PENTRONIC NEWS

PENTRONIC Scandinavia's leading manufacturer of industrial temperature sensors

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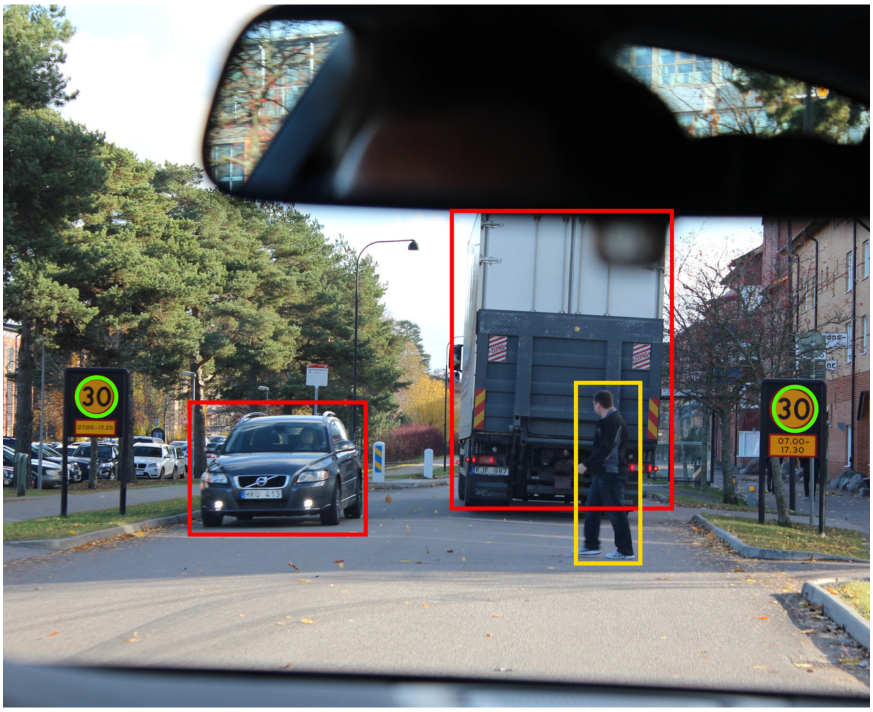
Next time it might be your life that's saved by temperature



Cameras and sensors are used to discover potential dangers to the car.

Temperature measurement is saving more and more lives in traffic. But for this to work, the measurements must be correct and the equipment must continue to function for many years in temperatures from –40 to +85 °C.

The key is active safety systems, which are becoming more and more common and numerous in cars. The Swedish-American company Autoliv is a world leader in this field and temperature measurement is one of the methods used to warn the driver and, if necessary, to brake the car or steer it aside if its sensors detect danger.

The technology is based on measuring a variety of different quantities.

"One type of technology used is IR pyrometry, for instance to detect animals on the side of the road in the dark," explains Göran Pettersson, a test engineer at Autoliv's development centre in Linköping.

Invisible to the eye

IR is non-contact temperature measurement that makes it possible for the vehicle's safety systems to disclose dangers invisible to the human eye.

Temperature is involved in everything Autoliv develops and manufactures. At the same time as car equipment is becoming more sophisticated, customers expect their cars to start in all weathers and function impeccably for many years. This is especially important for all the safety systems. In most cases they will never be used but they must function just in case.

As a result, everything is rigorously tested at two stages of the development process. First the design is tested and then new tests are done after the equipment is ready for serial production.

"The safety must be unchanged at temperatures from –40 up to +85 degrees," Göran says. "One common test method is to create temperature cycles across the entire range inside a climate cabinet. Because the test objects are relatively small, you don't need a big cabinet, so normally the built-in temperature sensors are sufficient to control the measuring range in question.

Accelerated ageing

Autoliv has its own climate laboratory where it recreates the conditions that a car in use could be exposed to. One method is accelerated ageing in climate chambers where the temperature alternates for two or three months between arctic cold and tropical heat.

