PENTRONIC Skandinavia's leading manufacturer of industrial temperature sensors

NO. 2017-1

PENTRONIC NEWS

It's all about temperature!

NEW SENSOR MEASURES ADIABATIC SURFACE TEMPERATURE AND INCIDENT RADIATION

CONTINUED ON PAGES 2-3

Welcome to the "new" Pentronic News

Our customer magazine has always had two aims – to inform readers about products and services, and to be a source of knowledge about temperature measurement. In these respects the new Pentronic News will not be different. The change is intended to modernise the look of the magazine and make it easier to read. We hope you will enjoy the new format.

2016 IN REVIEW

We can look back on yet another successful year for Pentronic thanks to you and all our other business partners. Our journey to develop and offer more products in the smart sensor market continues at an ever-faster speed. During the year we were also trusted with developing several complex sensors. I hope and believe that our knowledge and extensive experience have contributed to Pentronic being considered for these projects. In the field of calibration we have also seen an increased need for our services.

In January 2017 we concluded the acquisition of a Dutch subsidiary, RS Technics BV. The purpose of the acquisition is to broaden our market outside the Nordic region. RS Technics develops and manufactures sensors in the fields of temperature, pressure and moisture content as well as electronic devices for measurement and control. In 2016 we were also awarded Volvo Cars' major quality prize, the Volvo Quality Through Excellence Award. It is yet another confirmation of our efforts to stay at the forefront with regard to quality and customer service.

2017

In conclusion, I would like to thank you for doing business with us during 2016 and to say that we look forward to all the challenges of 2017. Pentronic's strength comes from the fact that we supply individual custom-made sensors with a short delivery time while simultaneously being a series manufacturer of significant volumes for world-leading customers within their market segments. Always with the same focus on quality and delivery reliability. You are most welcome to challenge us too.

Rikard Larsson
Managing Director

FROM PAGE ONE.

Pentronic has worked with Professor Ulf Wickström at Luleå University of Technology to develop a thermocouple that measures adiabatic surface temperature, which is the weighted mean temperature of the gas temperature and the radiation temperature. The radiation temperature or the incident radiation can then be calculated when we know the adiabatic surface temperature and the gas temperature.

THE NEW SENSOR is a Plate Thermometer Heat Flux Meter.

A few sentences to illustrate the difference:

A fire doesn't care what the gas temperature alone is. The fire spreads when a sufficiently high adiabatic surface temperature has developed on combustible surfaces.

The difference between being in the sunshine or in the shade on a warm summer's day depends on the differing radiation temperatures. The air temperature is the same but the radiation means that surfaces in the sunshine become much hotter.

The measuring method is based on the results of fire research done at the research institutes RISE, until recently SP,

"That sensor is now standard equipment in fire research but is designed for measuring high temperatures in furnaces."

in Borås, Sweden. Ulf Wicksröm is SP´s former director for the department of fire technology and 20 years ago he worked with Pentronic to develop a similar sensor for taking readings in furnaces.

"That sensor is now standard equipment in fire research but is designed for measuring high temperatures in furnaces," he says. "There is a need for doing similar measuring at lower temperatures."

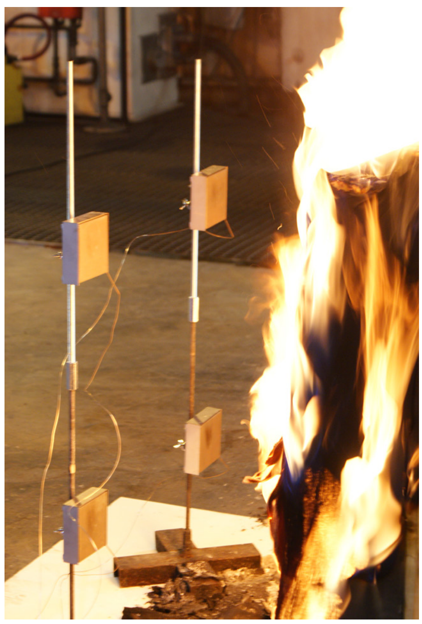
In order for the innovation to be comprehensible, the concept of adiabatic surface temperature must be explained. Ulf Wickström uses a metaphor:

"If you go outdoors on a lovely summer's day you experience radiation from the sun. In the shade of a tree you feel the gas temperature but not the radiation from the sun. The adiabatic or effective temperature is a combination of the radiation temperature and the gas temperature."

