SHEATHED THERMOCOUPLES – PRACTICAL ADVICE AND PROBLEM SOLVING, PART 1

Encased thermocouples – called sheathed thermocouples – are very common on the market. This article offers practical advice about their bendability and crushability, types of measuring junction, and insulation properties plus common terminology associated with this kind of temperature sensor. In the next issue of *Pentronic News* you can read Part 2, which discusses some of the most common sources of error with thermocouples.

A sheathed thermocouple is constructed of a sheath material, which is also called MI cable, with MI standing for mineral insulated. We thereby understand that this is a cable with conductors which are separated mechanically and electrically by a mineral, most commonly magnesium oxide, MgO.

Because magnesium oxide is moisture sensitive, all the open ends of the cable must quickly be sealed or stored at oven temperature. Otherwise the insulation deteriorates, leading to measurement error. The outer casing – the sheath – consists of steel or nickel-based alloys formulated to react to the minimal extent with wires and insulation. Inconel sheath material is commonly used in types K and N thermocouples. The term metal sheathed thermocouple is used. Sheathed thermocouples are normally sold in the metric diameters of 0.5 – 1.0 – 1.5 – 2.0 – 3.0 – 4.5 – 6.0 millimetres, although other dimensions are fully possible. Common dimensions for the wires are approx. 20% of the sheath's outer diameter. The thickness of the sheath is usually about 10% of the outer diameter. See Figure 1.

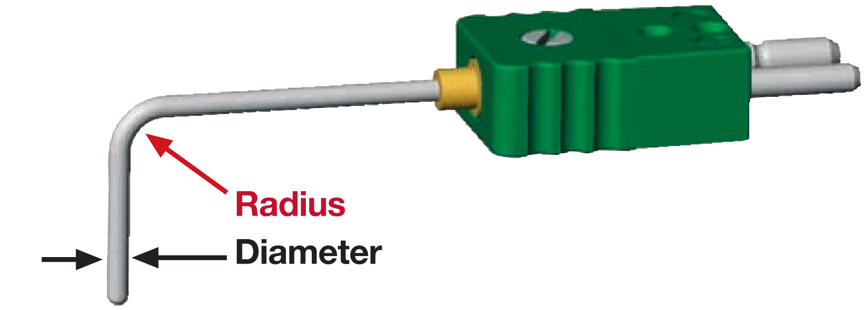

Figure 2. The bend radius must be greater than twice the sheath diameter. Example: A 3 mm Ø sheath must be bent over at least a 12 mm Ø round material.

USE COMMON SENSE WHEN BENDING

Because the sheath material is considered to be a cable, we understand that it is bendable, and it is, because the magnesium oxide becomes very tightly packed when the initial material is drawn down to the desired outer diameter. Bending the cable over sharp edges is prohibited. The manufacturers usually state that you can bend it as long as the radius of the bend is greater than twice the sheath diameter. See Figure 2.

A good tip for smaller-dimension sheaths is to shape the bend carefully with your fingers. The homogenous structure also makes possible to use pressure-tight compression fittings with steel cones to determine the insertion depth when measuring through a wall. When the fitting is tightened, the cone is pressed firmly onto the sheath. This does not happen with cones made of PTFE material – instead, with them the insertion depth can be altered afterwards. However, PTFE cones drastically reduce the pressure resistance. See Figure 3.

DIFFERENT MEASURING JUNCTIONS

Joining the wires and sealing the measuring junction can basically be done in three different ways as shown in Figure 4 A-C: Isolated,

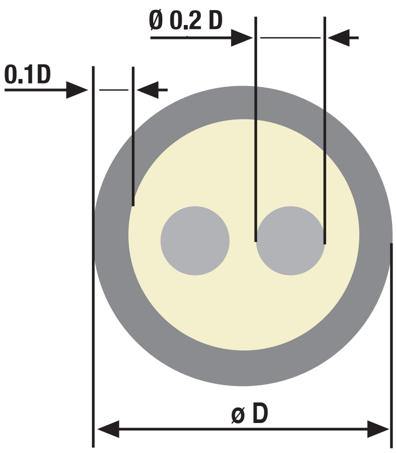

Figure 1. A cross-section of sheath material. The measurements are approximate.

