PENTRONIC NEWS

PENTRONIC Scandinavia's leading manufacturer of industrial temperature sensors

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Tomorrow's connected factories are starting to appear in Pentronic's financial results

"Automatic processes require more temperature measurement and more calibration," says Rikard Larsson, managing director of Pentronic.

2015 was yet another record year for Pentronic. Net sales increased by 10 percent and the number of employees exceeded 90.

"One important cause is our customers' export successes," explains Managing Director Rikard Larsson.

The annual financial results point to other reasons as well. If it were just a matter of customer success, Pentronic's growth would lie mainly in a greater number of delivered temperature sensors. However, instruments and services are now expanding just as strongly, with field calibration as the area where demand has increased the most.

It could be that the phenomenon popularly called Industry 4.0 is being reflected in Pentronic's financial results. Tomorrow's connected and highly automated factories are starting to become a reality today.

"Automatic processes require more temperature measurement and more calibration," Rikard says.

A new generation

Pentronic is well equipped for this development. Over the years the company has invested heavily in its two production units in Verkebäck and Västervik in terms of machinery and more rational flows. Investments made in 2015 included yet another lathe. The result for the year was that net sales increased more than the number of employees, which means that productivity continues to improve while the high level of delivery performance remains unchanged.

At the same time, Pentronic has implemented generational changes in terms of both technology and human resources. Young, well-trained colleagues have taken over the relay baton. Customers also alter their team line-ups, and so Pentronic contributes market-leading knowledge and experience in temperature measurement when key employees retire.

More field calibration

Pentronic is part of the industrial group Indutrade, which is listed on Nasdaq Stockholm. Measurement technology has gained a more prominent role within the group, with its own business area, Measurement & Sensor Technology. The integration means that the included companies work more closely with each other and can benefit from each other's various forms of expertise.

The beginning of 2016 revealed that this growth continues unabated. For example, Pentronic has never performed so many field calibrations within such a short time as it will do this summer.

"We're equipped to handle additional production increases and can add a second production shift," Rikard says.

Planned investments

There are plans to expand the factory in Västervik, as a first stage with a complete final inspection process. Parts of the final inspection are currently done in Verkebäck.

The product range will also grow. Pentronic currently has one basic model of sensor with a built-in transmitter and digital output signal. The sensor is designed to be tailored to customer requirements, and several models are under development.

Pentronic offers its own bus for digital sensors, with an efficient protocol and a peripheral gateway to the superior system. There are also plans for sensors that can be connected directly to one of the market's leading industrial buses.

"Pentronic has the technology for tomorrow's connected factories. That's one reason why our net sales increased by 10 percent last year," Rikard Larsson concludes.

New postal address

Pentronic's head office in Verkebäck-Gunnebo is still located beside the same beautiful inlet of the Baltic Sea. However, because the Swedish postal service has altered its distribution channels, freight and post for Pentronic should now be addressed to:

Pentronic AB, Bergsliden 1
SE-593 96 Västervik, Sweden

If you want to drive to Pentronic using a navigation system, remember to input Västervik as your destination. Otherwise you will be led into the forest several kilometres away from Gunnebo.

Customer requests and new technology are the foundation of Pentronic's product development

Every work day Pentronic's design department produces six or seven new model numbers, totalling about 1,500 per year.

To achieve this, the sales and design departments must be flexible and responsive to customers' wishes.

"We focus on the interface between the various departments so customers' requests can be quickly and accurately conveyed by the sales team to the design engineers and then on to production," says Lars Björkvik, Manager Mechanical Design and Production at Pentronic.

The design department consists of seven people: three in mechanics and four in electronics. They are supported by a number of consultants, primarily in software development.

Pentronic is undergoing an intensive development phase, with new technology for smart temperature sensors, digital bus and gateways for communication with other systems.

"In relation to the company's size, this current development phase is among the biggest I've been involved in," Lars says. "The products themselves are already completed. Now we're working on getting them approved in accordance with SIL level 2 and Ex, that is, explosion protection. This involves extensive processes that normally only large companies have the resources for. But it must be done so that the new technology will be acceptable to customers. The main bodies we are consulting with are Sweden's national testing institute, SP, and NEMKO in Norway."