The adiabatic surface temperature determines if combustion will occur and if a fire will spread.

A similar concept exists: heat flux or heat flow. It is measured using sensors that require water cooling and that are expensive and awkward to use, especially in the field. This is the background of the current development programme.

"We've developed a sturdy plate thermometer that takes readings based on Ulf Wickström's theories," explains



Picture from a fire test.

Pentronic's project manager Christophe Zaninotti. "The construction has been carefully developed and the materials have been carefully selected to meet his criteria."

The actual thermocouple merely measures the temperature. With the aid of the product's design and a formula, the temperature can be recalculated to that of the incident thermal radiation. Pentronic is also developing an instrument that automatically does this calculation and immediately displays both the adiabatic surface temperature and the incident thermal radiation.

The equipment is initially intended to be used in fire research and in trainings/demonstrations for emergency services personnel. When doing tests, it is important to understand the effect of thermal radiation at various distances. Because the sensors are sturdy and inexpensive, they are also suitable for fixed installations for early warning of fire spread risk.

"There will certainly be other applications in the future but it takes some time to introduce a new temperature concept and a new measuring method," Ulf Wickström says.

More and more of Pentronic's customers are interested in measuring radiation temperature. It is relevant not only in the case of fires but also when measuring the indoor climate in both homes and vehicles. In these situations both cold surfaces and the sun's rays have a major effect on whether we experience the temperature as being colder or warmer than the air temperature.

The new sensor type is called a Plate Thermometer Heat Flux Meter (PTHFM).

Professor Ulf Wickström.

Christophe Zaninotti.

THE RIGHT CONTACT WITH THE NEW SALES ORGANISATION

Pentronic's sales organisation. From left at back: Boije Fridell, Karoline Haneck, Jonas Bertilsson, Michael Steiner, Camilla Gustafsson, Per Bäckström, Isabelle Hagström, Annelie Appelqvist, Christophe Zaninotti, Kristin Nilsson, Dan Augustini. Small photo: Morgan Norring.

Pentronic has been growing for many years. Now the sales organisation is being adapted to fit the company's bigger footprint.

"We'll be more efficient and have more time for customer contacts," says Sales Manager Dan Augustini.

PENTRONIC BEGAN AS AN ENGINEERING COMPANY whose sales organisation tended to consist of engineers and problem solvers. All the sales employees were inside sales representatives, field sales representatives and technical experts at the same time.

By splitting up the sales roles, we can give our customers even better service. We now always have inside sales representatives on hand who can quickly respond to product enquiries and process orders. We also always have several field sales representatives who are out visiting customers and solving their measurement problems. And we have technical experts within the sales department who can handle more unusual solutions. This new organisation will make us more efficient and ensure that every stage of the sales process happens. Previously, customer visits tended to be too few when there was too much to do at the office.

"Most of our orders currently arrive by email," Dan says. "Everything goes to a single inbox and orders are then assigned to whoever is best suited to the task."

Orders from contract customers are handled directly by the order processing office without going via a sales representative. This alone leads to improved efficiency.

The next role is the inside sales representative, who is always in the office and can answer customers quickly. To be more specific, Pentronic has three efficient inside technical sales engineers: Boije Fridell, Karoline Haneck and Isabelle Hagström.

In contrast, Jonas Bertilsson and Christophe Zaninotti are the travellers. Both are field sales representatives and their first priority is to visit customers. Even though many contacts today now go via email and phone, it is important to have personal meetings with customers so that we can understand their overall measurement situation and thereby suggest the best solution. When we do this, customers can be sure they will get the best possible measurement.

