Application Note: Temperature Measurement

There are multiples ways to install and use a temperature probe. It depends on a multitude of factors such as the probe itself, the temperature range, the duration of the use, the presence of thermal radiation. In Figure 1, the two form factors of temperature probe sold by Jericho can be seen.

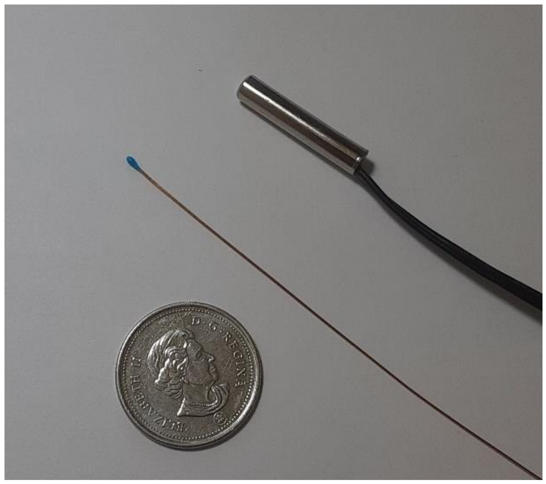

Figure 1 Jericho thermistor probes
TH-1 (small) and TH-2 (large)

Important note: Avoid impacts on the probe and the controller to maintain their accuracy and functionality. Do not exceed the probe maximum temperature to maintain the accuracy of the probe because strong thermal expansion plays a role in the gradual drift of the probe properties and accuracy.

Surface measurements

If you want to measure the temperature of a surface, you can often just use a regular adhesive tape (e.g., scotch tape). The small probe can be taped horizontally, vertically or upside down. The large probe being heavier it will need a stronger adhesive to be tied to vertical surfaces. The lead wire should also be tied in order to reduce the tension on the probe adhesive tape.

In Figure 2, small and large factor probes can be seen with regular tape and electric tape.

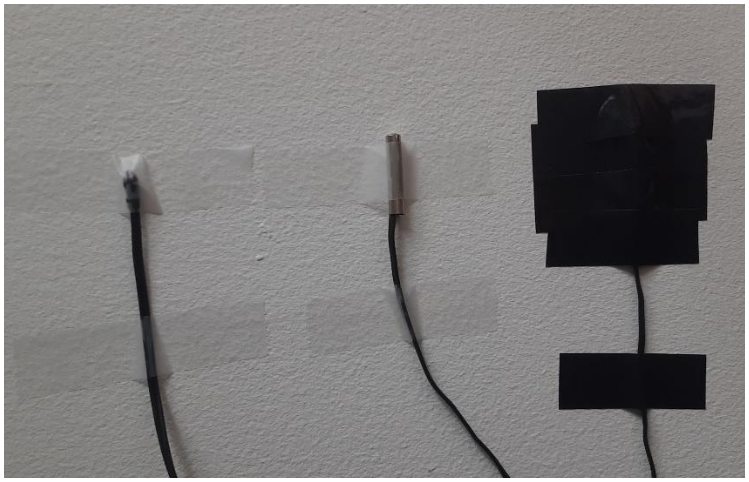

Figure 2 Easy techniques to position small and large thermistor probes for wall surface temperature measurements

Radiant heat transfer

If the surface is exposed to significant radiant heat transfer, the adhesive tape should have the same radiative properties than the surface studied, or as close as possible. Otherwise, the tape and probe will have a temperature different than the surrounding surface. Radiant heat transfer is often negligible when temperature differences between surfaces/elements are lower than 10°C. Some examples of significant radiant heat transfer are: outdoor measurements, indoor measurements that includes a cold wall (e.g., poorly isolated brick wall in the winter).

Adequate measurements in situations with non-negligible radiant heat transfer can be done in one of two ways: by applying the same material on the probe (e.g., paint) or by using a surface material for the probe that has a similar radiative property. For example, if you are measuring the surface temperature of a painted wall, the emissivity of the electrical tape is very close (epsilon ≈ 0.95). You can also paint over the adhesive tape. If you are measuring the temperature of a polished aluminum surface, the probe should be tied with a reflective aluminum tape instead. If the adhesive and the surface have the same emissivity, the adhesive should be nearly invisible on a thermal camera. If you do not have access to a thermal camera, you can also use a list of emissivity for common materials (Yunus A. Çengel 2007) to help you out.

Contact resistance

Contact resistance is one of the common source of measurement errors. Contact resistance occurs between two contacting objects when the thermal resistance between the two is non negligible. This is one of the reasons why your probe might not have the same temperature as the surface around it. You can lower the contact resistance by adding a substance which increases the thermal transfer between the two objects, such as CPU thermal paste. Our large format probe is more susceptible to contact resistance, since the contact point between a cylinder and a flat surface is a line. Contact resistance is an important topic of introductory heat transfer handbooks (Yunus A. Çengel 2007).

In hot and wet environments where nothing can be permanently glued and no holes can be drilled, strong neodymium magnets can offer an alternative, as seen in Figure 3. Due to the high resistance values of the thermistor, the possible electromagnetic interaction between the fixed magnetic field of the magnets and the very-low current circulating in the wires should be negligible in the final reading. Other types of sensors such as active sensors or thermocouples could be negatively affected by the magnets.

