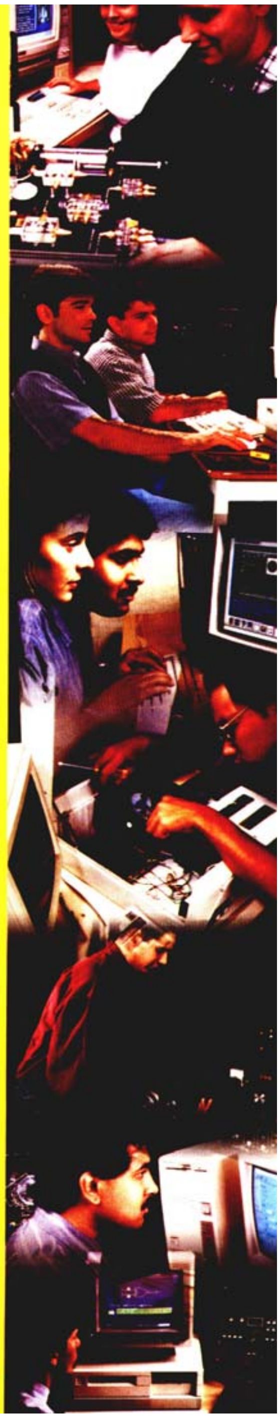
Instrumentation and Process Control

Calibration Bench for Mobile Workstations

Student Manual
76015-20

Printed in Canada



Lab-Volt®

Table of Contents

Introduction

The rapid advances of instrumentation technology have greatly expanded the variety of tasks performed by instrument technicians at industrial plants. Technician are tasked with calibrating, troubleshooting and repairing instruments ranging from pneumatic booster relays to microprocessor based automatic controllers. To successfully perform these tasks without adversely affecting plant availability or maintenance costs, effective training is essential.

The Lab-Volt Mobile Process Control Trainers are designed for hands-on training in the measurement, control and troubleshooting of processes. The stations can operate independently, or in certain combination configurations to simulate complex processes. All instruments in the Lab-Volt Mobile Instrumentation and Process Control System are patch connected to permit alternate control schemes and adaptation of new technology in the future. The Calibration Bench workstation completes the family. This workstation can accommodate two students and is designed for basic study of operation and calibration of instruments.

Exercise 1

Calibration of a Pressure Gauge

OBJECTIVES

At the completion of this laboratory exercise, you will have been introduced to calibration procedures and terminology. You will also be able to use a precision test gauche to calibrate a pressure process gauge.

DISCUSSION

Gauges are among the most common instruments that a technician has to deal with. As shown on Figure 1-1, pressure gauges consist of a dial or indicator and a pressure element. This pressure element converts the pressure into a physical displacement. The most widely used elements are diaphragms, bellows and Bourdon tubes.

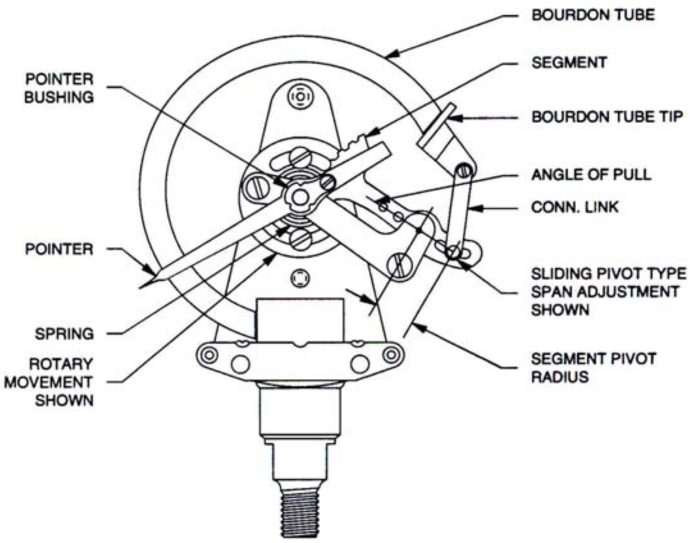


Figure 1-1. Typical Pressure Gauge Assembly.

To ensure proper indication, even the best gauges must be checked periodically. Dead weight testers are the most accurate devices for calibrating a gauge. A precision weight is placed on a piston to create the exact pressure desired.

$$[Pressure] = \frac{[Force]}{[Area]}$$

$$Pa = \frac{N}{m^2}$$

$$= \frac{kg \cdot m/s^2}{m^2} = \frac{kg}{m \cdot s^2}$$

Using the English units of measure, this relation is:

$$[Pressure] = \frac{[Force]}{[Area]}$$

$$psi = \frac{lbf}{in^2}$$

Note: *The English unit used to measure force is the pound-force (lbf). One pound-force correspond to the mass of one pound multiplied by the gravitational acceleration on earth.*

Dead weight testers however, are extremely expensive. Sometimes it is more convenient to use a test gauge for calibration rather than a dead weight tester.

An important term used in the calibration of gauges is accuracy. Accuracy is the conformity of an indicated value to an acceptable standard value, or true value. Accuracy is in fact measured in terms of inaccuracy, and when used as a performance specification, is assumed to mean reference accuracy. Reference accuracy is a number or quantity that defines the limits that errors, in the indicated values of a device, will not exceed when the device is used under referenced operating conditions (temperature, operating range, etc.). Accuracy is usually expressed as a percentage of span, or upper range value.

The best accuracy and repeatability is obtained by lightly tapping the gauge before each pressure reading. In some installations, oil residue and dirt trapped in the piping can cause errors. These errors have the most effects when low pressure range gauges are used.

In this exercise, you will use the Calibration Bench to calibrate a gauge on the Pressure Process Station.

