PROCESS CONTROL SYSTEMS

HANDS-ON SKILLS FOR LEARNING ACTIVITY PACKET 7:

LIQUID LEVEL CONTROL

ITEMS NEEDED FOR HANDS-ON SKILLS

Amatrol Supplied

1 T5552 Process Control Learning System
1 T5552-C1-A Single Loop PID Controller

School Supplied

1 Water (10 Gallons or 38 Liters)
1 Compressed Air Supply
1 Needle Nose Pliers

SECOND EDITION, LAP 7, REV. B

Amatrol, Inc., 2400 Centennial Blvd., Jeffersonville, IN 47130 USA, Ph 812-288-8285, FAX 812-283-1584 www.amatrol.com

SKILL 1 CONTROL THE LEVEL IN A TANK USING ON/OFF CONTROL

Procedure Overview

In this procedure, you will use the control relays on the T5552 to control the level in the process tank using on/off control.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Perform the following substeps to set up the T5552, as shown in figure 1-1.

NOTE

The appearance of the electrical outlet will differ based on the electrical power supplied at your location.

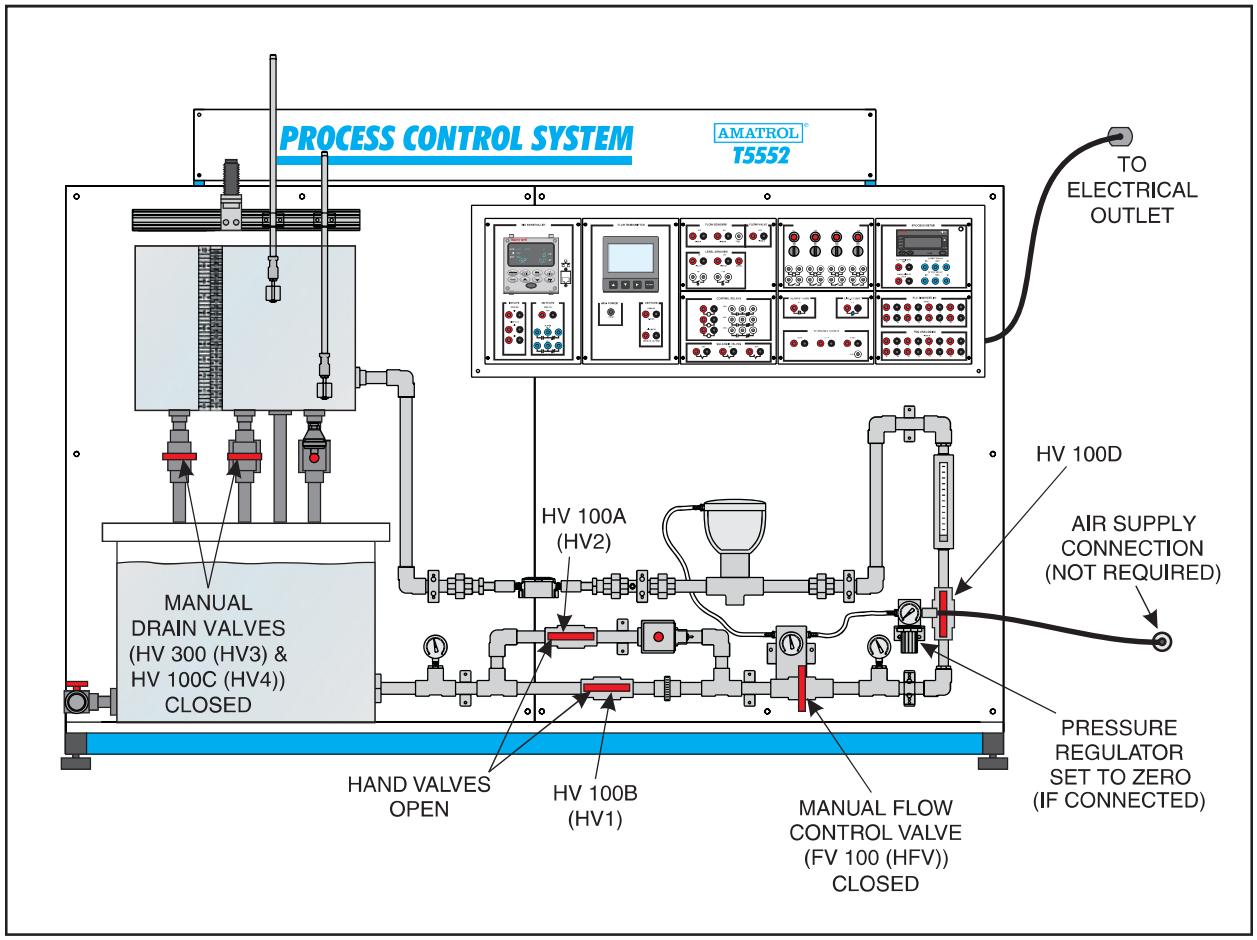

Figure 1-1. T5552 Setup

A. Determine if the air supply line is connected to the T5552.

B. If the air supply line is connected, adjust the pressure to 0 psi. If the air supply line is not connected, do not connect it. You will not need it for this skill.

   The diaphragm actuator proportional valve is an air-to-close type, so zero air pressure will cause it to be fully open.

C. Plug the power cord into an electrical outlet.

D. Fill the reservoir tank with water.

E. Close (fully clockwise) the two process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**.

F. Open (fully counterclockwise) the flow control hand valves HV 100B (HV1) and HV 100A (HV2).

G. Open (fully counterclockwise) the flow control hand valve **HV 100D**.

H. Fully close (fully clockwise) the manual flow control valve, **FV 100 (HFV)**.

❑ 3. Connect the on/off control circuit according to the ladder diagram in figure 1-2. Figure 1-3 shows a pictorial diagram.

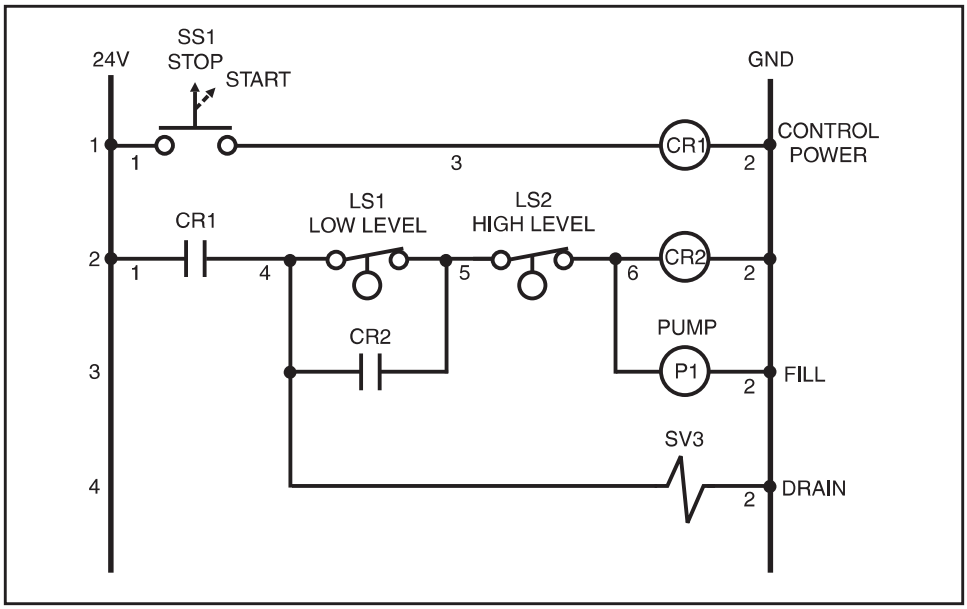

Figure 1-2. On/Off Control Ladder Diagram

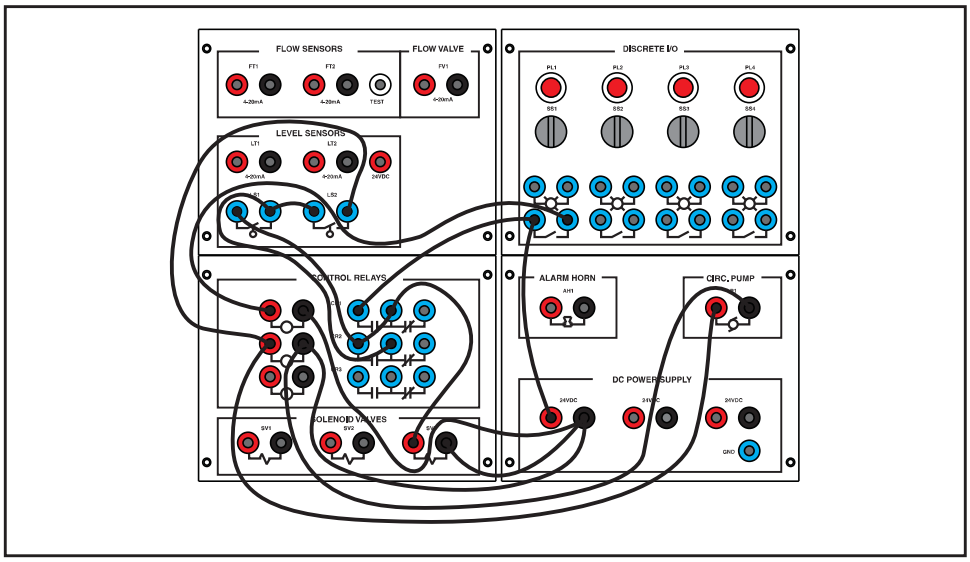

Figure 1-3. On/Off Control Circuit Pictorial

❑ 4. Determine if the float switches are in the normally closed or normally open position.

Figure 1-4. Float Switches in the Process Tank

Amatrol supplies the float switches on the T5552 in the normally open configuration. However, for this circuit, the float switches must be normally closed. You can quickly determine which state the float device is in by looking at it from the top. If you look down on the float device and see writing (e.g. manufacturer's name), as shown in figure 1-5, the float device is in the normally open state.

Figure 1-5. Float Device with Writing Side Up

NOTE

Another method used to quickly check the configuration of a level switch is to place an ohmmeter across the contacts. The meter will read a small resistance if the switch is normally closed and an infinite resistance if it is normally open.

❑ 5. Perform the following substeps to change the float switches on the T5552 from normally open to normally closed if they are normally open. If they are already in the normally closed state, skip to step 6.

A. Locate and remove the retaining clip by pulling it off, as shown in figure 1-6, with needle nose pliers.

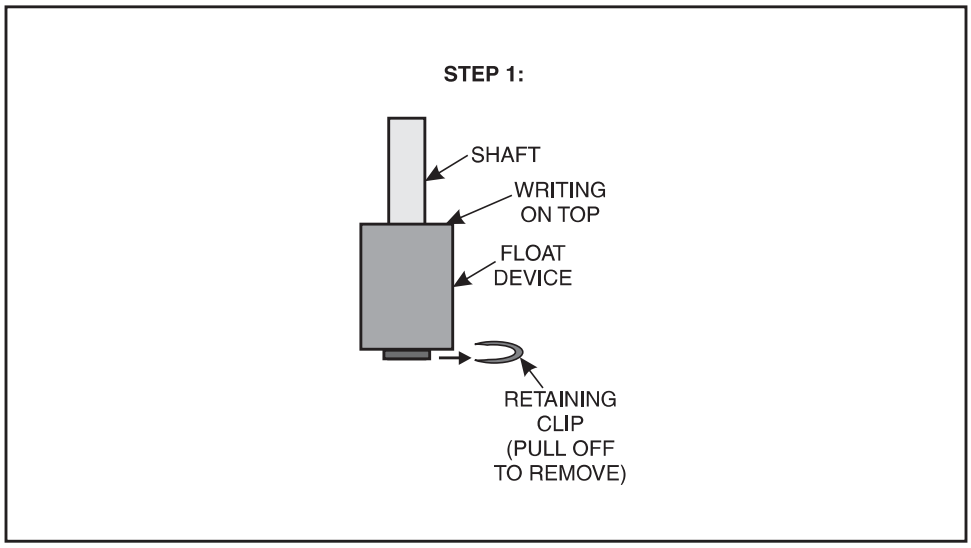

Figure 1-6. Location of Retaining Clip

B. Slide the float device off the shaft, as shown in figure 1-7.

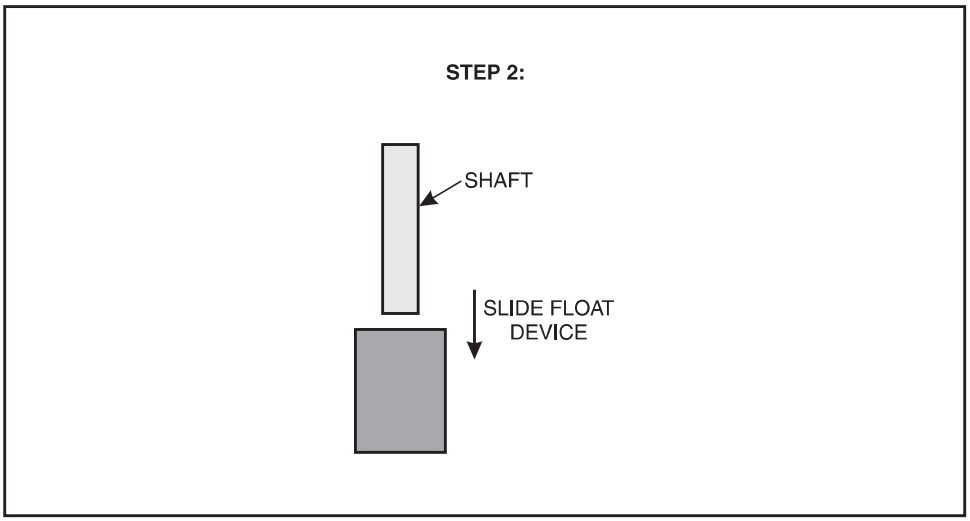

Figure 1-7. Remove Float Device

C. Rotate the float device 180° (end over end), as shown in figure 1-8.

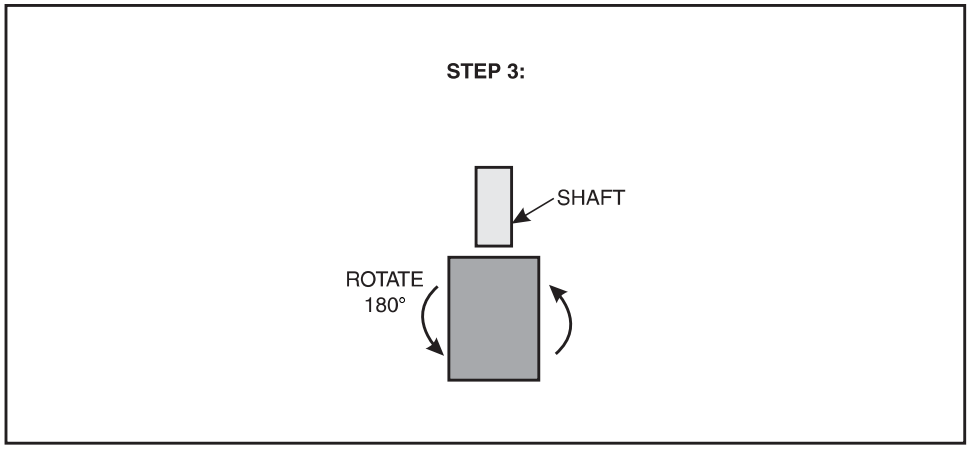

Figure 1-8. Rotate Float Device

D. Slide the float device back on the shaft and replace the retaining clip, as shown in figure 1-9.

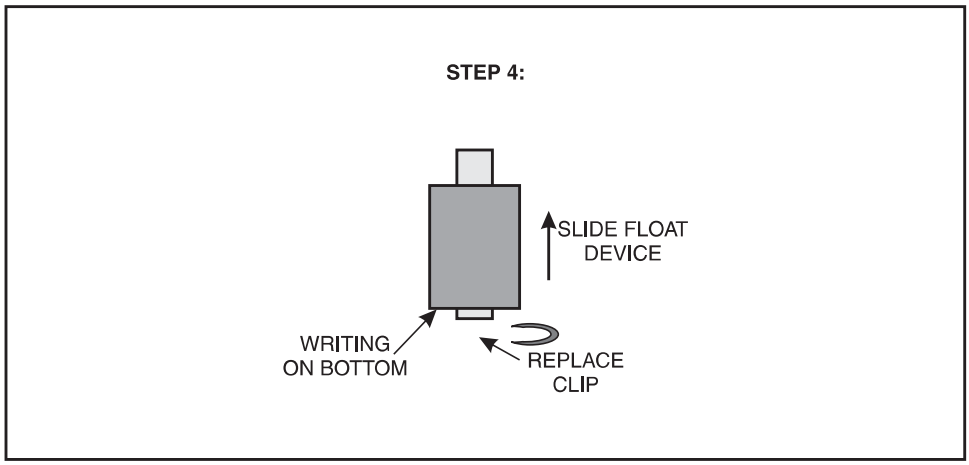

Figure 1-9. Replace Float Device and Retaining Clip

❑ 6. Perform the following substeps to set the float switches at the desired lower and upper levels.

