the laboratory operations other than that the measurement devices used for the products must be traceably calibrated, where traceability is available.

CALIBRATION METHODS

There are two main calibration methods:

- Fixed point calibration
- Comparative calibration

where fixed point calibration consists of a direct link to the applicable definition of the temperature scale, ITS-90. Other calibrations are done by comparison in a stable medium between a reference measurement system and a calibration object.

FIXED POINT CALIBRATION

The sensor is inserted into a fixed point cell such as the triple point of water or the freezing point of tin or zinc. No reference system is required because these well-defined natural phenomena have been assigned a temperature figure in accordance with the ITS-90 temperature scale. See the table to the right.

Fixed point calibration is done at national metrology centres, accredited calibration laboratories and certain corporate laboratories. In a laboratory environment extremely small measurement uncertainties are possible, often < 0.01 °C. The small fixed point cells that are on the market provide excellent reference temperatures for the occasions when careful monitoring is needed of both thermocouples and Pt100 sensors.

COMPARATIVE CALIBRATION

Comparative calibration is the most common calibration method in industry. The measurement uncertainty achieved is often sufficient for the calibration of equipment in industrial processes. There are two main ways to do a comparative calibration:

- In situ (on site)
- In a separate furnace/bath

No	Temperature (°C)	Temperature (K)	Element	Phase shift
16	1064.18	1337.33	Gold	Freezing point
15	961.78	1234.93	Silver	Freezing point
14	660.323	933.473	Aluminium	Freezing point
13	419.527	692.677	Zinc	Freezing point
12	231.928	505.078	Tin	Freezing point
11	156.5985	429.7485	Indium	Freezing point
10	29.7646	302.9146	Gallium	Melting point
9	0.01	273.16	Water (TP)	Triple point
8	-38.8344	234.3156	Mercury	Triple point
7	-189.3442	83.8058	Argon	Triple point
6	-218.7916	54.3584	Oxygen	Triple point
5	-248.5939	24.5561	Neon	Triple point
4	=-252.85	=20.3	e-H_2/He	Boiling point
3	=-256.15	=17.0	e-H_2	Boiling point
2	-259.3467	13.8033	e-H_2	Triple point
1	-270.15/-268.15	3 / 5	Helium	Boiling point

The ITS-90 primary fixed points. Platinum resistance standards (SPRT) are used from phase transition 2 up to and including 15 in the table. Within accreditation, AKL 0076 at Pentronic uses the fixed points marked in green (8-15), which cover the most common calibration intervals. The more intense green shade indicates the temperature scale's fundamental fixed point. The temperature 0 K or –273.15 °C cannot be realised.

IN SITU

In situ means on the spot or on site. The advantage of the in situ method is that it preserves the sensor's normal working environment. The sensor arrangement is thereby exposed to the same protective tube losses, radiation exchanges and other similar factors as during normal operation. No deviating factors affect the calibration. Whether the temperature of the sensor's position is representative of what you really want to measure is another question to be considered later.

IN A SEPARATE FURNACE/BATH

In this type of calibration you place the sensor being compared in a separate bath or furnace or similar device that is constructed to give stable temperatures. This method is characterised by good control over the heat source's stability and absolute temperature. This method must be used if it is not possible to do an in situ calibration.

If you would like to discover even more about temperature measurement, Pentronic offers courses in "Traceable temperature measurement" in Västervik or at your own premises if required. For more information visit www.pentronic.se

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