PENTRONIC Skandinavia's leading manufacturer of industrial temperature sensors

NO. 2017-2

PENTRONIC NEWS

It's all about temperature!

PENTRONIC IS HONOURED BY TETRA PAK

CONTINUED ON PAGE 3

All problems need their own unique solution

I hope you enjoy the new format of our customer magazine. We welcome your opinions and suggestions for how we can develop our communication with you.

In this issue of *Pentronic News* we focus on one of our strengths: flexibility. To us, flexibility means that we design and manufacture temperature sensors exactly how you want them to look like and function in the best way for your particular application. In most cases it is more cost efficient that we adapt the sensor to the application than vice versa.

Sustainability is an important issue to us. This spring we have done an energy survey with the aim of reducing our energy consumption. Another example is our recycling of noble metals, which you can read about on page 6.

In April we received yet another sign of appreciation from our customers when we were given an award for being one of the best suppliers to Tetra Pak. I would like to thank the entire team at Pentronic who made this possible.

Summer is rapidly approaching and with it what I hope will be a pleasant and relaxing summer.

Rikard Larsson
MANAGING DIRECTOR

MORE THAN 100 NEW VERSIONS OF TEMPERATURE SENSORS EVERY MONTH

Pentronic would have to revise its website several times a day to keep its range of temperature sensors up to date.

"EVERY MONTH we add more than a hundred new article numbers – our standard is customisation," explains Sales Manager Dan Augustini.

Pentronic has been manufacturing customised temperature sensors from the very beginning. Most of them are Pt 100s and thermocouples. The foundation is a system of modules that can be adapted to the intended purpose. The result is the right temperature sensor for every task.

"Some of them are only produced as a single unit whereas others are produced in the tens of thousands," says Managing Director Rikard Larsson.

The alternative to customising the sensor to the intended task would be to adapt the measuring environment to the existing sensors. It is obvious that having the right sensor offers many advantages, such as measurement performance, ease of installation and other factors that influence the quality of the measurement process and the customer's costs.

Manufacturing special sensors sounds time consuming but thanks to the modular system and Pentronic's long experience there is not much difference between producing a limited catalogue range and customising the sensors. In addition, for some years now Pentronic has been saving all documentation, even for articles that are only produced as a single unit. These sensors already have an article number and can promptly be manufactured again.

"Today there are nearly 20,000 article numbers in our system and every year another 1,200 to 1,500 designs are added," Dan says.

Ordering a customised sensor

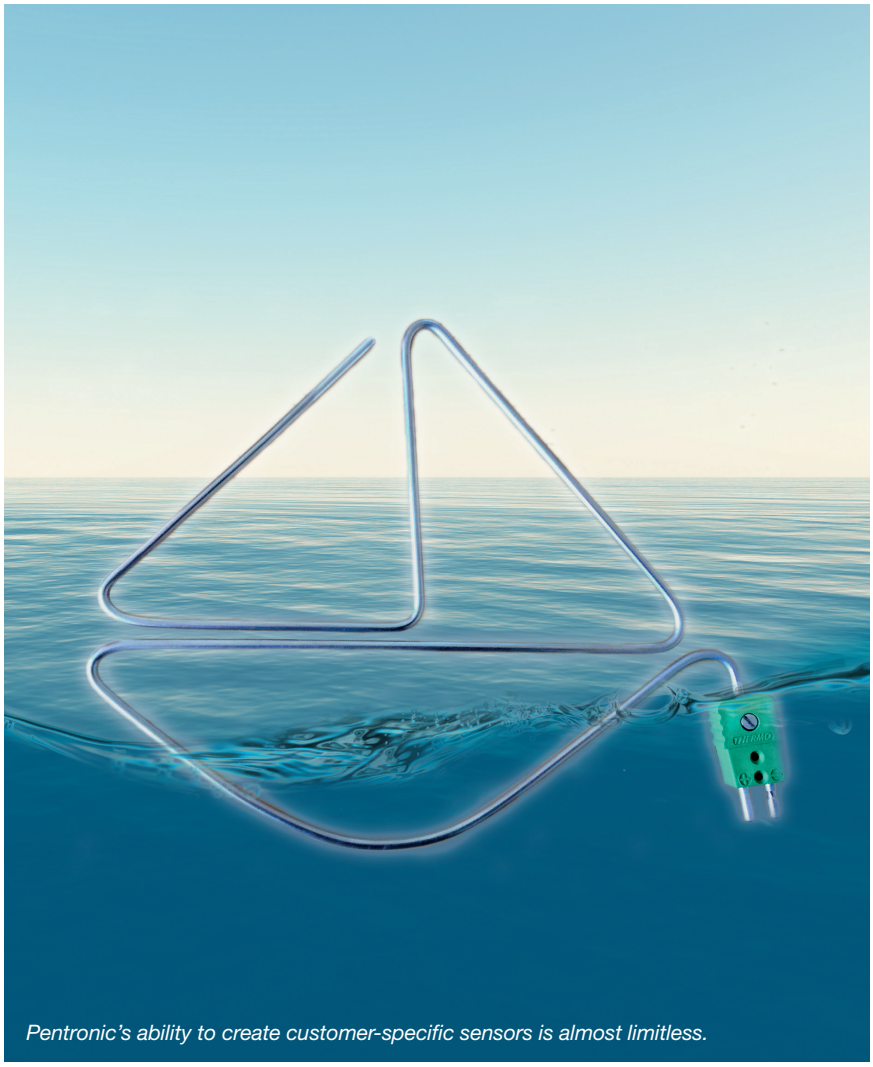
"Today there are nearly 20,000 article numbers in our system and every year another 1,200 to 1,500 designs are added"

