PENTRONIC NEWS

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IT´S ALL ABOUT TEMPERATURE!

PENTRONIC Scandinavia's leading manufacturer of industrial temperature sensors

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The right temperature for sensitive medicines during the whole transport

Envirotainer tests containers and different load configurations in its own climatic chambers.

The Swedish company Envirotainer is the world leader in containers for temperature-controlled air cargo shipments. The secret is availability, airworthiness and monitoring temperature at every stage. Laboratory manager David Graaf sums up the situation: "What we supply, works."

The major market in this sector is the rapid and reliable transport of temperature-sensitive medical products such blood plasma, insulin and vaccines. Some 20 percent of these products are destroyed during transport because at some stage the cooling chain breaks.

Envirotainer solves this problem with unique products combined with a high service level.

The product itself is a container with a built-in cooling and heating system. The temperature is maintained at the correct level all the way from loading to unloading at the destination. In terminals, on trucks and in aircraft cargo holds.

"The transport companies lease containers for every trip and then return them to one of our stations," Graaf says.

In-house climatic chambers

The arrangement resembles car hire, where customers have no worries about maintenance and binding up capital. Instead they hire a reliable function when required. Envirotainer guarantees every container's airworthiness and performance.

Supplying a function in this way places especially high demands on such functions as temperature measurement. Data on the container's temperature is logged throughout the journey. Graaf emphasises that this is not the same as the products' temperature, which depends on how the shipment is packed. Just like in storage facilities, it is therefore important to measure the temperature of the actual shipment.

"We have two climatic chambers of our own where we test the containers and configurations of the load under various circumstances," he says. "The transport companies and their customers can access this data."

Useful input from Pentronic

Pentronic supplies measurement equipment to Envirotainer's laboratory and has also acted as a consultant to solve the issue of how to measure temperature in the most reliable way.

"That run-through gave us some useful input," Graaf says.

Envirotainer has two versions of its container: one with cooling and heating functions and one with only cooling.

In containers with both cooling and heating functions the temperature can be set between 0 and 25 °C. Depending on the ambient temperature in the aircraft cargo hold, heating is at least as important as cooling. Because using compressors for cooling consumes a lot of energy, the batteries are dimensioned appropriately.

Containers for transporting frozen products maintain the temperature with the help of dry ice.

Envirotainer develops and manufactures its containers in Rosersberg north of Stockholm and has stations and accredited agents in all populated parts of the world.

David Graaf maintains traceability of the temperature readings by calibrating in a water bath against an externally calibrated reference sensor.

Lathes enable Pentronic to manufacture to order

Pentronic distinguishes itself from most manufacturers of temperature sensors by manufacturing its own subcomponents.

"It's the only option when you have customer-driven production," says Matts Pettersson, the production manager of the machining department.

Manufacturing is a combination of automation and manual work. Multi-axle CNC lathes are complemented with manual processing. The operators must have a good knowledge of the materials, know how to programme the machines and also have the necessary manual skills.

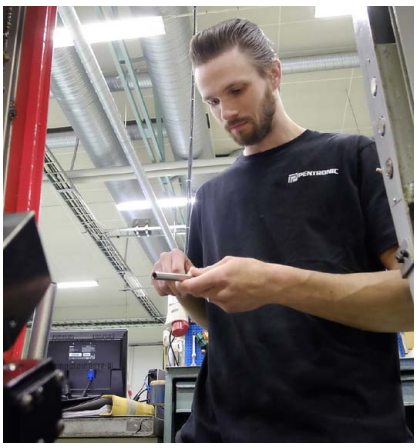
"We adapt the material to the sensor's intended environment and we use many different types of alloys," Matts explains. "For example, there are differences in cutting speed and swarf build up, which require know-how, experience and close attention."

In-house toolmaking

The series sizes vary from unique pieces to 12,000 units. One might think that short series are produced with the support lathe but that is seldom the case. Hard-to-work materials mean it is faster to programme a controlled lathe to make a product requiring closer tolerances.

One recurring difficult task is to drill small and up to 800 mm long holes. Everyone who has tried this knows it is quite the challenge. The risk is that the drill goes off course and comes out at the wrong place. To do a precision job successfully requires a specially constructed drill plus the use of a special technique.

"We manufacture the longest drill ourselves," Matts says, and shows a number of examples, some of which are so thin that in normal lengths they would be broken off in a hand-held drill.



