Evaluating Sensor Placement In A Thermal System

In all thermal systems there are four major parts:

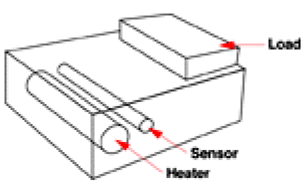
1. **The Work Load** - This is the material to be heated and is generally associated with a cycle time or a time rate of passage over or through the heated part.
2. **The Heat Source** - Either electrical resistance, or fuel fired heat.
3. **The Heat Transfer Medium** - The solid, liquid or gas that transfers the heat energy to the load.
4. **The Controlling Device** - The sensing and controlling devices that control the amount of heating and maintain a specific temperature for the load.

With these four parts in mind, consider placement for each of these with respect to the others.

Of the four major parts of a closed loop system, the sensor's location will play a major role, provided the other elements of the system have been properly selected. Placement of the sensor in relationship to the work load and heat source can compensate for various types of energy demands from the work load. Sensor placement can limit the effects of thermal lags in the heat transfer process. The controller can only respond to the temperature changes it "sees" through feedback from the sensor location. Thus, sensor placement will influence the ability of the controller to regulate temperature about a desired set point.

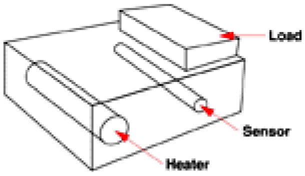
Be aware that sensor placement cannot compensate for inefficiencies in the system caused by long delays in thermal transfer. Realize also that in most thermal systems, temperature will vary from point-to-point.

Sensor in a Static System



We call a system "static" when there is slow thermal response from the heat source, slow heat transfer, and minimal changes in the work load. When the system is static, placing the sensor closer to the heat source will keep the heat fairly constant throughout the process. In this type of system, the distance between the heat source and the sensor is small (minimal thermal lag); therefore, the heat source will cycle frequently, reducing the potential for overshoot and undershoot at the work load. With the sensor placed at or near the heat source, it can quickly sense temperature changes and maintain tight control.

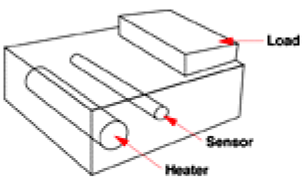
Sensor in a Dynamic System



We call a system "dynamic" when there is rapid thermal response from the heat source, rapid heat transfer and frequent changes in the work load. When the system is dynamic, placing the sensor closer to the work load will enable the sensor to "see" the load temperature change faster, and allow the controller to take the appropriate output action more quickly. However, in this system type, the distance between heat source and sensor is notable, causing thermal lag or delay. Therefore, the heat source cycles will be longer, causing a wider swing between the maximum (overshoot) and minimum (undershoot) temperatures at the work load.

We recommend that the electronic controller selected for this situation include the PID features (anticipation and offset ability) to compensate for these conditions. With the sensor at or near the work load, it can quickly sense temperature rises and falls.

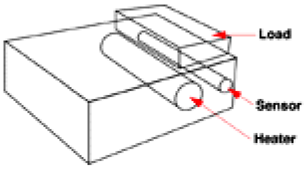
Sensor in a Combination Static/ Dynamic System



When the heat demand fluctuates and creates a system between static and dynamic, place the sensor half-way between the heat source and work load to divide the heat transfer lag times equally. Because the system can produce some overshoot and/or undershoot, we recommend that the electronic controller selected for this situation include the PID features (anticipation and offset ability) to compensate for these conditions. This sensor location is most practical in the majority of thermal systems.

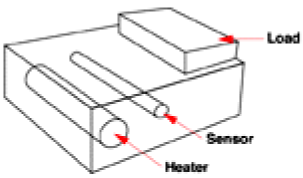
Sensor Placement Examples In Solids

The various methods of contact heat transfer can be categorized into conduction (typically solid or liquid), and convection (typically a liquid or gas). A conduction system might consist of the heat source in direct contact with the heat transfer medium which in turn heats the load. The information here discusses three different response systems using different temperature sensor locations.



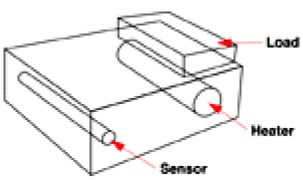
Best

The heat source is close to the work and the sensor is close to both the heat source and the work. This short heat conduction path minimizes thermal lag.



Practical

The heat source is distant from the work and the sensor is located between the source and the work. The longer heat conduction path increases thermal lag in the system, but being located mid-way, the sensor can respond to work or heat source changes without excessive lag.

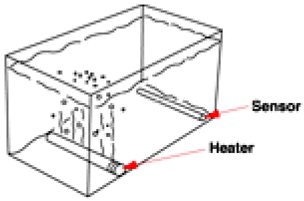


Poor

The heat source is close to the work and the sensor is distant from both the heat source and the work. The sensor is too far from the heat conduction path to respond to temperature changes without excessive lag. The sensor is also located too far from the workload.

Sensor Placement Examples In Liquids

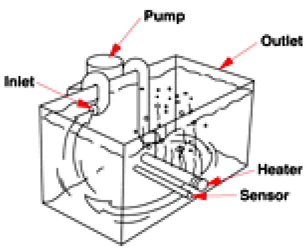
The examples shown to the right are for liquid tank heating. As shown, the sensor must be located relatively close to the heat source in order to sense possible overheating of the fluid in that localized area.



Poor Liquid Heating Control

The convection heat path between the heat source and sensor is too long, creating excessive lag and temperature overshoot.

Note: Sensor placement in convection applications is the most important consideration.



Best Liquid Heating Control

The shorter convection heat path between the heater and the sensor, and a circulation pump to reduce heat gradients, minimize thermal lag and temperature overshoot.

National Plastic Heater,

Sensor and Control Inc.

Toll Free: 1-877-674-9744

sales@nphheaters.com www.nphheaters.com