"It is a huge puzzle and we must test and validate every tiny function of it," says Emil Ritzén, who is one of the Pentronic employees on the electronic and software development team, along with Victor Nilsson, Erik Gullqvist and Jan-Erik Johansson.

To do all the necessary tests, the team has designed and built an automatic test bench and a climate cabinet. For example, if the software code is altered, testing is automatically done.

"The aim is to find all the potential error sources," Victor Nilsson explains.

At this stage, the software development process is still mostly distinct from the mechanical design process. But that relationship will change after the approval process is finished.

"Changing the electronics can affect heat generation, which in turn requires mechanical changes," Emil Ritzén says as an example.

The mechanical designs are the responsibility of Staffan Hällmar, the group's expert on cutting and machining, Daniel Sjögren, who is the CAD specialist with special expertise in thermocouples, and Edin Beganovic, who has many years of experience with Pt100s.

Together they supply six or seven new model numbers every day, ranging from minor adaptations to existing modular systems, to totally new engineering designs.

"When our sales engineer gives us the customer's requests, we first develop a model for the customer to consider. Then we work to produce the final design," Staffan Hällmar explains.

The close proximity between the sales engineers and the design engineers is mirrored in that between the design engineers and the production department. Some of the production stages can be seen through the window of the design department.

"This closeness is invaluable – within five minutes we can agree on something that would otherwise require a formal meeting," Daniel Sjögren says.

"New software coding can increase heat generation, which in turn requires mechanical changes," says Emil Ritzén. The photos also show the other team members. From left: Emil Ritzén, Victor Nilsson, Daniel Sjögren, Edin Beganovic and Staffan Hällmar.

Smart sensors function more reliably at a lower total cost

For 100 years industry has measured temperature in more or less the same way. Signals from thermocouples and resistance thermometers are transformed into an analogue signal of 4 to 20 mA.

Now this technology is about to be phased out. Pentronic is leading the way in digital measurement.

Digitalisation itself is not new – it has been happening for 50 years and is replacing and complementing analogue technology in one area after another. Now it's the turn of temperature measurement.

"This is a consequence of the development known as industry 4.0 or the connected factory," explains Pentronic's sales manager Dan Augustini.

Pentronic is at the forefront of this change. The company offers smart temperature sensors with digital communication, a bus that requires little energy and allows for up to 50 sensors on one cable, plus a gateway for communication with e.g. Profibus, Profinet and Ethernet/IP.

"We also have a prototype of the world's first thermocouple with an IO link," Dan reveals.

Smart temperature sensors have big advantages. The entire measurement system is simpler to install, maintain and upgrade, all at a far lower cost. Many of Pentronic's customers are machine builders. Today some machines can be so covered by cables – one for each sensor – that they are pink (the colour code for type N thermocouples).

"Normally no calibration is required from the point where the signal becomes digital," Dan Augustini says.

With a digital bus it is enough to have one cable running between the sensors. Normally no calibration is required from the point where the signal becomes digital.

"Digital transmission only has two states. Either it works or it doesn't. There are no errors that can sneak in like they can in an analogue circuit," Dan says.

The remaining task is to calibrate the actual probe tip. Thermocouples and Pt100s are still the best methods for rapid measurement response and low measurement uncertainty respectively.

"It could also be possible to create an exchange system for smart temperature sensors. We would deliver new ones after the calibration has expired and take back the old ones, which we would inspect and calibrate before sending them out again," Dan says.

The result is what is popularly known as a circular process, in which the resources are reused. It also paves the way for purchasing temperature measurement as a function.

Sooty sensor

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

QUESTIONS ANSWERS

QUESTION: We are measuring the temperature in an exhaust pipe using a type K sheathed thermocouple mounted at a right angle to the pipe wall and with the probe tip in the centre of the pipe. The thermocouple diameter is 6 mm and the pipe's inner diameter is 150 mm. On the outside of the pipe is 30 mm mineral wool as insulation. The gas temperature is approx. 250 °C and the average velocity of the gas is 5 m/s. During a disturbance of production the thermocouple acquired a thin coating of soot. Does this thin coating have any significant effect on the measurement result?