The float switch shafts, shown in figure 1-10, are mounted so you can slide the shafts up and down by loosening the adjustment screws.

A. Loosen LSH 200A's (LS1's) adjustment screw by turning it counterclockwise one or two turns so that the shaft can be moved up or down.

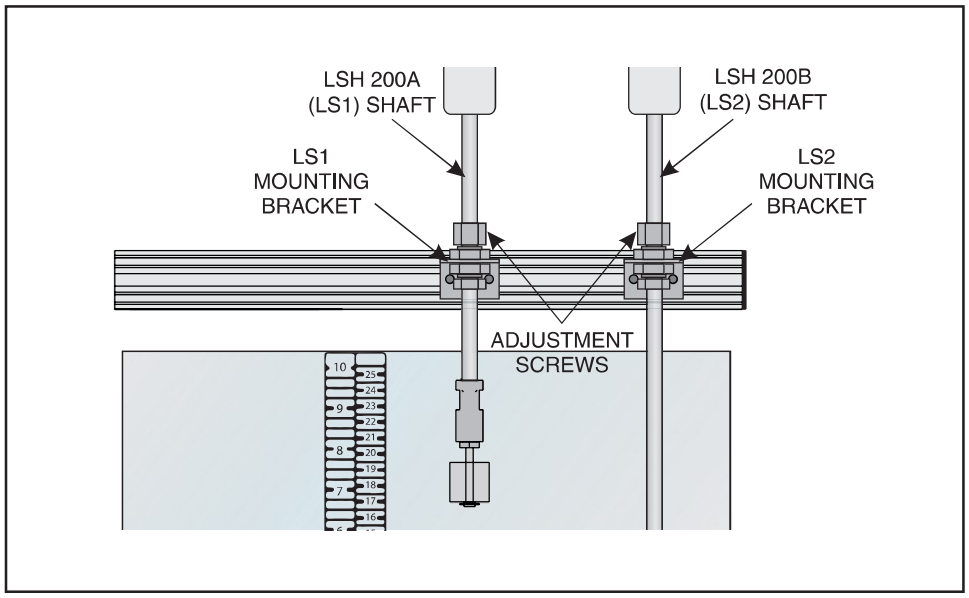

Figure 1-10. Float Switch Mounting Brackets

B. Move LSH 200A's (LS1's) shaft so that the bottom of the switch is even with the 1-inch (2.5-cm) mark, as shown in figure 1-11. Then tighten the adjustment screw to lock it in position. This is the lower level.

Figure 1-11. Level Switch at 1-Inch (2.5-cm) Mark

C. Reposition LSH 200B (LS2) to the 2-inch (5-cm) level using the same procedure as substeps A and B.

This is the high level.

Setting the low level switch to 1-inch (2.5-cm) and the high level switch to 2-inches (5-cm) creates a dead band of 1 inch (2.5 cm).

❑ 7. Remove the lockout/tagout.

❑ 8. Perform the following substeps to operate the circuit.

A. Open (fully counterclockwise) the manual flow control valve, **FV 100 (HFV)**.

B. Make sure that **SS1** is in the **OFF** (up) position.

C. Turn on the main circuit breaker.

D. Place **SS1** in the **ON** position and observe the operation of the circuit.

NOTE

All solenoid valves on the T5552 are normally closed. Therefore, they remain closed until their solenoid coil is energized. When the solenoid coil is energized, the valve opens.

E. Allow the process to go through a complete cycle (i.e. water level rises from the low level limit to the high level limit and drops back to the low limit) and record how long it takes to complete the cycle.

Time to complete cycle: _____ (seconds)

F. Remove control power by placing **SS1** in the **OFF** position.

G. Open (fully counterclockwise) the process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**, until the water is below the low-level switch LSH 200A (LS1). Then, close (fully clockwise) the manual drain valves.

❑ 9. Perform the following substeps to operate the circuit and observe the effects of widening the dead band.

A. Slide the high-level float switch LSH 200B (LS2) up to the 4-inch (10.0-cm) level.

This will effectively triple the dead band (from 1 inch to 3 inches or 2.5 cm to 7.5 cm).

B. Place **SS1** in the **ON** position and observe the operation of the circuit.

C. Allow the process to go through another cycle and record how long it takes to complete the cycle.

Time to complete cycle: _____ (seconds)

D. Determine if the circuit cycles more or less frequently than in step 8?

Cycle Frequency _____ (higher/lower)

You should find that the circuit cycles less frequently. This is due to the increased dead band.

E. Remove control power by placing **SS1** in the **OFF** position.

❑ 10. Perform the following substeps to shut down the T5552.

A. Open (fully counterclockwise) both of the manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**, on the process tank to completely drain the tank. When the tank is empty, close (fully clockwise) both valves.

B. Turn off the main circuit breaker.

C. Disconnect the control circuit.

SKILL 2 DESIGN AN ON/OFF LEVEL CONTROL SYSTEM

Procedure Overview

In this procedure, you will design an On/Off level control system. The purpose of this system is to maintain the liquid level between two points.

❑ 1. Review the following design parameters. These parameters contain the information you need to design the circuit.

- Selector switch SS2 will be used to simulate a pushbutton that energizes the circuit.
- Selector switch SS1 will be used to simulate a "stop" pushbutton.
- Use a high-level float switch set at 7 inches (18 cm).
- Use a low-level float switch set at 2 inches (5 cm).
- The pump will be controlled by one control relay contact.
- The solenoid drain valve will be controlled by a second control relay contact.
- The pump should start when selector switch SS2 is turned on and should continue to run when the switch is turned off (simulated start pushbutton).
- The pump should continue to run and fill the tank until the high-level float switch is reached. At this point, the pump should stop and the solenoid valve should open and begin draining the tank.
- The tank should drain until the low-level float switch is reached. At this point, the solenoid valve should close and the pump should turn on and begin filling the tank.
- Both float switches will be NC switches.

NOTE

This circuit will require the use of a third relay to provide the seal-in contact for the start switch (SS2).

❑ 2. Design your circuit on a sheet of paper.

❑ 3. Ask your instructor to verify your circuit and give you permission to connect the circuit.

❑ 4. Perform a lockout/tagout.

❑ 5. Perform the following substeps to set up the T5552.

A. Fill the reservoir tank with water.

B. Close (fully clockwise) the two process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**.

C. Open (fully counterclockwise) the manual flow control valve, **FV 100 (HFV)**.

D. Place selector switch **SS2** in the **OFF** position.

E. Place selector switch **SS1** in the **ON** position.

❑ 6. After receiving permission, connect your circuit.

❑ 7. Notify your instructor that you are ready to operate the circuit.

Your instructor must check and approve your setup before you can continue.

❑ 8. Remove the tagout tag and lockout device.

❑ 9. Turn on the main circuit breaker.

❑ 10. Turn selector switch **SS2** on and then off immediately to simulate the pressing of a start pushbutton.

The pump should start and begin to fill the process tank with water. The solenoid drain valve SV 100C (SV3) should be closed. The tank should continue to fill past the low level switch. When the level reaches the high-level float switch LSH 200B (LS2) (7-inch or 18-cm mark), the pump should stop and the solenoid drain valve should open and begin to drain the tank.

When the level reaches the low-level float switch LSH 200A (LS1) (2-inch or 5-cm mark), the solenoid drain valve SV 100C (SV3) should close, and the pump should restart and begin filling the tank. The circuit should continue to cycle in this manner until selector switch **SS1** is turned off (stop button pressed).

❑ 11. Perform the following substeps to shut down the T5552.

A. Turn off selector switch **SS1** to stop the circuit.

B. Close (fully clockwise) the manual flow control valve, **FV 100 (HFV)**.

C. Open (fully counterclockwise) both manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**, to drain the process tank. When the tank is completely drained, close (fully clockwise) the valves.

D. Turn off the main circuit breaker.

E. Disconnect the circuit.

SKILL 3 PROGRAM A HONEYWELL UDI 1700 PROCESS METER'S DISCRETE OUTPUTS AS ALARMS

Procedure Overview

In this procedure, you will connect and operate a circuit to measure the level in a process tank. You will also program a process meter to use its relay contacts as high and low level alarms.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Perform the following substeps to set up the T5552, as shown in figure 3-1.

NOTE

The appearance of the electrical outlet will differ based on the electrical power supplied at your location.

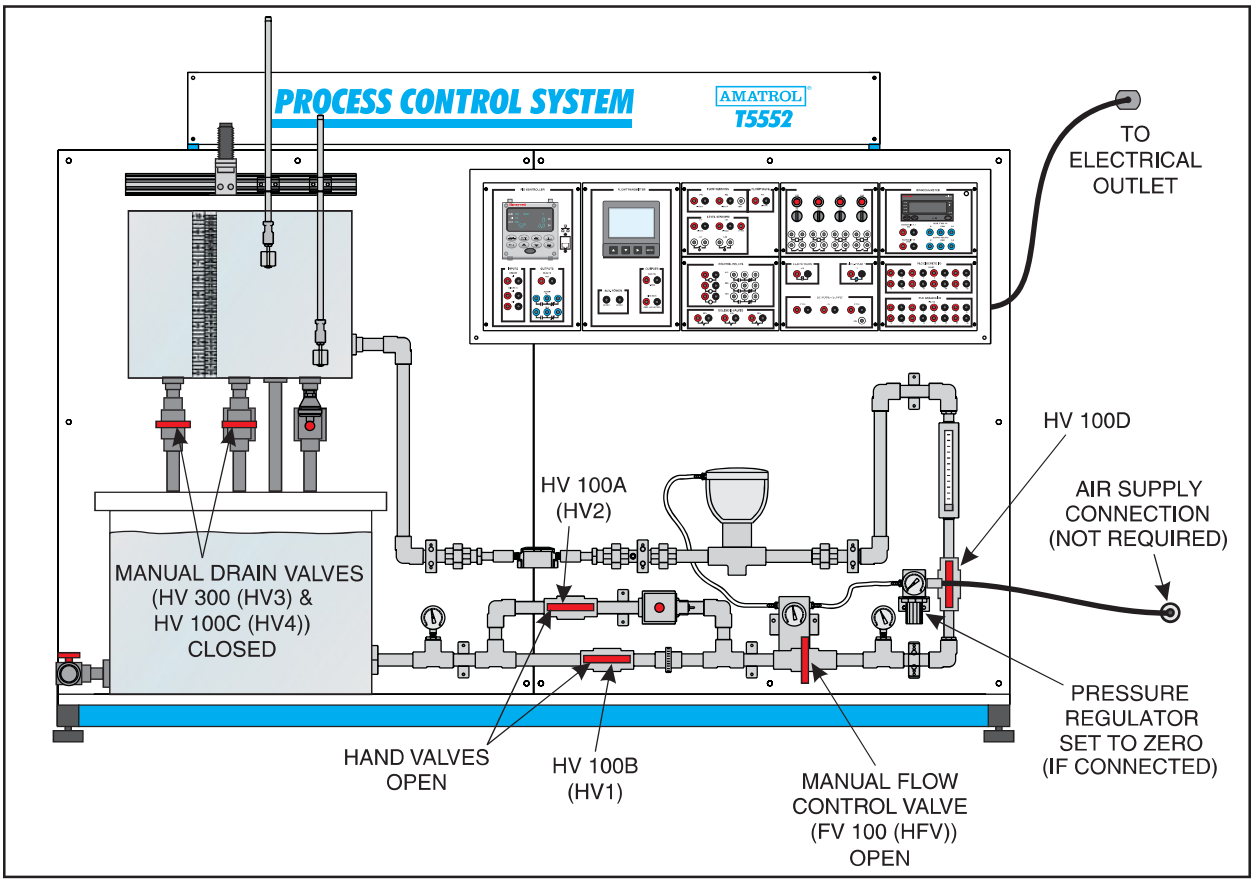

Figure 3-1. T5552 Setup

A. Determine if the air supply line is connected to the T5552.

B. If the air supply line is connected, adjust the pressure to 0 psi. If the air supply line is not connected, do not connect it. You will not need it for this skill.

   The diaphragm actuator proportional valve is an air-to-close type, so zero air pressure will cause it to be fully open.

C. Fill the reservoir tank with water.

D. Close (fully clockwise) the two process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**.

E. Open (fully counterclockwise) the manual flow control valve, **FV 100 (HFV)**.

F. Open (fully counterclockwise) the flow control hand valves, **HV 100B (HV1)** and **HV 100A (HV2)**.

G. Open (fully counterclockwise) the flow control hand valve **HV 100D**.

H. Connect the circuit shown in figure 3-2.

   This circuit allows you to determine the level of water in the process tank using the process meter and indicates high and low level alarm conditions using indicator lamps.