from Pentronic is often quicker than surfing the Internet to find an already existing one that can do the job. Many stories tell of people inventing technical things on a paper napkin. In this case it is true. A simple sketch together with the technical requirements is often enough. Then Pentronic's sales engineers and technicians take the requirements to the production department.

"Take a photo with your phone and send it to us," Rikard advises.

The modular system offers many possibilities. Because Pentronic manufactures its modules itself, they can also be customised, for example with different insertion depths. If necessary, new subcomponents and compression fittings can be manufactured so that the result is the right temperature sensor for the right task. The possibilities are almost limitless.

So the question is, why spend hours trying to find the exact sensor you need when you can ask Pentronic? Your sensor probably already exists or we will create a new version based on your wishes.



Pentronic's ability to create customer-specific sensors is almost limitless.

TETRA PAK AWARDS PENTRONIC AS ONE OF ITS BEST SUPPLIERS IN 2016

Pentronic has been awarded by Tetra Pak with the certificate Bronze Supplier 2017 for "Excellence in Quality, Delivery and Cost performance during the year 2016".

THE AWARD was presented at a ceremony in Lund coordinated via video link with two more locations in the world – China and Italy. Tetra Pak has many suppliers. It singles out a few of them with a certificate for their good performance throughout the year.

First Tetra Pak does an overall assessment of the supplier, which also includes non-measurable parameters. The supplier's compliance with Tetra Pak's requirements, including cost development, quality and delivery precision, are then measured on a Score Card. Only those suppliers that meet these stringent requirements receive the award. In 2016 Pentronic was one of them.

Pentronic's Sales Manager Dan Augustini received the certificate for Bronze Supplier 2017 from Tetra Pak.

GFM CAMERA SIMULATOR AND GLASS FLOW SIMULATOR BACK IN PRODUCTION

GEDEVELOP by PENTRONIC

In order to be able to help customers again with the service and inspection of their GFM systems, Pentronic worked in the autumn of 2016 to update the electronics to the latest version, and both products are now available for purchase again.

ABOUT GEDEVELOP AND GFM

The company Gedevelop, which is part of Pentronic, markets, develops and sells cameras for the non-contact measurement of glass flow in the manufacture of glass wool for insulation. Precise measurement and control of the glass flow gives customers better products at less cost. The camera system is called GFM – Glass Flow Measurement.

www.gedevelop.com

GFM Glass Simulator article number M 1802008

WHEN YOU WANT TO TEST THE SYSTEM AND DO NOT HAVE LIQUID GLASS

The GFM Glass Simulator together with the system's camera provides a realistic reproduction of the glass flow, which allows testing of the GFM system with known flow parameters. By using the GFM Glass Simulator, testing can be made very realistic to resemble normal production. Because the test equipment simulates the flow, all basic functions such as flow, diameter, intensity and readings can be checked. The GFM Glass Simulator is an indispensible tool for testing whether the GFM camera is fully operational.