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart in Appendix E to obtain the list of equipment required for this exercise.

Calibration of a Pressure Gauge

PROCEDURE

CAUTION!

You are working with high pressures! Be careful when removing or adding air lines.

☐ 1. Move the Pressure Process Station next to the Calibration Bench. If this is not possible, remove the large 0-690 kPa (0-100 psi) gauge (PI-2) from the Pressure Process Station Panel.

> **Note:** *In this exercise you are going to calibrate the gauge from the Pressure Process Station, using the 0-690 kPa (0-100 psi) gauge on the Calibration Bench as your "true" reference value. You are not going to adjust the Pressure Process Gauge. You are going to record and graph its indicated value against true value and then use this table to resolve true pressure measurement values in later exercises.*

☐ 2. Connect the gauge to the 0-690 kPa (0-100 psi) regulator port. Refer to Figure 1-2. Attach a male "Eastman" fitting to the end of the tubing which connects to the regulator port. Use a wrench to tighten the fitting slightly more than finger tight. For most applications, finger tight is adequate. However, in this exercise you are working with high pressures.

☐ 3. Use the 0-690 kPa (0-100 psi) regulator to adjust the pressure from 0 kPa to 690 kPa (0 psi to 100 psi) and back to 0 kPa (0 psi).

Complete the Calibration Data Sheet and graph your results (see next pages).

Calibration of a Pressure Gauge

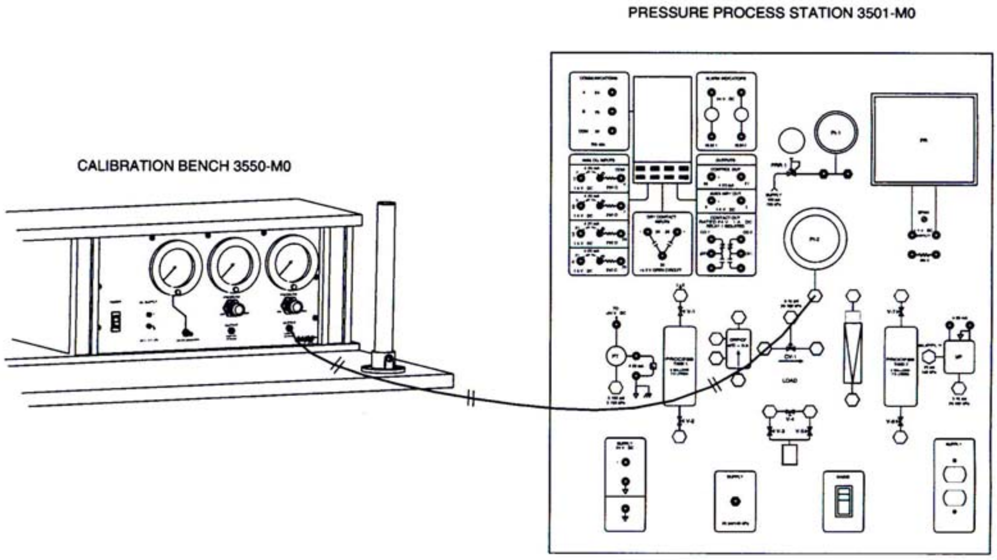


Figure 1-2. Calibration of a Pressure Gauge.

☐ 4. Turn off the power.

CONCLUSION

In this exercise you have been introduced to the calibration principles of a gauge. Using a precision test gauge on the Calibration Bench you have recorded and plotted the calibration curve of a pressure gauge.

REVIEW QUESTIONS

1. In process control, which characteristic is the most important: accuracy or precision?

   ____

   ____

   ____

Calibration of a Pressure Gauge

2. When calibrating the gauge, why is it necessary to take readings on both increasing and decreasing pressures?

   ____

   ____

   ____

3. If you were to accurately calibrate the pressure gauge, what adjustments on the gauge would be needed?

   ____

   ____

   ____

4. What primary element is used in this gauge to give a pressure indication?

   ____

   ____

   ____

Calibration of a Pressure Gauge

Calibration of a Pressure Gauge

CALIBRATION DATA SHEET

APPLICATION DATA

INSTRUMENT NUMBER: ______________

FUNCTION: ______________

LOCATION: ______________

INPUT RANGE: ______________

REQUIRED ACCURACY: ______________

DATE OF CALIBRATION: ______________

INSTRUMENT NAMEPLATE DATA

MANUFACTURERS NAME: ______________

MODEL NUMBER: ______________

SERIAL NUMBER: ______________

OUTPUT RANGE: ______________

INPUT	% SPAN	DESIRED OUTPUT	ACTUAL OUTPUT	REMARKS
	0			
	25			
	50			
	75			
	100			
	75			
	50			
	25			
	0			

ALARMS

ALARM FUNCTION : ______________

ALARM SETTINGS:

LOW SETPOINT	ACTUAL TRIP POINT	HIGH SETPOINT	ACTUAL TRIP POINT

Calibration of a Pressure Gauge

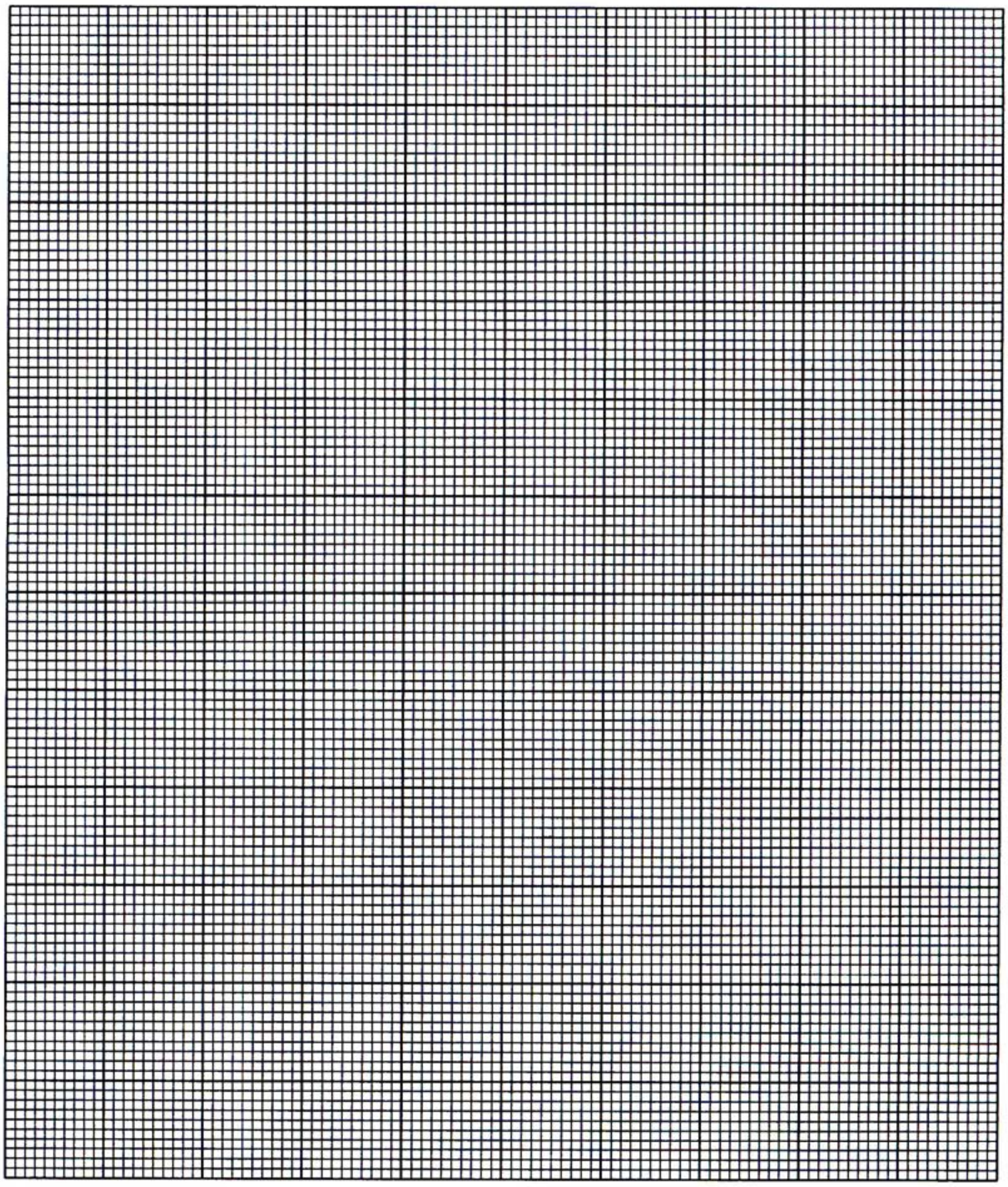


Figure 1-3. Calibration curve of a pressure gauge.

Exercise 2

Calibration of a Pressure Transmitter

OBJECTIVES

At the completion of this laboratory exercise, you will be able to calibrate a pressure transmitter to a specified pressure range.

DISCUSSION

A pressure transmitter is used to sense the pressure of a measured variable and convert it to a proportional electronic or pneumatic output signal. Pressure transmitters are available with a variety of primary elements. The selection of a pressure transmitter should be based on the pressure range to be measured.

Primary elements for pressure measurement are available to satisfy a variety of applications. Capsules and bellows are commonly used for low pressures. Bourdon tubes are available for use at medium, high, and very high pressures. Diaphragms cover the pressure range from low to high. Diaphragms are often used in conjunction with strain gauge elements to produce electrical outputs proportional to the measured pressure.

Like most transmitters, pressure transmitters generally have two adjustments that relate the magnitude of the measured variable to the output signal. These adjustments are the zero, and span or range. The zero adjustment sets the transmitter output at its minimum value when the applied pressure is at its minimum value. The span or range adjustment sets the transmitter output at its maximum value when the applied pressure is at its maximum value. When these two adjustments have teen set and checked, the transmitter is calibrated.

The calibration procedure given in this exercise applies to the electronic pressure transmitter used on the Pressure Process Station, Model 3501-M (that is, a Foxboro IGP10-A20 pressure transmitter). In this procedure, the transmitter is calibrated to provide an output current varying between 4 and 20 mA when the pressure applied to this transmitter is varied between the lower range value of 0 kPa (gage) (0 psig) and the upper range value of 552 kPa (gage) (80 psig), respectively.

To calibrate this transmitter for a different pressure range, follow the same procedure by adapting it in the following way:

– In the *Transmitter Configuration* (first) part of the procedure, set the lower and upper range values (LRV and URV) of the transmitter to the minimum and maximum pressures to be measured by the transmitter.

– In the *Transmitter Calibration* (second) part of the procedure, calibrate the lower range value (LRV) of the transmitter by applying the minimum pressure to be measured. Calibrate the upper range value (URV) of the transmitter by applying the maximum pressure to be measured.

Calibration of a Pressure Transmitter

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart in Appendix E to obtain the list of equipment required for this exercise.

PROCEDURE

CAUTION!

You are working with high pressures! Be careful when removing or adding air lines.

☐ 1. Remove the Pressure Transmitter from the Pressure Process Station. You are going to calibrate it using the Calibration Bench for a pressure range of 0 to 552 kPa (gage) (0 to 80 psig).

☐ 2. Mount the Pressure Transmitter to the pipe stand on the Calibration Bench.