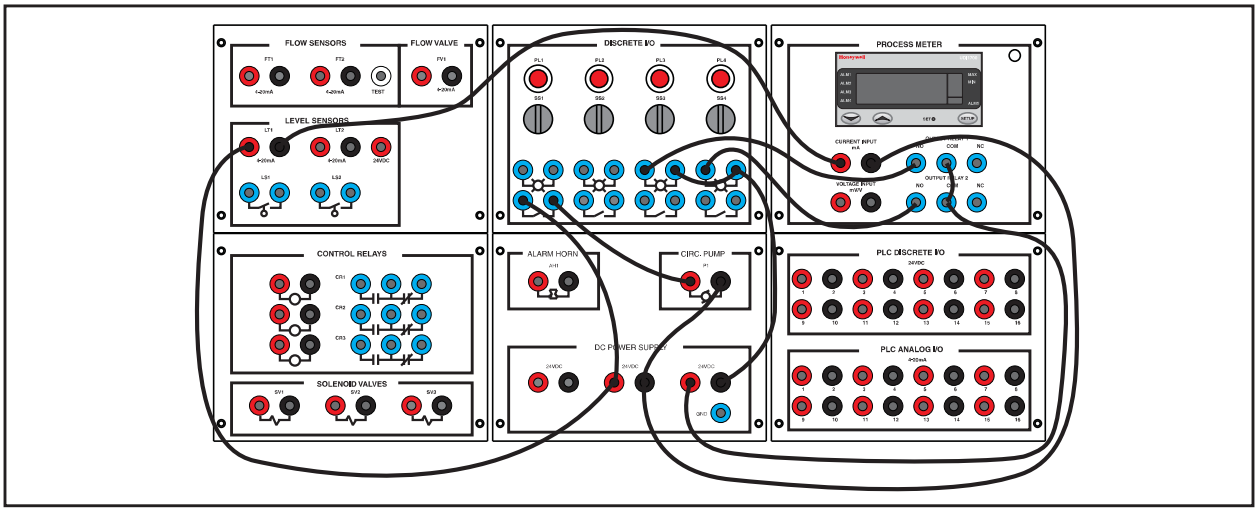

Figure 3-2. Level Circuit using Process Meter Alarm Relays

Figure 3-3 shows the wiring diagram for the level circuit.

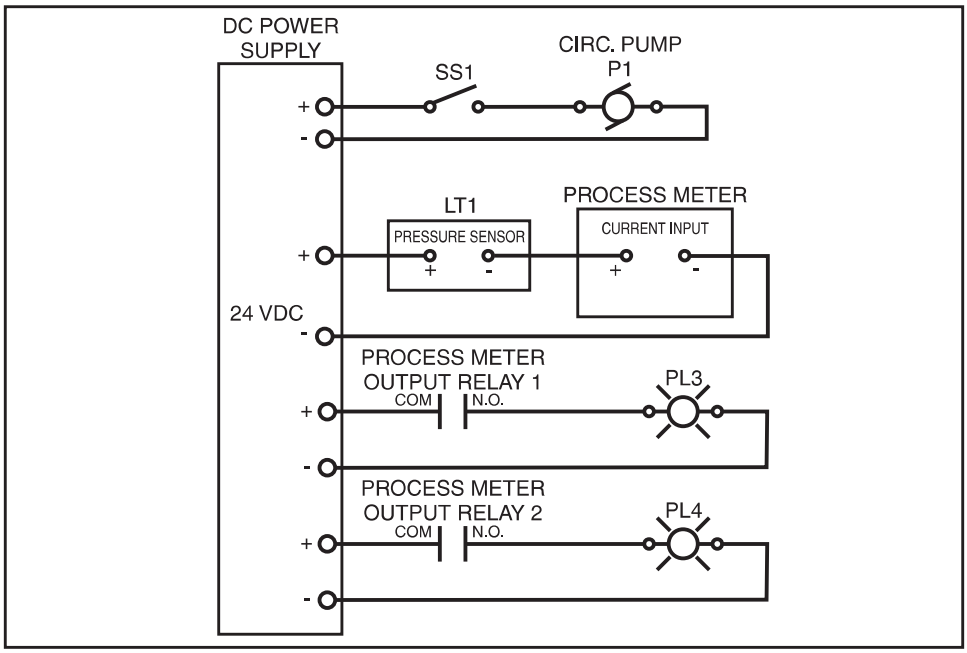

Figure 3-3. Wiring Diagram for the Level Circuit Using Process Meter Alarm Relays

- ❑ 3. Remove lockout/tagout.
- ❑ 4. Make sure selector switch **SS1** is in the **OFF** (up) position.
- ❑ 5. Perform the following substeps to enter the Configuration Menu on the Honeywell UDI 1700 process meter.

  A. Turn on the main circuit breaker.

  B. Press and hold the **SETUP** key and then press the up ▲ arrow key.

     This places the meter in the Select Mode.

  C. Use the up ▲ and down ▼ arrow keys to scroll to the Configuration Menu (ConF).

     The Configuration Menu is locked and requires the unlock code.

  D. Use the up ▲ and down ▼ arrow keys to set the value to **20** and press the **SETUP** key to enter the unlock code.

     The first parameter in the Configuration Menu (inPt) should appear.

❑ 6. Perform the following substeps to verify the Input Type (inPt) and Scale Range Limits (ruL and rLL).

A. If necessary, use the up ▲ and down ▼ arrows to change the input type parameter.

The parameters should be set to **"4_20"** for 4-20 mA.

If you change the parameter setting, press the SETUP key to bring up the Yes prompt and press the up ▲ arrow key to accept the new value.

B. Scroll to the next parameter, Scale Range Upper Limit (ruL).

C. If necessary, use the up ▲ and down ▼ arrows to change the parameter.

The parameter should be set to **27.7** (for inches) or **70.4** (for cm)..

If you change the parameter setting, press the SETUP key to bring up the Yes prompt and press the up ▲ arrow key to accept the new value.

D. Scroll to the next parameter, Scale Range Lower Limit (rLL).

E. If necessary, use the up ▲ and down ▼ arrows to change the parameter.

The parameter should be set to **0.0**.

If you change the parameter setting, press the SETUP key to bring up the Yes prompt and press the up ▲ arrow key to accept the new value.

❑ 7. Perform the following substeps to set the Alarm 1 parameters. These parameters are located in the Configuration Menu.

A. Scroll to the Alarm 1 Type parameter (ALA1).

B. Use the up ▲ and down ▼ arrow keys to set the parameter to **P_Lo**.

This sets Alarm 1 as a Process Low Alarm.

C. Press the **SETUP** key to bring up the Yes prompt.

D. Press the up ▲ arrow key to accept the setting.

E. Scroll to the next parameter (PLA1).

This is the Process Low Alarm 1 parameter.

F. Use the up ▲ and down ▼ arrow keys to set the value to **2.0** (for inches) or **5.0** (for cm).

This sets the low alarm value as 2.0 inches or 5 cm.

G. Press the **SETUP** key to bring up the Yes prompt and then press the up ▲ arrow key to accept the setting.

H. Scroll to the next parameter (AHY1).

This is the Hysteresis setting for alarm 1.

I. Use the up ▲ and down ▼ arrow keys to set the value to **0.1** (for inches) or **0.3** (for cm).

This sets the hysteresis to 0.1 inch or 0.3 cm.

J. Press the **SETUP** key to bring up the Yes prompt and then press the up ▲ arrow key to accept the setting.

❑ 8. Perform the following substeps to set the Alarm 2 parameters.

A. Scroll to the Alarm 2 Type parameter (ALA2).

B. Use the up ▲ and down ▼ arrow keys to set the parameter to **P_Hi**.

This sets Alarm 2 as a Process High Alarm.

C. Press the **SETUP** key to bring up the Yes prompt.

D. Press the up ▲ arrow key to accept the setting.

E. Scroll to the next parameter (PhA2).

This is the Process High Alarm 2 parameter.

F. Use the up ▲ and down ▼ arrow keys to set the value to **8.0** (for inches) or **20.0** (for cm).

This sets the alarm value as 8.0 inches or 20.0 cm.

G. Press the **SETUP** key to bring up the Yes prompt and then press the up ▲ arrow key to accept the setting.

H. Scroll to the next parameter (AHY2).

This is the Hysteresis setting for Alarm 2.

I. Use the up ▲ and down ▼ arrow keys to set the value to **0.1** (for inches) or **0.3** (for cm).

This set the hysteresis to 0.1 inch or 0.3 cm.

J. Press the **SETUP** key to bring up the Yes prompt and then press the ▲ arrow key to accept the setting.

❑ 9. Perform the following substeps to set the Output Usage parameter for the Alarms.

These parameters are also located in the Configuration Menu.

A. Scroll to the Output 1 Usage parameter (USE 1).

This parameter sets the relay action for alarm 1.

B. Use the up ▲ and down ▼ arrow keys to set the parameter to **A1nd**.

This sets Alarm Relay 1 as direct acting, non-latching. That means that when the process variable value is below the low alarm value (2.0 inches or 5.0 cm), the NO contact of Alarm Relay 1 is closed and the NC contact is open. Since non-latching is also selected, the contacts will return to their normal states when the process variable exceeds 2.0 inches or 5.0 cm.

C. Press the **SETUP** key to bring up the Yes prompt and then press the up ▲ arrow key to accept the setting.

D. Repeat substeps A-C to set the Output Usage 2 parameter (USE 2) to **A2nd**.

❑ 10. Perform the following substeps to exit the Configuration Menu and the Select Mode.

A. Press and hold the **SETUP** key and then press the up ▲ arrow key.

This exits the Configuration Menu and returns to the Select Mode.

B. Use the up ▲ and down ▼ arrow keys to scroll until "OPtr" appears on the display.

C. Press the **SETUP** key to exit the Select Mode and return the meter to the normal operating mode.

❑ 11. Perform the following substeps to set the Process Variable Offset parameter (OFFS).

The Process Variable Offset Parameter is located in the Set Up Menu. Since the level sensor is mounted beneath the process tank, the offset value is used to make the process variable value read 0.0 when the level is at the zero inch (zero centimeter) mark on the tank.

A. Press and hold the **SETUP** key and then press the up ▲ arrow key to enter the Select Mode.

B. Use the up ▲ and down ▼ arrow keys to scroll to the Set Up Menu (SEtP).

The Set Up Menu is locked and requires the unlock code.

C. Use the up ▲ and down ▼ arrow keys to set the value to **10** (for inches) or **25.4** (for cm) and press the **SETUP** key to enter the unlock code.

The first parameter in the Set Up Menu is the Input Filter Time Constant (FILt) parameter.

D. Scroll to the Process Variable Offset (OFFS) parameter.

E. Use the up ▲ and down ▼ keys to change the value to **-4.1** (for inches) or **-10.4** (for cm).

The sensing element for the level sensor is located approximately 4.1 inches (10.4' cm) below the zero-inch (zero-centimeter) mark in the tank. A setting of -4.1 (or -10.4) offsets the zero reading so that the meter displays 0.0 when the water is at the zero-inch (zero-centimeter) mark on the tank.

F. Press the **Setup** key to accept the value.

G. Press and hold the **Setup** key and press the up ▲ arrow key to exit the Set Up Menu.

Control elements are wired to a Honeywell process meter's relay terminals in the same manner as alarm elements. The external power supply is required to power the solenoid.

Figure 3-4 shows a liquid level control process with a solenoid valve wired to the normally open contacts of output relay 1 on a Honeywell process meter. A pressure-type level sensor is wired to the input terminals of the process meter, as figure 3-4 also shows. In this configuration, the process meter receives an analog input and provides a discrete (on/off type) output. The advantage of this type of on/off control system is that the high and low levels are programmable and therefore do not require switches to be changed.

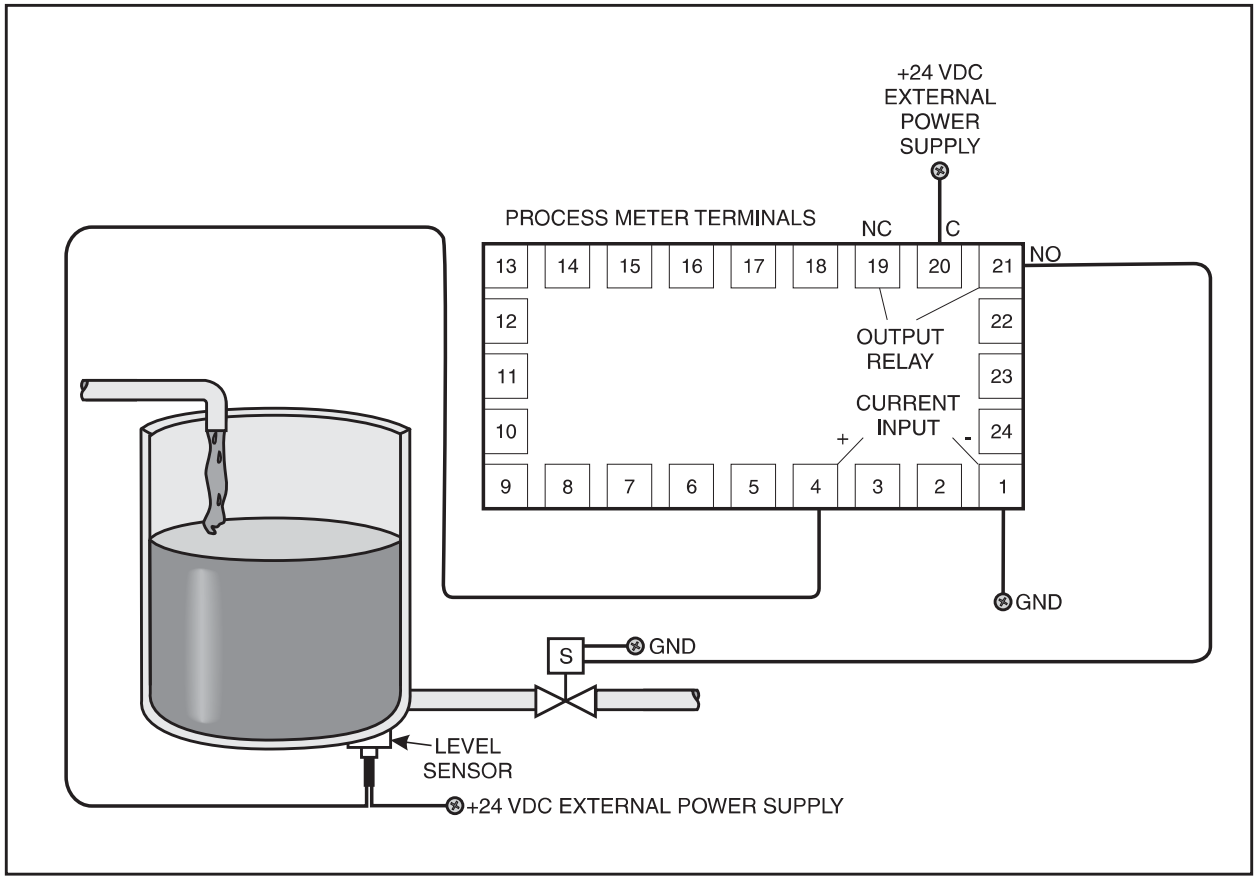

Figure 3-4. Relay on a Process Meter Wired to a Solenoid Valve for On/Off Control

SKILL 4 — PROGRAM A HONEYWELL UDI 1700 PROCESS METER'S DISCRETE OUTPUTS TO PERFORM ON/OFF CONTROL

Procedure Overview

In this procedure, you will connect and operate a circuit to measure the level in a process tank. You will also program a Honeywell UDI 1700 process meter to use its relay contacts for on/off control.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Perform the following substeps to set up the T5552, as shown in figure 4-1.

NOTE

The appearance of the electrical outlet will differ based on the electrical power supplied at your location.