GFM Camera Simulator article number M 1802002

WHEN YOU WANT TO TEST THE SYSTEM WITHOUT EITHER LIQUID GLASS OR A CAMERA:

The GFM Camera Simulator allows testing of the GFM system with known input signals in place of a real camera. By using the GFM Camera Simulator, it is easy to track errors on the central unit and the camera cable. Because the test equipment simulates signals from a GFM camera, all basic functions, readings, alarms etc. can be checked.

RS TECHNICS BV NOW PART OF PENTRONIC

As of January 2017 RS Technics BV in the Netherlands is now a wholly owned subsidiary of the Pentronic Group.

RS TECHNICS has been in the market for over 25 years and develops and manufactures industrial sensors for temperature, pressure and moisture content. The company also develops and manufactures electronic systems for measurement and control. Customers are primarily in the processing, food and marine industries. RS Technics is characterised by high levels of quality and service, which include the express delivery of customer-specific sensors within 24 hours.

The aim of the acquisition is to increase Pentronic's presence in Europe and to be able to provide optimum service to customers in the Netherlands and neighbouring countries. The company will continue operating under its brand name of RS Technics. For more information you are welcome to visit www.rstechnics.nl.

STRAIGHT FROM THE LAB

NEW CALIBRATION BATH CAN HANDLE BOTH SHORT INSERTION DEPTHS AND SENSITIVE ELECTRONICS

The new generation of temperature sensors with short insertion depths and integrated electronics is placing special demands on calibration equipment.

Pentronic has invested in a new oil bath in order to calibrate these sensors as well.

THE NEW BATH is called the Isotech 785. It is filled with nine litres of vegetable oil and differs from previous baths in that the oil is stirred in the opposite direction: down the walls and up in the centre, where the sensor being calibrated is located.

"The result is smaller vertical temperature gradients. In previous calibration baths the gradient in the upper part of the bath could be at a few hundredths of a degree. With this bath it is at least ten times better," explains Laboratory Manager Lars Grönlund.

The result is that shorter sensors can now be calibrated with greater accuracy. Or, to put it another way, it is now possible in practice to verify that the sensors are as good as they really are.

The integrated electronics are another issue. On some types of sensors they are located only a few centimetres from the process connection. This can cause problems when the transmitter is located only a few centimetres from the surface of the hot calibration bath.

"We've built a fixture that provides water cooling of the electronics during calibration," Lars says.

SWEDAC ACKREDITERING
0076
ISO/IEC 17025

The first task of the new bath will be to verify Pentronic's own sensors with short insertion depths and built-in electronics. Because the calibration is done under accreditation it is not possible to make any promises but the probable result is that the already low measurement uncertainties will be tightened further. The new bath will also be used for the laboratory's calibration assignments at temperatures from 90 to 230 °C.

Lars Grönlund with the new calibration bath, which improves measurement accuracy when calibrating temperature sensors with short insertion depths.

TIME CONSTANT

QUESTION: I have come across the time constant τ in various contexts. What does it mean and how can it be used?

Johan H

ANSWER: The time constant is a measurement of how fast a parameter in a system changes over time. In an electrical system the voltage can be one such parameter and in a thermodynamic system the temperature can be one. Originally the prerequisite for the concept of the time constant was that the system's change over time must be governed by a first-order ordinary differential equation, but the concept is now also used in other contexts. An RC circuit, where a capacitor C discharges via an electrical resistance R, is one example of a system in which the voltage's variation over time follows a first-order differential equation. If the voltage was originally V_0 volt then the voltage, V volt, changes during the discharge in accordance with the equation

$$V = V_0\, e^{-t/(RC)}$$

where t is the time in seconds, R the resistance in ohms, and C the capacitor's capacitance in farad. The time required for the voltage to drop from V_0 to $V_0 e^{-1} = 0.37\, V_0$ (i.e. 37% of V_0) is called the time constant τ and is normally given in seconds. In this case $\tau = RC$.