☐ 3. Connect the one quarter inch tubing as shown in Figure 2-1. Use a male fitting from the patch cord package to make the connection at the 0-690 kPa (0-100 psi) regulator port.

> **Note:** *Tighten the fitting onto the tubing with a small wrench or pair of pliers. For most applications, finger-tight is sufficient. However in this exercise you are working with high pressure.*

☐ 4. Connect the digital multimeter (DMM) of the Calibration Bench (placed in ammeter mode) and the transmitter to the 24 V dc power supply. Note the polarity as shown in Figure 2-1. The transmitter red supply lead corresponds to the positive (+) lead, while the yellow supply lead corresponds to the common lead. The transmitter can deliver a maximum current of 20 mA. Select the appropriate current range on the multimeter. Turn on the 24 V dc power supply.

Transmitter Configuration

☐ 5. Starting from the main display of the pressure transmitter upon power up, press the **Next** transmitter button twice. The transmitter display indicates **CONFIG**. Press the **Enter** transmitter button to access the Configuration menu.

> **Note:** *After a few minutes of inactivity, the transmitter display will automatically return to the main display.*

- ☐ 6. Press **Next** twice to advance the display to the **OUTMODE** item. Press **Enter** to select **LINEAR,** then press **Enter** to accept this selection. This sets the transmitter output mode to linear.

- ☐ 7. The display now indicates **OUTFAIL**. Press **Next** three times to advance the display to the **EGU SEL** item. Press **Enter**, then use the **Next** button to select the desired pressure measurement unit (**KPA** or **PSI**). Press **Enter** to accept this selection.

- ☐ 8. The display now indicates **EGU LRV**. Press **Enter**. The display now shows the default (or last) value for the lower range value (LRV), with a polarity (dash) sign flashing in front of this value. Set the lower range value to "000.0" ("00.00" in psi mode) by performing the following steps:

  a. Press the **Next** button a few times and observe that this causes the polarity sign to alternate between positive (_) and negative (–). Set the polarity to positive (_), then press **Enter**.

  b. The first digit is now flashing. Using **Next**, select the desired digit (0), then press **Enter**. Your selection is entered and the second digit is flashing.

  c. Repeat step b until all four digits are 0's.

  d. The display now indicates **SET DP** (decimal point). Using **Next**, move the decimal point until it is located between the third and fourth digits (second and third digits in psi mode), then press **Enter** to accept the lower range value setting (000.0 in kPa mode or 00.00 in psi mode).

- ☐ 9. The display now indicates **EGU URV**. Press **Enter**. The display now shows the default (or last) value for the upper range value (URV), with a polarity (dash) sign flashing in front of this value. Set the upper range value to "552.0" kPa ("80.00" psi) by performing the following steps:

  a. Using the **Next** button, set the polarity to positive (_), then press **Enter**.

  b. The first digit is now flashing. Using **Next**, select the desired digit ("5" in kPa mode or "8" in psi mode), then press **Enter**. Your selection is entered and the second digit is flashing.

  c. Repeat step b in order to set the three remaining digits to "5", "2", and "0" respectively (set the three remaining digits to "0" in psi mode).

  d. The display now indicates **SET DP** (decimal point). Using **Next**, move the decimal point until it is located between the third and fourth digits (second and third digits in psi mode), then press **Enter** to accept the upper range value setting (552.0 in kPa mode or 80.00 in psi mode).

☐ 10. The display now indicates **CANCEL**. Press **Next** to advance to the **SAVE** item, then press **Enter** to save your configuration settings and to return to the main display. The display should now indicate 0.0 kPa (gage) (0.00 psig).

Transmitter Calibration

☐ 11. Press Next once in order for the transmitter display to indicate **CALIB**. Press **Enter** to access the calibration menu.

☐ 12. The display now indicates **CAL ATO**. With the minimum pressure being applied to the transmitter (0 kPa (gage) or 0 psig), press **Enter** to accept this pressure value. The transmitter now indicates **ATO DONE**, indicating that the calibration has been done at zero pressure.

☐ 13. Press **Next** to advance the display to the **CAL LRV** item. With the minimum pressure still applied to the transmitter (0 kPa (gage) or 0 psig), press **Enter** to accept this pressure value as the lower range value. The transmitter now reads **LRV DONE**, confirming the calibration at 0% of the transmitter range. The ammeter reading corresponds to the minimum transmitter output current (4.0 mA approximately).

☐ 14. Press **Next** once to advance the display to the **CAL URV** item. Adjust the 0-690 kPa (0-100 psi) pressure regulator on the Calibration Bench, Model 3550-M, in order for a pressure of 552.0 kPa (gage) (80.0 psig) to be applied to the pressure transmitter, as read on the transmitter display. Press **Enter** to accept this pressure value as the upper range value. The transmitter now reads **URV DONE**, confirming the calibration at 100% of the transmitter range. The ammeter reading corresponds to the maximum transmitter output current (20.0 mA approximately).

☐ 15. Press **Next** several times until you reach the **SAVE** item. Press **Enter** to save your calibration settings and return to the main display. The display should now indicate 552.0 kPa (gage) (80.0 psig) approximately.

> **Note:** *During transmitter configuration or calibration, a single change can affect other parameters. Consequently, if you enter a value in error, re-examine all the values previously entered or momentarily disconnect the transmitter positive (+) supply lead from the 24 V dc power supply to restore the transmitter to its starting configuration and redo the procedure.*

☐ 16. Complete the transmitter calibration data sheet and verify the transmitter calibration for the entire calibration range of 0-552 kPa (gage) (0-80 psig). To do so, vary the pressure applied to the transmitter over the entire calibration range, using the pressure regulator, and plot the transmitter output current versus the applied pressure.