"Sometimes we just have to design a customer-specific sensor in order to provide good enough measurement," Jonas says.

Correct sensor placement is of course critical for a good result.

"Don't hesitate to contact us about a visit. We're here for our customers," Christophe says.

Michael Steiner and Morgan Norring also visit customers. Both are key account managers (KAM) and work with larger contract customers. Even though we know our major contract customers well, new measurement needs are constantly emerging. These might involve more accurate measurement, calibration or new projects.

"We gain a clearer structure and can handle orders more efficiently. At the same time our customer interface is significantly larger," Dan explains.

Pentronic is still such a small company that the sales representatives and key account managers have design engineers and other specialists close at hand. The organisation also has a new function, technical support, headed by Per Bäckström. A number of the sales representatives managers also have their own specialist expertise that they use to support their colleagues. The same holds true for the sales manager, whose own field is electro-optical test systems.

"The aim of the new organisation is for the customer to encounter the right expertise at every contact," Dan Augustini concludes.

Jonas Bertilsson and Christophe Zaninotti.

MEET PENTRONIC AT TRADE FAIRS

PENTRONIC WILL BE EXHIBITING at several trade fairs this year. The first one will be Advanced Engineering in Gothenburg on 8–9 March. The fair is a meeting place for the development and efficiency of tomorrow's high-tech industry and engineering. Sweden's biggest electronics fair in 2017, Elektronik, will also be held at the same time and place.

Pentronic will be there to exhibit interesting products and services. In addition to ordinary sensors, we will also demonstrate smart sensors with both analogue and digital signals. Some of our large range of instruments will also be on display.

The next fair will be the Euro Expo industrial fair in Skellefteå on 22–23 March.

MEASURING AIR TEMPERATURE WITH A SHEATHED THERMOCOUPLE

QUESTION: I've read that we can use a thin thermocouple to measure the air temperature inside a workshop or factory and achieve acceptable accuracy. Is this always the case at a normal room temperature?

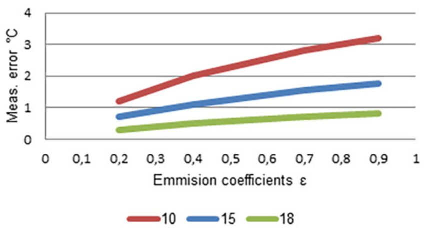
Ali M

ANSWER: Unfortunately your question cannot be answered with a simple yes or no, as the answer is considerably more complex. To illustrate the problem, we will take a simplified case and study an empty workshop where the stationary air has the constant temperature of 20.0 °C. We assume that the surface temperature of the walls, floor and ceiling – the wall temperature – is lower than 20 °C. We will measure the air temperature at about the centre of the workshop using a horizontally oriented sheathed thermocouple whose outer diameter is within the range of 0.5 mm to 3.0 mm.

Because the wall temperature is lower than the air temperature, the radiation from the thermocouple to the walls means that the thermocouple's temperature will fall below the air temperature. Heat is now transferred to the thermocouple from the air via convection. In the case of a stationary condition, we achieve an equilibrium whereby the heat flow from the thermocouple to the walls is equal to the heat flow from the air to the thermocouple. The heat transfer from the stationary air to the thermocouple occurs via natural convection.

Diagram 1 shows how the measurement error (the difference between the air temperature and the measured temperature) for a sheathed thermocouple with an outer diameter of 1.0 mm depends on the parameters of the thermocouple's emissivity and the wall temperature. We assume that the emissivity of 0.2 - 0.4 apply for a new thermocouple and the emissivity of 0.7 - 0.9 for a dirty thermocouple. The wall temperatures shown in the diagram are 18 °C, 15 °C and 10 °C.

Diagram 1.



Measurement errors depending on different emissivity at wall temps. 10, 15 and 18 °C. Outside diameter 1.0 mm.

