PENTRONIC NEWS

PENTRONIC Scandinavia's leading manufacturer of industrial temperature sensors

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The digital industrial revolution has begun

– SMART TEMPERATURE SENSORS FROM PENTRONIC

"Smart sensors with a digital bus can give four to eight times less measurement uncertainty," says Erik Gullqvist, one of the developers behind Pentronic's smart measurement system.

Up to eight times better measurement performance with lower installation costs and simplified maintenance.

That's the effect of Pentronic's smart measurement system.

The system includes temperature sensors with an integrated and system calibrated transmitter, independent transmitter and gateway for a digital solution.

Industrial measurement systems usually work like this: a sensor indicates the measured temperature in the form of voltage or resistance. A transmitter transforms this into a 4-20 mA process signal or into digital information, which is then sent to a superior system.

Each stage of the chain adds measurement error. Without system calibration the final error is about ± 1 °C.

Integrated and system calibrated

Pentronic's experienced engineers have worked with the company's in-house accredited laboratory to develop temperature sensors with an integrated transmitter. The aim was to achieve better performance and lower costs for installation and maintenance.

The first step was a miniaturised high-performance transmitter to be mounted inside the sensor. The transmitter is considerably smaller than existing signal transmitters for terminal heads. The transmitter and sensor are a system calibrated unit with 50 percent less measurement uncertainty at ± 0.4 °C for Pt100 sensors.

"We've been manufacturing this sensor for a number of years," explains Pentronic's sales manager Dan Augustini. "It is built to be robust and about 60,000 units are currently operating."

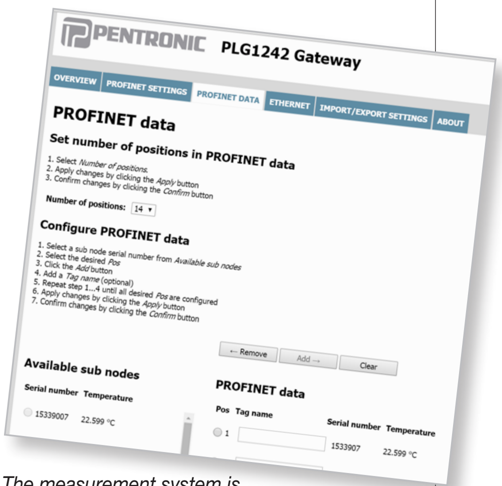
The installation and maintenance are made easier because the units reach the customer already calibrated. No further calibration is required: just mount the unit in place and start it up. However, each sensor still has one cable attached to it, with large installations involving many cables.

Smart systems

"The system features smart sensors with a digital bus," says Erik Gullqvist, one of the developers behind the digital measurement system. "The smart sensors are connected to a gateway that transmits the information via industrial buses such as Profinet or Ethernet/IP.

Pentronic's gateway can handle up to 50 smart sensors. This arrangement removes additional error sources and measurement uncertainty can be reduced to about ± 0.2 °C for Pt100s. This is four to eight times better than conventional measurement systems.

The gateway connected to the superior system is configured via a Web interface. All sensors are connected to one and the same cable. The result is lower costs for installation and maintenance.



The measurement system is configured via a Web interface.

The team that manufactures thermocouples in larger series

Pentronic's manufacturing of thermocouples focuses on precision and quality. This highly skilled craftsmanship requires experience, manual dexterity and good eyesight.

"Our thinnest sheath material is 0.5 mm in diameter," says Jens Jupiter, production manager for sensor manufacturing. "The wires are so thin they are welded together underneath a microscope."

"Temperature is a critical parameter for our customers," Jens explains. "Important properties are the sensor's performance and suitability for the measurement task, as well as reliable deliveries."

Short series, many sensors

"Our longest series comprises 10 to 15 thousand sensors a year," he says. "We also offer thousands of product items and are constantly adding more."

Pentronic manufactures thermocouples at both its facilities. The factory in Verkebäck produces the more complex sensors in short series or when express orders are required. The sensor types produced in larger series are mainly built by the team in Västervik.

