PENTRONIC NEWS

PENTRONIC Scandinavia's leading manufacturer of industrial temperature

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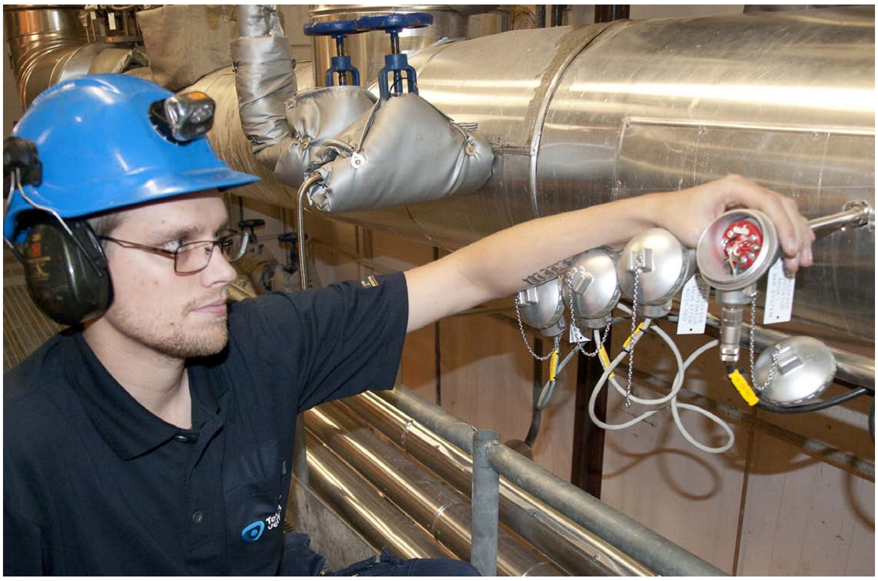
The right temperature lets a Swedish energy company keep on growing



"High availability requires among other things that we have a reliable supplier of temperature sensors," says Mattias Halvarsson, electrical and instrument engineer at the Gärstad plant in Linköping.

The central Swedish city of Linköping needs more energy so it can continue to expand. More and more of that energy is coming from recycled waste. The energy producer is the regional heating, electricity and waste management company Tekniska verken.

"The right temperature is crucial to our waste incineration programme," explains Mattias Halvarsson, electrical and instrument engineer at the Gärstad plant, which transforms waste into electricity and heat.

Linköping was the first Swedish city to produce district heating from waste incineration.

One of the critical temperatures is 1000 °C, the minimum required to reduce the NOX content.

The incineration facility began operating in 1958 and was later replaced by two district combined heat and power (CHP) plants. One of them, the Gärstad plant, uses only waste as its fuel.

"We have four incinerators with a total capacity of 183 MW heat and 68 MW electricity," Mattias says.

The four incinerators use a total of 420,000 tonnes of waste per year. Maximum energy yield from the waste is achieved in part by accurate temperature measurement and calibration. All critical temperature sensors are calibrated at least once a year.

On-site calibration

"I use a block calibrator to check the entire on-site measuring circuit, which includes temperature sensors, transmitters and cabling," Mattias explains. "The calibrator is linked to an electronic data logger so we have a record of every inspection."

The Gärstad plant squeezes out every drop of energy from the fuel with the aid of flue gas condensation, heat pump and electricity production. The efficiency rate is 95 percent and the emissions are low from what is already an environmentally benign process.

One result is that critical readings can be found in all temperature intervals. Partly this is due to the desire to optimise the operations, and partly in order to ensure that the minimum temperatures required by environmental regulations are achieved.

"To reduce the NOX levels the temperature must be at least 1000 °C," Mattias says as one example.

Various sensor types

The large temperature interval means that several types of temperature sensors are used. In the hottest parts of the incinerators only one type of sensor works – type S thermocouples sheathed in ceramic protection tubes. For reasons of cost, type K thermocouples are used as soon as the temperature level is lower, and at still lower temperatures Pt100s are used.

The entire measurement system is digitalised with PROFIBUS. Unlike analog signals, the digital ones and zeros are not affected by the ambient environment along the length of the signal cable. This means that a reading Mattias determines during calibration is identical to that displayed in the control room.

In the northern hemisphere winter is the big challenge for all types of power plants, whether they produce electricity or heat, from waste or nuclear power. Tekniska verken therefore prioritises preventive maintenance and a high level of availability. These are the reasons why the company has chosen Pentronic as its supplier of temperature sensors.