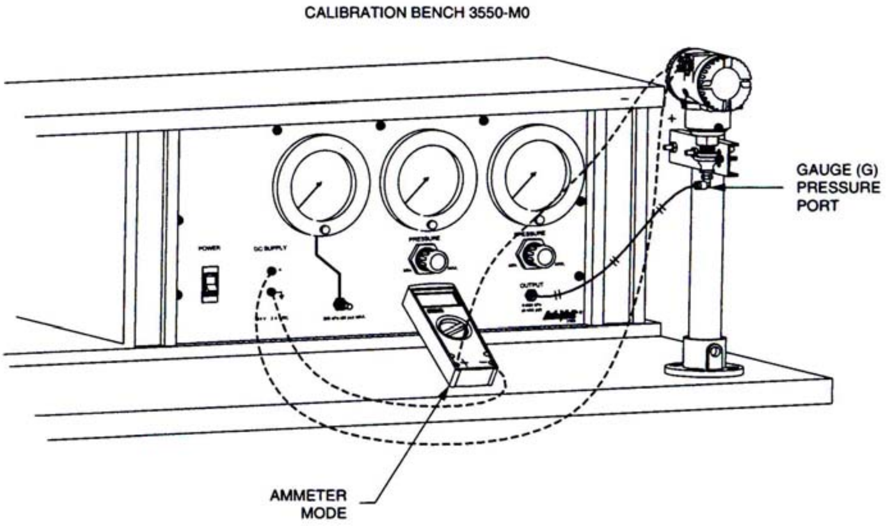


Figure 2-1. Calibration of a Pressure Transmitter.

CONCLUSION

In this exercise you learned to calibrate a pressure transmitter. The electrical output of the pressure transmitter was compared against the Calibration Bench's Pressure Gauge which indicated an accurate measurement of the input pressure.

REVIEW QUESTIONS

1. Do you think it would be useful to actually disconnect the input to the Pressure Transmitter when setting the zero? Why?

____

____

____

____

____

____

Calibration of a Pressure Transmitter

2. Would an instrument with a listed accuracy of ±2% of span be less or more accurate than the one listed as ±2% of upper range value?

3. Why was the calibration data collected for increasing and decreasing input signals?

4. What is the principal limitation of a pneumatic transmitter?

Calibration of a Pressure Transmitter

CALIBRATION DATA SHEET

APPLICATION DATA

INSTRUMENT NUMBER: ____________

FUNCTION: ____________

LOCATION: ____________

INPUT RANGE: ____________

REQUIRED ACCURACY: ____________

DATE OF CALIBRATION: ____________

INSTRUMENT NAMEPLATE DATA

MANUFACTURERS NAME: ____________

MODEL NUMBER: ____________

SERIAL NUMBER: ____________

OUTPUT RANGE: ____________

INPUT	% SPAN	DESIRED OUTPUT	ACTUAL OUTPUT	REMARKS
	0			
	25			
	50			
	75			
	100			
	75			
	50			
	25			
	0			

ALARMS

ALARM FUNCTION : ____________

ALARM SETTINGS:

LOW SETPOINT	ACTUAL TRIP POINT	HIGH SETPOINT	ACTUAL TRIP POINT

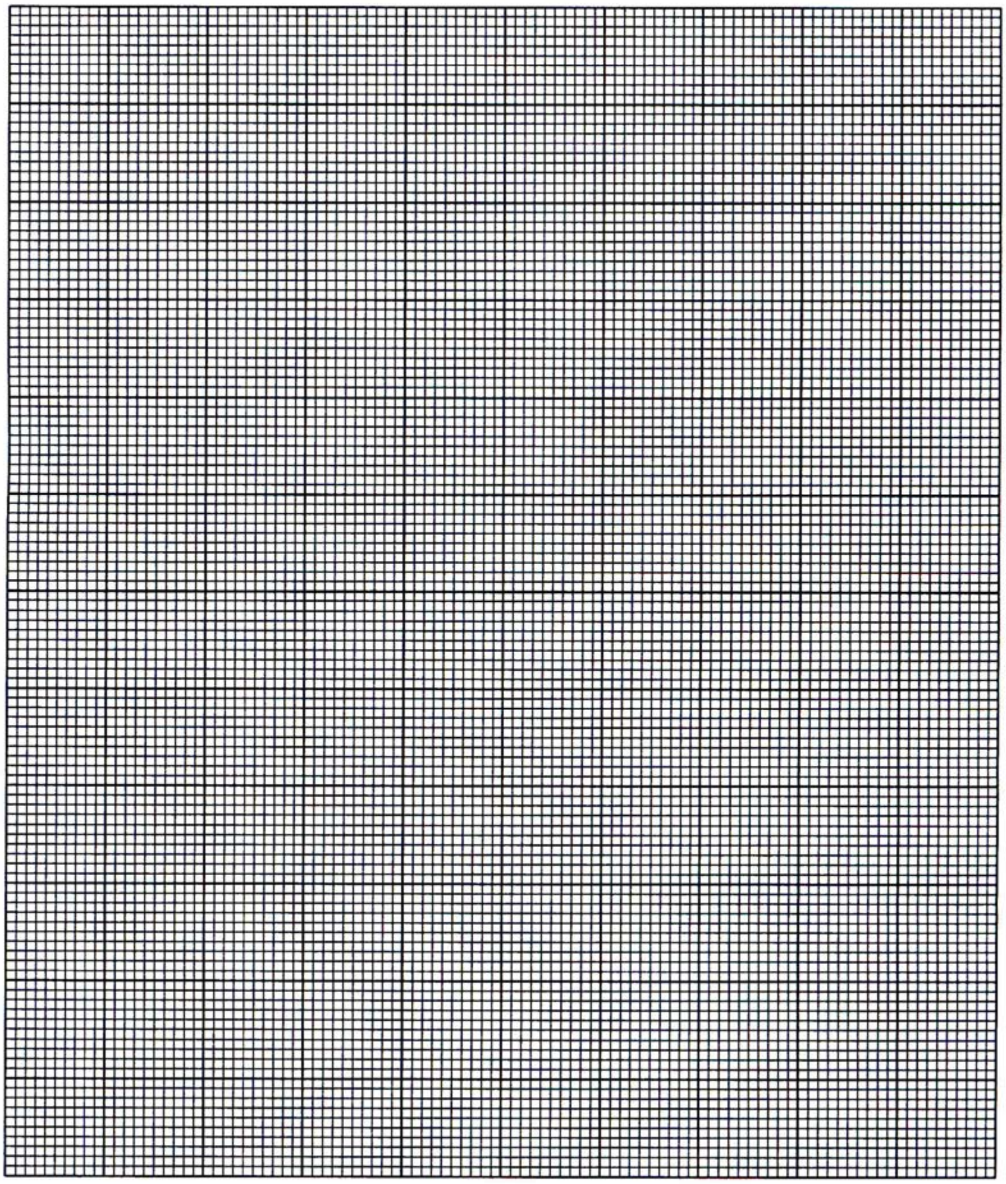


Figure 2-2. Transmitter calibration curve.

Exercise 3

Calibration of a Differential Pressure Transmitter

OBJECTIVES

At the completion of this laboratory exercise, you will be able to calibrate a differential pressure transmitter to a specified pressure range.

DISCUSSION

A differential pressure transmitter may be used for the measurement of liquid level or flow of a fluid in a pipe.

A differential pressure transmitter measures the difference of pressure applied across its measuring element. The differential pressure detected by the differential pressure transmitter is related to a column of fluid by the following relationship:

$$\text{Pressure} \propto \text{Density of fluid} \times \text{Height of fluid}$$

The height of fluid is normally expressed in centimeters or inches of water (cmH_2O or inH_2O). If the density of the fluid remains constant, which is normally the case, then the pressure is directly related to the height of the fluid. Therefore, accurately determined, reproducible pressures can be applied to a differential pressure transmitter by varying the height of a column of fluid of a known density.

Many of the primary elements used for the measurement of fluid flow produce a differential pressure. Some examples are orifice plates, pitot tubes, flow nozzles and venturi tubes. The primary element included with your Flow Process Station is a venturi tube. The transmitter converts the sensed differential pressure to a standard electronic or pneumatic signal used to actuate an indicator or control device.

Calibration of a differential pressure transmitter is the process of matching the zero and full scale outputs of the transmitter to the minimum and maximum differential pressures applied. The actual differential pressures that are to be applied to the differential pressure transmitter are derived from the specific application. As for most transmitters, the two adjustments available for the calibration are the zero and span or range.

It is necessary to determine the upper and lower range values of differential pressures which will be applied to the transmitter. This can be done by measurement using a differential pressure gauge. The gauge is then connected to the flow element while the flow is adjusted from minimum to maximum. These values may also be resolved by calculation, or empirical data collection. These values may also be resolved by calculation, or empirical data collection. In this exercise you will need to refer to the venturi tube flow curve in Appendix A.

The calibration procedure given in this exercise applies to the electronic pressure transmitter used on the Flow Process Station, Model 3502-M (that is, a

Foxboro IDP10-D20 differential pressure transmitter). On this station, the transmitter is used to measure the differential pressure across a venturi tube. The pump on this station can provide flow rates between 0 and 38 L/min (0 and 10 gal/min). The flow curve of the venturi tube (shown in Appendix A) indicates that a differential pressure of 127 cmH_2O (50 inH_2O) approximately will develop across this tube at a flow rate of 38 L/min (10 gal/min) Consequently, the transmitter will be calibrated to provide an output current varying between 4 and 20 mA when the differential pressure across its high and low pressure ports is varied between 0 cmH_2O (0 inH_2O) (lower range value) and 127 cmH_2O (50 inH_2O) (upper range value), respectively.

To calibrate the transmitter for a different pressure range, follow the same procedure in the following way:

- In the *Transmitter Configuration* (first) part of the procedure, set the lower and upper range values (LRV and URV) of the transmitter to the minimum and maximum differential pressures to be measured by the transmitter.

- In the *Transmitter Calibration* (second) part of the procedure, calibrate the lower range value (LRV) of the transmitter by applying the minimum differential pressure to be measured. Calibrate the upper range value (URV) of the transmitter by applying the maximum differential pressure to be measured.

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart in Appendix E to obtain the list of equipment required for this exercise.

PROCEDURE

CAUTION!

Water and electric power are present in this laboratory exercise. Be careful of possible electrical shock hazard.

☐ 1. Remove the Differential Pressure Transmitter from the Flow Process Station and mount it to the pipe stand at the Calibration Bench. If time does not permit this, you may calibrate the transmitter in place at the Flow Process Station.

☐ 2. If the transmitter has been connected to the Flow Process Station, you will need to purge any remaining water before performing an air calibration. (If not, skip this step and go immediately to step 3). Connect a 0.64 cm (1/4 in) tube to the 0-205 kPa (0-30 psi) regulator port on the Calibration Bench. Set the pressure to 41 kPa (6 psi) and connect it to both the high and low pressure vents on the transmitter. Open the transmitter vent plugs and blow any water out of both sides of the transmitter and the sensing lines.