The diagram shows that the difference between the air temperature and the wall temperature has a major influence on the measurement error. The smaller the temperature difference, the smaller the measurement error. The thermocouple's emissivity also has a major influence on the measurement result. The lower the emissivity, the lower the measurement error. Among other things, this means that a dirty thermocouple produces a bigger measurement error than a new one.

Diagram 2 shows how the thermocouple's outer diameter influences the measurement error. The diameters studied have the standard values of 0.5 mm, 1.0 mm, 2.0 mm and 3.0 mm. The two curves shown correspond to the wall temperatures of 18 °C and 15 °C respectively and in both cases the emissivity is 0.2. The thermocouple's outer diameter indirectly influences the measurement error via the heat transfer coefficient, which increases as the diameter decreases. Diagram 2 shows that the smaller the outer diameter of the thermocouple, the smaller the measurement error becomes.

In conclusion, the two parameters – the thermocouple's emissivity and the temperature difference between the air and the wall – have a greater influence on the measurement error than the third parameter -the thermocouple's outer diameter. The calculation of the measurement error depends on a number of conditions and simplifications. Other conditions and simplifications will produce other results, but the three parameters that have been discussed here still have the same type of influence on the measurement error. Whether the measurement error is acceptable or not must be decided from case to case.

QUESTION ? ANSWER

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

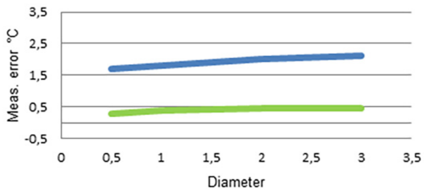


Diagram 2. 15 18

Measurement errors depending on the thermocouple diameter at wall temps. 15 and 18 °C. Emissivity 0.2.

The answer to the question is: Yes, in some cases it is possible to measure the air temperature with acceptable accuracy using a thermocouple if it is new, thin, and the temperature difference between the wall and the air is small. However, this is not always the case. In each measurement situation, don't forget to check the conditions and the required accuracy.

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

VOLVO HONOURS PENTRONIC

PENTRONIC HAS RECEIVED the Volvo Cars Quality Excellence (VQE) Award for 2016 in the "Non Automotive Parts" category.

At a ceremony in Gothenburg on 25 January 2017 Pentronic received a statuette as proof that Volvo appreciates the quality work we do every day. Volvo includes a lot in its VQE concept – including quality, delivery reliability, environmental work, the work environment, ethics and continual improvement efforts. Openness and communication are also important to a long-term business relationship.

In addition to the award ceremony, as one of the invited suppliers we were given an inspiring look into Volvo's future with self-driving cars plus a presentation of the car models that will soon be launched.

Mikael Steiner with the Volvo Cars Quality Excellence (VQE) Award.

With this issue Pentronic begins its training in temperature measurement. We will start lesson 1 with a historical review and then continue with thermodynamics, heat transfer and quality assurance with calibration. Only after that will we move on to temperature sensors – primarily thermocouples and Pt100s.

LESSON 1 THE NATURE AND HISTORY OF TEMPERATURE

TEMPERATURE – HEAT

Temperature does not exist. It is a theoretical model constructed so that humans can measure, compare and understand changes of kinetic energy among a body's smallest components such as atoms and molecules.

In contrast, heat does exist and is described as being the amount of kinetic energy inside a body. From this it follows that everything above absolute zero (-273.15°C) is heat. But this definition leads to peculiar effects. For example, an iceberg contains more heat than a cup of coffee, because the iceberg contains a greater amount of energy.

Anyone who puts a finger on the iceberg and the coffee respectively experiences the opposite. What we then feel is the heat, the kinetic energy, at a given point. Temperature is our tool for describing this experience in a comparable and reproducible way. The coffee feels hotter than the iceberg because it has a higher temperature.