The electronics are not the only system to be put under stress. The properties of the materials used change with the temperature; they age and their function can worsen over time.

"The tolerances become closer because we're using more and more optical systems, which means we must use other materials in order to retain the function whatever the temperature," Göran says.

The totality is most important

It is one thing, however, to validate a function in a laboratory setting but totally another when everything is sitting installed in the relevant model of car.

"Some sensors are also exposed to slush and road salt," Göran adds.

"A modern car has a large number of computers on the same bus, linked to other systems with tasks like braking the car or increasing the steering resistance. It's only possible to test how everything works together in a car when it's finished and complete."

It's a challenge to get everything to work properly even on an early January morning when the mercury has dropped below minus 30 degrees. The fact that it does all work is the result of extensive testing done at several stages and under carefully controlled conditions. But how many car drivers think about that?

"Using more and more optical systems places higher demands on temperature measurement," says Göran Pettersson.

A working life spreading knowledge about temperature

Hans Wenegård was hired at Pentronic in 1979.

Since then the company has been transformed from a manufacturer of temperature sensors into a supplier of expertise and solutions in the field of temperature measurement.

Hans has played an active role in this change.

He is now retiring after two years of working beyond normal retirement age but he hopes to continue giving courses.

"Temperature is an interesting area and I've been able to do many different things here at Pentronic," he says.

As a young man he faced a choice between becoming an engineer or a teacher. The engineering side won, perhaps because he grew up in Linköping near the main base of the Swedish air force wing F3. After high school he trained to become a graduate engineer and was then hired at Saab's aeronautics division, where he worked with measurement technology. Five years later the moving van with his belongings headed to Västervik and Pentronic.

"At first I worked in the instrument department soldering circuit boards and other products," he remembers.

At that time Pentronic was mainly a workshop but its then-owner Torsten Lindholm was both knowledgeable and interested in temperature measurement in practice. As a result, as early as 1988 Pentronic became one of the first companies in Sweden to have its own in-house accredited temperature laboratory.

"The laboratory has been incredibly important in raising the level of knowledge within the company and at our customers," Hans says.

Things really accelerated when the first customers began to certify themselves in accordance with the ISO 9000 and ISO 14000 standards. Measurement equipment then became the focus of attention and many people became puzzled by statements such as that all measurement devices had to be traceable to national standards.

That was the origin both of this magazine, which was published for the first time in Swedish in 1990, and of Pentronic's programme of training courses, which began a year later. In both cases Hans was involved, as editor of the magazine and as an instructor for the courses.

"This then led to contacts with universities and to Pentronic's continued cooperation still today with academics such as Professor Emeritus Dan Loyd. We've learned a lot from him, not least about heat transfer," says Hans, who appreciates the contacts with the research world.

At that time Pentronic also had to become certified in accordance with ISO 9000 and ISO 14000. The project manager appointed to handle this process was the person who was already instructing workers at other companies in the same situation: Hans Wenegård.

Hans Wenegård.

For the space of ten years Pentronic's training programme was extremely active, due partly to a pent-up need for training and partly to more stringent temperature measurement requirements. Today traceability and other aspects of quality assurance are taken for granted. But even though the first decade's obvious need for training has lessened, Hans still believes that there is still a need for another reason:

"Measurement technology has disappeared from the universities' engineering programmes. But the old truth that you get out of a computer what you put into it still applies, or, as we said back then, 'Garbage in, garbage out'. No algorithms can compensate this over-reliance on computer technology."

In recent years the role of instructor has occupied more and more of his working time. It is Hans who writes the technical articles on the back page of this magazine. Not only does he instruct Pentronic's own courses, he has also participated in courses given by the postgraduate education institute STF Ingenjörsutbildning, for Instrumenttekniska föreningen (a Swedish association of engineers interested in instrument technology and automation) and other professional bodies, and at a large number of training events held at customers' premises.