Bo B

ANSWER: The thermocouple acquires heat from the gas via forced convection. It also emits heat to the pipe wall via radiation if the wall temperature is lower than the sensor temperature. The sensor then measures a temperature that is slightly lower than the gas temperature. The heat flow via radiation depends partly on the surfaces' emission coefficients. A sooty surface has a higher emission coefficient than a clean surface, which means that a sooty thermocouple emits more heat to the pipe wall than a clean thermocouple does. In turn, this means that the sooty sensor will measure a slightly lower temperature than the clean one. In order to determine how large this difference is, we must estimate the heat flow to and from the sensor.

We assume now that the insulated pipe emits heat to the surroundings via natural convection and radiation. With an assumed ambient temperature of 20 °C we can calculate the wall temperature T_{wall} at 233 °C. If the sensor is regarded as a long cylinder in cross flow, we can estimate the heat transfer coefficient α between the gas and the thermocouple at 90 W/(m²K). A new clean thermocouple is assumed to have an emission coefficient ε = 0.40 and a sooty one ε = 0.95.

The heat flow, Q W, via forced convection from the gas with the temperature T_{gas} = 250 °C to the thermocouple with the temperature T °C can be written as

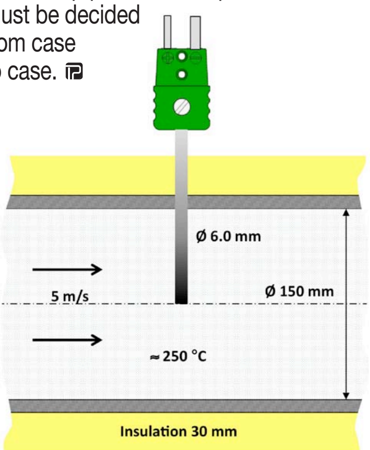
$$Q = \alpha A(T_{gas} - T) = \alpha A(250 - T) \quad (1)$$

where A is the thermocouple's heat-transferring area. The heat flow via radiation between the thermocouple and the pipe wall can in this case be written as approximately

$$Q = \varepsilon A C_s[(T + 273)^4 - (T_{vägg} + 273)^4] = \varepsilon A C_s[(T + 273)^4 - (233 + 273)^4] \quad (2)$$

where C_s is the Stefan-Boltzmann constant, $5.67 \cdot 10^{-8}$ W/(m²K⁴). We have assumed that the pipe is long and that the thermocouple's heat-transferring area, A, is very small in relation to the pipe wall area. By combining equations (1) and (2) we can determine the temperature T that the sensor measures in a stationary situation. For a new sensor with ε = 0.40 we find T = 248.0 °C and for a sooty sensor with ε = 0.95 the temperature is 245.9 °C. In this case the difference is very small – in theory 2.1 °C or 0.8% of the exhaust temperature.

During a startup, the thermocouple adapts to the temperature in the stationary situation considerably faster than the pipe wall does. If we assume that the pipe wall temperature is 50 °C instead of 233 °C, but that the other conditions are the same as previously, we get the temperatures 235.9 °C and 220.9 °C for a smooth and sooty sensor respectively. With the assumed wall temperature, 50 °C, the difference during the startup is 15 °C or 6% of the operating temperature, to subsequently fall to 2.1 °C. In this case, the deviation between the clean and sooty sensors under operating conditions is small. Whether or not the measurement error during the startup phase is acceptable must be decided from case to case.



The probe tip has become sooty from the flow of exhaust in the pipe. How does this affect the temperature measurement?

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

Half are interested in receiving mailings but which half?

Starting with the last issue of Pentronic News Pentronic is updating its address database for its customer magazine via the enclosed survey form. The intention is to complement the magazine with a newsletter customised for various industries.

"The problem of customer databases is that they go out of date quickly," explains Hans Wenegård, who is in charge of the project. "The postal service will only tell us that the addressee is not at the stated address. Regular customers give us better information about who has left the company, changed job or retired. It's also common that companies change name and then their old address only works for a limited time."

Books about marketing usually claim that only half of a company's customer database is interested in receiving mailings. The reason is that the mailings contain information of no interest to the reader. The difficulty is finding out which addresses are in which half of the database.