THE PIONEERS

The thermometer was invented at the beginning of the 17th century by the Italians Galileo and Santorio at the Accademia del Cimento in Florence and by the Dutchman Drebbel. The first thermometer consisted of a spiral-shaped glass tube filled with alcohol. The tube was not closed and therefore the instrument also measured the air pressure at the same time. The academy in Florence also developed simple scales, which included the divisions of 40 and 80 degrees between the "fixed points" of the high summer temperature and the low winter temperature.

However, the thermometer had no real practical use until 1714, when the German physicist Daniel Gabriel Fahrenheit developed a temperature scale that made it possible to take comparative measurements. He is also considered to be the inventor of the mercury thermometer as it is today – that is, mercury inside a closed glass tube.

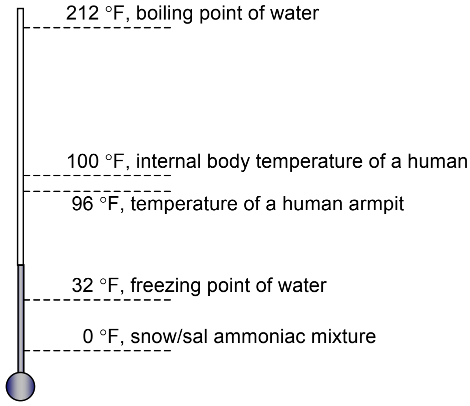
It is worth pointing out that the glass thermometers containing mercury that may still be in use are being used by special exemption. Mercury is a stable substance but it becomes dangerous out in the environment. Today we use other liquids such as coloured alcohol.

THE TEMPERATURE SCALES

FAHRENHEIT

Fahrenheit created a 100-degree scale in which zero degrees was the temperature of a mixture of sal ammoniac and snow – the coldest he could achieve in his laboratory in Danzig.

As the upper fixed point he used the internal body temperature of a healthy human being and gave it the value of 100°F. In degrees Celsius this scale corresponds approximately to the range of -18 to +37 degrees.



Fahrenheit's mercury-in-glass thermometer with the reference points that were apparently used.

Because it can be awkward to achieve the upper fixed point, he apparently introduced the more practical fixed points of +32°F and +96°F, which were respectively the freezing point of water and the temperature of a human being's armpit.

Fahrenheit's scale was later extended to the boiling point of water, which was assigned the temperature value of +212°F.

ANDERS CELSIUS

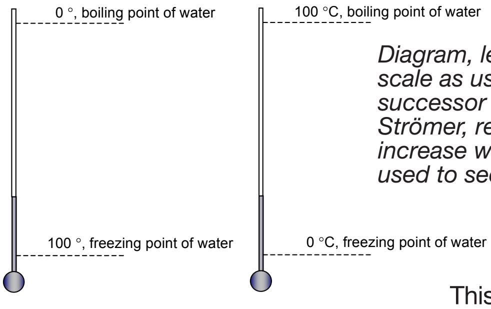
At the same time, people were considering having a scale with more natural divisions whereby 0 degrees was defined as the melting point of ice and 100 as the boiling point of water. We know that even before 1737 Linneaus was using this scale, which was later named after the Swedish astronomer Anders Celsius.

In 1742 Celsius launched the scale in reverse order, arguing that water should boil at 0 degrees and freeze at 100. Not until eight years later was the scale reversed by his successor as professor at Uppsala University, the mathematician Mårten

A finger feels how the heat energy (also called thermal energy) moves (see the arrow) in or out depending on whether the temperature of the object being touched is higher or lower than the finger's.

Anders Celsius.

Strömer. As an interesting aside, it is worth mentioning that as early as 1743, Professor Christin in Lyon had built the first mercury thermometer with the Celsius scale "the right way round".



Diagram, left: The 100-degree temperature scale as used by Anders Celsius. Right: His successor as professor at Uppsala, Mårten Strömer, reversed the scale so that its values increase with the energy level just as we are used to seeing it today.

RÉAUMUR

During the same period, the Frenchman Réaumur developed his own scale. He also began with the freezing and boiling points of water but he divided his scale into 80°R, because his favourite mixture of water and alcohol expanded itself from 1,000 till 1,080 units of volume between the fixed points.