The factory at Västervik is almost complete. In come raw materials in the form of wires, rods, sheath materials and granulated plastics. Out go complete sensors ready for delivery to Pentronic's customers.

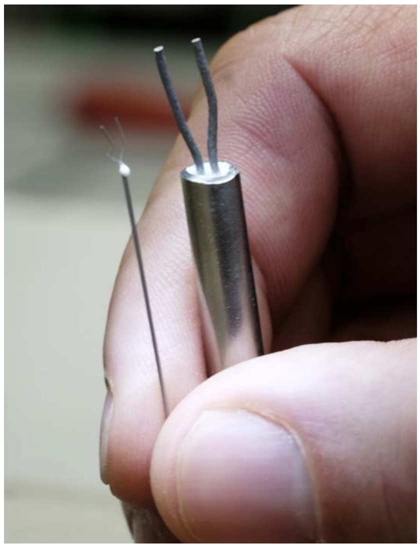
In-house training

The thermocouple production group consists of about 20 specialists. One person is responsible for all the manufacturing steps required for an order. The only remaining step is a final inspection, which is done by an independent individual. Like the engines in super sports cars, every thermocouple from Pentronic has a person's name behind it.

Generational changes occur in a continual and well-organised process. Each new employee is trained by experienced colleagues in a kind of apprentice system. Everyone also attends courses to learn how temperature, measurement and calibration work.

"There is no school in our field so we must do the training ourselves," Jens says. "It takes six months before the new employees can work independently."

Manufacturing thermocouples is a highly skilled job. Here are just over half of the specialists at Pentronic.



The thin sheath material is 0.5 mm in diameter. The wires are scarcely visible to the naked eye and are welded under a microscope.

Delivery with precision

Even apparently ordinary tasks, such as welding, are done differently at Pentronic. Welding methods at the company include water, laser and TIG.

With the exception of water welding, this sounds conventional but it is not. Ordinary TIG welding involves thoroughly burning through the material.

"At Pentronic we must make a perfect seam using the lowest possible heat," Jens explains.

While the craftsmanship is highly sophisticated, each step in the process is standardised. This enables predictable performance, quality and delivery time.

Pentronic adds more resources for a growing market

Pentronic is actively exhibiting at trade fairs and in other contexts where it was not previously represented.

"Sensor technology is increasingly important in more and more fields and we want to attract more customers," explains sales manager Dan Augustini.

This autumn the company exhibited at two small niche trade fairs in Sweden. Jonas Bertilsson and Morgan Norring met with the steel industry at Euroexpo in Borlänge. Dan Augustini and Raphael Adout of CI Systems were at Photonic, a trade fair for optics, laser and light research at AlbaNova University Center at KTH Royal Institute of Technology in Stockholm. Pentronic is CI Systems' new representative in Sweden.

Isabelle Hagström is a trainee sales engineer.

Pentronic has also hired Isabelle Hagström, a graduate engineer specialising in energy. She is now being trained in temperature measurement and the company's routines.

The need for temperature sensors and other sensor types is constantly increasing. During the first three quarters of this year alone, sensor manufacturing increased by about 15 percent.

"To maintain our good service we're expanding our organisation with more sales engineers and greater production resources," Dan says. "Now we can grow again, which is why we will be more visible in the market."

Does a tea cosy keep the tea hot longer?

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

QUESTION: In our lunchroom we usually put a tea cosy over the teapot to keep it warm. Does the tea cosy really do any good or are we just imagining it?

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ANSWER: The easiest way to find this out is to take the specific teapot and measure the tea's temperature drop after a specified time with and without the tea cosy. Just before taking the reading you must stir the liquid so that you measure an average temperature.