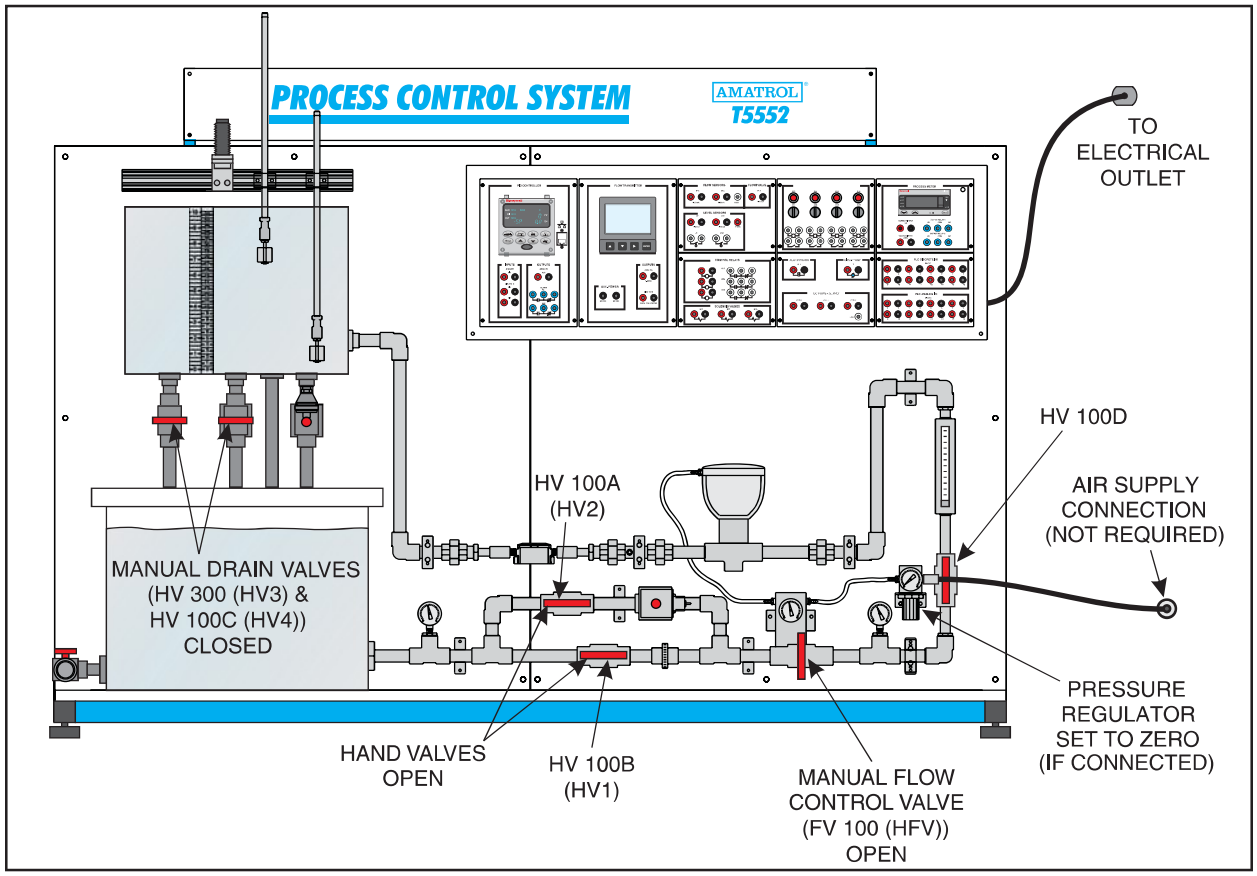

Figure 4-1. T5552 Setup

A. Determine if the air supply line is connected to the T5552.

B. If the air supply line is connected, adjust the pressure to 0 psi. If the air supply line is not connected, do not connect it. You will not need it for this skill.

   The diaphragm actuator proportional valve is an air-to-close type, so zero air pressure will cause it to be fully open.

C. Fill the reservoir tank with water.

D. Close (fully clockwise) the two process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**.

E. Open (fully counterclockwise) the manual flow control valve, **FV 100 (HFV)**.

F. Open (fully counterclockwise) the flow control hand valves, **HV 100B (HV1)** and **HV 100A (HV2)**.

G. Open (fully counterclockwise) the flow control hand valve **HV 100D**.

H. Connect the circuit shown in figure 4-2.

   This circuit allows you to determine the level of water in the process tank using the process meter and control the level in the tank using on/off control.

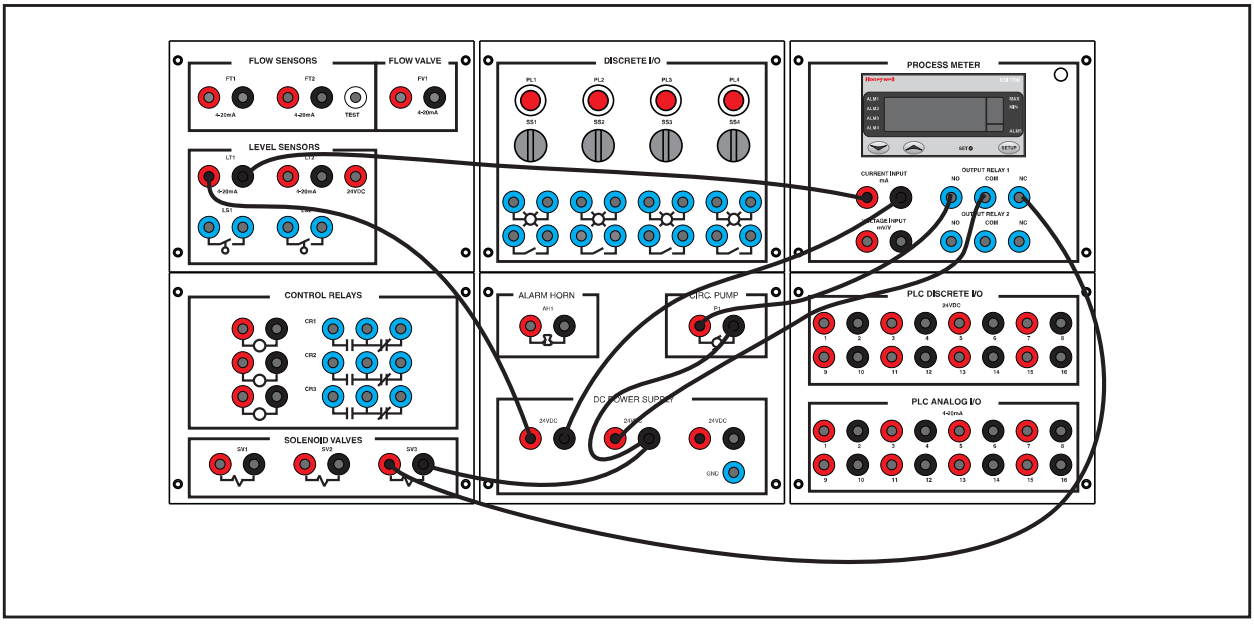

Figure 4-2. Circuit for On/Off Level Control Using a Low Level Alarm

Figure 4-3 shows the wiring diagram for the level circuit.

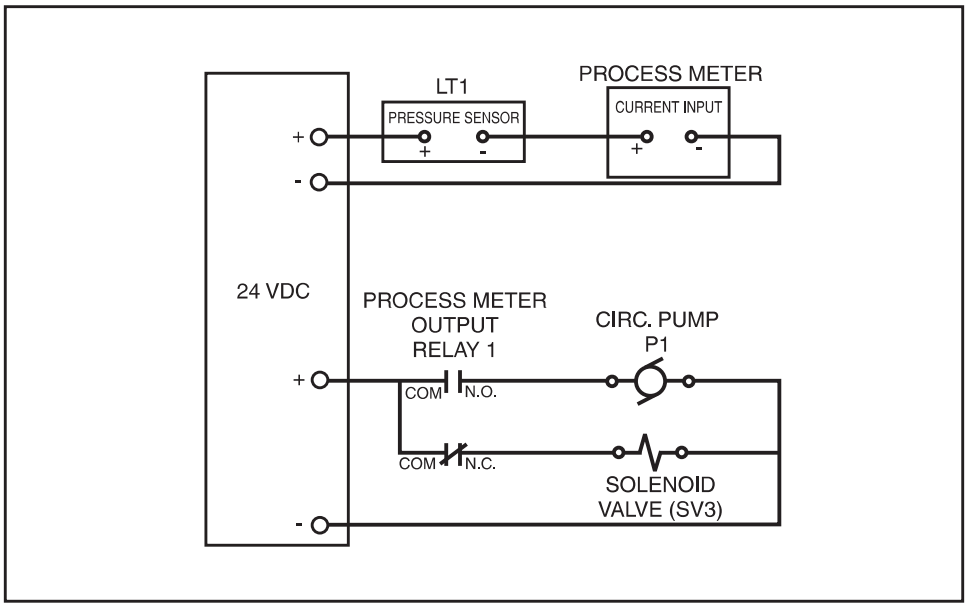

Figure 4-3. Wiring Diagram for the Level Circuit Using Process Meter Alarm Relays

Figure 4-4 shows the P&ID for the T5552. The active components and wiring are highlighted.

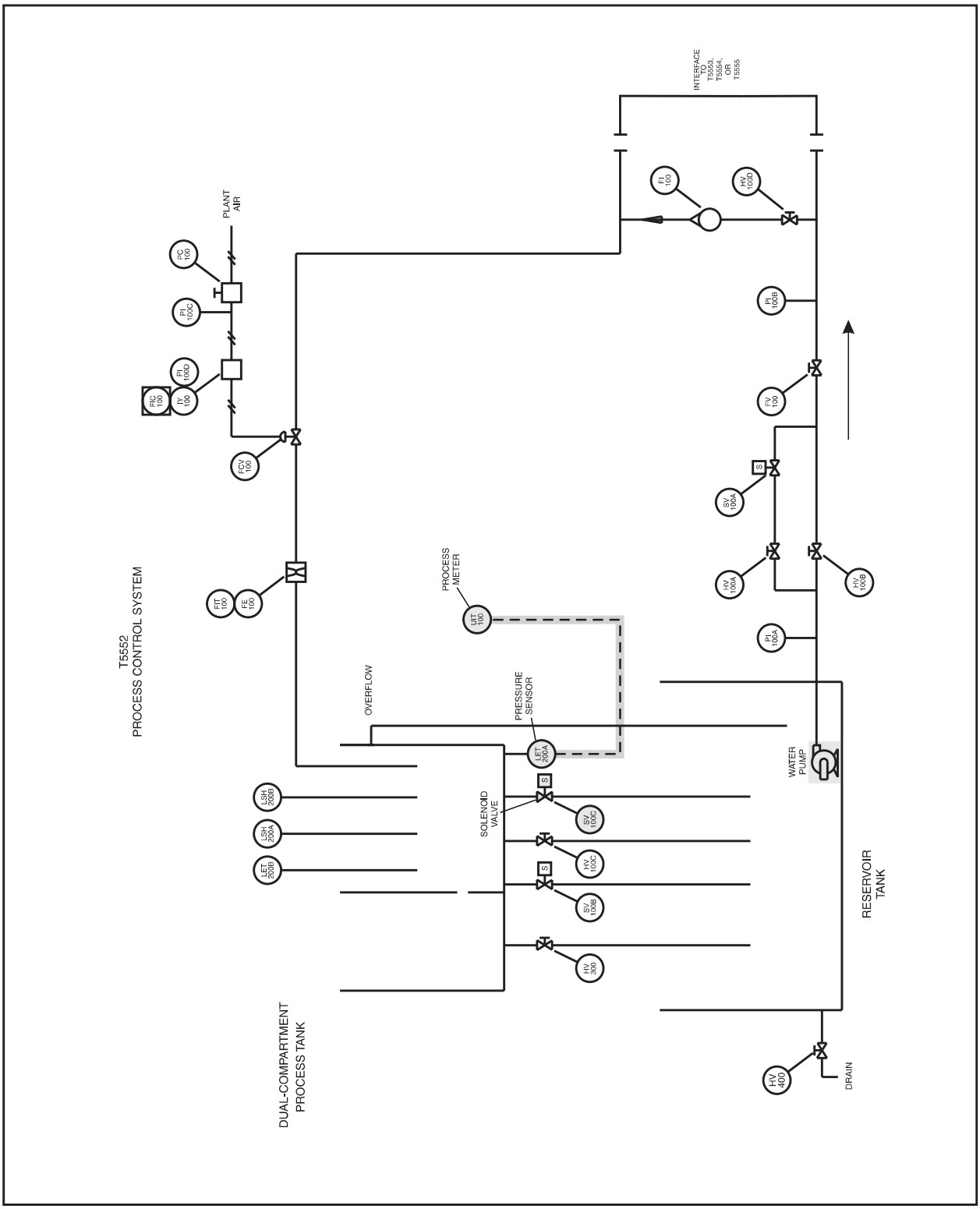

Figure 4-4. T5552 P&ID

❑ 3. Remove lockout/tagout.

❑ 4. Program the process meter according to the parameter values listed in the table in figure 4-5. Notice that it shows that you will turn off alarms 2-5 because you will not use them in this skill.

Also notice that the Output Usage (USE 1) setting is set for Alarm 1, reverse, non-latching. That makes the NO contact energized as long as there is no alarm condition and the NC contact is not energized. When an alarm condition is present, the NO contact is not energized and the NC contact is energized.

With the PhA1 parameter set to 6.0, and the AHY1 parameter set to 2.0, the process meter maintains the level between 6.0 and 4.0 inches. With the PhA1 parameter set to 15.0, and the AHY1 parameter set to 5.0, the process meter maintains the level between 15.0 and 5.0 cm.

MENU GROUP	PARAMETER	VALUE
ConF	inPt	4_20
	ruL	27.7 (for inches) or 70.4 (for cm)
	rLL	0.0
	ALA1	P_Hi
	Pha1	6.0 (for inches) or 15.0 (for cm)
	AHY1	2.0 (for inches) or 5.0 (for cm)
	ALA2-ALA5	nonE
	USE1	A1nr
SEtP	OFFS	-4.1 (for inches) or -10.4 (for cm)

Figure 4-5. Honeywell UDI 1700 Process Meter Parameter Settings for On/Off Control

The process variable's value on the display should indicate the water level in the tank. If there is a difference between the indicated value and the actual level, adjust the Process Variable Offset (OFFS) parameter until the indicated value matches the actual level.

❑ 5. Turn on the main circuit breaker.

❑ 6. Perform the following substeps to control the level in the process tank using on/off control.

A. Determine the state of the process pump and the solenoid drain valve SV 100C (SV3).

Process Pump _____(On/Off)

Solenoid Valve _____ (Energized/De-energized)

You should find that the process pump is on and the solenoid drain valve is de-energized. The process pump is connected to the normally open relay contact, and the relay is programmed reverse, non-latching. Therefore, the pump is running because the level is below the high level limit (6.0 inches or 15.0 cm). Also, because the process variable (PV) is below the high level limit, the normally closed relay contact that is wired to the solenoid drain valve is open. Therefore, the solenoid drain valve is de-energized (closed). You should notice that the process tank is filling.

B. Allow the tank to continue to fill and determine the level at which the solenoid drain valve SV 100C (SV3) becomes energized (opens). You can determine this by listening for a "click."

Level _____ (inches or cm)

You should find that the solenoid drain valve opens and begins to drain the process tank when the level reaches 6.0 inches or 15.0 cm, which is the high alarm value.

C. Determine the state of the process pump.

Process Pump _____(On/Off)

You should find that the process pump is off. After the level reaches the upper limit, an alarm condition exists. Therefore, the relay contacts return to their normal state (normally open for the contact wired to the process pump). You should notice that the process tank is draining because the solenoid drain valve is open.

D. Determine the state of the process pump and the process tank solenoid drain valve SV 100C (SV3) when the level drops to 4.0 inches or 10.0 cm.