Calibration of a Differential Pressure Transmitter

Note: *A differential pressure transmitter may be calibrated using either water or air pressure. To ensure accuracy, the transmitter must be filled with only one medium, either water or air. A mixture of the two produces calibration errors. If air is used, any water in the differential pressure transmitter causes error due to its weight. Likewise, if water is used, any air in the transmitter causes an error due to its compressibility. Since we are using air for calibration, all water must be removed from the Differential Pressure Transmitter.*

☐ 3. Connect the digital multimeter (DMM) of the Calibration Bench (placed in ammeter mode) and the transmitter to the 24 V dc power supply. Note the polarity as shown in Figure 3-1. The transmitter red supply lead corresponds to the positive (+) lead, while the yellow supply lead corresponds to the common (⏚) lead. The transmitter can deliver a maximum current of 20 mA. Select the proper range on the multimeter. Turn on the 24 V dc power supply. Finally, connect the pneumatic hand pump of the Calibration Bench to the high (H) pressure port of the pressure transmitter.

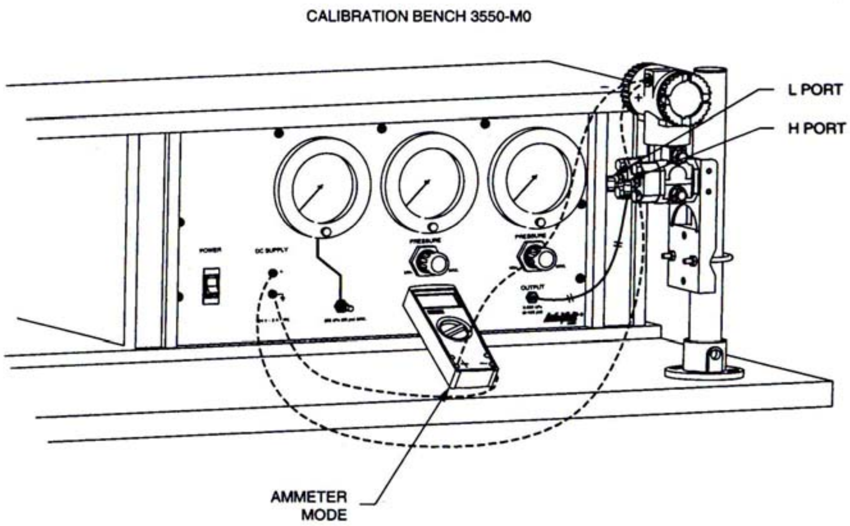


Figure 3-1. Calibration of a Differential Pressure Transmitter.

Transmitter Configuration

☐ 4. Starting from the main display of the transmitter upon power up, press the **Next** transmitter button twice. The transmitter display indicates **CONFIG**. Press the **Enter** transmitter button to access the Configuration menu.

Calibration of a Differential Pressure Transmitter

Note: *After a few minutes of inactivity, the transmitter display will automatically return to the main display.*

☐ 5. Press **Next** several times to advance the display to the **M1 MODE** item. Press **Enter** to select **M1 LIN**, then press **Enter** to accept this selection. This sets the transmitter output mode to linear.

Note: *To linearize the signal provided by the pressure transmitter, the square root function of the Foxboro controller on the Flow Process Station will be used. Note, however, that the pressure transmitter output can be set to either linear or square root mode (SQ<1C or SQL<4L). When it is set to the square root mode, the transmitter pressure units must be user defined by accessing the CUSTM U selection of the transmitter, under the M1 EGU Configuration menu item.*

☐ 6. The display now indicates **M1 EGU**. Press **Enter**.

☐ 7. The display now indicates **PRESS U**. Press **Enter**. Using the **Next** button, select the desired pressure measurement unit (**cmH_2O** or **inH_2O**), then press **Enter** to accept this selection.

☐ 8. The display now indicates **RERANGE**. Press **Enter**.

☐ 9. The display now indicates **M1 URV**. Press **Enter**. The display now shows the default (or last) value for the upper range value. Set this value to "127.00" cmH_2O ("050.00" inH_2O) by performing the following steps:

a. The first digit is flashing. Using the **Next** button, select the desired digit ("1" in cmH_2O mode or "0" in inH_2O mode), then press **Enter** to accept your selection.

b. The second digit is flashing. Using **Next**, select the desired digit ("2" in cmH_2O mode or "5" in inH_2O mode), then press **Enter**.

c. Repeat step b in order to set the three remaining digits to "7", "0", and "0" respectively in cmH_2O mode (set the three remaining digits to "0" in inH_2O mode).

d. The display now indicates **Place DP** (decimal point). Using **Next**, move the decimal point until it is located between the third and fourth digits, then press **Enter** to accept the upper range value setting (127.00 in cmH_2O mode or 050.00 in inH_2O mode).

☐ 10. The display now indicates **M1 LRV**. Press **Enter**. The display now shows the default (or last) value for the lower range value. Set this value to "000.00" by performing the following steps:

a. The first digit is flashing. Using the **Next** button, select the desired digit (0), then press **Enter**. Your selection is entered and the second digit is flashing.

b. Repeat step a in order to set the four remaining digits to 0.

c. The display now indicates **Place DP** (decimal point). Using **Next**, move the decimal point until it is located between the third and fourth digits, then press **Enter** to accept the lower range value setting (000.00).

☐ 11. Press **Next** several times to advance the display to the **SAVE** item, then press **Enter** to save your configuration settings and to return to the main display.

Transmitter Calibration

☐ 12. Press **Next** once in order for the transmitter display to indicate **CALIB**. Press **Enter** to access the calibration menu.

☐ 13. The display now indicates **CAL ATO**. With the minimum pressure being applied to the transmitter, press **Enter** to accept this pressure value and wait until the transmitter indicates **ATOdone**. This confirms that the calibration has been done at zero pressure.