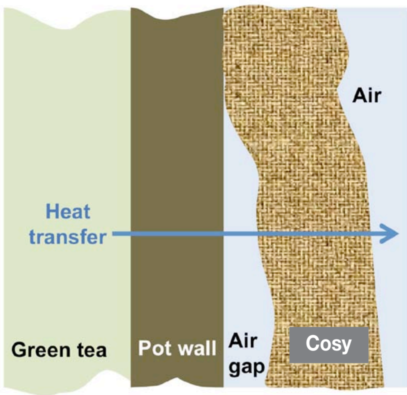
Most of the heat transfer from the liquid to the teapot's surroundings occurs via the teapot wall where there is liquid inside. Here natural convection occurs between the liquid and the teapot wall and then there is thermal conduction inside the wall. On the outside surface of the teapot there is natural convection in the air and radiation into the room. The thermal resistance between the liquid and the wall, and the resistance inside the teapot wall are small compared with the thermal resistance between the teapot's outside surface and the surroundings. The result is that the teapot wall in this area and the liquid have about the same temperature.

Some heat transfer also happens via the teapot lid to the surroundings and from the teapot bottom to the table. The heat flow from the liquid to the inside of the lid occurs by natural convection and radiation in the layer of air above the liquid. The thermal resistance between the liquid and surroundings via the air inside the teapot and lid is higher than the resistance between the liquid and surroundings via the teapot wall. The result is a lower heat flow per unit area.

The tea cosy's wall contains a fluffy material with low thermal conductivity. When you put the tea cosy onto the teapot, this increases the thermal resistance on the outside of the teapot, reduces the heat flow, and thereby also reduces the cooling-off speed. When there is an air layer between the teapot and the inside of the tea cosy, the thermal resistance is increased further. Within this air layer, the heat transfer occurs mainly via radiation and thermal conduction in the air.

From the bottom of the teapot to the table, the heat transfer occurs via conduction. Normally the teapot bottom is not entirely flat and an air gap exists between most of the teapot bottom and the table. In this space, the heat transfer occurs via radiation and thermal conduction in the air. By putting the teapot on a heat-insulated mat, for instance made of cork, you can further reduce the heat flow.

An example: For a small pottery teapot that contains 0.8 litres and stands on an insulated mat at a room temperature of 22 °C, the tea temperature falls in 15 minutes from 90 °C to 78 °C with a tea cosy. Without a tea cosy, the liquid becomes 4 °C cooler.



Heat transfer from the tea to the surroundings of a teapot with a tea cosy.

Tests using Pentronic's 0.8 litre teapot with tea cosy reveal that the temperature drops from 90 °C to 78 °C in 15 minutes. Without the tea cosy the temperature drops a further 4 °C.

Dirty thermowell

A dirty protection tube with the associated temperature sensor behaves in thermal terms in the same way as a teapot with a tea cosy. The temperature sensor and the tea respectively acquire a longer response time. In the case of the teapot this is desirable but for temperature sensors normally the reverse is true.

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

STRAIGHT FROM THE LAB

How an accredited laboratory is inspected

SWEDAC ACKREDITERING 0076 ISO/IEC 17025

A calibration laboratory's accreditation is a time-limited commodity.

The laboratory's quality system and methods are audited every sixteenth month. Every fourth audit is also a new accreditation process, during which everything must be inspected and assessed. Meanwhile, the demands are constantly being made tougher in order to create continual improvement.

Pentronic's calibration laboratory had its latest audit at the end of summer 2015. An in-between one, the inspection was done by two assessors from the Swedish Board for Accreditation and Conformity Assessment (Swedac), one for the quality system and one for methods and technology. The accreditation is done in accordance with ISO 17025, a standard with the same structure as ISO 9000 and ISO 14000 but with more stringent requirements. For example, under ISO 9000, the company itself sets the requirements and follows up on them. The quality system is what is being audited – that the company meets its own demands.

When a calibration laboratory is accredited in accordance with ISO 17025, the requirements are set by a national authority, Swedac, which then does regular inspections to ensure that the demands are being met.

The most recent audit of Pentronic resulted in a few comments and suggestions for improvement. These have all been complied with. The next audit will be done in autumn 2016.