Process Pump _____(On/Off)

Solenoid Valve _____ (Energized/De-energized)

You should find that the process pump turns on and the solenoid drain valve de-energizes. This allows the tank to begin to fill again.

E. Allow the cycle to repeat so that you understand the process.

F. Open (fully counterclockwise) the process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**, to drain the process tank. When the process tank is empty, close (fully clockwise) the valves.

❑ 7. Perform the following substeps to shut down the T5552.

A. Turn off the main circuit breaker.

B. Disconnect the circuit.

SKILL 5 — CONFIGURE AND OPERATE A HONEYWELL UDC 3500 CONTROLLER BASED CLOSED LOOP LIQUID LEVEL SYSTEM

Procedure Overview

In this procedure, you will set up and operate a basic closed loop control system to control the level of a liquid in a process tank. You will first configure the controller then operate the closed loop system.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Perform the following substeps to set up the T5552, as shown in figure 5-1.

NOTE

The appearance of the electrical outlet will differ based on the electrical power supplied at your location.

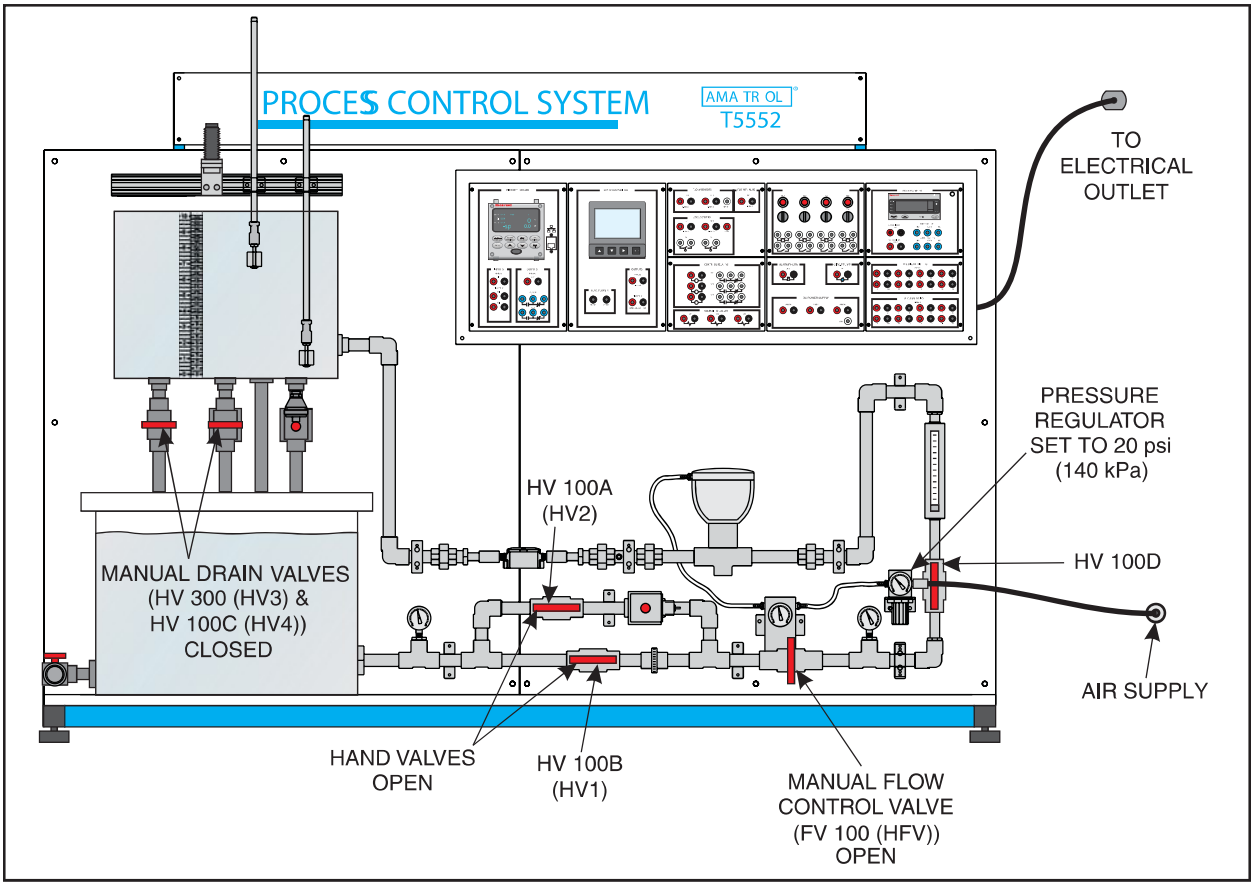

Figure 5-1. T5552 Setup for Closed Loop Level Control

A. Connect the air supply line to the T5552.

B. Set the pressure regulator to 20 psi (140 kPa).

C. Fill the reservoir with water.

D. Close (fully clockwise) the two process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**.

E. Open (fully counterclockwise) the manual flow control valve, **FV 100 (HFV)**.

F. Open (fully counterclockwise) the flow control hand valves, **HV 100B (HV1)** and **HV 100A (HV2)**.

G. Open (fully counterclockwise) the flow control hand valve **HV 100D.**

H. Connect the circuit shown in figure 5-2.

This circuit allows you to operate a closed loop level control system.

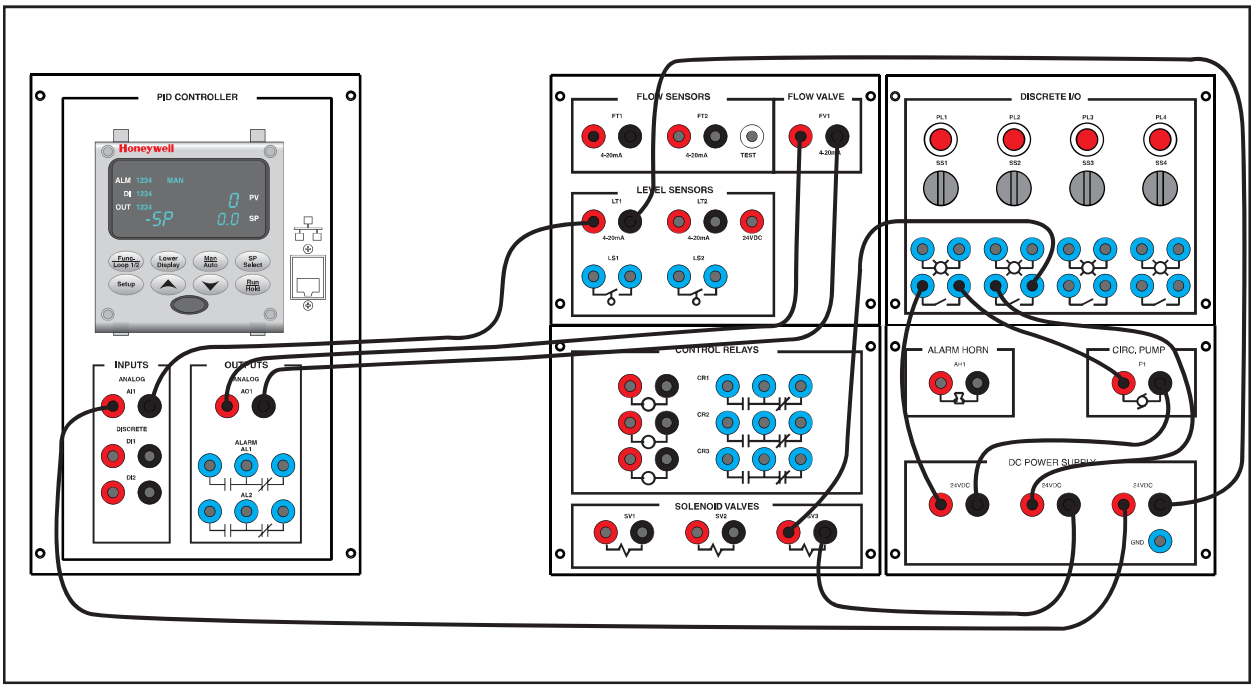

Figure 5-2. Connections for Closed Loop Level Control

Figure 5-3 shows the wiring diagram for the level control circuit.

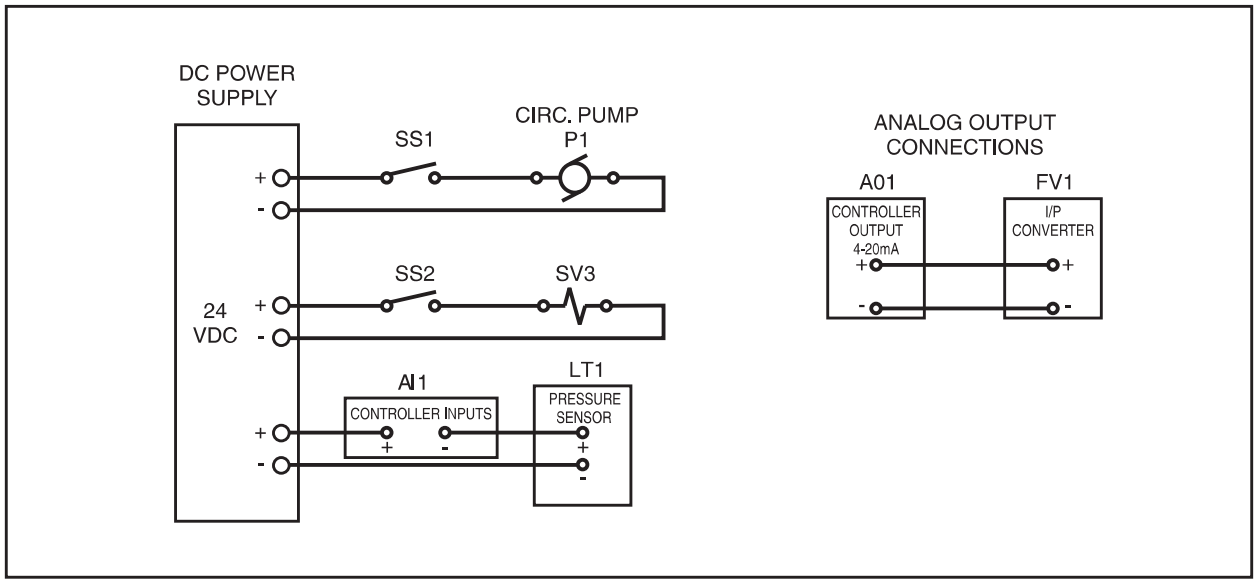

Figure 5-3. Wiring Diagram for a Level Sensor Connected to a Honeywell Controller

Figure 5-4 shows the P&ID for the T5552. The active components and wiring are highlighted.

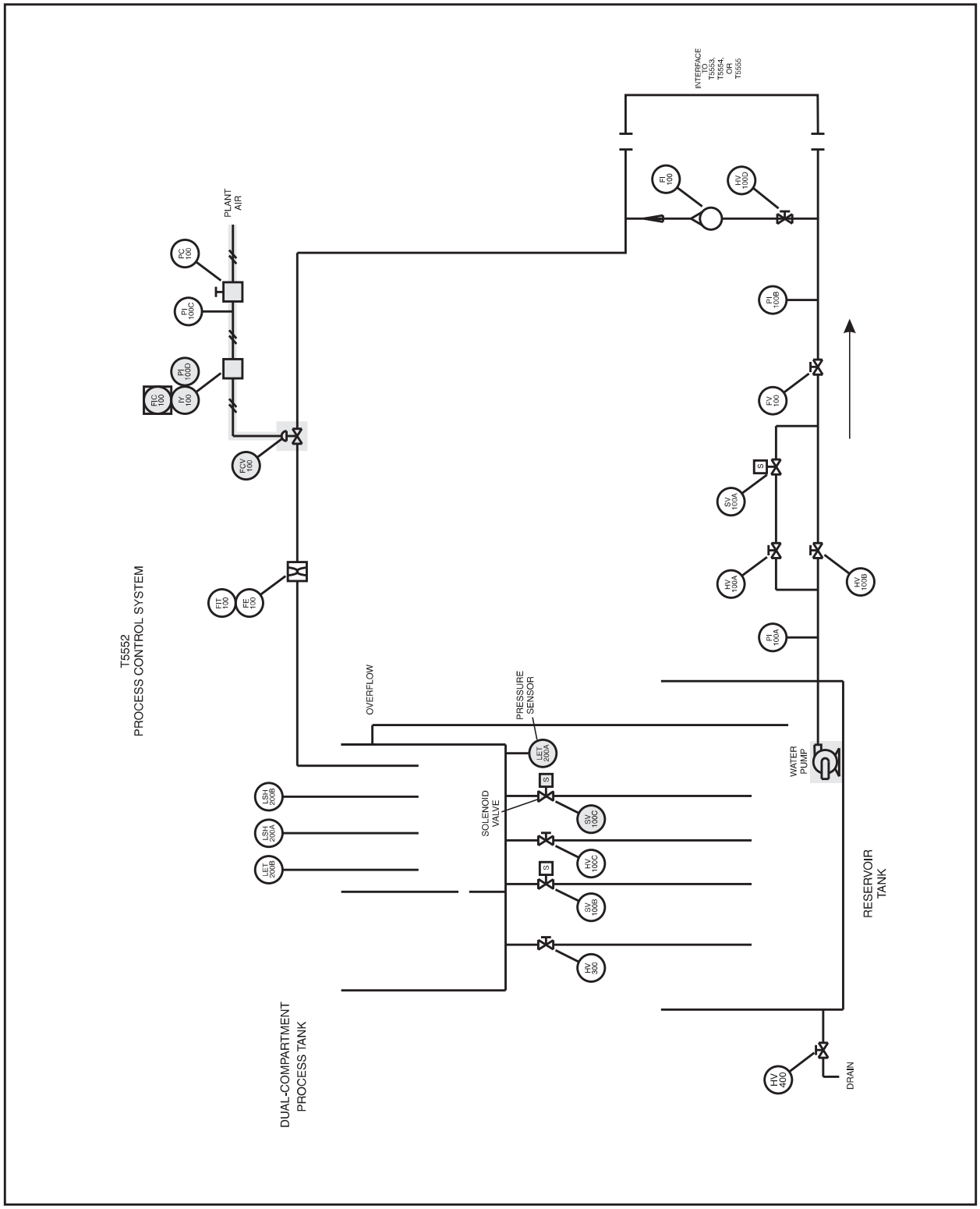

Figure 5-4. T5552 P&ID

❑ 3. Remove the lockout/tagout.

❑ 4. Make sure selector switch **SS1** is in the **OFF** position (up).

SS1 is used to turn the circulation pump on and off.

❑ 5. Perform the following substeps to set up the Honeywell process controller for closed loop control.

A. Turn on the main circuit breaker to apply power to the system.

B. Observe the display of the process controller as it goes through its power-up sequence.

When the startup diagnostic test is done, "TEST DONE" appears on the display briefly.

The controller should then enter the control display mode.

C. Press the **Setup** key repeatedly to scroll through the different selections until INPUT 1 appears on the display.

D. Press the **Func Loop 1/2** key.

The parameter "IN1 TYPE" should appear on the screen.

E. Use the up ▲ and down ▼ keys to set the parameter to **1-5V**. This indicates an electrical input type of 1 - 5 V.

The level sensor outputs a 4-20 mA signal. However, the input terminals of the loop controller have a 250-ohm resistor installed across them, changing the 4-20 mA signal to a 1-5 V signal.