If we overlook the temperature difference in a sheathed thermocouple that is sitting in a measuring circuit and regard the thermocouple as a "lump" with the temperature T(t) then the cooling is governed by a first-order ordinary differential equation. If the temperature of the thermocouple's surroundings is changed stepwise from the initial temperature T_0 °C to the ambient temperature T_{amb} °C ($T_{amb} < T_0$) then the thermocouple's temperature T(t) °C is changed in accordance with the equation

$$(T(t) - T_{amb})/(T_0 - T_{amb}) = e^{-t((hA)/(c\rho V))}$$

where h is the heat transfer coefficient in W/(m²K), A the thermocouple's heat transferring area in m², t the time in s, ρ the density in kg/m³, c the specific heat capacity in (Ws)/(kgK) and V the volume in m³. The capacitor's capacitance C in the RC circuit is represented by (ρcV) and the resistance R by 1/(hA). Because the thermocouple contains various materials, the quantities ρ and c are mean values. In the case of the thermocouple the time constant τ becomes

$$\tau = (c\rho V)/(hA).$$

The quantity (cρV), where (ρV) is the thermocouple mass, is a measurement of the thermocouple's ability to store energy. The greater the specific heat capacity and the greater the mass, the greater is the thermocouple's storage capacity – the time constant increases. The quantity 1/(hA) is a measurement of the thermal resistance. The smaller the value of the product (hA), the greater the thermal resistance, and it thereby takes longer time to change the thermocouple's temperature – the time constant increases.

However, there is an important difference between the RC circuit and the thermocouple. The RC circuit always has a constant time constant, $\tau = RC$, whether it is connected to an electrical network or is "lying on the shelf". In contrast, the thermocouple's time constant varies and depends on the heat flow to or from the thermocouple, which here is characterised by the quantity (hA), i.e. the product of the heat transfer coefficient and the heat transferring area.

QUESTION ? ANSWER

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

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

SEND US YOUR OLD THERMOCOUPLE WIRE MADE OF PLATINUM. BOTH YOU AND THE ENVIRONMENT BENEFIT!

ARE YOU REPLACING YOUR PROCESS SENSORS or do you have old worn-out ones lying about?

We buy back scrap noble metal (platinum) for recycling from type S, R and B sensors. (Even sensors made by another company.) For more information contact Pentronic's sales department, telephone +46(0)490-258500 or email info@pentronic.se.

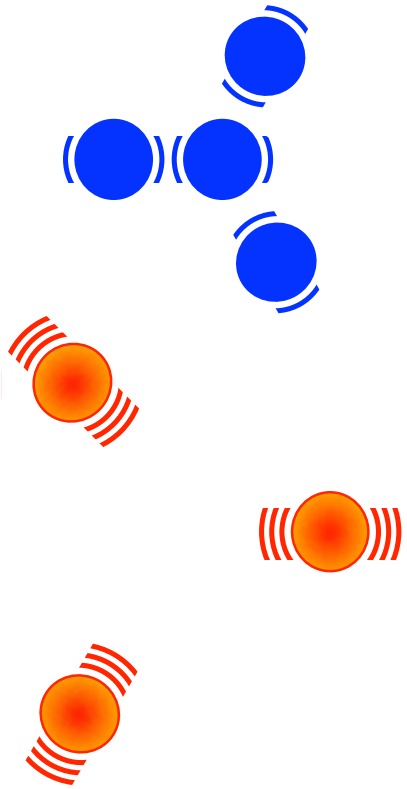
Recycling involves far less energy, resources and emissions than new production. Platinum is also a finite and very scarce resource.

In the first lesson we did a historical review. Now we will work through the basic theory necessary for being able to measure temperature at all – thermodynamics and heat transfer.

LESSON 2 THERMODYNAMICS AND HEAT TRANSFER

A TEMPERATURE MODEL – THE KINETIC THEORY

The smallest constituent parts of a hot body have greater movement than those of a cold body. The average value of the kinetic vibrational energy of atoms and molecules in a body is a measurement of its temperature.



This figure indicates that hot materials have greater kinetic energy (energy from motion) in their smallest constituent parts whereas colder materials have a lower kinetic energy level. Higher energy levels also usually require more space.

THERMODYNAMICS

To understand temperature measurement you must have a basic knowledge of thermodynamics and heat transfer.

