Date: ________________ Name: ___________________________________

DEMONSTRATION EXERCISE 18
CHARACTERISTICS OF OVERRIDE (SELECTOR) CONTROL

OBJECTIVE: To demonstrate the application and behavior of override (selector) control loops, in particular, the benefit of using external reset feedback to prevent reset windup of the non-selected controller.

BACKGROUND: Override (selector) control is applicable whenever, in normal operation, one controller has control of the valve (or other final control element), but in abnormal circumstances, is overridden by a second controller which then takes control of the valve.

Examples include:

- Distillation columns. In order to prevent tower flooding due to excessive upward vapor velocity, a differential pressure controller across some section of the tower may override a composition (or tray temperature) controller and reduce reboiler heat input.

- A batch digester in a pulp mill. Upon start up, steam to the digester may be controlled by a steam flow controller until the digester pressure reaches set point, then a pressure controller overrides the flow controller and assumes control of the valve.

- Process heater control. In normal operation an outlet temperature controller controls the fuel to the heater; in event of a high tube temperature, a tube temperature controller overrides the outlet temperature controller to reduce fuel to the heater.

This last example will be used as the scenario for this laboratory exercise. The assumed process and control configuration is shown in the figure below.

In each case, if PID controllers are used for both the normal (primary) and abnormal (auxiliary) controllers, then unless provisions are made otherwise, the non-selected controller will undergo "reset windup." One means of preventing reset windup is by the use of a PID controller modification known as "external reset feedback" (ERF), or sometimes "external reset" or "reset feedback."

This exercise demonstrates override (selector) control both with and without external reset feedback.

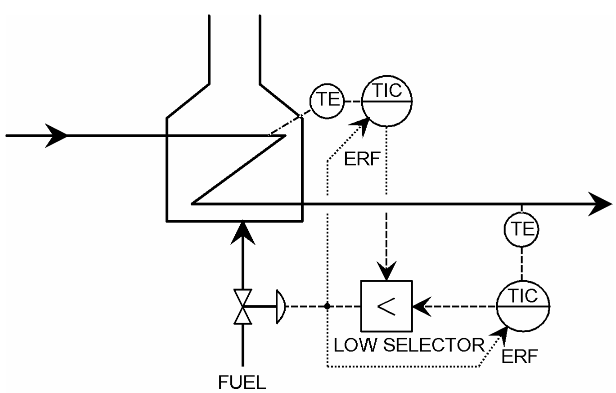

Figure 1
OVERRIDE CONTROL APPLICATION EXAMPLE

1. RUNNING THE PROGRAM

Start **Windows.**

Run **PC-ControLAB.**

2. CONTROLLER SETUP

Select **Control | Retrieve Strategy, Model and Tuning** Highlight "Override.stg" and press **Open**.

The Override control strategy display contains two controller faceplates. These are independent controllers, called the Primary and Auxiliary, respectively. A selector function, not shown on the display, selects the lower of the two controller outputs for transmission to the final control element (valve). The Primary Controller is assumed to be in control of the process in normal circumstances; the Auxiliary Controller can override (i.e, its output can become lower than the Primary's output, hence become selected) and control the process during abnormal operations. Initially, both controllers use external reset feedback. Both controllers are already tuned for their service.

Put both controllers in Automatic.

The Primary Controller represents the Heater Outlet Temperature Controller; *both its set point and PV are initially at 275 DegF. After the controller is placed in Auto, its output (the black line) comes to equilibrium at 35%.*

The Auxiliary Controller represents a Heater Tube Temperature High Limit Controller. Initially the tube limit (set point) is at 1400 DegF, but the actual tube temperature (PV) is only 1200 DegF. After the controller is placed in Auto, its output (the blue line) comes to equilibrium at about 43%

This is a normal operating condition. An unseen selector switch selects the lower of the two controller outputs, in this case the Primary Controller, as the signal to the fuel valve.

Select the Auxiliary Controller, then select **Control | Control Options**. Note that YES has been chosen for "Reset Feedback."

Select the Primary Controller and repeat the steps above to confirm that (external) reset feedback is being used for the Primary Controller.

Verify that tuning parameters have been entered for each controller.

	PRIMARY	AUXILIARY
Gain:	2.0	0.8
Reset:	8 minutes/repeat	5 minutes/repeat
Deriv:	0 minutes	0 minutes

Because of the number of variables plotted in this exercise, you may want to turn off automatic variable labeling and only label the variables on demand. If so, press **LABEL Auto**.

3. OPERATION WITH EXTERNAL RESET FEEDBACK

Observe that after equilibrium is established with the conditions established above:

The Primary process variable is on set point.
(The heater outlet temperature is on set point.)

The Auxiliary process variable is below set point.
(The heater tube temperature is below its limit.)

The Primary Controller's output is less than that of the Auxiliary Controller, hence the Primary Controller is in control of the valve.