"Publishing an email newsletter offers us new possibilities," Hans continues. "We can adapt our message to our customers' specific industries. We can also alert readers when a new issue of Pentronic News is available and provide a link to the PDF version at our website. The advantages are both environmental and financial. We're also planning to include in the newsletter a relatively basic how-to section about temperature measurement where we interweave theory with practical tips."

The survey about what information customers want and how they want to receive it is also included in this issue and the next one of Pentro¬nic News (2016-2 and -3). After that, Pentronic will remove the addresses that have not answered from the distribution database.

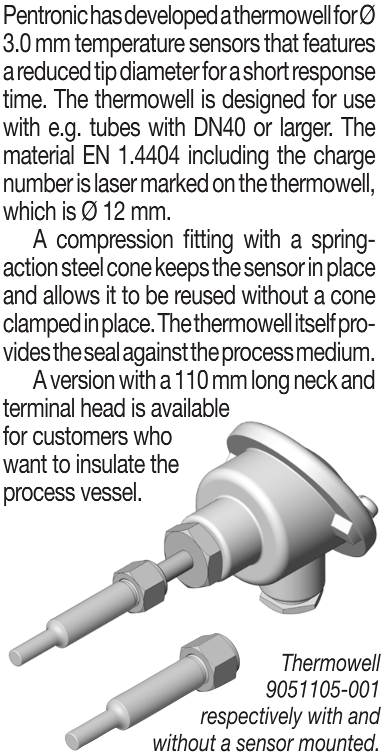
PRODUCT-INFO

Weld-in thermowell in small dimensions

Pentronic has developed a thermowell for Ø 3.0 mm temperature sensors that features a reduced tip diameter for a short response time. The thermowell is designed for use with e.g. tubes with DN40 or larger. The material EN 1.4404 including the charge number is laser marked on the thermowell, which is Ø 12 mm.

A compression fitting with a spring-action steel cone keeps the sensor in place and allows it to be reused without a cone clamped in place. The thermowell itself provides the seal against the process medium.

A version with a 110 mm long neck and terminal head is available for customers who want to insulate the process vessel.



Thermowell 9051105-001 respectively with and without a sensor mounted.

What is the significance of the extension cable's length?

Pentronic is frequently asked how the length and thereby the resistance of the extension cable to the thermocouple influences the measurement result. In fact, several error sources are associated with the cable's length. This article discusses some of them.

The concern can stem from the former days of temperature measurement where the indicator face displayed a resistance value that a thermocouple with an extension cable had to fulfill for the temperature scale on the indicator face to be correct. Even the first-generation battery indicators could show appreciable errors of tenths of a degree if a too long and too thin cable was used.

Insignificant measuring current

Modern indicators contain a digital voltmeter (DVM) with very high input resistance, say 10 megohm. A thermocouple such as a type K has greater resistance than a copper pair cable of the corresponding diameter and length. For example, a type K with a wire diameter of 0.5 mm and a length of one metre has a resistance of 4.9 ohm per double metre (dbm) that is, including both the wires. The corresponding resistance for copper wire is 0.17 ohm/dbm.

To assess the measurement error, we can calculate what proportion of the thermoelectric voltage is lost along the length of the thermocouple's extension cable. See Figure 1. In practice, for a 100 m cable, the measurement result is reduced by approx. 0.049% due to the voltage division. This means that the absolute error caused by the voltage division also increases approximately in step with the temperature level. At 500 °C this corresponds to a reading that is approximately 0.25 °C too low. The thermocouple's sensitivity is nonlinear but can be assumed to be approx. 40 µV/°C for type K. Higher input resistance on the temperature indicator's digital voltmeter and/or increased cable diameter reduces the losses. However, increasing the cable length naturally increases the measurement error.

Already at 250 to 550 °C other phenomena exist, such as SRO hysteresis [Ref 1], which have a significantly greater influence on the measurement result. The error of 0.25 °C is not large compared with SRO hysteresis, which can make the reading vary by up to 4 to 5 degrees.

