TYPE 503: THREE STAGE AQUASTAT IN COOLING

General Description

A three stage aquastat is modeled to output three ON/OFF control functions that can be used to control a fluid cooling system having up to a three stage cooling source.

Nomenclature

T'_{Cn}	[ºC]	New cooling set point temperature for stage n.
T_{Cn}	[ºC]	Old cooling set point temperature for stage n.
γ_n	[0 or 1]	Cooling control signal at the previous time step for stage n.
DT_{db}	[ºC]	Dead band temperature difference for hysteresis effects.
γ_{SetUp}	[0 or 1]	Set up control signal.
DT_{SetUp}	[ºC]	Dead band temperature difference for set up effects.

Detailed Description

This controller commands first stage cooling at warm fluid temperatures, second stage cooling at warmer fluid temperatures, and third-stage cooling at even higher fluid temperatures. The user has the option to disable first stage cooling during second stage and third stage cooling, and to disable second stage cooling during third stage cooling.

In many cooling applications, a desired fluid temperature may depend on the time of day or the day of the week. This variation of the cooling set point temperatures are modeled here using an optional set up control function and a set up temperature difference.

As with many controller components in TRNSYS, instabilities may occur when system temperatures are at or very near to their set point values. Again as with other controllers, these instabilities can be reduced by adding hysteresis (dead bands) to the controller such that the controller signal does not change until the system temperature has reached its set point plus (or minus) a small delta temperature. Hysteresis effects can be included in the model by supplying the optional dead band temperature difference DTdb. A single value of DTdb, is applied to all three output control functions.

PARAMETER 1, NSTK, sets the number of oscillations permitted within a time step before the output state of the controller is stuck. It is recommended that NSTK be set to a value of 3 or 5. Odd values of NSTK ensure that if controller sticking becomes a problem, the controller will change states between time steps and that the system will move toward a more stable state. For a more detailed discussion of controller stability problems, see the introduction to the Controllers section (chapter 4.4) of the TRNSYS documentation set.

The cooling ON/OFF temperatures are set as follows:

$$T'_{C1} = T_{C1} - \gamma_1 \, DT_{db} + \gamma_{SetUp} \, DT_{SetUp} \qquad \text{(Eq. 503.1)}$$

$$T'_{C2} = T_{C2} - \gamma_2 \, DT_{db} + \gamma_{SetUp} \, DT_{SetUp} \qquad \text{(Eq. 503.2)}$$

$$T'_{C3} = T_{C3} - \gamma_3 \, DT_{db} + \gamma_{SetUp} \, DT_{SetUp} \qquad \text{(Eq. 503.3)}$$

At each iteration, the current values of the watch temperatures are compared to the current values of the cooling ON/OFF temperatures as computed using equations 503.1 through 503.3. The controller sets the value of the appropriate stage's output control signal to 1 if the current watch temperature is above the corresponding cooling ON/OFF temperature.

In this model, dead band temperature differences for both hysteresis and temperature set up are centered on the set point temperature.

If hysteresis effects are not used, then the dead band DTdb is set to zero. If the set up option is not used, both γ_{SetUp} and DT_{SetUp} are set to zero.

NOTE: Care should be taken when choosing dead bands and set points. Dead bands that are greater than the temperature difference between the set points will cause the controller to have convergence problems.