Technical

Thermal Systems

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The result obtained with a precision temperature controller, as with any tool, depend upon how skillfully it is used. Close temperature control can be maintained only if the thermal system is properly designed so that it responds quickly and accurately to operating conditions.

Thermal systems have four elements, all of which contribute to systems control performance. They are: 1. WORK (or load) — the material or product which must be maintained at a controlled temperature; 2. HEAT SOURCE — the device which delivers the heat used by the system, such as gas, oil, or electric heaters; 3. HEAT TRANSFER MEDIUM — the material which transmits the heat from the heat source to the work; 4. CONTROLLER — the instrument which controls the heat flow on the basis of the difference between sensed temperature and controller's set point.

In addition, careful consideration must be given to the physical make-up of the system. The proper location of heat sensor and work-load, a good selection of the heat transfer medium, and use of reliable components are all essential to the development of a **good thermal system.**

Although in practice, thermal systems are not purely steady or variable, they usually are predominantly one or the other.

For basic system design, the following rule of thumb will be helpful: where the heat demand is relatively steady, the sensing element of the controller should be placed **close** to the **heat source**; where the demand is largely variable, it should be near the **work area.** A complicated system may require several different sensing element locations before a suitable one is found. One should always remember, however that the element should be closer to the area where a temperature change must be sensed with minimum **thermal lag.** (Thermal lag is the delay in heat transfer from place to place in the thermal system).

The effect of various sensing element locations on the control of predominantly static or dynamic systems is clearly illustrated in **Fig. 1.**

Fig 2 applies to liquid and gas systems which require additional considerations. Because the heat demand is basically steady, the sensing element should normally be located close to and above the heat source to minimize system **bandwidth.** (Bandwidth is the total temperature variation above and below the average operating temperature measured at some point in the system).

Fig. 1

Poor Liquid Heating Control

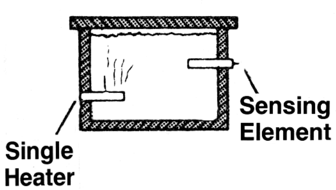


Fig. 2

Optimum Liquid Heating Control

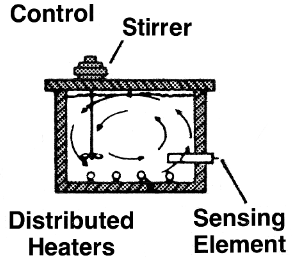
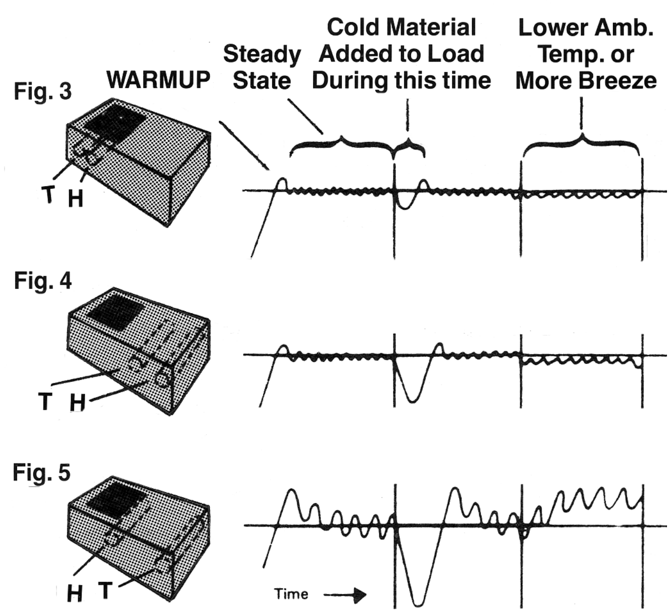


Fig. 3: Close grouping of heater, sensing element and work. Where this layout is feasible, it gives excellent control under most conditions and is desirable when the thermal load changes frequently. The heat transfer paths from he work and heater to the thermostat are short, so that thermal lag is slight. System inertia is low because of the small mass of heat transfer medium. Rapid cycling will hasten recovery of the system from thermal upsets.

Fig. 4: Thermostat between heater and load. This is a "general purpose" arrangement for installations where the heat demand my be alternately steady and variable. By being midway between them, the sensing element can respond to changes at the work and the heater without excessive lag in either instance.

Fig. 5: Heater at load, thermostat distant. This arrangement practically guarantees poor control. The sensing element is too far from either the heater or the load to respond to temperature changes from either one without excessive lag. The arrangement is presented primarily to emphasize that, unless you are careful in placing the element, the controller may find it impossible to maintain even fair control.

Temperature of the Load



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