Temperature Control Information

Temperature control: Precision and Accuracy

The temperature control system in Barnstead Thermolyne furnaces consists of four major components: controller, power-switching device, heating elements, and a thermocouple sensor (Figure 1). All of the Barnstead Thermolyne furnace control systems are closed-loop for accuracy and safety. In a closed-loop system, the temperature sensed by the thermocouple gives a feedback signal to the controller that in turn regulates power to the heating elements by means of the switching device. The selection of components within the control loop for a particular furnace model is largely based on the desired operating temperature range and the magnitude of overall temperature error that is acceptable within that range. The overall error is defined as the difference between the set value and the actual value of the furnace chamber or load. The overall error is broken down into the precision of the temperature reading and its accuracy.

Temperature precision is largely determined by the controller. Our economy solid tube furnaces use analog controllers and all other Barnstead Thermolyne furnaces utilize microprocessor (digital) three-term controllers (Proportional + Integral + Derivative or PID). PID control is very precise in that small fluctuations in chamber temperature are quickly adjusted to maintain the set temperature. In addition, the PID type controller reaches the desired chamber temperature and reduces the chance of overshooting the value. This is particularly important to consider if the furnace workload is sensitive to temperatures slightly above the setpoint. Temperature control in furnaces is the most precise above 260°C. Other factors to consider with regard to accuracy include the size and density of the material being heated and the thermal lag of the material relative to the chamber temperature. Large, dense materials will obviously require more time to reach the set temperature.

Over-Temperature Protection (OTP)

Digital controllers are designed with two types of OTP. A "full-scale high" alarm will be in effect when the furnace chamber exceeds its maximum allowable temperature. The controller will cut power to the heating elements until the chamber cools to a value below this limit. This value is defined by the heating capacity of the elements, the thermocouple, and the insulation and cannot be modified by the operator. The second type of OTP, the "deviation high" alarm is designed to protect the furnace workload and can be changed by the operator. We recommend setting this value to 20°C above the working temperature of the load.

Sensor Break Protection

All Barnstead Thermolyne controllers provide for a safe response should there be a loss of input signal because of a broken thermocouple or an open circuit. Power to the heating elements is terminated and a message flashes on the display.

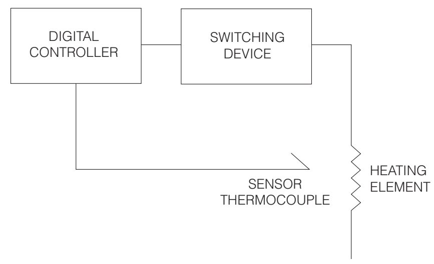

Figure 1

Tuning

The digital controllers can be automatically tuned to improve product or process quality. Self-tuning is a built-in software package for automatically determining the PID and other control parameter values. For maximum performance, this feature should be used the first time the furnace is used and each time the setpoint or the type of load is changed.

Programming

Many processes require the temperature to vary according to a precise profile with time. The digital controllers allow a programmed function which is stored in non-volatile memory. Programs consist of functions and associated settings called segments. These segments can be assembled into a program in a fixed format, such as a succession of ramp/dwell pairs (Figure 2). Segments include:

Ramp: The setpoint temperature increases or decreases at a linear ramping rate until a specified target level is reached.

Step: A step is a specialized type of ramp segment where the setpoint jumps to the specified target level. It is used when the most rapid change in measured value, limited by the heating elements, is desired.

Dwell: The length of time required at a target temperature.

Communications

Bi-directional digital communications via an RS-232 port is an option with select digital controllers. Eurotherm Controls has available a free demonstration program called the Communications Sampler. This program enables Windows® to communicate with a single controller. The controller's parameters can be displayed on the screen and the value of the parameters can be changed with the computer keyboard. Two off-the-shelf software packages, Eurotherm's iTools and SpecView allow the user to supervise groups of controllers, as well as retrieve data for logging and trend plots.




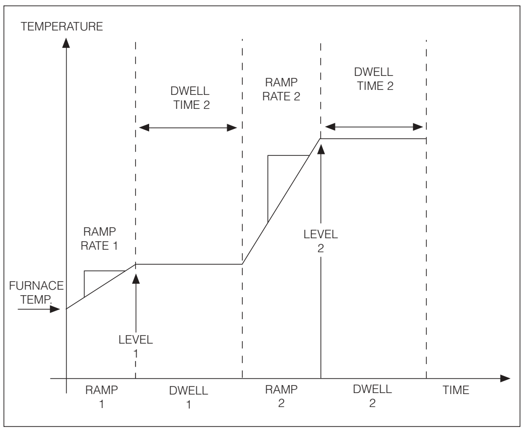

Figure 2

Group B1

Holdback

If the measured value lags behind the setpoint by a preset amount during ramp or dwell, the holdback feature can be used to freeze the program at its current state. The program will resume when the error comes within the holdback value.

Gain Scheduling

Gain scheduling is the automatic transfer of control between two sets of PID values. Select digital controllers do this at a preset measured temperature. Gain scheduling is used for difficult to control processes which show large changes in their response time or sensitivity at high or low temperatures.

Group C1 and D1

TEMPERATURE CONTROLLER SPECIFICATIONS

Feature	Group B1 Single Setpoint Digital	Group C1 8 Segment	Group D1 16 Segment 4 Stored Programs
Temperature Display	Toggles between set and actual	Dual Display	Dual Display
Over Temperature Protection	*Yes	Yes	Yes
Sensor Break Protection	Yes	Yes	Yes
Self Tuning	Yes	Yes	Yes
Adaptive Tuning	No	Yes	Yes
Holdback	No	Yes	Yes
Gain Scheduling	No	Yes	Yes
Communications	No	No	Yes

** Dependent on furnace model*