Pentronic is one of the few manufacturers of temperature sensors with its own production of subcomponents. Gustav Gyllenram inspects the results.

The operators know the materials and also have the manual skills, which are both necessary when doing high-precision CNC processing.

Reliable deliveries

In previous years Pentronic's expertise in working with tricky alloys was almost unique. Nowadays the skills also exist elsewhere but the company continues to have its own production.

"Ordering five units from a subcontractor just doesn't work," Matts says. "Then we'll get the delivery next year. Temperature sensors are often critical to a customer's production process so we have to deliver quickly and at the right time."

The manual methods are mainly used to adapt Pentronic's standard range. The only adjustment needed might be to change a size. Then the support lathe is brought out and the result is a customised standard sensor.

The machining department has six employees split into two shifts. Each operator is in charge of two CNC machines and also does manual processing. Matts Pettersson is cautious about joining the production team himself.

"I've worked as a lathe operator before but it's something you have keep doing all the time if you want to get good results," he says.

A course right where you work?

"Could a review of temperature measurement be useful at your workplace?" wonders Hans Wenegård, who is in charge of customer training at Pentronic.

"Pentronic can customise a one- or two-day course package to your requirements," Hans says. "We take the desired content from our popular course Traceable Temperature Measurement, which we have given in Västervik, Sweden, for the past 25 years. On the first day there is time to present a selection of theoretical topics. The practical sessions are held on the second day."

"The original course has sections on scientific principles, thermocouples, Pt100s/Pt1000s (RTDs), IR pyrometry, calibration and assessing measurement uncertainty plus seven different laboratory practical sessions on the sections. All you have to do is choose which topics we should include and to what extent."

The course can be held in Swedish or English. Pentronic has also given customised courses in Norway, Finland and China.

Read more at www.pentronic.se > Services > Education/training.

Exhaust gas temperature during startup is hard to determine in catalytic converters

QUESTION: To find out if the exhaust gas temperature varies between the different channels in our catalytic converters we take control readings with thin sheathed thermocouples. So as not to disturb the flow upstream of the catalytic converter we insert the thermocouples from the rear. The thermocouples sit freely inside the channels and the distance from the thermocouple tip to the leading edge of the channel is about one channel diameter. During the startup process the exhaust gas heats the catalytic converter up to the operational temperature, which is just over 300 °C. After the startup the exhaust gas temperature is constant or changes very slowly. How good is the measurement result?

Joel J

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

QUESTIONS ANSWERS

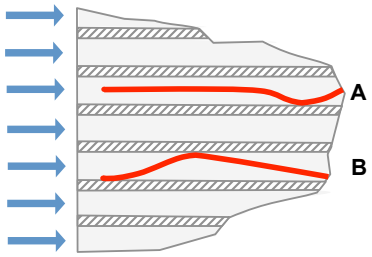


Figure 1. Catalytic converter channels with thin sheathed thermocouples (red) inserted from the rear against the flow direction.

ANSWER: When you insert a thermocouple so it sits freely in one of the channels inside the catalytic converter you will measure a temperature that is being affected by both the exhaust gas temperature and that of the channel wall. If the thermocouple tip is lying totally freely in the channel, see A in Figure 1, you will mainly be measuring the gas temperature but the wall temperature also has some effect. Heat is transferred from the gas to the thermocouple and channel wall via forced convection. The thin thermocouple is heated up faster than the channel wall and thereby reaches a slightly higher temperature than the wall. This means that heat is transferred from the thermocouple to the channel wall via radiation. In this case the wall temperature will affect the measurement result.

If the thermocouple tip is in contact with the channel wall, see B in Figure 1, the wall temperature will have a large influence on the measurement value. The heat exchange between the thermocouple and the channel wall occurs via heat conduction. As in the previous case, the heat is transferred from the gas to both the thermocouple and the channel wall via forced convection. The better the contact is between the thermocouple and the wall, the greater the influence of the wall temperature on the measurement result. In this case the influence of radiation on the measurement result is small.

The gas velocity in a catalytic converter is often high and the force from the gas flow will influence the thermocouples' location in the channels. In reality, therefore, we do not know if the thermocouple tip is in contact with the channel wall or how good any contact is. We must also assume that the contact between the thermocouple and the wall varies during the startup phase. In some cases the thermocouple will vibrate. During startup it is therefore somewhat unclear which temperature is being measured.