Fast and reliable

"Pentronic has fast deliveries, knows about temperature measurement, and supplies the sensors with documentation so we can immediately incorporate them into our system," Mattias says.

Pentronic also supplies know-how. Mattias has taken Pentronic's Traceable Temperature Measurement course and gives it a nod of approval, even though it initially makes life more difficult by highlighting potential measurement errors that most people are happily ignorant about.

Linköping is one of Sweden's fastest growing cities and has just passed the 150,000 population mark. Growth demands more energy, so Tekniska verken has decided to expand the Gärstad plant. The fifth waste incinerator will start to produce electricity and heat in 2016, which will reduce the use of oil and coal in the city's other heating plants.

Pentronic resisted the downturn with reliable deliveries and more customers

Pentronic had a successful year in 2013 despite the weak global economic situation and the continued strength of the Swedish krona.

"We compensated for reduced sales to some of our existing customers with new customers and increased exports," comments Managing Director Lars Persson.

2013 was a tough year for many countries and companies, with the after-effects of the 2008 crisis still continuing.

"We believe we've taken large market shares," Persson explains. "Both our customer numbers and exports have increased. Temperature is one of the more important parameters used to verify processes, performance and functions. The underlying driving force is tougher requirements for temperature measurement in order to save energy, cut costs, raise quality and reduce environmental impact."

These reasons should explain why exports to China are increasing. It is becoming more and more important for Chinese companies to solve these issues in a credible way in the eyes of the world. It's a task they are increasingly doing with temperature sensors from Pentronic.

Increasing needs

In most industries, careful temperature control using reliable sensors can lead to greater efficiencies and thereby cost savings. This holds true for everything from the heat treatment of steel components to the pasteurisation and packaging of milk. Despite the economic situation, Pentronic's machine manufacturing customers are experiencing success in the global market. Their increasing demands for temperature measurement are being prompted not only by their own cost savings but also by their end customers' demands for better product quality.

Lars Persson predicts a successful 2014 for Pentronic.

Delivery precision: 99.5%

Another factor could be that customers are delaying replacing their own equipment. When their needs finally become acute, they prioritise suppliers known to have high delivery reliability.

"In 2013 Pentronic shipped 99.5 percent of all customer orders on the date specified in the original order acknowledgement," Persson says.

There are two possible reasons why Pentronic's business has thrived. One is that the total market is growing because reliable temperature measurement is becoming more and more important. The other is that Pentronic has increased its own market shares.

Whichever is the case, what is definite is that an economic upswing will lead to rapid volume increases. So does Pentronic have the capacity to respond to demand without affecting quality and delivery times?

"In recent years we've invested heavily in our production facilities and we are dimensioned for a rapid volume increase," Persson says. "Västervik has a long engineering tradition and good workforce availability. In previous upswings we've been able to rapidly increase our capacity.

"We believe we'll have an excellent 2014."

Merger after five years' "engagement"

The union between Pentronic and Inkal Industrikalibrering is now complete.

"We're now part of Pentronic," says Morgan Norring, who manages the operations in the Swedish city of Karlstad.

Inkal originated as the laboratory of Uddeholm Tooling and has cooperated closely with Pentronic since being founded 20 years ago.

Inkal's operations consist of an accredited calibration laboratory and the manufacture of high temperature thermocouples. Most customers are in the local steel and processing industries.

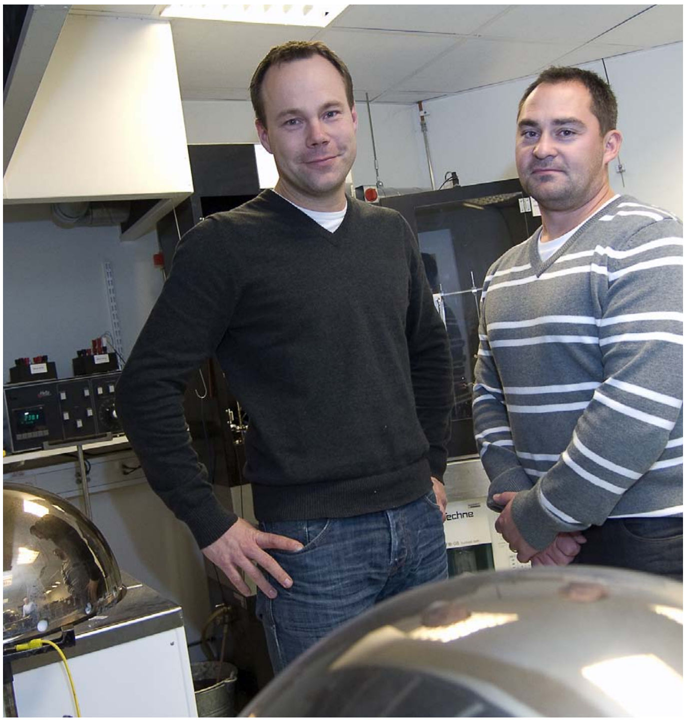
Pentronic acquired Inkal Industrikalibrering in 2008 to strengthen its position in the high temperature field. At the same time, Inkal's customers gained access to Pentronic's extensive resources and know-how.