The Auxiliary Controller, even with a sustained condition in which its measurement is below set point, is **not** winding up.

Select the Primary Controller and press **StepIncr** once to increase the primary process load by 5%, from 300 (75%) to 320 gpm (80%).

(You can read the input flow rate in engineering units by clicking on the white label “Feed Rate” above the chart. The label turns red and the coordinates on the right hand side of the chart change to show the units of the input flow. Alternatively, you can read the input flow rate in percent by reading the coordinates on the left hand side of the chart.)

If you clicked on the “Feed Rate” label, then SELect *the Primary (Temperature) Controller before proceeding. The Primary Controller must always be selected in this Exercise when making load changes.)*

(The process phenomena that this represents is an increase in throughput to the heater. To maintain the same outlet temperature, additional fuel is required. This additional firing causes the combustion zone to become hotter, consequently the tube temperature to rise.)

Observe that after equilibrium is again achieved:

The Primary process variable is again at set point.

The Auxiliary process variable is closer to its set point than before, but still below set point.

The Primary Controller output is still below the Auxiliary Controller output, hence is still in control of the valve. But the Auxiliary Controller is NOT WINDING UP!

With the Primary controller selected, press **StepIncr** again to increase the Primary process load by another 5%, from 320 (80%) to 340 gpm (85%). Observe that after equilibrium is achieved:

The Auxiliary process variable is still beneath its set point.

The Primary process variable is at set point.

The Auxiliary Controller output is still above the Primary Controller output, hence has not yet taken over control of the valve.

Now make a significant load change. Press **StepIncr** twice, increasing the load from 340 gpm

(85%) to 380 gpm (95%).

Observe that the Auxiliary PV (tube temperature) goes above set point, which causes the Auxiliary Controller output to drop below the Primary Controller output. Observe the cross-over point where the Auxiliary Controller output becomes the lower of the two outputs. Observe the behavior of both process variables at that point.

Observe that when equilibrium is achieved, the heater tube temperature is at the limit, and the heater outlet temperature is below set point. We have lost control of our process temperature, but we have saved the heater.

Observe also, that even though the Primary Controller can no longer control its process variable, its output is **not** winding up, due to the behavior of the external reset feedback.

With the Primary Controller selected, press **StepDecr** twice to decrease the primary load from 380 (95%) to 340 gpm (85%).

(This simulates the cause for the abnormal condition, such as an excessive throughput rate, being removed.)

Observe (after equilibrium is achieved):

The Primary Controller has again taken over control of the valve. Its process variable is at set point.

The Auxiliary Controller process variable is less than set point. Yet it is **not** winding up.

Now decrease the Primary load from 340 (85%) to 300 gpm (75%), and let the process stabilize at the initial conditions in preparation for the rest of the exercise.

4. OPERATION WITHOUT EXTERNAL RESET FEEDBACK

Return to the conditions, including set points, controller tuning and process loads, established in Section 2. PUT BOTH CONTROLLERS IN MANUAL.

Select the Primary Controller, select **Control | Control Options**. Choose NO for “Reset Feedback.”

Select the Auxiliary Controller and repeat these steps to discontinue use of Reset Feedback for the Auxiliary controller.

Put both controllers in Automatic.

Observe that the Auxiliary Controller immediately begins to wind up. That is, due to the integral action, its output rises to its limiting value of 100%

We will now make the same pattern of load changes as before. Select the Primary Controller and increase the primary load from 300 gpm (75%) to 320 gpm (80%).

Observe that since the Auxiliary process variable does not exceed its set point, the Auxiliary Controller output remains at its limit.

Now increase the primary load to 340 gpm (85%).

Same as above.

Now increase the primary load to 380 gpm (95%).

Observe that the Auxiliary Controller output remains at its limit until the Auxiliary process variable crosses its set point. Then the Auxiliary Controller starts to "unwind."

Observe also that until the Auxiliary Controller output goes lower than the Primary controller output, the Auxiliary Controller has no effect on the valve position *(i.e., on furnace firing).*

Observe that once the Auxiliary Controller takes over control, then the Primary controller begins to wind up.

When the Primary Controller output has reached its limit, decrease the primary load to 340 gpm (85%)..

This is the load range that should permit the Primary Controller to be on set point, with the Auxiliary Controller less than its limiting value. Yet, due to the wind up condition of the Primary Controller, it requires almost 45 minutes for this controller to unwind so that its output can take over control from the Auxiliary Controller. During this time, the Primary process variable is significantly above set point.

This exercise demonstrated the behavior of an override control system upon a changeover from the Primary to Auxiliary Controller and back, both with and without external reset feedback. While the values used may have demonstrated extremes of behavior, the advantage of external reset feedback over conventional PID control is obvious. Several manufacturers offer external reset feedback, or an equivalent technique, in their commercial controllers.