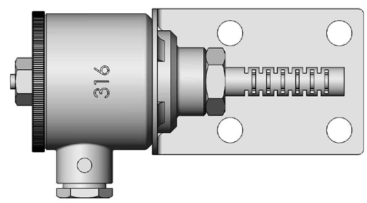
PRODUCT-INFO

Temperature sensor that withstands tough outdoor conditions

Pentronic offers a temperature sensor made completely of stainless steel, including the SEG type terminal head and the mountings. The sensor can thereby withstand a tough outdoor environment much better than aluminium and plastic materials. The enclosure rating is IP 56.

The sensor is used to measure outdoor air temperature, for example for a climate control system, or for other applications where outdoor temperature is important. The temperature sensor shown here can be modified with regard to its mountings, measurements and accuracy.

The sensor component is a Pt100, IEC60751 Class A, which means that the Pt100 resistor's tolerance is ± 0.15 °C at 0 °C.



Sharpen your temperature measurement chain

An ordinary temperature measurement chain of Pt100 sensors can have a measurement uncertainty of ± 0.8 °C under given conditions. In this article we will examine how we can reduce this measurement uncertainty at least down to ± 0.2 °C by taking various steps.

A normal measurement chain for lower process temperatures up to e.g. 160 °C is often composed of Pt100 sensors that are connected to a transmitter in an adjoining electrical cabinet. See Figure 1, Measurement Chains 1 and 2. The electronics transform the signal to 4-20 mA current for onward transport to an analogue/digital transformer (A/D) and connection to a superior control system.

The sensor is three-wire connected to the transmitter. Calibration has not been done; instead, the sensor is presumed to be Class A in accordance with the IEC 60751 standard, that is, ± 0.15 at 0 °C. At the interval's upper limit of 160 °C the tolerance is then ± 0.47 °C. Due to temperature drift when the cabinet temperature is increased, the uncertainty in the transmitter can be ± 0.5 °C across the entire measuring interval.

As a result of the A/D transformation during the next stage, the measurement uncertainty becomes approximately ± 0.2 °C, which applies to all the A/D transformations in Figure 1. Once the signal is in digital form, no more errors arise in the measurement value.

Pt100 three-wire connections are uncertain

However, we have an uncertainty remaining in the analogue chain that we cannot disregard: the weakness in the three-wire connection. This consists of the difference between the resistances in the cable's three wires en route from the Pt100 resistor to the transmitter. Wire resistance includes all contact resistances such as in the screw connectors and other connection points.

The cable resistance can be calibrated away but slow oxidation of the contact points changes the conditions over time, especially in difficult process environments. A three-wire connection requires that all three links must have equal resistance. Every difference becomes incorporated in to the measurement error. In fact, this applies only to the white wire and one of the red ones, but because there are two red ones we cannot determine which one is the critical one. In order to be certain, we must ensure that all of them have the same resistance. We have based this analysis on a measurement error of 0.1 °C but in a bad environment this error can increase over time up to at least a couple of degrees.

By adding up the partial uncertainties (u_i) according to the rules for calculating measurement uncertainty (see Figure 2) we get the following uncertainties in the interval limits: 0 °C gives ± 0.7 °C and 160 °C gives ± 0.8 °C respectively. There is an additional uncertainty due to the probe tip's design because that can vary according to the measurement task.

Measurement Chain 2 is composed of an uncalibrated four-wire-connected Pt100 and a Pentronic PAT1201 analogue transmitter for a DIN rail with improved properties: ± 0.25 °C uncertainty in both the interval limits. Thus the total uncertainty will be ± 0.4 and ± 0.7 °C respectively at the limits. The four-wire connection totally eliminates the three-wire cable's long-term drift.