"The collaboration works really well," says Norring, who will remain with the Karlstad operations.

The customer relationship is what is important, which is why Inkal had remained a separate company wholly owned by Pentronic. But in the long run having two companies and double accreditation is impractical, which is why the merger has now taken place. Inkal is now integrated into Pentronic and the laboratory in Karlstad will remain accredited, officially as a branch of the laboratory in Verkebäck.

"This means we'll have more time for our core activity and to do field work," Norring says.

Pentronic's Managing Director Lars Persson says the merger is a practical step. Since being acquired, Inkal has functioned as part of Pentronic. For Inkal's customers, the only difference is that the name on their calibration certificates is now Pentronic.



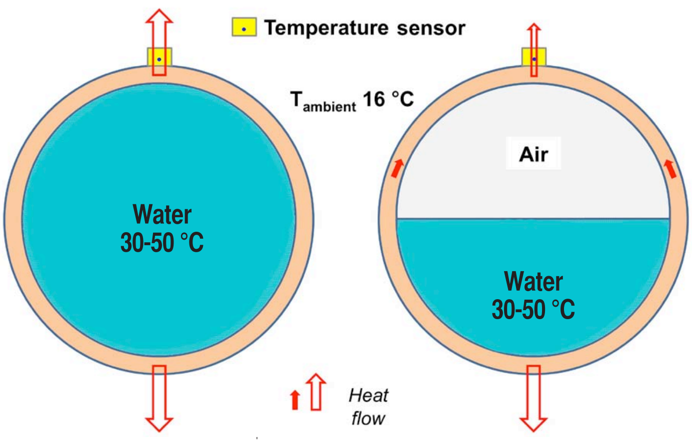
Inkal has become Pentronic and Morgan Norring (right) is in charge of the accredited laboratory's branch in Karlstad. Here he is together with Pentronic's laboratory manager Lars Grönlund.

Measuring water temperature from the outside of a half-full plastic pipe

QUESTION: We have replaced an uninsulated horizontally mounted steel pipe with a plastic pipe with the same inner diameter, 100 mm. Inside the pipe, water is flowing at a temperature of 30 to 50 °C. Most of the time the pipe is full of water but during some lengthy periods it is scarcely half full. The temperature inside the room is about 16 °C. We measured the water temperature by mounting a sensor on the top outside surface of the steel pipe. Can we do the same with a plastic pipe?

Roland G

ANSWER: The heat flow from the water inside the completely full pipe to the outside surroundings occurs via forced convection on the inside surface of the pipe, thermal conduction inside the pipe wall, and convection and radiation on the pipe's outside surface. We will assume that the wall thickness is the same in both the steel pipe and the plastic pipe and that the other conditions are also the same. We will also assume that the process is static. Given the same heat flow, the temperature difference across the pipe wall will be slightly greater for the plastic pipe than for the steel pipe, which means that the plastic pipe's external temperature will be lower. However, when the steel pipe is replaced with a plastic pipe there is a reduction of the heat flow, which means that the plastic pipe's external temperature increases. When these changes are combined, the external temperature of the plastic pipe will be slightly less than that of the steel pipe. When the plastic pipe is full of water, it should normally be possible to measure the water temperature with sufficient accuracy by using an external surface mounted sensor. See further [Ref 1], which discusses surface mounted sensors.



The case of a plastic pipe that is half full of water is much more complex. In the upper section of the pipe's interior, the heat transfer is now occurring between the air and the pipe wall and not between the water and the pipe wall. The heat transfer to the pipe wall occurs mainly by natural convection in the air and not by forced convection in the water. This means that the heat transfer coefficient on the upper inside surface of the pipe is considerably less when the pipe is half full than when it is full of water. It also means that the pipe's external temperature at the sensor's location will be lower, leading to significantly greater measurement error.