Antenna effect

A greater error source can be that the extension cable captures electrical interference signals by acting as an unintentional antenna. One common example of this is the low-frequency sine interference emitted by power cables (up to approx. 400 Hz). If the extension cable's wires are twisted, each twist basically divides the effect of the interference in half. Normally, modern transmitters and the input stages of the subsequent electronic equipment are equipped with serial or common-mode interference suppression. The interference can usually be reduced enough by using sufficiently strong attenuation, i.e. a large number of decibels. One alternative can be to place the transmitter as close to the thermocouple as possible and thereby reduce the latter's ability to absorb interference. See Figure 2.

The sensitivity of 40 µV/°C creates a small thermoelectric voltage, which, when it is superimposed on a sinusoidal interference, can cause measurement errors ranging from fractions of a degree up to causing the indicator to reach its end position. See Figure 4.

Shielding for high frequencies

For higher-frequency interferences (greater than approx. 400 Hz) generated by transient signals, "spikes", mobile phones, citizen band radios or electrically pulsed digital communications, shielding must be used. It can be necessary to shield both the cable causing the interference and the one affected by it.

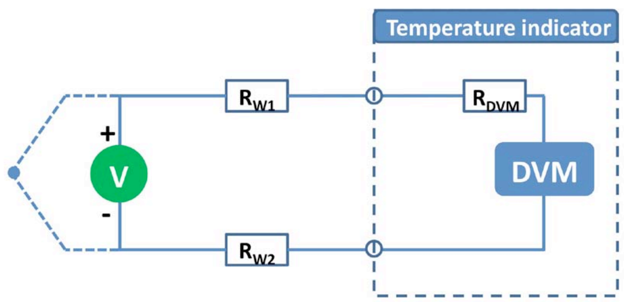


Figure 1. V = The thermocouple's generated voltage. $R_{W1} + R_{W2}$ = the cable resistance per meter of cable length for type K is 4.9 ohm for a wire diameter of 0.5 mm. RDVM ≥ 10 megohm. A 100 metre-long such cable reduces the DVM's share of V by 0.049%. At 500 °C this corresponds to approx. 0.25 °C.

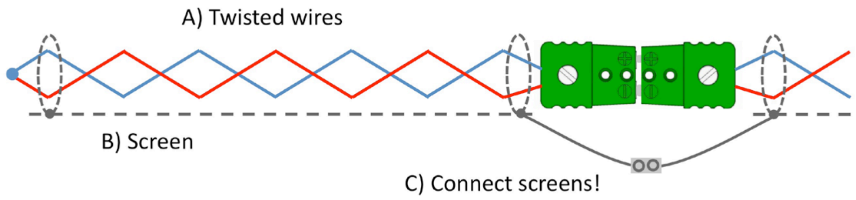


Figure 2. A thermocouple consisting of an (A) twisted-pair and (B) shielded extension cable. Using a twisted multi pair cable dampens interfering frequencies up to approx. 400 Hz. Shielding dampens e.g. the influence of square waves containing high frequencies. (See further Figure 3). (C) shows a simple way to connect all the shields into a continuous length that can be grounded at a shared point.

On a shielded cable, the shielding should also cover the splicing points. Grounding should normally be done at a central point in order to avoid ground currents that can alter the voltage potential in the grounding points and thereby unintentionally modulate the measurement signal. Thermocouple connectors are available with three pins, one of which is designed to connect the shield through the splicing points. In some high-frequency situations, the exposed short length of the connector can also absorb interference, and then it may also be necessary to also shield the connectors from the surroundings.

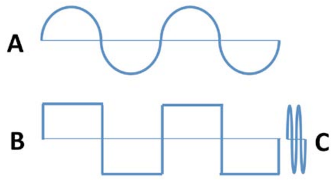


Figure 3. A) Sine wave. B) A square wave contains high sine frequencies in order to be able to create steep flanks. C) The flanks in B become steeper the greater number of high-frequency sine waves the wave contains.

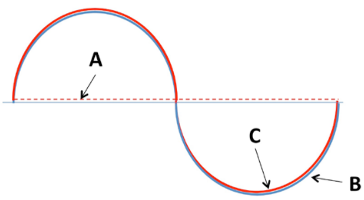


Figure 4. A) The small, low-frequency DC component from the thermocouple (the dotted line) that we want to measure. B) An interfering sine-shaped AC component (blue). C) The resulting signal to the indicator (red).

References see www.pentronic.se > News > [Ref 1] See Pentronic News 2010-1, page 4

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