The influence of insulation resistance on temperature measurements

Technical Note

How to get an early warning of low insulation resistance

This Technical Note describes how the insulation resistance influences the measurements on RTD's and thermocouples and how to get an early warning regarding errors due to low insulation.

The structure of an RTD and a thermocouple have properties which can lead to erroneous measurements. This is independent of brand and type. One of the most common sources of error is the insulation in the thermometer, which, if too low, can give a serious degradation of the measurement. Insulation can be lowered by moisture, heat, vibration. Physical or chemical influence or radioactive influence. This Technical Note will give an explanation to the necessity of keeping an eye on the insulation resistance.

RTD's

The RTD element is a low-resistance sensor and a too low insulation resistance will influence the measurement. Figure 1shows the electrical schematic for an RTD and the insulation resistance connected to a temperature transmitter.

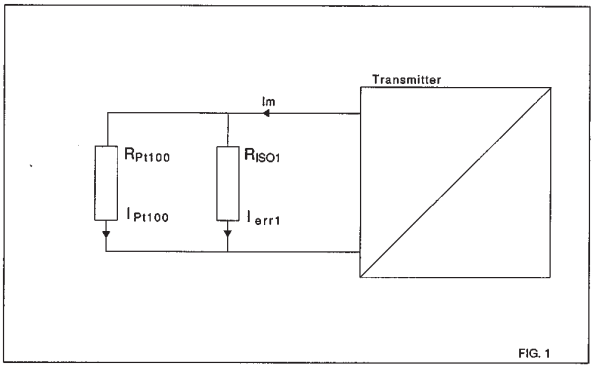


FIG. 1

The measuring current goes through the RTD element, but a negligible fraction is normally passing through the high insulation resistance Riso 1. When the insulation is lowered, a greater fraction of the current will pass through the insulation. As a result of this, the measured voltage over the combined resistance of RTD and insulation resistance will be lower than if the insulation resistance was sufficiently high. This will give a too low measured temperature value and this is not dependent on whether the transmitter is isolated or not. If the transmitter is without galvanic isolation between input and output, a low insulation resistance between sensor and earth can carry a part of the measuring current. This will also give a too low indicated temperature. With an isolated transmitter this will not happen. Please see Figure 2.

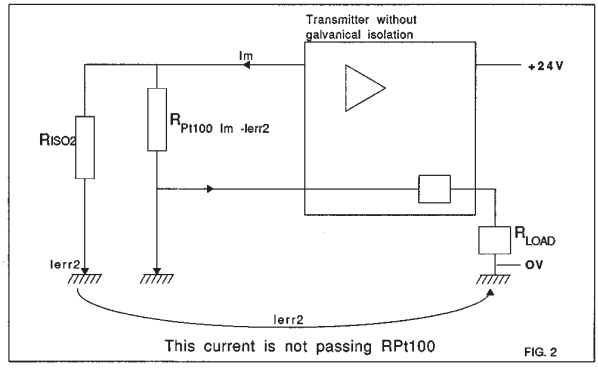


FIG. 2

Thermocouples

Low insulation in thermocouple sensors will give other errors. EMF from the thermocouple is not particularly sensitive for low insulation. The problem is rather that a low insulation will give a new measuring point on the location of the low insulation. If this location is near the intended measuring point, the error will be negligible. If the low insulation is in a location where the temperature differs from the measuring point, there is a possibility of a significant error. Low insulation in thermocouples can also give problems with the indication of sensor breakage. Pleas see Figure 3.