The latest training, at the time this article was written, was a course in measurement technology for Pentronic's own employees. Over the years there have been quite a few of these, which explains something that visitors to Pentronic's production often remark on: Assemblers and operators know why they are doing specific work tasks and can explain why.

"It's a terrific crew on every level," says Hans Wenegård, who is keen to continue his teaching duties, health permitting. He is not concerned about the future. Pentronic has a number of employees who have participated in the training programme and who can take over the teaching and administration.

Pentronic is hiring and expanding

Pentronic is expanding and hiring more employees to increase capacity and make room for more products in the field of electronics.

The expansion of the factory in Västervik is proceeding at full speed to increase production capacity. The addition will give us more efficient acceptance testing and inventory management while also freeing up existing space for production. In addition our focus on manufacturing smart measurement systems also continues.

Per Johansson, Pentronic.

"We will be increasing volumes in that area," Managing Director Rikard Larsson.

In line with this priority Per Johansson has been hired as a hardware developer. He comes most recently from the nuclear power station at Oskarshamn, Sweden and before that was a development engineer at Electrolux. Long experience of high safety requirements and electronics development were important factors in the recruitment process.

The hot electronics box

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

QUESTION: A closed electronics box is mounted on one of our machines as shown in the figure. The box's outer dimensions are 70x150x200 mm^3 and the wall material is aluminium. The heat production in the box is 40 W and we have measured the box's temperature to be 60 °C when the temperature in our workshop is 18 °C. We will be replacing the electronics, and the heat production will then increase to about 50 W. Is it possible to calculate in advance what temperature the electronics box will have, and is there an easy way to cool it if necessary?

Martin A

ANSWER: In this case the heat flow from the electronics box to the surroundings occurs mainly via natural convection and radiation. Some heat transfer also occurs via thermal conduction to the machine stand via the fastening. Very approximately, the heat flow to the surroundings via convection and radiation can be written

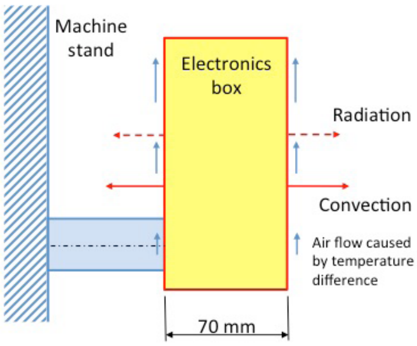
$$Q = h_{tot} A (T_{box} - T_{surr}) \quad (1)$$

where h_{tot} in W/(m^2K) is a total heat transfer coefficient that includes both convection and radiation, A in m^2 is the heat transfer area, T_{box} in °C is the electronics box's outer temperature, and T_{surr} in °C is the ambient temperature. All quantities are mean values. The heat transfer via conduction to the machine stand is not included in the equation (1).

With the given values, h_{tot} becomes approximately 9 W/(m^2K), which in this case is a reasonable value. If we assume that the value is constant, when we increase the heat production to 50 W we find that the temperature increases from 60 °C to just over 70 °C. This estimate is based on many assumptions and approximations but it still gives us some idea of the temperature increase we can expect.

This temperature is so high that you should consider reducing it. In addition, inside the box the temperature of some components will be higher than the box's outer temperature. Even if the electronics can endure the high temperature, they will have a shorter lifespan.

Unfortunately there is no easy way to reduce the temperature of the existing electronics box when the heat production increases. Based on the equation (1) we find that for a specified heat production Q we can reduce the temperature of the electronics box by increasing the heat transferring area A and/or the total heat transfer coefficient h_{tot}. The



area can be increased by e.g. equipping the electronics box with fins but this would require replacing the existing box. The heat transfer coefficient can be increased by increasing the air velocity around the box with a fan but this also requires a rebuild.