During the operational stage the measurement situation is often more favourable. The gas temperature is almost constant when the catalytic converter has achieved its operational temperature of about 300 °C. The wall and thermocouple should now have about the same temperature as the gas that is flowing into the channel in question and we are now measuring a relevant temperature. During the operational stage and while the gas flow is constant it is therefore not so relevant whether or not the thermocouple has contact with the channel or not. In the case of vehicle engines, where the gas flow and gas temperature vary greatly, similar problems unfortunately occur as those during the startup phase.

The thermocouple disrupts the flow inside the channel, which reduces the flow velocity and increases the response time. By fixing the probe tip in the centre of the channel, we reduce the uncertainty during the startup, but the equipment increases the flow resistance and reduces the velocity. Whether or not you should accept the uncertainty during the startup phase must be decided from case to case.

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

Find hot and cold spots with a thermographic camera!

The TC-1 infrared thermographic camera quickly finds high or low temperature deviations contact free on objects that are moveable, live, hard to access or where thermal load should be avoided.

Other typical applications are to take readings on gearboxes, bearings, electric motors and pumps to detect overheating before any damage occurs. The camera can detect heat or cold leaks from insulated furnaces or buildings. The measuring range is -20 to 250 °C and the temperature distribution is shown on the display, which is 40 x 50 mm. The emissivity is preset at 0.95, which covers organic materials but can be adjusted between 0.10 and 1.00.

Image storage capacity 8 Gb.

Part number: 06-81001

STRAIGHT FROM THE LAB

Now environmental agency thermometers can be calibrated year round

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"Environmental inspectors can now send us their electronic indicators with two sensors for calibration year round for the same price as during our previous special discount weeks in spring and autumn," says Pentronic's laboratory manager Lars Grönlund.

"If you also send in your IR pyrometer at the same time, it will be calibrated for its discounted price too, because there is then a synergy effect. Like before, contact-type measurement equipment is calibrated at -18, 0.8, 0 and 60 °C. We calibrate IR pyrometers at -10, 0 and 60 °C, all within the accreditation limits. The only difference from before is that we no longer send out our recall letters, which customers can replace by marking their own calendars."

Just like before, Pentronic calibrates all makes of sensors and indicators. If you have questions contact the laboratory.

What affects a Pt100 sensor's precision?

The Pt100 (RTD) is known to be the most accurate type of industrial sensor. However, all types of Pt100 resistor are not equivalent. In this article we sort out the various possibilities and limitations.

The IEC 60751:2008 standard is the most recent one from the IEC to describe platinum thermometers. Unlike previous versions of the standard, this one is based on the actual conditions affecting resistors and complete ready-to-use sensors. The standard also takes into account whether the complete sensors contain wirewound or film resistors. See Figure 1. Pt100 and Pt1000 are normally the most common types in industrial uses but other ohm numbers than 100 and 1000 do occur at 0 °C. The tolerances in degrees C are the same but the resistance values differ relative to the basic resistances. [Ref 1]

Wirewound vs film resistors

Film resistors have limited measuring ranges compared with wirewound ones. See Figure 2. This is because film resistors are less tolerant of heat and cold than platinum-wire ones. If you exceed the limits of the measuring range, there is a large risk that the resistance-temperature relationship within the limits is altered to a wider tolerance class or that the resistor is actually destroyed.

The standard defines general tolerance classes (given in Figure 2). Nothing stops manufacturers from making resistors that meet the tolerances within larger or smaller temperature ranges. In such cases the IEC requires that the manufacturer and purchaser must be in agreement.

Hysteresis is another phenomenon that is affected by the sensor construction. The cause of hysteresis is the differing length expansions of the platinum wire or film and the surrounding resistor body. The more fixed the physical connection is, the more the platinum is stretched or compressed with the changes in temperature, and the more it therefore alters its basic resistance due to causes other than the temperature dependence of the electrical resistance. Wirewound resistors with

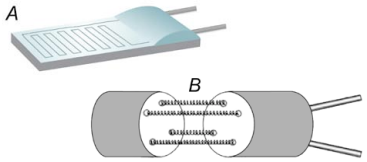

Figure 1. A) A film resistor. The "wire" is cut out from a thin sheet of platinum, which is fixed to a substrate. B) A wirewound resistor with 80% free wire, which minimises unintended resistance changes due to the differing expansion of the wire and the resistor body.

80% of the wire's length freely suspended are the best of the industrial versions.