HEAT WAS A SUBSTANCE

Only near the end of the 18th century did researchers begin to understand the nature of heat. Until then, heat was believed to consist of a particular substance called "caloric".

It was the American-born Briton Count Rumford who tracked down the explanation by demonstrating that a specific amount of ice weighed the same when it was melted. The caloric theory could thereby be dismissed. He also succeeded in getting water to boil by boring a blunt drill into a piece of metal. Rumford was convinced that the movement of the drill was transformed into heat vibrations in the metal's atoms.

THE IDEAL GAS LAW

At the beginning of the 19th century the ideal gas law was developed from Boyle's law by several well-known researchers, including the Frenchmen Charles and Gay-Lussac and the Italian Avogadro. The law states:

$p V = R T$ where

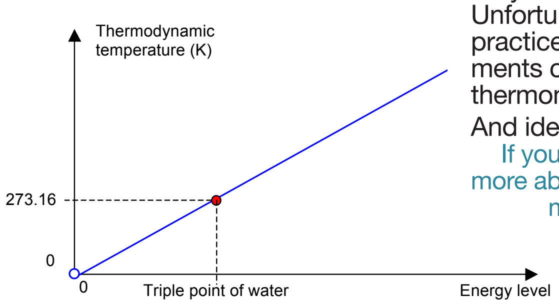
p = the gas pressure
V = the enclosed volume (in moles)
R = the universal gas constant
T = the absolute temperature of the gas

This law is the starting point of Avogadro's temperature scale, which begins at absolute zero. Today absolute zero is defined as -273.15°C. The problem with the gas thermometer is that it assumes that so-called "ideal gas" exists.

THERMODYNAMIC SCALE

At the same time, other research was also being done into the field of energy. The Frenchman Carnot, the German Mayer and the Briton Joule were some of those who made major contributions to explaining the connection between different forms of energy. Joule's experiments included determining the amount of mechanical effort required to raise the temperature of 1 gram of water by 1°C.

The research resulted in the laws of thermodynamics. In about 1850 the Briton Kelvin defined temperature in accordance with these laws. Today we still do not know what temperature really is. Instead, we use the theories of thermodynamics because they agree sufficiently well with experimental tests.



The thermodynamic scale is defined by two points: the triple point of water (solid circle) and absolute zero (empty circle), which cannot be achieved.

Temperature is a measurement of what is regarded as the "animation" or movements of the smallest components of matter such as atoms and molecules. From experience we know that increasing thermal (heat) energy leads to higher temperatures, and as a rule requires that matter expands in volume. (Compare with the ideal gas law!) It is therefore not unreasonable to assume that the lowest temperature is to be found where the so-called animation or movement has stopped. This occurs at absolute zero, 0 K.

To maintain agreement with the already accepted Celsius scale, it was decided that 1°C = 1 K = 1/273.16 of the thermodynamic temperature at the triple point of water.

We can say that thermodynamic temperature scale is defined by one fixed point and one fictive zero point – absolute zero. The fixed point is the triple point of water, which is a state of equilibrium between water's three phases of solid, liquid and gas. In this condition, water assumes a highly stable and difficult-to-disrupt state of equilibrium, which has been assigned the theoretical temperature value of precisely 0.01°C. Note that in practical experiments such precision cannot be achieved. However, it is relatively simple to achieve the triple point of water with a measurement uncertainty of less than ±0.001°C.

Absolute zero cannot be fully achieved. Empirically, it has been established at -273.15°C. At Helsinki University of Technology researchers study low temperatures and in their experiments have apparently come down to nK (nanokelvin = 10-9) away from absolute zero.

The Kelvin scale is scientifically and mathematically correct. Unfortunately it is not useable in practice because the measurements can only be taken with gas thermometers containing ideal gas. And ideal gas does not exist.

If you would like to discover even more about temperature measurement, Pentronic offers courses in "Traceable temperature measurement" in Västervik or at your own premises if required. For more information visit www.pentronic.se

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