If the temperature of the machine stand is always lower than that of the electronics box you can increase the heat flow to the stand by reducing the thermal resistance between the box and the stand. Greater heat flow to the stand reduces the box's temperature. This possibility also requires a rebuild. Another possibility you should explore is whether it is possible to reduce the heat production in the electronics box. It may not be necessary for all the electronics to be constantly activated. Some of them may only need to be activated on certain occasions. A lower heat production produces a lower temperature.

Which measure(s) to choose to reduce the temperature of the electronics box depends on the circumstances of each individual case. When doing a rebuild you should also install one or more measuring points inside the electronics box and at least at the box's casing so that you can monitor the temperature.

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

STRAIGHT FROM THE LAB

New standard for sheathed thermocouples

SWEDAC ACKREDITERING 0076 ISO/IEC 17025

The new standard was released in April and has the designation IEC 61515 (2016). One topic it deals with is continual maximum temperatures in stationary air for sheathed thermocouples. The standard also governs the relationship between seller and buyer, who can make a number of demands. However, both parties must be in agreement and understand the consequences of those demands.

With regard to acceptance testing and suchlike, the IEC 61515 format is similar to that of the corresponding standard for Pt100s: IEC 60751 (2008). It states that the temperature-emf relationship, tolerances and cable colours cannot be altered.

Sheathed thermocouples are ordinary thermocouples without noble metal wires such as those found in types N, K, J, E and T. For example, N and K with a Ø3 mm outer diameter and a sheath of Inconel 600 are both given a stated temperature limit of 1070 °C.

For anyone taking measurements in this temperature range, the temperature limit is critical, especially if materials or environments damaging to types N and K, such as a vacuum, are present. What you can do is to switch to a type R or S thermocouple, or, for higher temperatures, a type B. The disadvantage with these is their requirement for ceramic protection tubes, which can easily break when industrial furnaces are being filled and emptied.

Pentronic has recently acquired its own furnace to monitor how sheathed thermocouples function at higher temperatures. The furnace's maximum temperature is 1700 °C. It is now being tested and is not part of the accreditation process.

Does Pentronic News benefit you?

Is what we write about relevant to you?

VWe would like to call your attention to the fact that the magazine will no longer be sent to your address if you do not fill in the enclosed form. Choose between a paper copy sent to you in an envelope or a download via the mailings we plan to do from Issue 4 this year.

If you miss filling in the enclosed form now you can always subscribe for free later on via our home page (www.pentronic.se/home.aspx) and the Pentronic News heading, says Pentronic's Sales Manager Dan Augustini.


PENTRONIC NYTT

Nästa gång kan det vara ditt liv som räddas av temperaturmätning

Mismatched thermocouple cables cause measurement error

Assume that a customer is using a type K thermocouple to take readings and that the instrumentation (transmitter or input circuit) is also designed for type K but that the customer for some reason has bought an extension cable for type N. Would there then be a measurement error, and, if so, how can it be compensated for? This is a common question asked of Pentronic and we will it discuss here.

A measuring circuit with a mixture of extension cables might look like the one shown in Figure 1. The section between the first splice (T_{splice} = 70 °C) and the reference junction (T_{ref} = 40 °C) consists of a type N cable whereas the thermocouple itself is type K, as is the instrumentation.

Table 1 shows the splices' temperature in degrees Celsius and also the corresponding emf (electro-motive force) in microvolts for the thermocouple type at issue here. The values are nominal and we must therefore hope that the real values lie within the relevant tolerance limits for the respective thermocouple types in accordance with the IEC 60584 standard. The relationship is given in equation (1), which specifies between the curly brackets which thermocouple type and thereby which table is intended.

$$E_{K\text{-}N\text{-}K} = \{E(T_{meas}) - E(T_{splice})\}_{TAB\ K} + \{E(T_{splice}) - E(T_{ref})\}_{TAB\ N} + \{E(T_{ref})\}_{TAB\ K} \qquad (1)$$

Look at row 1 in Table 1. The measured temperature is 900 °C. The first splice between type K and type N maintains 70 °C and could be a terminal head that is heated by the protection tube's losses through a furnace wall.