In the half-full pipe some heat transfer occurs inside the pipe wall from the bottom of the pipe to the top of the pipe due to the temperature difference, which increases the wall temperature at the sensor's location and reduces the measurement error. Because thermal conductivity is significantly greater in steel than in plastic, the heat transfer inside the pipe wall from the bottom of the plastic pipe to the top is less than the corresponding heat transfer in the steel pipe. In turn, this means that the measurement error for the half-full plastic pipe is greater than for the half-full steel pipe.

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

QUESTIONS ? ANSWERS !

If possible, you should insulate the pipe at the location of the sensor in order to reduce the measurement error. You can also place the sensor on the underside of the pipe to reduce the measurement error but this increases the risk of corrosion and of poor thermal contact between the sensor and the pipe wall. Many factors influence the possible locations for the sensor and so its placement must be decided in each individual case. Wherever you place the sensor on the pipe, you must always regularly check that it is in good contact with the pipe.

Replacing a steel pipe with a plastic one will also influence the response time when the temperature of the water changes. A half-full plastic pipe combined with a sensor that is externally mounted on top of the pipe is a particularly unfavourable situation and will lead to a long response time.

References see www.pentronic.se > News > Pentronic News > Pentronic News Archive
[Ref 1] Pentronic News 2013-4

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STRAIGHT FROM THE LAB

Calibration recall

SWEDAC ACKREDITERING 0076 ISO/IEC 17025

Let Pentronic recall your temperature sensors and instruments when it's time to recalibrate. That way you ensure the quality of your measurements and avoid the risk of outdated calibration certificates causing problems during audits.

"We have twenty years of experience in recalling equipment for recalibration," says Lars Grönlund, manager of Pentronic's accredited calibration laboratory.

The particular equipment he is referring to is for food safety inspections. More than 100 Swedish municipalities rely on Pentronic to recalibrate the instruments and sensors they use during official food inspections.

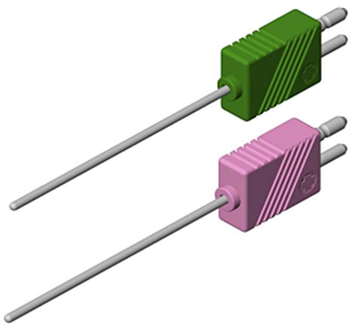
If any penalties are imposed for food safety breaches, the Swedish courts require evidence that the measuring equipment is properly calibrated. As a result, the municipalities ask Pentronic to recall the equipment before the calibration certificates run out.

This service has existed for 20 years. Pentronic has efficient routines for making recalls at prearranged times. The service is available to all customers and can be adjusted as required.

Moulded connectors eliminate connector problems

Pentronic's sheathed thermocouple with moulded plastic connectors eliminates many sources of error compared with traditionally mounted devices, particularly in rugged environments. The tensile and torsional strength are dramatically better, which is important in situations of heavy use. The moulding method ensures a seal against dampness that would otherwise lead to false readings. Vibrations have a minimal effect because there are no terminal screws or lid that can loosen.

Pentronic keeps in stock a number of standard lengths with a moulded connector. The plastic withstands up to 150 °C but readings should be taken with the connector closer to room temperature to ensure optimal measurement accuracy.



Precise calibration requires identical temperature sensors

Ideal calibration requires that the zeroth law of thermodynamics be met. Every deviation from that law increases the uncertainty of the correction value you are trying to determine. This article discusses some factors that increase uncertainty and suggests how you can improve your calibration in practice.

The theory states that to achieve perfect calibration, the zeroth law of thermodynamics must be met. See Figure 1. This law states that if two systems (S1 and S2 with the temperatures T1 and T2) are each in thermal equilibrium with a third system (S3 with the temperature T3) then both the first two systems (S1 and S2) are in thermal equilibrium with each other. There is no heat exchange with the surroundings. The term ‘thermal equilibrium’ means that the same amount of thermal energy is flowing to each body as is flowing from each body, that is, the net flow to the body is zero. The significance of this is that all the systems have the same temperature. (T1 = T2 = T3).

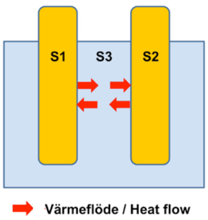


Figure 1. The zeroth law of thermodynamics. For thermal equilibrium to occur between all three bodies, S1, S2 and S3, they must have the same temperature: T1 = T2 = T3. Unfortunately, this is an ideal situation that is impossible to achieve, because heat exchange with the surroundings cannot be avoided. See further Figure 2.