The zeroth law of thermodynamics:

If two bodies are in thermal equilibrium with a third body, then the first two bodies must also be in thermal equilibrium with each other. In other words, if the bodies have the same temperature, no heat is transferred. We understand this intuitively but it is not stated in any of the other laws so it was added afterwards and put first. All temperature measurement and calibration are based on this axiom.

The first law:

Energy can neither be created nor destroyed but only converted between different energy forms.

The second law:

This can be formulated in various ways but the most suitable formulation for measurement techniques is that heat never moves by itself from a cold body to a hot one.

HEAT TRANSFER

There are three different mechanisms of heat transfer and they can occur simultaneously or separately: heat conduction, convection and radiation. Knowledge about these various distribution methods is important for understanding what is happening in a measurement situation. This understanding makes it possible to prevent measurement error by arranging the installation so that the sensor does not disrupt the measurement process by e.g. creating new transport routes for the heat flow.

Conduction

In accordance with the temperature model shown above, in which atoms (or molecules) are vibrating, we can understand that an atom with a high level of vibration will soon influence its neighbour to also vibrate. This vibration or heat spreads because the vibrational energy is transferred from atom to atom. This is called thermal conduction. See the figure and table below.

Medium	Conductivity
Solid materials	**W / (m K)**
- Ag, Cu	420, 380
- Al (the element)	220
- Stainless steel	15
- Glass 0.93	
- Wood, pine	0.1 – 0.4
- Glass wool	0.035
Liquids	
- Water 20 – 100 °C	0.60 – 0.68
Gases	
- Air 20 – 100 – 300 °C	0.025 – 0.032 – 0.045

Heat transfer by conduction. Vibrational energy is transferred from atom to atom. In general, metals are the best conductors. Gases are the worst.

Metals are generally excellent thermal conductors. In liquids and gases the molecules maintain a greater distance from each other, so the vibrations cannot be spread so easily. A vacuum does not contain any molecules so it cannot conduct any heat.

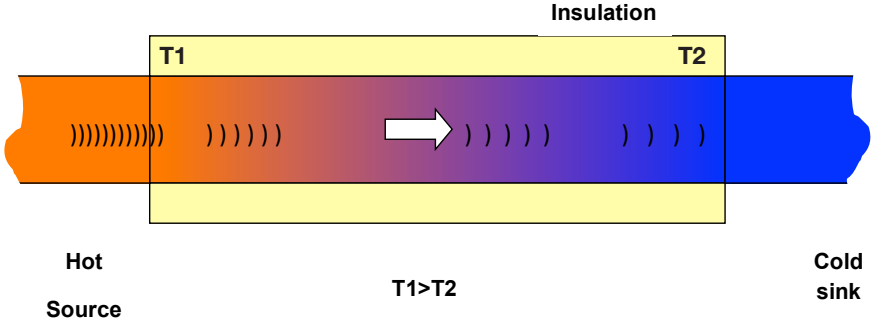
Convection

Convection is motion within a fluid (= liquid or gas)

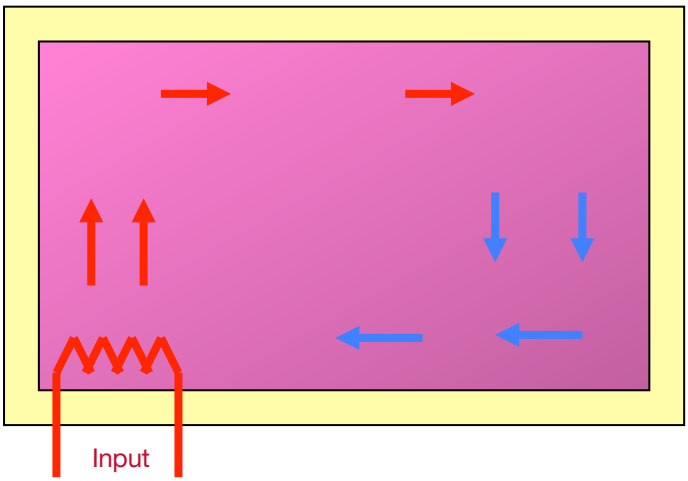
Natural convection involves movements generated by density differences due to temperature differences. A hot fluid is “lighter” than a cold one and “rises”.

Forced convection is achieved by using mixers, pumps and fans. The temperature of the fluid can thereby become more even throughout its volume.

