TEMPERATURE MEASUREMENTS UNDER UV LAMPS

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This has frequently been a troublesome subject. As it relates to UV curing, the typical purpose of temperature measurement is to determine the instantaneous or peak temperature of a temperature-sensitive substrate or of an ink or coating as it passes under UV lamps. Surface temperature rise is affected by the radiant energy arriving at the surface, the thermal absorptivity of the ink or coating, and the thermal conductivity of the substrate.

There are several methods of measurement, and they ALL have deficiencies. We must understand the errors in each of these methods, or we will not understand the data we obtain. As we know from radiometry, when a measurement is used as a SPECIFICATION and the methods of making the measurement are not defined, they can be of little value and certainly misleading. This is even more of a problem with thermometry.

1. Temperature Tabs
A variety of these devices are available. By a non-reversible reaction, they indicate the maximum temperature to which the tab was exposed. They do not function properly when they are exposed to infrared radiation, because they directly absorb radiant heat. Worse, they block the substrate from the radiation that would otherwise heat it.

A somewhat more useful way to apply tabs is to laminate them between a top film and a backing. Obviously, this is limited to structures like self-adhesive labels, it will yield a reasonably accurate measurement because the actual material and its surface is exposed to the radiant energy. The absorptivity and specific heat of the material affect the temperature to which it rises. The tab temperature will rise by conduction of heat from the upper film while the backing tends to insulate it from heat loss. (Even this technique is not valid if the substrate is significantly more conductive than the ink or coating film.)

***2.* Thermocouples**
Except for thick samples where the only interest is in the bulk average temperature (such as circuit boards or the insides of components), thermocouples are difficult to use reliably. A thermocouple reports only the temperature of its little metal bead — it must be in nearly complete thermal contact with what it is measuring, or it will just rise to any temperature it wants to. If it is subjected to radiant heating with insufficient conductive contact, it will show a temperature that has little to do with the temperature of whatever it is attached to — usually much higher.

It is impossible to measure "air temperature" with a thermocouple that is also receiving radiant energy; its temperature rises because of radiant heating dictated by the absorptivity of its surface, compounded by its specific heat, while the air is actually cooling it! No wonder some people have observed ridiculously high "temperatures" when they pass an unprotected thermocouple under a UV lamp!

Placing a cover or 'protective' coating around the thermocouple doesn't help, either. As you see from the above example, all that has been achieved is changing the absorptivity and mass of the thermocouple. If you change the absorptivity of the thermocouple bead by coating it with a reflective or non-reflective coating or even foil, you measure still a different "temperature."

Attempts to measure surface temperature of a radiated part often include various schemes of adhesives to improve conductive contact and over-taping to reduce the effects of radiation. All of this can interfere with an accurate measurement.

3. Non-Contacting Thermometers

Also called infrared thermometers, these non-contact electro-optical devices measure the infrared emittance of a warm or hot surface. They respond to surface temperature because the infrared emission from a surface is a function of the temperature and the emissivity of the surface.

To make measurements, the hand-held instrument is located a few inches away from the surface. It can respond quickly; measurements can be taken in 1 -2 seconds. Measurements can also be made continuously by connection of the instrument's signal output to a chart recorder.

While an optical thermometer is calibrated for emissivity, organic and many non-metallic materials have an emissivity of 95% (compared to a 'blackbody,' or perfect emitter, having 100%). This allows readings with good accuracy without recalibration by simply using a constant of 0.95.

One disadvantage of non-contact thermometers used with UV lamps is the difficulty of measuring the surface when it is directly under the lamp. This can be easily compensated for; two measurements made in sequence at known times after exposure allow a backwards computation of the peak surface temperature. Most of the time, a quick measurement made as soon after exposure as possible is sufficient.

We conclude that a non-contacting IR thermometer is the most accurate and reliable method of measuring surface temperature, although it is limited to measuring immediately after exposure to the UV lamps.

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