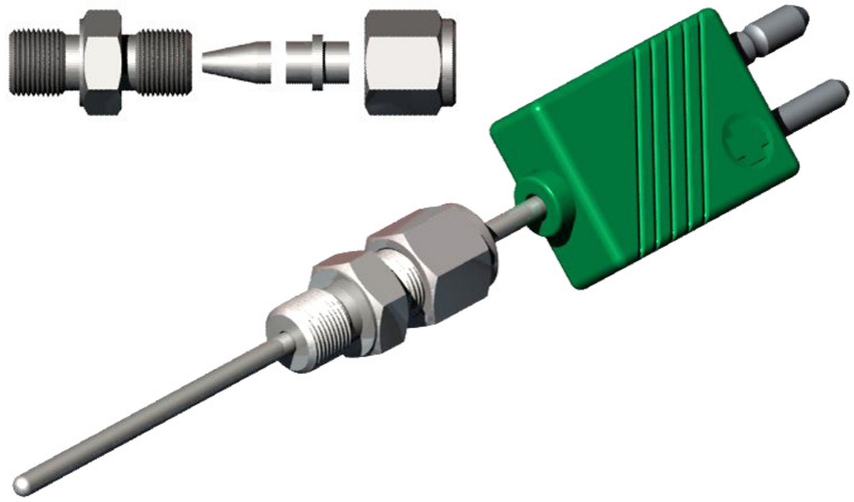

Figure 3. A pressure-tight compression fitting can facilitate the installation of sensors. Pentronic's compression fittings consist of a body, cone, and in some cases, pressure bushing plus gland nuts, which provide clamping force.

grounded and exposed junctions. Which one you should choose depends on which properties you prioritise. An isolated junction is recommended as the first choice because it is the safest construction. The wires and sheath are separated by magnesium oxide, which does not place the same requirements on the galvanic isolation of subsequent measuring instruments as is necessary for grounded and exposed junctions.

The biggest argument in favour of using a grounded junction is that it has a slightly faster response time than an isolated junction due to the measuring junction's direct metallic contact with the sheath, which facilitates heat transfer. The grounding introduces a risk of breaks in the event of rapid temperature cycling of a few hundred degrees. This is due to the tensions resulting from the differing length expansions of the sheath and wires.

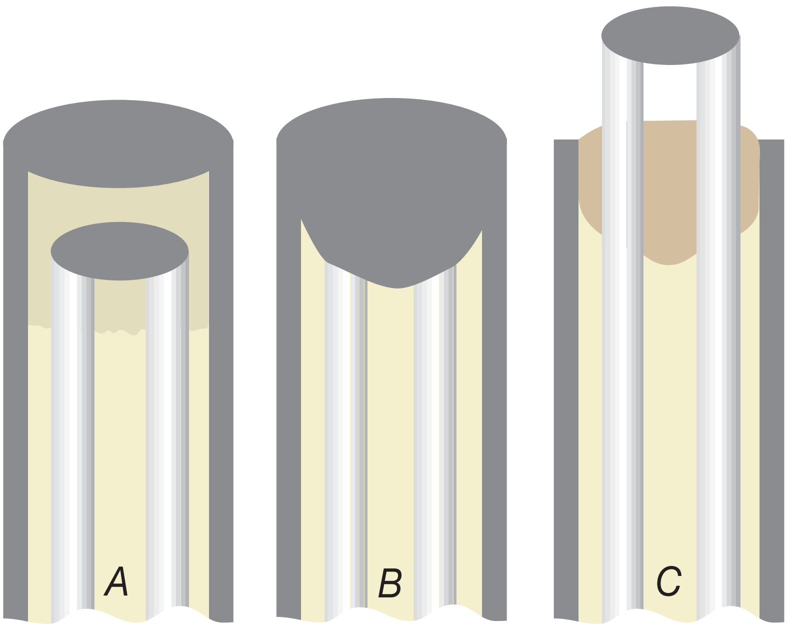

Figure 4. A: Isolated junction, B: Grounded junction, C: Exposed junction

Another limitation of grounded junctions is the electrical contact between the measuring junctions when two or more thermocouples are used to measure at the same installation. Remember that many liquids, including water, are sufficiently conductive to make it impossible to do differential measurement in the liquid. Two-pole switching loggers or isolating transmitters solve the problem.

An exposed junction should only be used when a short response time is a high priority, e.g. when measuring in air flows. The reason is that the sealing limits the temperature level and is sensitive to mechanical stresses.

Sheath Ø, mm (single thermocouple)	Test voltage, Vdc	Insulation requirement, MΩ
D ≤ 0.8	1	> 20
0.8 < D ≤ 1.5	100	> 1000
D > 1.5	500	> 1000

Table 1. Pentronic's insulation requirements when doing final inspection of its own single sheathed thermocouples at room temperature. At higher temperatures, from 800–1000 °C, the insulation deteriorates drastically.