If we suppose that S1 and S2 are temperature sensors and S3 is a block oven or water bath, this ideal situation is complicated by additional thermal flows, which appear disruptive. The thermal flows are driven by the temperature difference between the insulated volume and the surroundings. See Figure 2. In the real world, perfect insulation does not exist and a temperature sensor must be connected to the outside world via a connection cable and protective tube. The result is that the heat that is conducted out from the calibration volume (S3) must be removed from that volume. The same applies to sensors S1 and S2. In turn, this means that sensors S1 and S2 lose their thermal equilibrium with the calibration volume S3.

Inside calibration equipment, a constant temperature is maintained by a control system that adapts the heating or cooling to the prevailing heat losses or gains respectively. However, this does not prevent the thermal flows from reaching the outside environment via the insulation, sensor protection tubes and cabling.

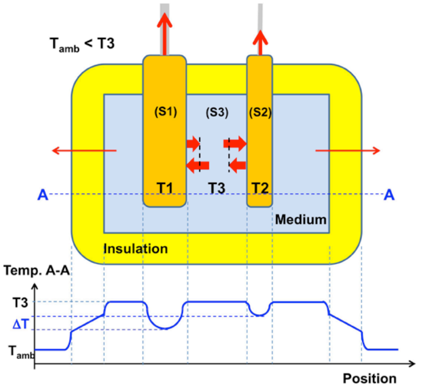


Figure 2. A hypothetical but realistic depiction of real-life calibration. Heat exchange with the surroundings means that perfect thermal equilibrium is impossible to achieve. Differences in the sensors’ physical construction such as the cross-section area cause differing thermal flows to the surroundings and thereby different temperatures in the respective sensor components.

Equal loss is best

As long as the temperature sensors – the reference and measurement objects – are constructed identically in terms of their materials and dimensions, and are also placed in the same way in the calibration bath or metal block, their deviations of thermal equilibrium will be similar and therefore the temperature difference (ΔT) between the probe tips will be minimal even though it will be at a slightly deviating temperature level. The greater number of physical differences that exist between the sensors, the greater is ΔT. See the temperature distribution in Figure 2.

Similarly, differing insertion depths can cause different temperatures at the probe tips. See Figure 3.

Due to the heat flow out from the calibration oven, the temperature decreases axially the closer we come to where the sensor enters the oven. This phenomenon is not very pronounced in liquid baths that are stirred but is more of a problem in block ovens.

Correct for measurement error

In the case of known deviations you can correct for the calibration’s measurement error and thereby reduce the remaining measurement uncertainty. Known deviations mean that “someone” – that is, the manufacturer or you yourself – has measured the block calibrator’s temperature distribution axially and radially inside the block under specified thermal loads. See further [Ref 1]. In general, calibration using block calibrators produces measurement uncertainties that are at best about a few tenths of a degree at low temperature. Hybrids with water or oil in the bottom of the hole improve the situation. At higher temperatures, up around 600 °C, the uncertainty can very well increase to the level of whole degrees. Read more about block calibrators in [Ref 2].

Calibration in a liquid bath using water, an alcohol-water mix, or oil gives significantly better accuracy, especially for water in the range of 0 < T < 100 °C. Under favourable conditions in a laboratory setting it is possible to get down to the mK level. It is more common to achieve hundredths of a degree, whilst ordinary heat-retention baths with circulation can often achieve tenths of a degree. The latter may need to be equipped with a lid and/or plastic spheres on the surface of the water in order to reduce evaporation and heat losses. Read more about liquid baths in [Ref 3].

Unfortunately, ideal calibrations do not exist. However, it is possible to reduce the sources of error by using reference sensors that are physically as identical as possible to the measurement objects. This applies primarily to the thermal flow along the axial direction, which is affected by such factors as the dimension of the protection tube, and to the heat transfer radially into the sensor component in the probe tip.

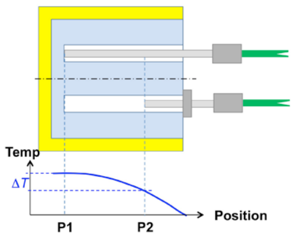


Figure 3. Particularly in block ovens the temperature varies with the insertion depth. If the reference sensor senses the bottom temperature (P1) and the measurement object is short (P2) due to a mounting component, they measure different temperatures even if both sensors otherwise have the identical construction. In this situation you can use the reference sensor to also measure at the P2 insertion depth and thereby minimise ΔT.

References see www.pentronic.se > News > Pentronic News > Pentronic News Archive
[Ref 1] Pentronic News 2009-1
[Ref 2] Pentronic News 2009-2
[Ref 3] Pentronic News 2009-3

If you have questions or comments, contact Hans Wenegård: hans.wenegard@pentronic.se