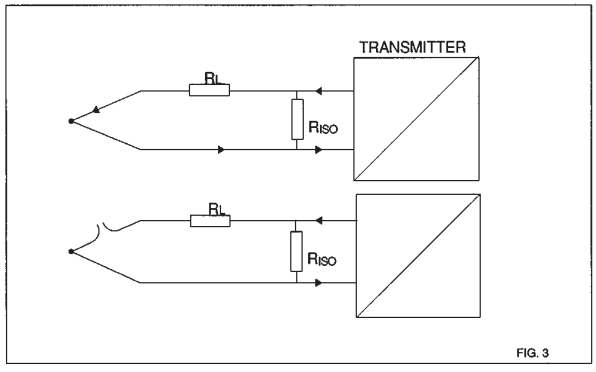


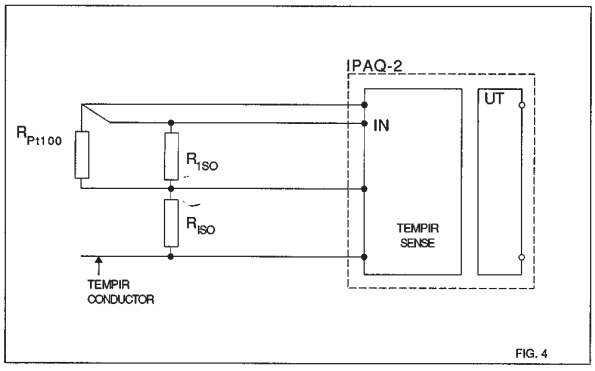
FIG. 3

Monitoring the insulation resistance

The TempIR transmitter is microcontroller based and does a couple of measurements and controls beyond the standard measurements. One of these controls is to monitor the insulation resistance of the sensor. To accomplish this the sensor must be furnished with an extra conductor. Under certain circumstances there is a possibility of using the cable shield. See below. When the insulation resistance is too low, the TempIRsense will signal this with a twinkling LED (on some models) and the output signal will go to a preprogrammed value.

RTD's

For RTD's the limit in insulation is 500 Kohm. By 400°C the added error is 0.4°C. If the insulation is lowered to 100Kohm there will be an added error of 1.6°C. See Figure 4

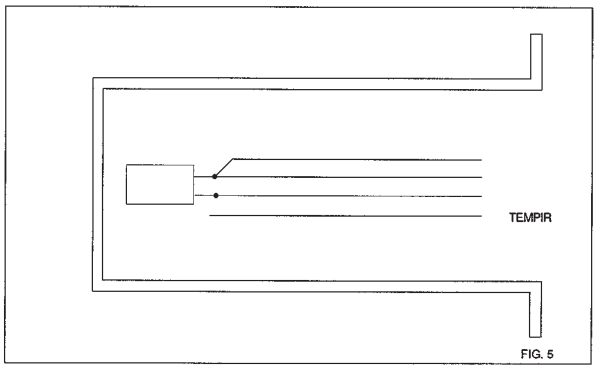


Thermocouples

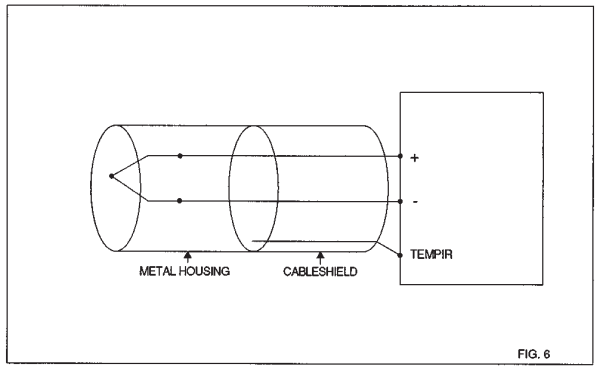
For thermocouples the limit of low insulation is 50 Kohm. The added error depends on the relation between the lead resistance R and the insulation resistance Risq. The error is also dependent on the temperature difference between the measuring point and the location of the low insulation. Under the following circumstances, measuring temperature 1000°C, ambient temperature 25°C and R equals 50 Ohm there will be an error of 1% if the insulation resistance is 5Kohm. This equals 10°C. It is assumed that the low insulation is in the are with 25°C.

Sensor Solution

TempIRsense is applicable for 3-wire RTD's and thermocouples. For correct usage the sensor must have an extra conductor. This conductor will have a separate terminal and go through the sensor all the way to the sensor element. See Figure 5.



Mineral insulated RTD's and thermocouples use an unconnected conductor. Due to the low insulation resistance in mineral insulated thermocouples at high temperatures, it is not useful to monitor the high temperature end, above 5-600°C depending on application. Instead, it is important to monitor connections and cables from the sensor to the transmitter. It is not recommended to use the housing of the sensor as the monitoring conductor.



One task of the housing is to keep interference outside the measurements. Connecting the housing to the TempIRsense terminal can lead to erroneous measurements. This is also applicable to cable sensors. See Figure 6.

Conclusion

Full control over
sensor and connection

Too low insulation resistance in temperature sensors can give erroneous measurement independent of brand and type. TempIRsense gives the possibility of substituting sensors with low insulation resistance in 3-wire RTD's and thermocouples in time. TempIRsense does not only monitor the sensor but also the conductors from the sensors terminal to the transmitter terminals. This gives full control on the condition of the measuring chain from measuring point to transmitter.

Causes of low insulation

- Moisture
- Contamination
- Physical influence (wear, jamming)
- Chemical influence (corrosion)
- Vibration
- Radioactive radiation

Examples of errors

RTD @ 400°C

Insulation Riso	Error
500K	0.4°C
100K	1.6°C
50K	3.1°C
10K	15°C

Thermocouple type K @1000°C

Insulation Riso	Error
50K	1°C
20K	2°C
5K	10°C

Ref: See Sensors Magazine, April 1995 Issue.
See Measurements & Control, September 1997 Issue. p. 276.