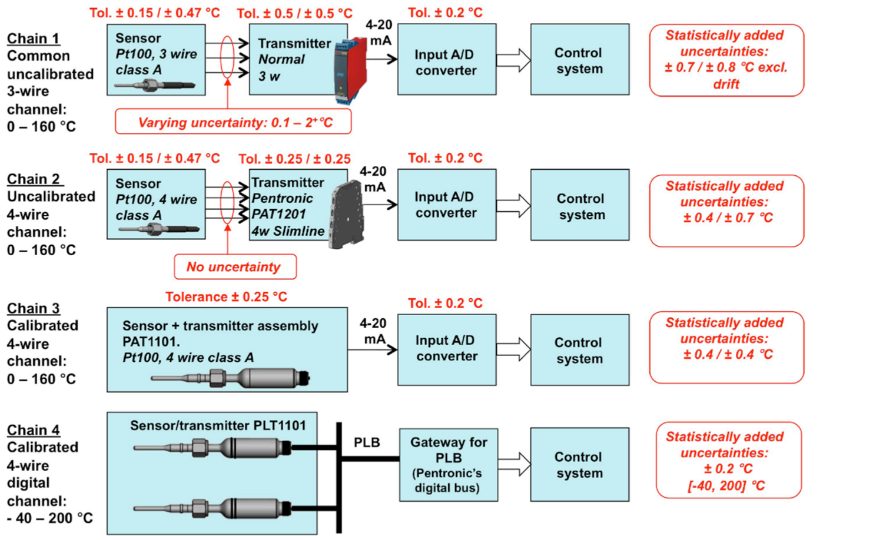


Figure 1. The figures show how we can sharpen the measurement chain from a measurement uncertainty ≥ |0.8| °C down to ± 0.2 °C. By using additional calibration points, Measurement Chain 4 can be pushed down to ± 0.05 °C. In all cases there will be additional uncertainties due to the probe tip's design and installation.

System calibration minimises errors

Measurement Chain 3 is composed of an integrated sensor and transmitter with an analogue output signal that was system calibrated upon delivery. This method allows us to really tighten up the tolerance limits used in measurement chains 1 and 2. The transmitter contains both an A/D and a D/A transformer. In this case the uncertainty is

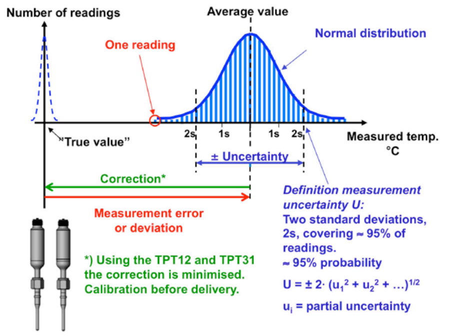


Figure 2. Definition of measurement error (deviation) and measurement uncertainty. The measurement error can be minimised by system calibrating an integrated sensor and transmitter.

± 0.25 °C. The system calibration also eliminates the measurement error. The total uncertainty not counting the probe tip is reduced to ± 0.4 °C.

Measurement Chain 4 in Figure 2 is based on the sensor and transmitter from the analogue Measurement Chain 3, whose A/D transformer was connected to a PLB digital measuring sub bus (PLB = Pentronic Low-power Bus). This bus can be linked via a gateway to most bus systems on the market. By system calibrating the sensor and transmitter and by transmitting digitally directly to the superior control system, we reduce the uncertainty to ± 0.2 °C at both interval limits, which in this case can be extended to - 40 and 200 °C.

Push down towards ± 0.05 °C

As before, the uncertainty level does not take account of the probe tip's properties. The system calibration is done at two temperatures. The Pt100 resistor is not totally linear. A small quadratic term, i.e. the equation "resistance as a function of temperature", creates a curve, which can be compensated for by doing a three-point calibration. The uncertainty can then be pushed down to ± 0.05 °C across the entire interval. The three-point calibration does require additional manual calibration work but this can be automated when more users demand greater measurement accuracy.

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

Pentronic's products and services

- ☐ Temperature sensors
- ☐ Connectors and cables
- ☐ Temperature transmitters
- ☐ IR-pyrometers
- ☐ Temperature indicators
- ☐ Temperature controllers
- ☐ Dataloggers
- ☐ Temperature calibration equipment
- ☐ Temperature calibration services
- ☐ Training courses in temperature
- ☐ Moisture and thickness monitors
- ☐ Flowmeters
- ☐ GFM Glass flow meters
- ☐ Electro-optical test systems

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