Date: ________________ Name: ___________________________________

# LABORATORY EXERCISE 3a
# VALVE AND POSITIONER RESPONSE

**OBJECTIVE:** To explore the way sticking of a valve stem, due to friction at the packing gland, prevents precise valve positioning, and to demonstrate the effects of adding a valve positioner to overcome the effect of stem friction.

**PREREQUISITE:** Completion of PC-ControLAB tutorial ( under **Help | Tutorial** ) or an equivalent amount of familiarity with the program operation.

**BACKGROUND**: Frequently the process control valve actuator consists of a air-filled chamber closed on one side by a diaphragm which is attached to the valve stem, either directly or through some type of mechanical linkage. The air pressure in the diaphragm is that of the control signal to the valve; this creates a force equal to the pressure times the diaphragm area. Opposing this force is a force due to the compression of a spring; the amount of compression is a function of the valve stem position. Thus, the net force on the stem is the difference between the force due to signal to the valve and the spring compression due to valve position. (There may also be a force due to the pressure drop of the process fluid through the valve.)

Valve sticking (sometimes called “sticktion”) is due to static friction between the stem and packing gland. It determines the net force on the stem (difference between signal to the valve and the actual stem position) required to initiate movement of the stem from a resting condition. Deadband (or hysteresis) is due to dynamic friction between the stem and packing gland. It is the amount of signal reversal required to cause the stem to move in the opposite direction. Collectively, these two phenomena are usually called the "dead band" of the valve.

Thus, friction between the stem and the packing gland manifests itself in two ways:

1) If there is a reversal in the direction of change of the signal to the valve, there will be a deadband, or finite amount of reversal of signal before the valve stem exhibits movement in the opposite direction. Until the signal reversal equals or exceeds this amount, the valve stem remains motionless.

2) If the signal to the valve is changing in a constant direction, and if the valve stem is currently not in motion, the stem will “stick” at that position until there is sufficient unbalance in forces to cause the stem to “slip” to a new position.

If a valve positioner is installed, it provides a local feedback system, comparing actual valve stem position with desired valve position (signal to valve). One of its purposes is to overcome the effect of stem friction. However, the combination of the stem friction and the high gain of a postioner will often cause the stem positioning response to a change in control signal to exhibit a second order underdamped response. This will be a fairly fast response and is of no consequence in relatively slow loops, like temperature or level. In fast loops such as flow, however, the response of the positioner-actuator-stem combination and the response of the flow itself are both relatively fast and may occur at approximately the same frequency. In that case, the interaction between the positioner and the process flow itself may result in undesirable loop behavior. Some authorities recommend the use of an air volume booster, rather than a positioner, for valves in flow control service.

## 1. STARTING THE PROGRAM

Start **Windows**.

Run **PC-ControLAB.**

## 2. PREPARATION

If the Feedback strategy is not already up (check the top line of the display, right hand end), then select **Control | Select Strategy | Feedback**. (We will not actually be using Feedback control. We select this strategy simply because the strip chart provides recording of two process variables, PV-1 and PV-2.)

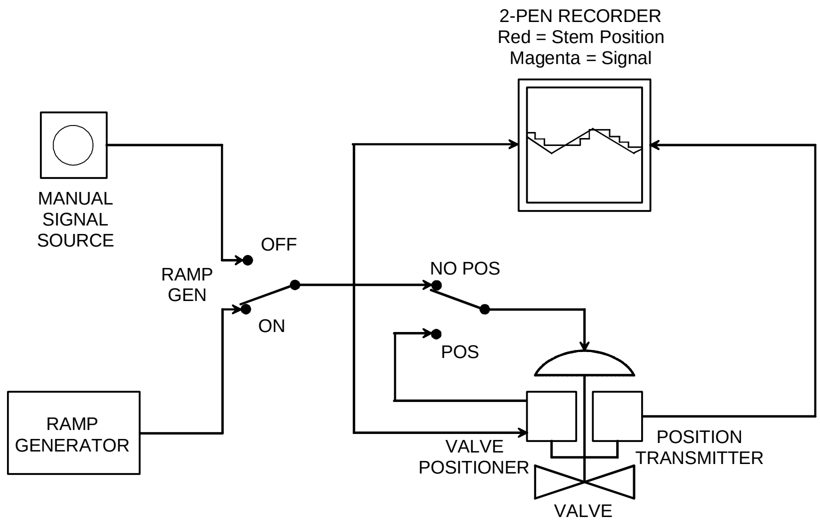
Select **View | Horizontal Grid Scale | Seconds**. (The chart now displays the last 60 seconds of operation rather than the last 60 minutes.)