F. Press the **Func Loop 1/2** key to move to the next parameter, "XMITTER1".

G. Use the up ▲ and down ▼ keys to set this parameter to **LINEAR**.

This indicates that the output varies linearly with the input.

H. Press the **Func Loop 1/2** key to move to the next parameter, "IN1 HIGH".

I. Use the up ▲ and down ▼ keys to set this parameter to **27.7** (for inches) or **70.4** (for cm). This is the maximum value for the pressure sensor on the T5552.

J. Press the **Func Loop 1/2** key to move to the next parameter, "IN1 LOW."

K. Use the up ▲ and down ▼ keys to set this parameter to **0.0.** This indicates the displayed value when the input signal is 1V.

L. Press the **Func Loop 1/2** key repeatedly until the "BIAS IN1" parameter appears.

M. Use the up ▲ and down ▼ keys to set the parameter to **-4.1** (for inches) or **-10.4** (for cm).

There is approximately a 4.1 inch or 10.4 cm offset between the bottom of the tank and the zero reading for the sensor. Entering this bias allows the tank sight scale to closely agree with the controller display.

N. Press the **Lower Display** key to exit the Setup menu.

O. The process variable's value on the display should indicate the water level in the tank. If there is a difference between the indicated value and the actual level, adjust the BIAS IN1 parameter until the indicated value matches the actual level.

P Press the **Setup** key repeatedly to scroll through the different selections until ALGORITHM appears on the display.

Q. Press the **Func Loop 1/2** key until CONT ALG appears on the screen.

R. Use the up ▲ and down ▼ keys to set this parameter to **PID A**.

S. Press the **Setup** key repeatedly to scroll through the different selections until **CONTROL** appears on the display.

T. Press the **Func Loop 1/2** key until the indicated parameter is displayed, and then use the up ▲ and down ▼ keys to set the parameter to the indicated value.

PARAMETER	SETTING
SP HiLIM	10.0 (for inches) or 25.4 (for cm)
SP LoLIM	0.0
ACTION	DIRECT
PBorGAIN	GAIN
MINorRPM	MIN

U. Press the **Setup** key repeatedly to scroll through the different selections until **TUNING** appears on the display.

V. Press the **Func Loop 1/2** key until the indicated parameter is displayed, and then use the up ▲ and down ▼ keys to set the parameter to the indicated value.

PARAMETER	SETTING
GAIN	20.0
RATE MIN	0.0
RSET MIN	0.25

This setup is using a Proportional-Integral-Derivative (PID) algorithm to control the diaphragm-actuator valve and in turn the water level in the process tank. The PID algorithm will be explained in more detail in a later LAP.

W. Press the **Setup** key repeatedly to scroll through the different selections until **COM** appears on the display.

X. Press the **Func Loop 1/2** key until **ComSTATE** is displayed, and then use the up and ▲ down ▼ keys to set the parameter to "DISABLE".

Y. Press the **Setup** key repeatedly to scroll through the different selections until **DISPLAY** appears on the display.

Z. Press the **Func Loop 1/2** key until **DECIMAL** is displayed, and then use the up ▲ and down ▼ keys to set the parameter to "ONE".

AA. Press the **Lower Display** key to exit the Setup menu and return to the control display mode.

❑ 6. Perform the following substeps to use the controller to automatically control the process.

A. Use the **Lower Display** key to display the SP value in the lower display.

B. Use the up ▲ and down ▼ keys to set the SP value to **3.0** (for inches) or **7.5** (for cm).

C. Place the controller in the **automatic** mode by pressing the **Man/Auto** key.

D. Place selector switch **SS1** in the **ON** position.

You should notice that water starts to flow into the tank. The controller is sending out a signal that tells the diaphragm-actuated valve to open and allow water to flow into the tank so that the actual level (PV) can reach the programmed setpoint (SP).

E. Note the time that the water starts to flow into the tank.

This will allow you to determine how long it takes to reach the setpoint.

F. Now observe the display of the controller as the tank continues to fill.

You should notice that the current PV value is displayed above the SP value, as figure 5-5 shows. The PV value should continue to increase as it approaches the SP.

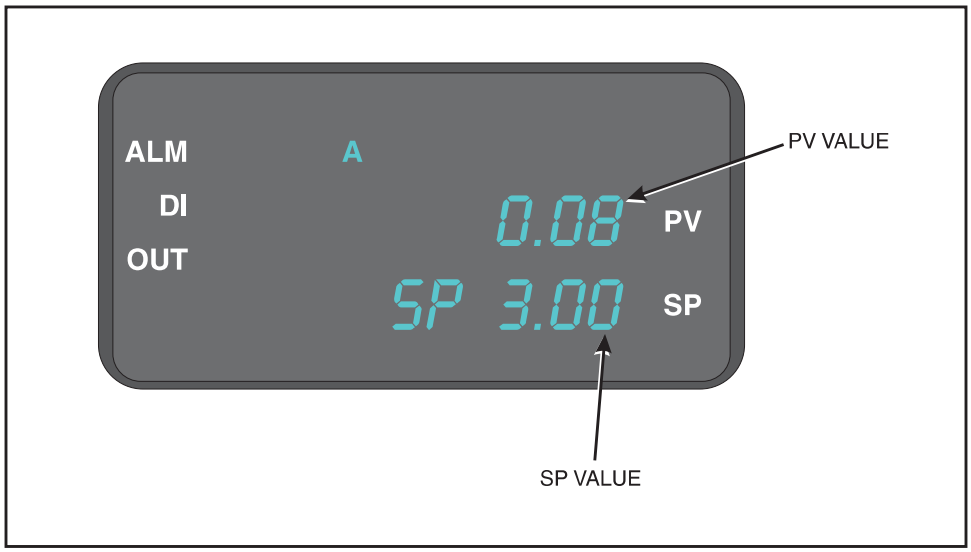

Figure 5-5. PV and SP Displayed

G. Use the **Lower Display** key to display the output (OUT) in the lower display.

H. Determine if the controller is changing the output to control the valve as the PV approaches the SP.

Is the output changing? _____ (Yes/No)

You should find that the controller is changing the output because it is in automatic mode.

I. When the output (OUT) of the controller reaches 100%, observe the value of the PV as indicated on the display of the controller.

Is the PV above or below the SP? _____ (Above/Below)

You should find that the PV stabilizes above the SP. The controller may not be programmed (tuned) to properly control the PV at the SP.

NOTE

This result depends on the settings in the controller. If the settings have been changed from the default values, you may get a different result.

J. Place selector switch **SS2** in the **ON** position.

This opens one of the process tank solenoid drain valves, SV 100 C (SV3), creating a demand disturbance on the process.

K. Observe the display of the controller.

You should notice that the PV value starts to drop.

L. Determine if the controller increases or decreases the output.

Output _____ (Increasing/Decreasing)

You should find that the controller decreases the output. This causes the diaphragm valve to open and allow more flow so that the level rises.

❑ 7. Place selector switch **SS2** in the **OFF** (up) position to close the solenoid valve SV 100C (SV3).

❑ 8. Place selector switch **SS1** in the **OFF** (up) position to stop the pump.

❑ 9. Change the SP to **5.00** (for inches) or **13.0** (for cm) and repeat step 6.

You should find that when you increase the SP to 5.00 (for inches) or 13.0 (for cm), the controller decreases its output (OUT) signal to the I/P converter so that the diaphragm valve opens. As the level approaches the SP, the controller should begin to increase its output signal to close the diaphragm valve.

❑ 10. Perform the following substeps to shut down the T5552.

A. Place selector switch **SS1** in the **OFF** position (up).

This will stop the circulation pump.

B. Place selector switch **SS2** in the **OFF** position (up).

This will close the solenoid drain valve SV 100C (SV3).

C. Open (fully counterclockwise) both of the manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**, on the process tank to completely drain the tank. When the tank is empty, close (fully clockwise) both valves.

D. Turn off the main circuit breaker.

E. Disconnect the control circuit.

SKILL 6 CONNECT AND OPERATE ALARMS ON A HONEYWELL UDC 3500 CONTROLLER

Procedure Overview

In this procedure, you will operate a level control circuit that uses the alarm relays on the Honeywell controller to indicate when the process variable goes above and below preset high and low limits, respectively.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Perform the following substeps to set up the T5552, as shown in figure 6-1.

NOTE

The appearance of the electrical outlet will differ based on the electrical power supplied at your location.

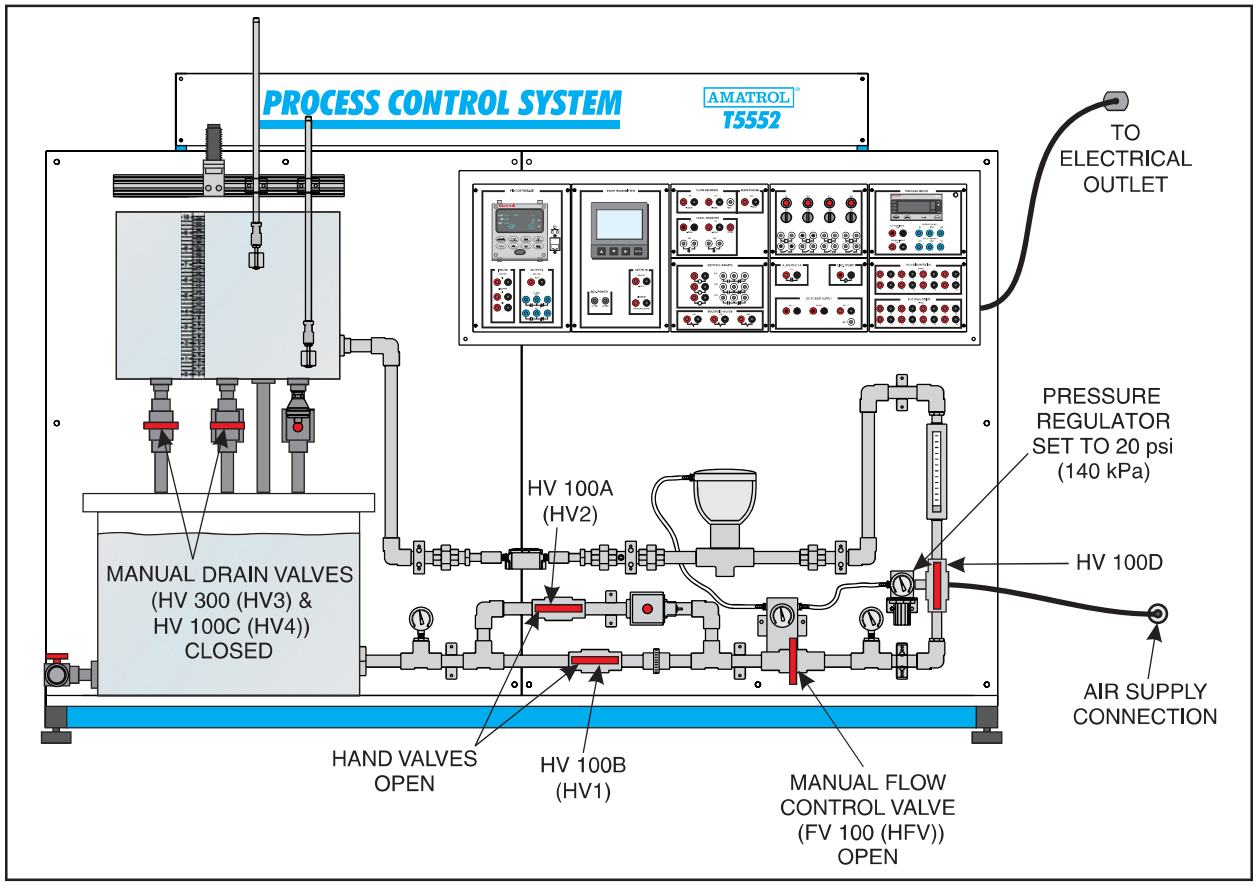

Figure 6-1. T5552 Setup

A. Connect the air supply line to the T5552.

B. Set the pressure regulator is set to 20 psi (140 kPa).

C. Fill the reservoir tank with water.

D. Close (fully clockwise) the two process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)** .

E. Close (fully clockwise) the manual flow control valve, **FV 100 (HFV)**.

F. Open (fully counterclockwise) the flow control hand valves, **HV 100B (HV1)** and **HV 100A (HV2)**.

G. Open (fully counterclockwise) the flow control hand valve **HV 100D**.

H. Connect the circuit shown in figure 6-2.

This circuit allows you to measure, display, and control the level in the process tank. The circuit also indicates high and low level alarm conditions.

Since the alarm relays on the UDC 3500 operate in the failsafe mode, the indicator light (PL2) is connected to the N.C. contacts of the alarm relay. That means PL2 turns on (N.C. contacts closed) only when an alarm condition occurs or if power to the relay is removed. When no alarm condition is present, the N.C. contact will be in its energized state (open).

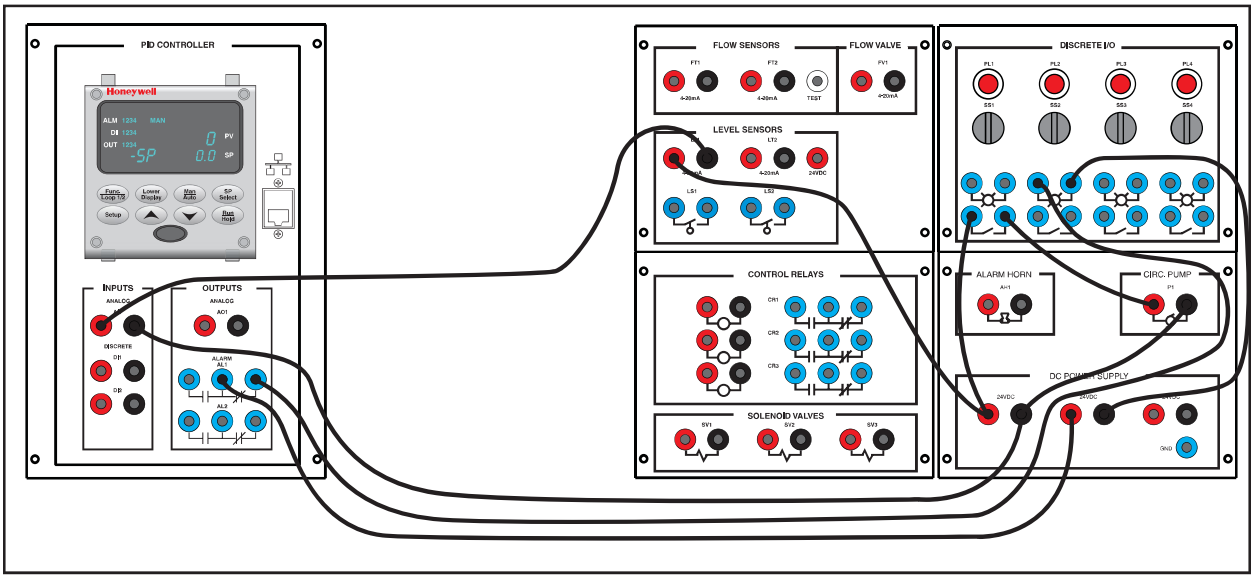

Figure 6-2. Level Circuit Using Controller Alarm Relays

Figure 6-3 shows the wiring diagram for the circuit.