Careful manufacture

The assembly of a resistor and its protection tube can cause additional measurement errors that alter the tolerance or its temperature interval. The risks depend on how the resistor is handled during manufacture. For example, finger grease must not come in contact with the resistor's body. At higher temperatures or lower pressures this can cause gases, which, if they penetrate the body, will contaminate the platinum wire and result in altered resistance. For the same reason, oil residues, which can occur in protection tubes, and heavy metals, must not come in contact with the platinum wire in the resistors.

Adhesives and gels, which are usually used for electrical isolation and vibration dampening inside the sensor, must also be carefully chosen with regard to the sensor's intended use. Otherwise measurement errors can already occur at temperatures from about 100 °C. The reason is that these materials' electrical isolation ability decreases with increasing temperature.

Calibration

Calibration is necessary in order to give the sensor readings traceability to the ITS-90 temperature scale. The most reliable way to establish traceability is a correction term with measurement uncertainty statements. [Ref 2]. An accredited calibration laboratory for temperature can perform such a calibration. Pt100 sensors are normally so stable that calibration at a few points is enough to establish traceability between the points as well. See Figure 3.

Pentronic's accredited laboratory performs calibration by comparison on Pt100 sensors within -80 to 200 °C with a measurement uncertainty of ± 0.015 °C, and within 200 to 550 °C with a measurement uncertainty of ± 0.02 °C. For this to be done, the method's required conditions, such as the minimum insertion depth, must be met. [Ref 3].

A less reliable method, of linking the read values to the temperature scale, can be to rely on the resistor manufacturer's stated tolerances, e.g. Class A, but do not forget that the complete sensor will add increased uncertainty. [Ref 4].

Pentronic's final inspection of Pt100/Pt1000 sensors is normally done in an ice-water bath using a reference sensor that is regularly calibrated in the accredited laboratory and thereby maintains traceability. Each supplied unit's test result at 0 °C is documented with a test certificate in accordance with EN 10204 3.1. The certificate is displayed on the Pentronic website. Look for Test Certificates under Services or Temperature Sensors. The sensor's ID number or our order number will take you to your test certificate, which is anonymised. If the platinum sensor is approved in accordance with Class A at 0 degrees, it will probably meet Class A even at higher temperatures. There is no extra charge for the test certificate.

However, if you want to be totally certain then accredited calibration at additional points is necessary.

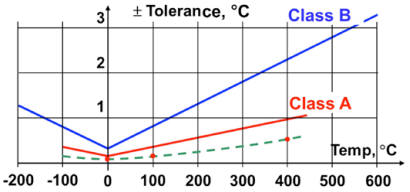

Figure 3. The diagram shows a typical behaviour of a platinum sensor in IEC Class A (the green dashed line). Three calibration points are shown (marked in red) within the interval 0–400 °C. Platinum is so stable that the points are sufficient to define the measurement properties within the whole range. See heading Calibration above discussing measurement uncertainty in the points.

Tolerance classes for Pt resistors				Tolerance classes for complete Pt sensors			Tolerance value at temperature T [°C]
Wirewound (W)		Film type (F)			Temperature range [°C]		
Tolerance class	Temperature range [°C]	Tolerance class	Temperature range [°C]	Tolerance class	Wirewound (W)	Film type (F)	
W 0.1	-100 – 350	F 0.1	0 – 150	AA	-50 – 250	0 – 150	± (0.1 + 0.0017·|T|)
W 0.15	-100 – 450	F 0.15	-30 – 300	A	-100 – 450	-30 – 300	± (0.15 + 0.002·|T|)
W 0.3	-196 – 660	F 0.3	-50 – 500	B	-196 – 600	-50 – 500	± (0.3 + 0.005·|T|)
W 0.6	-196 – 660	F 0.6	-50 – 600	C	-196 – 600	-50 – 600	± (0.6 + 0.01·|T|)

Figure 2. The tolerance classes and measuring ranges for platinum resistors that are wirewound and of film type (the orange field) and for complete temperature sensors (in blue). The grey column shows the expressions for the tolerances within each respective measuring range. \|T\| is the temperature value regardless of sign.

References see www.pentronic.se > News > Pentronic News > Pentronic News Archive
[Ref 1] See Pentronic News 2009-4 p 4
[Ref 2] See Pentronic News 2012-4 p 2
[Ref 3] See Pentronic News 2009-5 p 4
[Ref 4] See Pentronic News 2011-5 p 4

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