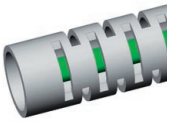
When is a radiation shield useful?

QUESTION: We are measuring the temperature in an exhaust pipe with a sensor that is inserted into the pipe. The sensor is equipped with a radiation shield. The engine is running with a mostly constant load and the temperature of the exhaust gases is fairly constant. On one occasion we measured the temperature of the exhaust gases both with and without the sensor's radiation shield. When we compared the results there was almost no difference. Is that correct? *Simon R.*

ANSWER: When you start up the engine, the temperature of the sensor, radiation shield and pipe wall is at about the same. Both the sensor and the radiation shield are quickly heated by the exhaust gases because the response time for both these components is relatively short. Generally it takes longer to heat up the pipe wall. The heat transfer to and from the sensor is governed by convection and radiation. If you measure the temperature of the exhaust gases during the engine start-up process with and without the radiation shield, there will be a difference. The radiation shield reduces the heat transfer due to radiation from the sensor to the cooler pipe wall. The wall subsequently also heats up. If the pipe is well insulated, the wall surface will take on a temperature that is slightly cooler than the temperature of the exhaust gases. In this situation, the radiation has little effect on the temperature of the sensor. The worse the pipe insulation is, the lower the temperature of the pipe wall, and the radiation therefore has an increased effect on the temperature of the sensor. Accordingly, in some cases there can be only a small temperature difference when you measure with or without the radiation shield. Under other conditions, there can be quite a large difference. When the temperature of the exhaust gases increases or decreases, you will always get different temperatures when you use sensors with or without a radiation shield. The factors influencing this temperature difference include i.a. the sensor's thermal properties, the convection, and the radiation.

In January 2010 the outdoor temperature in many places in southern Sweden dropped to below minus 20 °C and the temperature stayed at that low level for several days. If you had measured the temperature in a room with an exterior wall, you would have found that the temperature reading was different depending on whether you had used thermometer with a radiation shield or not. Without the radiation shield, the difference – the measurement error – could in some cases have been several degrees.



Sensor equipped with a radiation shield

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

QUESTIONS ANSWERS

The effect of the radiation also appears to increase over time. When the outdoor temperature drops, there is always some delay before the temperature of the inside of the exterior wall starts to drop, which delays the effect of the radiation. The response time of the wall depends partly on how the wall is built – the more solid the construction, the longer the response time.

AFFECTS BOTH SENSORS AND PEOPLE

Normally it can take between half a day to several days' time before the inside of the house's exterior walls has adapted to the lower outdoor temperature. In the same way, there is a delay before the inside temperature of the exterior walls rises when the outdoor temperature goes up.

A person who is inside a room with an exterior wall will be affected in the same way as a thermometer. Cold exterior walls increase the heat transfer via radiation from the person's body to his or her surroundings. The person feels that the temperature in the room is getting colder, even though the air temperature in the room is the same as in a room that only has interior walls.

If you have comments or questions, contact Professor Dan Loyd at the Institute of Technology at Linköping University: dan.loyd@liu.see