Select **Process | Select Model**. Choose the VALVE.mdl and press **Open**.

Select **View | Variable Plot Selection**. Select YES for PV-1 and PV-2 and NO for all other variables. Press **Clear**.

## 3. SIMULATED EQUIPMENT

The laboratory equipment model (see the figure) consists of a ramp generator which generates a triangular wave signal to the valve, the valve itself, and finally a recording of the signal to the valve (PV-2, magenta trace) and the actual valve stem (PV, red trace). Two switches permit selection of the modes of operation. One switch selects the signal source to be the ramp (triangular wave) generator or a manually set value. The other signal selects the destination of the signal as the valve positioner or directly to the valve, bypassing the positioner. The feedback controller is not used in this exercise.




**EQUIPMENT DIAGRAM FOR SIMULATED LATORATORY EQUIPMENT**

## 4. EXERCISE

Note from the chart record the triangular wave signal to the valve (PV-2). The actual stem position (PV-1) is lagging the signal to valve, and changes in steps.

Select **Process | Change Parameters**. Note the following:

Ramp Generator, On or Off? __________

Positioner being used, Yes or No __________

Value of Deadband? __________

Value of Slip-stick? __________

Observe the chart record when the signal is approximately in the middle of either an increase or decrease cycle. When the valve stem moves, approximately how much does it move?

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When the signal reverses, about how much does it have to change in order to get the initial stem movement following the reversal?

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If you think some other values of deadband and slip-stick may be more reasonable, change these values. (Select **Process | Change Parameters**. Highlight either Deadband or Stick-slip and enter a new value.) Does the response look reasonable? __________

Select **Process | Change Parameters**. Highlight "0=No Pos; 1=Pos". Enter 1.0.

Does the actual valve stem position now accurately track the signal to valve?

__________

We have been examining the static response of the valve stem to relatively slow changes in signal. We will now make step changes in signal, to see the dynamic response of the valve stem, both with and without a positioner.

If you changed the values for deadband and stick-slip from their original values, reenter:

| | | |
|---|---|---|
| Deadband | = | 5% |
| Stick-slip | = | 2% |

Also, take the positioner OFF the valve ("0=No Pos; 1=Pos". Enter 0.0), and turn the ramp generator off ("Ramp Gen: 0=Off; 1=On". Enter 0.0)

Note that the signal to the valve is now a constant value. Due to stem friction and the absence of a positioner, the actual stem position probably will not match the signal. True or False?

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Without a positioner, the actuator dynamics can be approximately modeled as a first order lag with a fast time constant. The effect of stem friction is still present, however.

In the "Change Parameters" list, select "Manual Signal Source" and enter a value of 70%.

Except for the stick-slip effect, does the valve stem respond approximately as a first order lag?

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What is the (approximate) time constant?
(Remember that the chart width represents 0 - 60 seconds) __________

In the “Change Parameters” list, note the Actuator time constant (minutes) __________

Now put the positioner on the valve. (“0=No Pos; 1=Pos”. Enter 1.0).

With a positioner, a valve positioner-actuator-stem system can act as an underdamped second order system. This is due to the fact that if there is a tendency of the valve to stick at one position, the positioner puts out increasingly higher air pressure until the stem moves. At that time, the air pressure may be too high, so the valve stem will overdrive the requested position, causing the positioner to decrease the air to the actuator. The net effect is a slight oscillating response, characteristic of a second order, underdamped system.

Change the “Manual Signal Source” to 50%. Is the response what is expected (underdamped, second order type of behavior)?

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Approximate period of oscillation (seconds): __________

***WHAT YOU SHOULD HAVE OBSERVED IN THIS EXERCISE:***

*Without a positioner, stem friction can cause valve sticking, limiting the resolution of valve travel and causing an excessive amount of signal reversal to initiate stem movement in the opposite direction. This can be detrimental in any type of feedback loop.*

*With a positioner, the effect of stem friction is largely overcome in the steady state. However, a dynamic effect is produced, approximating that of a relatively high frequency, damped second order system. If the valve is in a slow loop (e.g., temperature), this is probably of no consequence. However, if this is in a fast loop, such as a flow loop, this in itself may have a detrimental effect on loop behavior. The lab entitled Flow Control Loop Characteristics, illustrates this.*