Figure 3 Thermistor positioning inside a dishwasher with neodymium magnets and electric tape

Air measurements

Air measurements consist of measuring the temperature of a gas, whether it be the atmosphere, the air temperature inside a refrigerator or a gas inside a cavity (e.g., nitrogen chamber). These measurements can apply to static and flowing gases.

Due to the low mass and low heat capacity of gases, the heat transfer between the probe and the surrounding medium is of a lesser value. This is especially true in stagnant air. This means that the reaction time of the probe in this context is higher. If the important thing for the user is to have quick reaction time, then a smaller probe should be selected. If the important thing for the user is the probe solidity or the stability of the readings without resorting to noise control techniques, then a larger probe should be used.

It should also be noted that a larger probe will, by nature, measure the average temperature of a larger space volume. A smaller probe might be able to capture smaller details of the space or flow. For example, to determine the temperature profile of air flow inside a 50 cm duct, the small probe would be more adequate. The small probe would also minimize flow disturbance, which in itself would improve the quality of the measurements.

To hold the probe in mid-air, various supports can be used. It can generally be tied to low-conductivity materials such as a plastic rod, wooden sticks. Metallic supports, which have a higher thermal conductivity should be avoided in order to reduce the influence of the support temperature on the measurement (i.e., thermal leak). For similar reasons, the probe itself should not be touching the support, only the lead wire, if possible (see Figure 4). The probe should be sticking out from the support a bit (i.e., 1-3 cm). Finally, the probe can also be suspended to a rope, if the situation allows it and the exact probe position is not important.

Figure 4 Example of a low-cost probe support for air measurement using a bamboo stick and tape

Liquid measurements

Liquid measurements could include: rivers, rain, beverages, chemicals, boiling water, phase change materials. In liquids, the heat transfer can be quite good, due to the high heat capacity of the medium relative to the probe. Good heat transfer accelerates the obtainment of thermal equilibrium between the probe and the medium (i.e., reaction time). It also reduces the significance of source errors such as Joule effect and thermal leaks. This is especially true with liquid flow, where natural and/or forced convective heat transfer is significant. In Figure 5, an attempt at measuring the coffee temperature at two different depths can be seen.

Figure 5 Partial and full immersion of two thermistor probes for measurements in a coffee cup

Generally speaking, the same strategies than those for air measurements can be used to hold the probe into position. Special attention should be given to the adhesive tape sensitivity to the liquid. The chemical properties of the liquid (e.g., pH value) should be taken into consideration to avoid damage to the probe and lead wire (see product specifications). Radiant heat transfer is generally less of a preoccupation, unless the liquid is transparent to some light frequencies (e.g., sunlight can heat a probe at the bottom of a pool).

Solid measurements

Some users might want to measure temperatures inside solid volumes such as soil, sand, or concrete. The low cost of the Jericho thermistor probes makes them interesting for destructive measurements. Destructive methods are the methods for which the probe cannot be reused. For example, you will not be able to reuse a probe which has been cast into concrete to measure the evolution of the chemical reaction at various depths (Figure 6). Precision agriculture might also require soil temperature profiles to evaluate crop health or potential irrigation needs along soil humidity measurements (Figure 7). Positioning the probes in the soil or concrete can be done with anchors and techniques similar to air and liquid measurements. Corrosion risk should be evaluated when choosing between a plastic or a metal sensor enclosure.

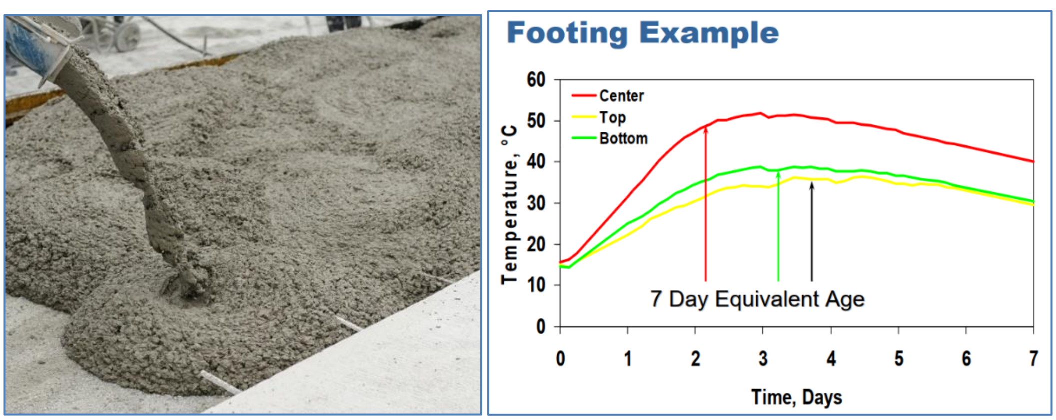

Figure 6 Example of concrete curing temperature curves by CP Tech Center

Figure 7 Humidity and temperature probes into a vine pot soil