Heat transfer from a fluid to a solid body is facilitated by increasing the flow of the fluid. Similarly, it is easier to transfer heat with a liquid than with a gas. This is because the liquid contains atoms or molecules that transfer its vibrational energy



Heat transfer by conduction. Vibrational energy is transferred from atom to atom. In general, metals are the best conductors. Gases are the worst.



This figure shows an example of convection in an electrically heated hot water storage tank. The heat exchanger or immersion heater heats the water, whose molecules become more spread out due to their increased vibrational energy. Their density is thereby decreased and the hot fluid rises. When the fluid cools due to heat loss or heat extraction to a heat exchanger, the molecules become packed more tightly due to their reduced vibrational energy and they sink.

more densely. No convection is possible in a vacuum because it does not contain any molecules.

Water transfers heat better than air

In the figure below, a fluid is flowing in a pipe. At a right angle to the flow direction, a sensor probe with a Ø 3 mm has been inserted to reach the centre of the pipe. The flow has a velocity of 8 m/s and a temperature of 50 °C. In heat transfer theory we speak about the heat transfer coefficient, h (alpha), which is given in W/(m²K), that is, the amount of heat transferred per square metre and degree C of temperature difference. The heat transfer coefficient varies with the type of fluid and its velocity. In this particular example the calculations give a coefficient for water of 47,000 W/(m²K) whereas air cannot transfer more than 160 W/(m²K). Thus in this example water transfers almost 300 times more heat than air.

In life we have learned that we can spend a long time in a sauna that is 70-80 °C hot. But we would never voluntarily think of putting our finger into a saucepan containing water of the same temperature!

Radiation

Radiation is an electromagnetic wave movement (in the infrared range) that does not require a medium for transporting heat. A vacuum is therefore no obstacle to radiant heat, as solar radiation proves.

The net radiation between two bodies travels from the hot to the cold body. All bodies with a temperature above absolute zero (0 Kelvin = -273.15°C) radiate thermal energy.

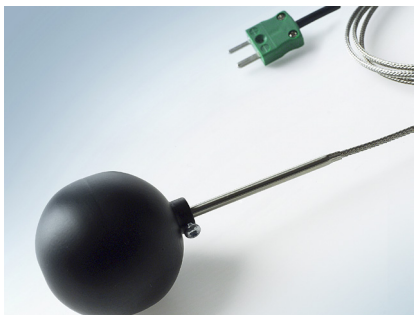
The sunbathing image here illustrates the sun's radiant heat. A cloud blocks some of the radiant heat, as most of us know from experience. Heat is transferred via convection between the person's body and the air (e.g. via the ocean breeze). Heat is conducted between the body and the sand. The direction is from the higher temperature to the lower one.

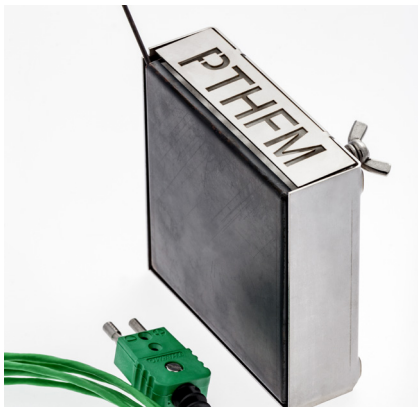
Thermal radiation is an often-ignored source of error in temperature measurement.

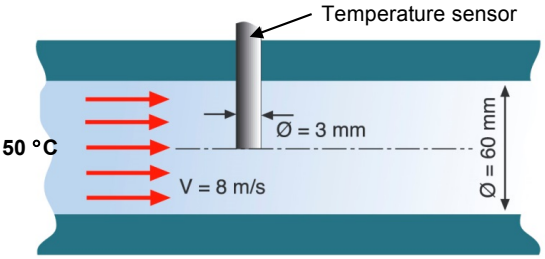
Examples:

- Reflectors for pyrometers
- The effect on a sensor when the surrounding surfaces differ in temperature from the fluid.
- In the case of combustion, the thermal radiation is significant.

A product that measures the air temperature and takes into account the effect of radiation is the black globe thermometer. A product that mostly measures thermal radiation is the Plate Thermometer Heat Flux Meter (PTHFM).







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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