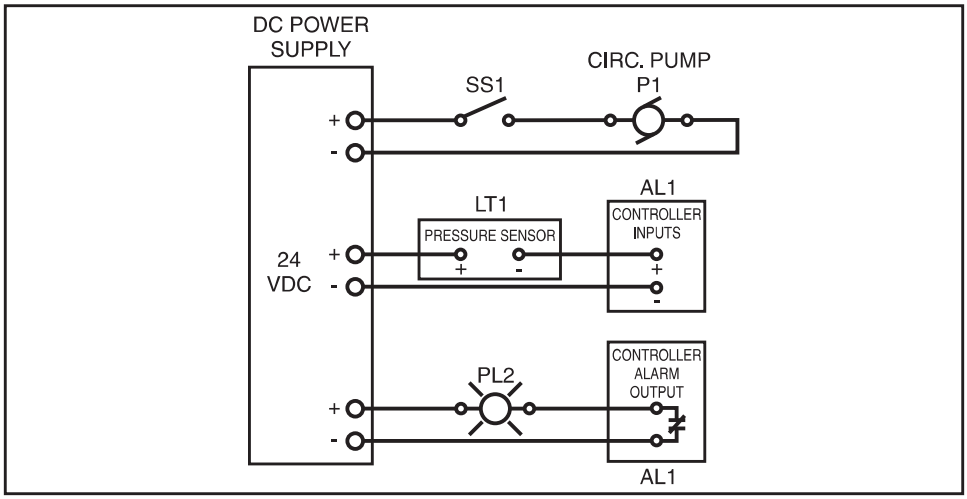

Figure 6-3. Wiring Diagram for Level Circuit

Figure 6-4 shows the P&ID for the T5552. The active components and wiring are highlighted.

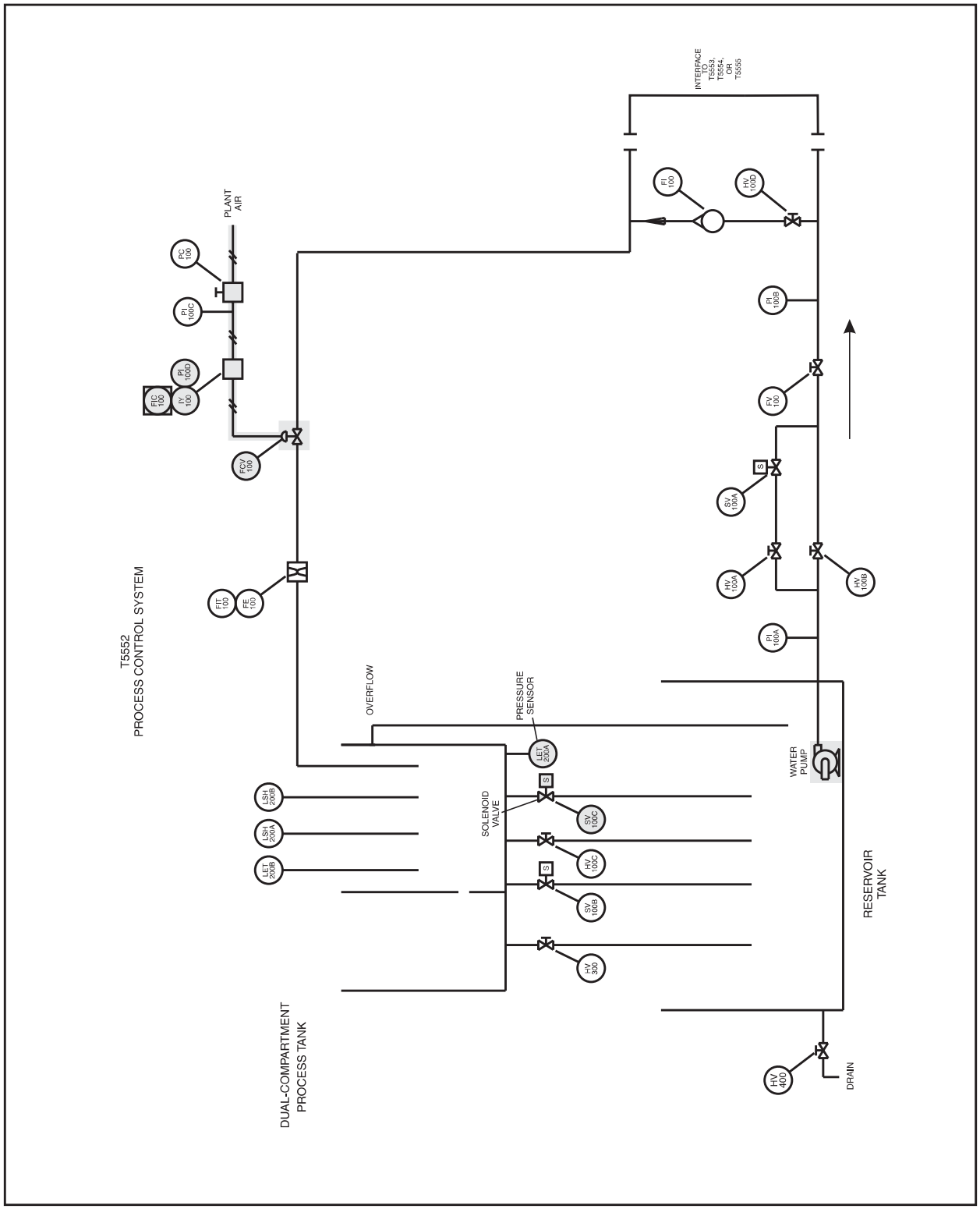

Figure 6-4. T5552 P&ID

- ❑ 3. Remove the lockout/tagout.
- ❑ 4. Turn on the main circuit breaker.
- ❑ 5. Perform the following substeps to set up the controller.

A. Verify the controller is in manual mode.

B. Press the **Setup** key to go to the setup menu.

C. Set the following parameters in the "INPUT 1" setup group:

NOTE

Recall that to scroll through the setup groups, press the Setup key. To scroll through the parameters in a group, press the Func Loop 1/2 key, and to change the parameter settings, press the ▲ and ▼ keys.

PARAMETER	SETTING
IN1 TYPE	1-5 V*
XMITTER1	LINEAR
IN1 HIGH	27.70 (for inches) or 70.4 (for cm)
IN1 LOW	0.000
BIAS IN1	-4.1 (for inches) or -10.4 (for cm)

*The level sensor outputs a 4-20 mA signal. However, the input terminals of the loop controller have a 250-ohm resistor installed across them, changing the 4-20 mA signal to a 1-5 V signal.

D. Set the following parameter in the "ALGORITHM" setup group:

PARAMETER	SETTING
CONT ALG	PID A

E. Set the following parameters in the "CONTROL" setup group:

PARAMETER	SETTING
ACTION	DIRECT
PBorGAIN	GAIN
MINorRPM	MIN

F. Set the following parameters in the "TUNING" setup group:

PARAMETER	SETTING
GAIN	20.0
RATE MIN	0.0
RSET MIN	0.25

This setup is using a Proportional-Integral-Derivative (PID) algorithm to control the diaphragm-actuator valve and in turn the water level in the process tank. The PID algorithm will be explained in more detail in a later LAP.

G. Set the following parameters in the "ALARMS" setup group:

PARAMETER	SETTING
A1S1TYPE	PV
A1S1 VAL	1.00 (for inches) or 2.5 (for cm)
A1S1 H L	LOW
A1S2TYPE	PV
A1S2 VAL	5.00 (for inches) or 13.0 (for cm)
A1S2 H L	HIGH

A1S1TYPE and A1S2TYPE parameters determine the type of value that triggers the alarm. In this case, A1S1TYPE and A1S2TYPE are based on the process variable (PV).

The A1S1 VAL parameter indicates the alarm 1 setpoint 1 value, which for this application is 1.00 inch or 2.5 cm. The A1S2 VAL parameter indicates the alarm 1 setpoint 2 value, which is 5.00 inches or 13.0 cm for this application.

The parameters A1S1 H L and A1S2 H L indicate whether the alarm is high (HIGH) or low (LOW). Therefore, A1S1 is a low alarm and A1S2 is a high alarm.

H. Press the **Lower Display** key to return to the control display mode.

I. The process variable's value on the display should indicate the water level in the tank. If there is a difference between the indicated value and the actual level, adjust the BIAS IN1 parameter (substep C) until the indicated PV value matches the actual level.

J. Make sure the output is displayed on the controller. If it is not, press the **Lower Display** key until "OUT" is displayed.

K. Determine if the alarm indicator light is on. Also, determine if the alarm indicator is present on the display of the controller.

Is the Alarm Indicator On? _____ (Yes/No)

Is the alarm indicator present on the controller display? _____ (Yes/No)

You should find that the indicator light (PL2) is on and the alarm indicator (1) appears on the controller display.

L. If the alarm indicator light is on, determine which level condition triggered the alarm.

Level Condition _____ (High Level/Low Level)

The level is below the 1-inch (2.5-cm) mark in the tank. Therefore, a low level condition exists.

❑ 6. Fully open (fully counterclockwise) the manual flow control valve, **FV 100 (HFV)**.

❑ 7. Turn on selector switch **SS1** to start the pump and allow the tank to fill above the 1-inch (2.5-cm) mark.

❑ 8. When the level rises above the 1-inch (2.5-cm) mark, fully close (fully clockwise) the manual flow control valve, **FV 100 (HFV)**.

❑ 9. Determine if the alarm indicator light (PL2) stays on and the alarm indicator (1) remains.

Does the Alarm Indicator Light (PL2) stay on? _____ (Yes/No)

Does the alarm indicator (1) on the controller display remain? ___ (Yes/No)

You should find that the alarm indicator light (PL2) does not stay on nor does the alarm indicator (1) remain after the level rises above 1 inch (2.5 cm) because it is in the operation range (1-5 inches or 2.5-13.0 cm).

With no alarm condition present, the alarm relay contacts are in their energized states. That means the N.C. contact is open.

❑ 10. Open (fully counterclockwise) the manual flow control valve, **FV 100 (HFV)**, and allow the tank to fill until the level is above the 5-inch (13-cm) mark.

❑ 11. When the level is above 5 inches (13 cm), close (fully clockwise) the manual flow control valve, **FV 100 (HFV)**.

❑ 12. Check the alarm indicator light (PL2) and display indicator (1) again.

Is the alarm indicator light (PL2) on? _____ (Yes/No)

Is the alarm indicator (1) present on the controller display? _____ (Yes/No)

You should find that the indicator light (PL2) is on and the alarm indicator (1) appears because the level is above the high level alarm setpoint (5 inches or 13 cm).

❑ 13. Repeat steps 5D - 12. Set the A1S1 VAL parameter to **3.00** (for inches) and **7.5** (for cm) and the A1S2 VAL parameter to **8.00** (for inches) or **20.0** (for cm).

You should find that the indicator light turns on (alarm indicator appears) when the level is either less than 3.00 inches (7.5 cm) or greater than 8.00 inches (20.0 cm).

❑ 14. Perform the following substeps to shut down the T5552.

A. Turn off selector switch **SS1** to stop the circulation pump.

B. Open (fully counterclockwise) both process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**, to drain the tank. When the tank is empty, close (fully clockwise) the valves.

C. Turn off the main circuit breaker.

D. Disconnect the circuit.

SKILL 7 — CONNECT AND OPERATE DISCRETE INPUTS ON A HONEYWELL UDC 3500 CONTROLLER

Procedure Overview

In this procedure, you will connect a level control circuit that uses the controller's discrete inputs to switch from one setpoint to a different setpoint.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Perform the following substeps to set up the T5552, as shown in figure 7-1.

NOTE

The appearance of the electrical outlet will differ based on the electrical power supplied at your location.

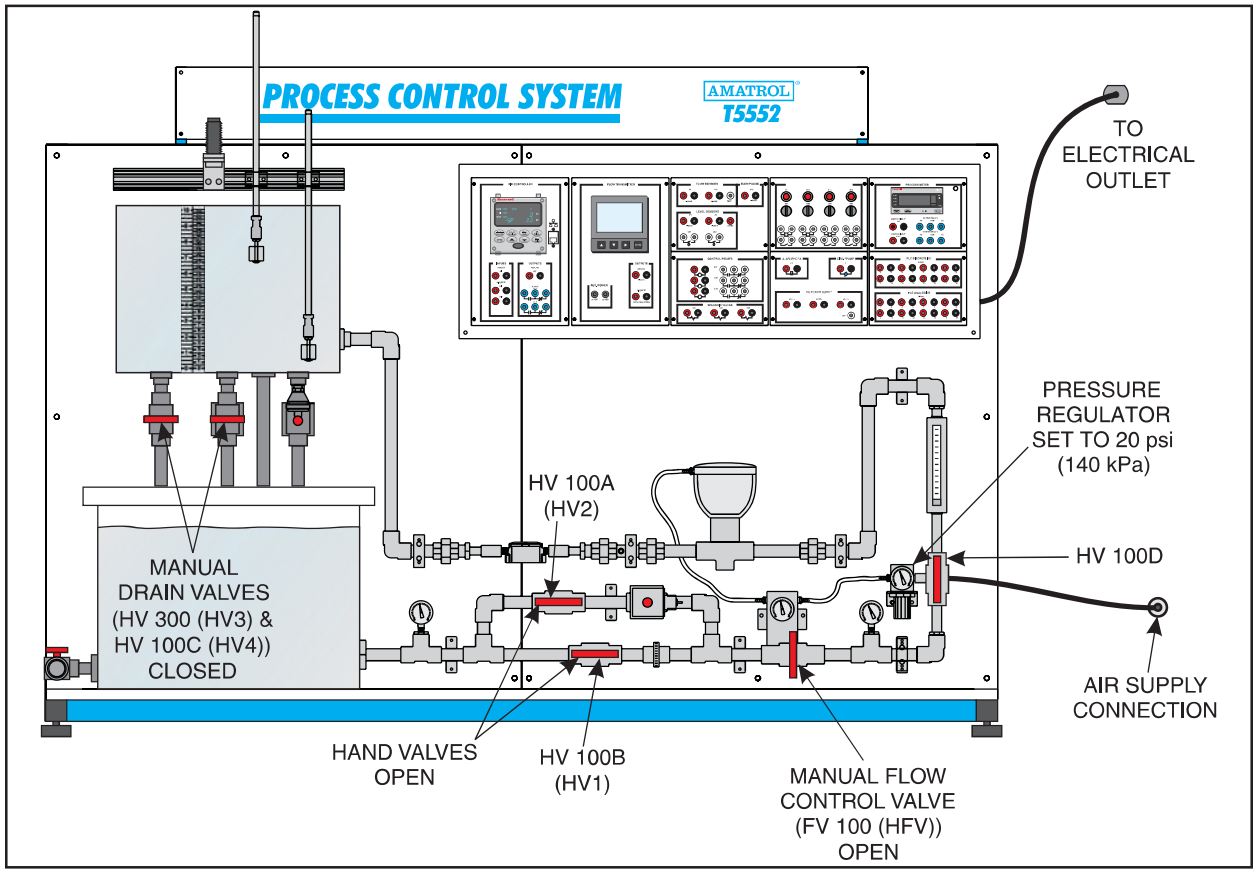

Figure 7-1. T5552 Setup

A. Connect the air supply line to the T5552.

B. Set the pressure regulator to 20 psi (140 kPa).

C. Fill the reservoir tank with water.

D. Close (fully clockwise) the two process tank manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**.

E. Open (fully counterclockwise) the flow control hand valves, **HV 100B (HV1)** and **HV 100A (HV2)**.

F. Open (fully counterclockwise) the flow control hand valve **HV 100D**.

G. Close (fully clockwise) the manual flow control valve, **FV 100 (HFV)**.

CAUTION

The discrete inputs on the Honeywell controller are contact closure. Therefore, you should never send a voltage to these inputs. Doing so will damage the controller.

