Date: ________________ Name: ___________________________________

LABORATORY EXERCISE 23
DRUM LEVEL CONTROL LOOPS

OBJECTIVE: To illustrate a liquid level control phenomena, known as “shrink and swell”, that is very common with steam boilers.

PREREQUISITE: Completion of the following exercises:

12 Tuning Liquid Level Control Loops
15 Characteristics of Cascade Control
16 Characteristics of Additive Feedforward Control

BACKGROUND:

This section will demonstrate the control of a boiler drum level in the presence of the phenomena known as "shrink and swell." The first type of control will be standard level control, cascaded to feedwater flow control. The second type will be three-element drum level control in which the steam outflow rate will be measured and will adjust the feedwater flow controller by feedforward control. The level controller output will be used as feedback trim. See Figure 3.

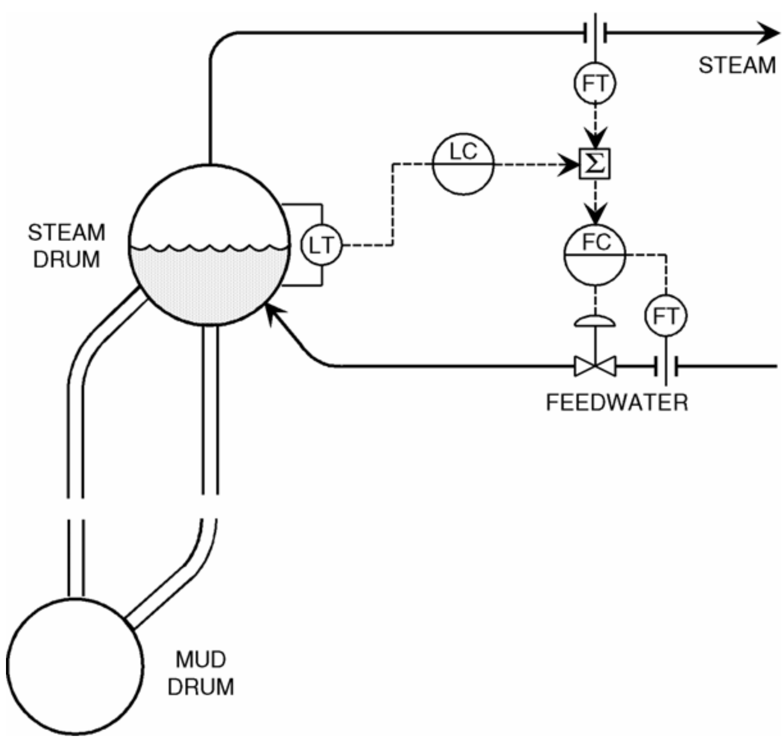

Figure 3
THREE ELEMENT CONTROL
DRUM LEVEL CONTROL

RUNNING THE PROGRAM

Start **Windows.**

Start **PC-ControLAB.**

1. DRUM LEVEL CONTROL

1.1 Control with Normal Cascade

Select **Control | Select Strategy | Feedforward Add**

Select **Model.** Highlight the Level2 process and press **Open**.

Select **Process | Change Parameters**. Set or confirm the following:

Parameter Label	Value
Valve Pos: 0=No; 1=Yes	1.0
Cont Inflo=1; Cont Outflo= -1	1.0

Enter the following tuning values:

Secondary Controller

Gain	0.5
Reset	0.15 minutes/repeat

Primary Controller

Gain	0.65
Reset	2.0 minutes/repeat

Put the Secondary controller in Cascade. Put the Primary controller in Automatic. For the moment, leave Feedforward OFF.

Change the Primary controller set point by 10%. The response should be essentially the same as in Section 3; that is, quarter cycle decay with a period of about 30 minutes. (In an actual application, the drum level response would be much faster than this.) When the loop has come to equilibrium, put the Primary controller in Manual. With the Primary controller selected, press **StepIncr** to simulate an increase in outflow. After the Primary PV has decreased about 15%, press **StepDecr**.

Did the Primary PV (level) immediately begin to decrease when **StepIncr** was pressed? ____________

Pur the Primary controller in Automatic. When the PV comes to equilibrium at the set point, then put the controller back in Manual.

So far we have not added the simulation feature that creates the drum level "shrink and swell" effect. We will add this feature now and repeat the above test

Through the **Process | Change Parameters** table, select the parameter labeled "BLK 57 LEAD TIME." (Be sure NOT to select "BLK 57 LAG TIME.") Change the parameter value from 1.5 to -3.0. Press [OK].

With the Primary controller selected and in Manual, press **StepDecr** to simulate a decrease in outflow. When the Primary PV has increased about 15%, press **StepIncr.**

Did the Primary PV (level) immediately begin to increase when **StepDecr** was pressed? ____________

Did the Primary PV (level) immediately stop increasing when **StepIncr** was pressed? ____________

You should have observed that when ***StepDecr*** *was pressed, the level initially decreased, then began to increase. This is known as drum level "shrink". Also that when* ***StepIncr*** *was pressed, then drum level increased farther before settling to an equilibrium value. This is known as drum level "swell". With straight level-to-flow Cascade control, when the steam flow rate is decreased, due to the "shrink" effect, the Primary (level) controller will initially sense an decrease in level, consequently will increase the set point of the Secondary (feedwater flow) controller. The correct response should have been to decrease the feedwater flow rate.*

Thus, due to the shrink-and-swell phenomena, pure Cascade control for this application will produce poor or unacceptable performance, particularly if the same tuning parameters are maintained.

Adjust the Primary controller SP to match the current PV, then put the Primary controller in Automatic. (Leave Feedforward Off.) Change the set point to 5% above the current PV.

Is the loop behavior acceptable? ___________

If the answer is NO, then we will significantly loosen the Primary controller reset tuning parameter. Enter the following for the Primary:

Gain:	0.65
Reset:	8 minutes/repeat

Is the loop now more stable? ___________

Your answer should be "YES", but you should also observe that the loop is very sluggish, taking an extremely long time to stabilize at set point.

Period of oscillation: ___________

When the loop is at (approximate) equilibrium, press **AutoLoad** to activate automatic, random load changes. Observe the loop for at least 60 (simulated) minutes.

Does the level stay near to the set point? ___________

We will now implement the three element drum level control scheme, using the steam flow measurement as a feedforward signal.

2.2 Three Element Drum Level Control

Select the Primary controller, press **Tune**, then select the **Feedfwd** tab. Enter 1.0 for Feedforward Gain. Leave the other parameters at 0.0. Press **Clear**.

At the Primary controller, put Feedforward control ON (Press **FFWD**.) Observe the loop for at least 60 (simulated) minutes, or longer.

Does the level eventually come to the set point? ____________

Once near the set point, does the level remain near to the set point? ___________