Because the thermocouple voltage is non-linear to the temperature, the corresponding voltage level has been taken from the applicable table, where E represents emf in microvolts. The next point of interest is the return to the type K cable at the reference junction. Assume that the temperature in this case is 40 °C. The correct presentation would be $E_{K\text{-}K\text{-}K}$, where all the cable components are of the same type. $E_{K\text{-}N\text{-}K}$ shows the emf of the arrangement shown here. The difference, -56 °C, is the measurement error, which proves to be fairly constant across a large temperature range. The minus sign is because type N gives a lower output signal than type K. In its turn, the lower output signal, which is assumed to be a constant -56 degrees, assumes that the temperature difference along the extension cable (type N) is a constant 70 °C or 40 °C respectively, which is not likely.

Thermocouple type K				Thermocouple type N			Indicator K	Presentation		Measuring error
T_{meas}	E_{meas}	T_{joint}	E_{joint}	E_{joint}	T_{ref}	E_{ref}	E_{ref}	$E_{K\text{-}K\text{-}K}$	$E_{K\text{-}N\text{-}K}$	∆T °C
900	37326	70	2851	1902	40	1065	1612	38938	36924	-56
500	20644	70	2851	1902	40	1065	1612	22258	20242	-56
200	8138	70	2851	1902	40	1065	1612	9750	7736	-56

Table 1. $E_{K\text{-}K\text{-}K}$ is the nominal output signal with all type K cables. $E_{K\text{-}N\text{-}K}$ is that of the measuring circuit disrupted by the foreign thermocouple type. The difference ∆T appears to be constant across the measuring range 900 – 200 °C but this is actually not the case, because the protection tube's losses heat the the terminal head more at a high measuring temperature than at a low one.

There are three ways to compensate for the mismatching extension cable's differing sensitivity [µV/°C]:

1. The first and best way is to get the correct extension cable, in this case, type K.

2. The second way is, if possible, to ensure that the ends of the mismatching cable maintain the same temperature, ($T_1 = T_2$). All sensitivity is thereby zeroed out, which can be possible within a closer temperature range. See equation 2.

$$E(T) = S_{N+/N-}\,(T_1 - T_2) \qquad (2)$$

where T is the temperature of the splices and S the extension cable's Seebeck coefficient.

3. The third possibility would be to compensate for the difference in voltage with some reverse voltage. However, it is not easy to make this arrangement responsive to temperature changes in, for example, a dynamic sequence of events such as a process start-up.

Which alternative is best must be discussed from case to case. The less work and cost involved in replacing the cable, the greater the reason for doing so. You must also consider your customers and what would happen if they discover that you are "fudging" with the cabling. Trust in a supplier's expertise strengthens a business relationship and makes it more likely that the customer will stay loyal.

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

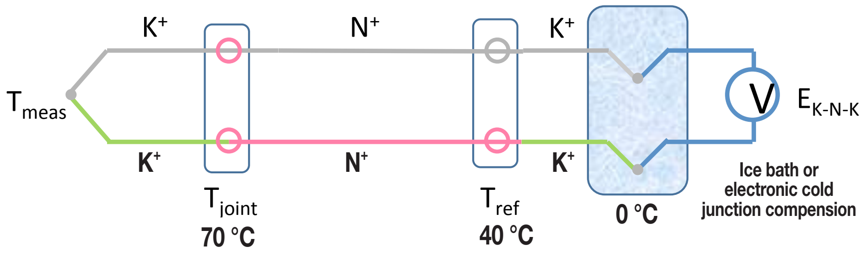


Figure 1. A thermocouple circuit is using a type K thermocouple to measure temperature. The splice between the terminal head and the reference junction has been done with a type N extension cable. A measurement error arises due to the differing Seebeck coefficients (sensitivities) of type K and type N.

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.

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