H. Connect the circuit shown in figure 7-2.

This circuit allows you to measure, display, and control the level in the process tank. This circuit also allows you to switch between different setpoints using the controller's discrete inputs.

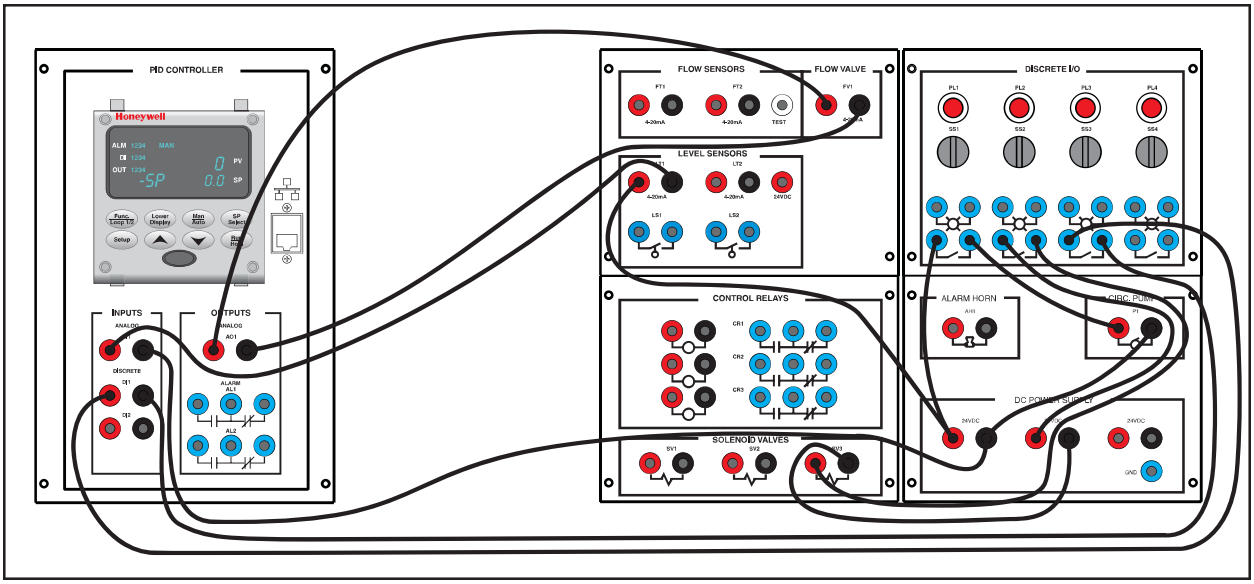

Figure 7-2. Level Control Circuit with Discrete Inputs

Figure 7-3 shows the wiring diagram for the circuit.

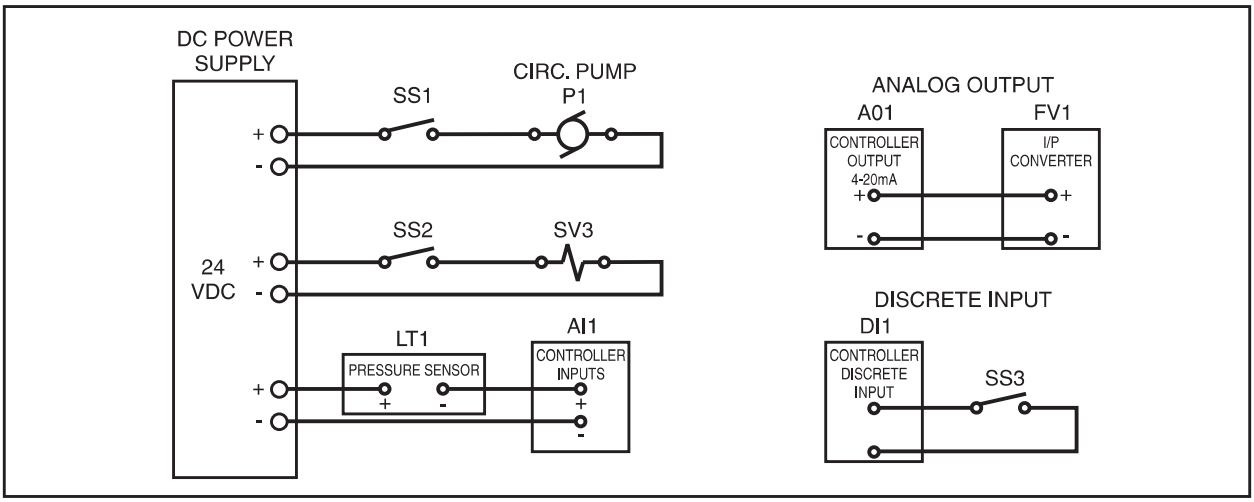

Figure 7-3. Wiring Diagram for Level Circuit with Discrete Inputs

Figure 7-4 shows the P&ID for the T5552. The active components and wiring are highlighted.

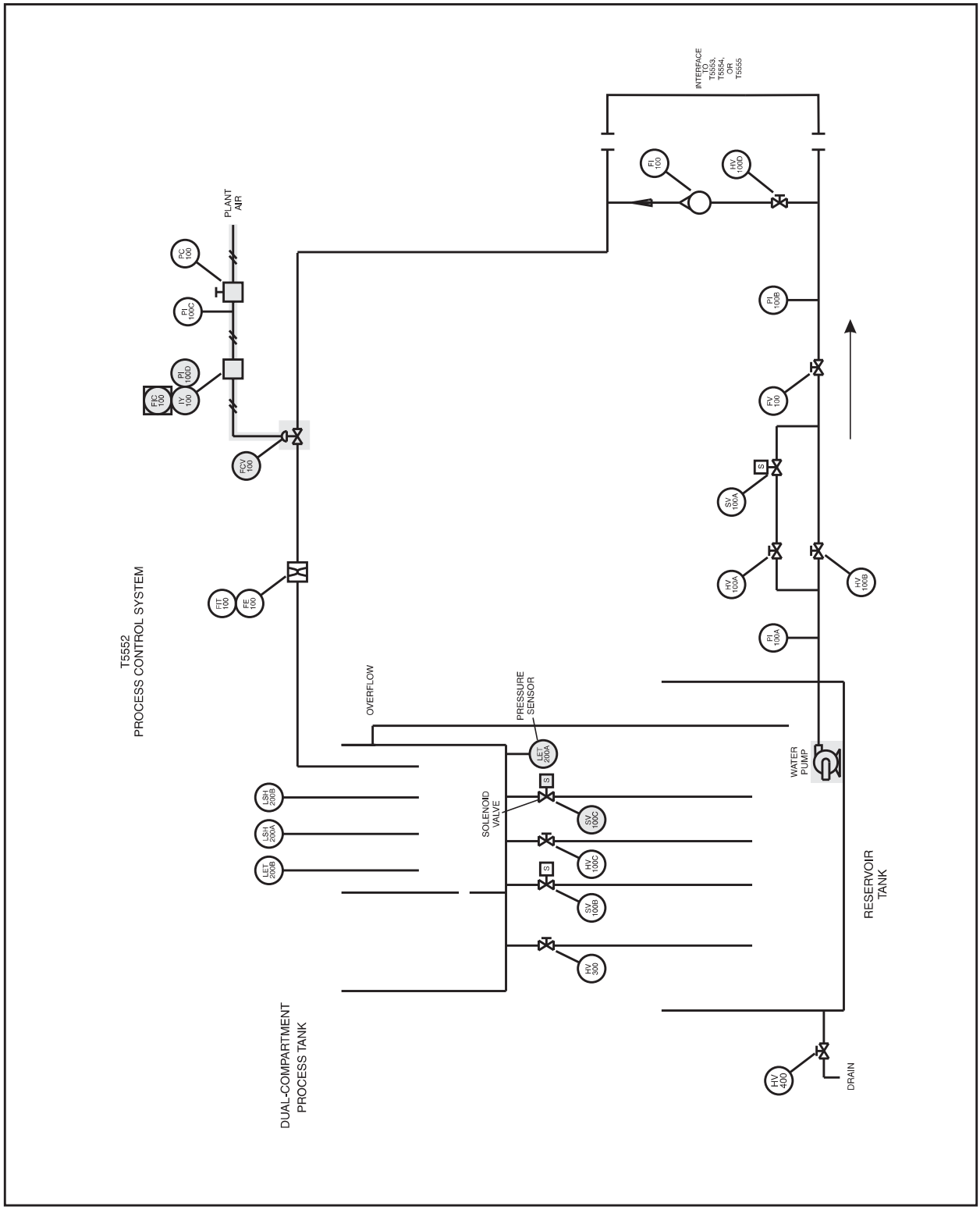

Figure 7-4. T5552 P&ID

- ❑ 3. Remove lockout/tagout.
- ❑ 4. Turn on the main circuit breaker.
- ❑ 5. Perform the following substeps to set up the controller

A. Verify the controller is in manual mode.

B. Press the **Setup** key to go to the setup menu.

NOTE

Recall that to scroll through the setup groups, press the Setup key. To scroll though the parameters in a group, press the Func Loop 1/2 key, and to change the parameter settings, press the up ▲ and down ▼ keys

C. Set the following parameters in the "INPUT 1" group:

PARAMETER	SETTING
IN1 TYPE	1-5 V*
XMITTER1	LINEAR
IN1 HIGH	27.70 (for inches) or 70.4 (for cm)
IN1 LOW	0.000
BIAS IN1	-4.1 (for inches) or -10.4 (for cm)

*The level sensor outputs a 4-20 mA signal. However, the input terminals of the loop controller have a 250-ohm resistor installed across them, changing the 4-20 mA signal to a 1-5 V signal.

D. Set the following parameter in the "ALGORITHM" setup group:

PARAMETER	SETTING
CONT ALG	PID A

E. Set the following parameters in the "CONTROL" setup group:

PARAMETER	SETTING
SP HiLIM	10.0 (for inches) or 25.4 (for cm)
SP LoLIM	0.0
ACTION	DIRECT
PBorGAIN	GAIN
MINorRPM	MIN
LSP'S	TWO

LSP'S is the local setpoint parameter. A selection of "two" allows you to program 2 local setpoints into the controller.

F. Set the following parameters in the "TUNING" setup group:

PARAMETER	SETTING
GAIN	20.0
RATE MIN	0.0
RSET MIN	0.25

This setup is using a Proportional-Integral-Derivative (PID) algorithm to control the diaphragm-actuator valve and in turn the water level in the process tank. The PID algorithm will be explained in more detail in a later LAP.

G. Set the following parameter in the "OPTIONS" setup group:

PARAMETER	SETTING
DIG INP1	TO 2SP

This tells the controller to change from setpoint 1 (SP) to local setpoint 2 (2SP) when the contact closes. The controller switches back to the original setpoint (SP) when the contact opens.

H. Press the **Lower Display** key to return to the control display mode.

I. The process variable's value on the display should indicate the water level in the tank. If there is a difference between the indicated value and the actual level, adjust the BIAS IN1 parameter (substep C) until the indicated PV value matches the actual level.

J. Use the **Lower Display** key to display the SP value.

K. Use the up ▲ and down ▼ keys to set the SP value to **3.00** (for inches) or **7.5** (for cm).

L. Use the **Lower Display** key to display the 2SP value.

M. Use the up ▲ and down ▼ keys to set the 2SP value to **5.00** (for inches) or **13.0** (for cm).

N. Press the **Man/Auto** key to place the controller in automatic mode.

❑ 6. Perform the following substeps to operate the circuit.

A. Fully open (fully counterclockwise) the manual flow control valve, **FV 100 (HFV)**.

B. Turn on selector switch **SS2** to energize the solenoid drain valve SV 100C (SV3).

C. Turn on selector switch **SS1** to start the pump.

Water should begin to fill the process tank. When the level reaches the 3-inch (7.5-cm) mark, the controller begins to adjust its output (OUT) to maintain the level at this point.

NOTE

This may take a couple of minutes since the controller may not be properly tuned (i.e. programmed).

D. After the level stabilizes at 3 inches or 7.5 cm, turn on selector switch **SS3** to actuate the discrete input (DI1).

E. Determine if the level in the process tank changes.

Does the level change _____ (Yes/No)

You should find that the level in the tank begins to rise to the second setpoint (5.0 inches or 13.0 cm). You should also notice a "1" next to the DI label on the display panel indicating that digital input 1 is active, as shown in figure 7-5.

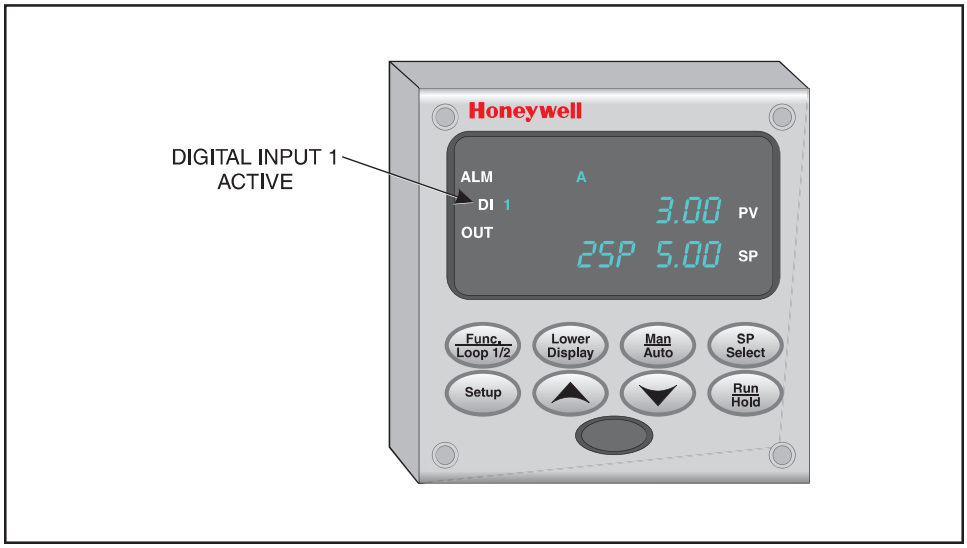

Figure 7-5. Discrete Input Active Indicator on a Honeywell Controller

F. After the level stabilizes at the second setpoint (5.00 inches or 13.0 cm), turn off selector switch **SS3** to deactivate the discrete input.

G. Determine if the level changes.

Does the level change? _____ (Yes/No)

You should find that the level in the tank begins to decrease to the original setpoint (3.0 inches or 7.5 cm). You should also notice that the "1" no longer appears next to the DI label on the display, indicating that the discrete input is not active.

❑ 7. Perform the following substeps to shut down the T5552.

A. Turn off selector switch **SS1** to stop the circulation pump.

B. Turn off selector switch **SS2** to close the solenoid drain valve SV 100C (SV3).

C. Fully close (fully clockwise) the manual flow control valve, **FV 100 (HFV)**.

D. Open (fully counterclockwise) both manual drain valves, **HV 300 (HV3)** and **HV 100C (HV4)**, to drain the process tank. When the tank is completely drained, close (fully clockwise) the valves.

E. Turn off the main circuit breaker.

F. Disconnect the circuit.