☐ 14. Press **Next** once to advance the display to the **CAL LRV** item. With the minimum pressure still applied to the transmitter, press **Enter** to accept this pressure value as the lower range value and wait until the display indicates **LRVdone**. This confirms that the calibration has been done at 0% of the transmitter range. The ammeter reading corresponds to the minimum transmitter output current (4.0 mA approximately).

☐ 15. Press **Next** once to advance the display to the **CAL URV** item. Using the pneumatic air pump, apply a pressure of 127.0 cmH_2O (50.0 inH_2O) approximately to the transmitter, as read on the transmitter display. Press **Enter** to accept this pressure value as the upper range value and wait until the display indicates **URVdone**. This confirms that the calibration has been done at 100% of the transmitter range. The ammeter reading at the upper range value corresponds to the maximum transmitter output current (20.0 mA approximately).

☐ 16. Press **Next** several times until you reach the **SAVE** item. Press **Enter** to save your calibration settings and return to the main display.

Calibration of a Differential Pressure Transmitter

Note: *During transmitter configuration or calibration, a single change can affect other parameters. Consequently, if you enter a value in error, re-examine all the values previously entered or momentarily disconnect the transmitter positive (+) supply lead from the 24 V dc power supply to restore the transmitter to its starting configuration and redo the procedure.*

☐ 17. Now that the differential pressure transmitter is calibrated, disassemble the calibration circuit and mount the transmitter on the Flow Process Station.

☐ 18. Connect the Differential Pressure Transmitter to the Calibration Bench as shown in Figure 3-2.

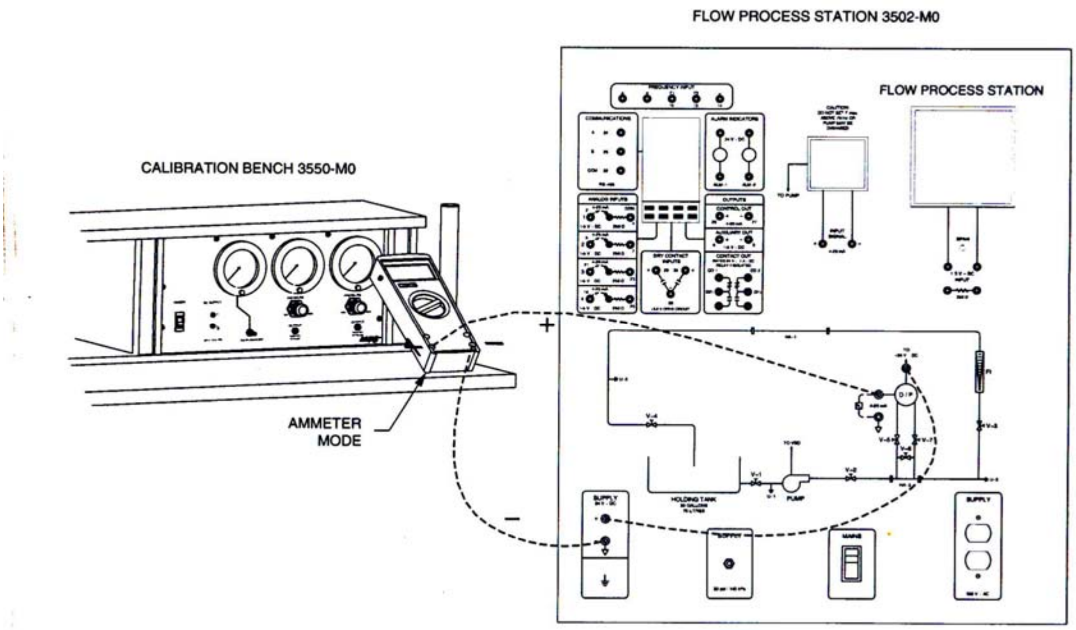


Figure 3-2. Flow Loop.

☐ 19. Using the Variable Speed Drive in manual mode, set a low flow rate and carefully bleed any air remaining in the transmitter. Use a cup to collect the water purged through the transmitter vent.

☐ 20. Complete the transmitter calibration data sheet and verify the transmitter calibration for the full calibration range of 0-127 cmH_2O (0-50 inH_2O). Graph your results.

CONCLUSION

In this exercise you learned to calibrate a differential pressure transmitter. You also learned that a differential pressure transmitter needs to be vented to produce correct readings.

REVIEW QUESTIONS

1. What is the function of a differential pressure transmitter in a low measurement channel?

____

____

____

2. Why is it necessary to purge all water from the transmitter before using air as the calibration medium?

____

____

____

3. Why would have it been better to calibrate the transmitter for a range of 5.3-38 L/min (1.4-10 gal/min)?

____

____

____

4. What would you do if you wanted to control the flow at a very low rate i.e. less than 3.8 L/min (1 gal/min)?

____

____

____

Calibration of a Differential Pressure Transmitter

Calibration of a Differential Pressure Transmitter

CALIBRATION DATA SHEET

APPLICATION DATA

INSTRUMENT NUMBER: ______________

FUNCTION: ______________

LOCATION: ______________

INPUT RANGE: ______________

REQUIRED ACCURACY: ______________

DATE OF CALIBRATION: ______________

INSTRUMENT NAMEPLATE DATA

MANUFACTURERS NAME: ______________

MODEL NUMBER: ______________

SERIAL NUMBER: ______________

OUTPUT RANGE: ______________

INPUT	% SPAN	DESIRED OUTPUT	ACTUAL OUTPUT	REMARKS
	0			
	25			
	50			
	75			
	100			
	75			
	50			
	25			
	0			

ALARMS

ALARM FUNCTION : ______________

ALARM SETTINGS:

LOW SETPOINT	ACTUAL TRIP POINT	HIGH SETPOINT	ACTUAL TRIP POINT

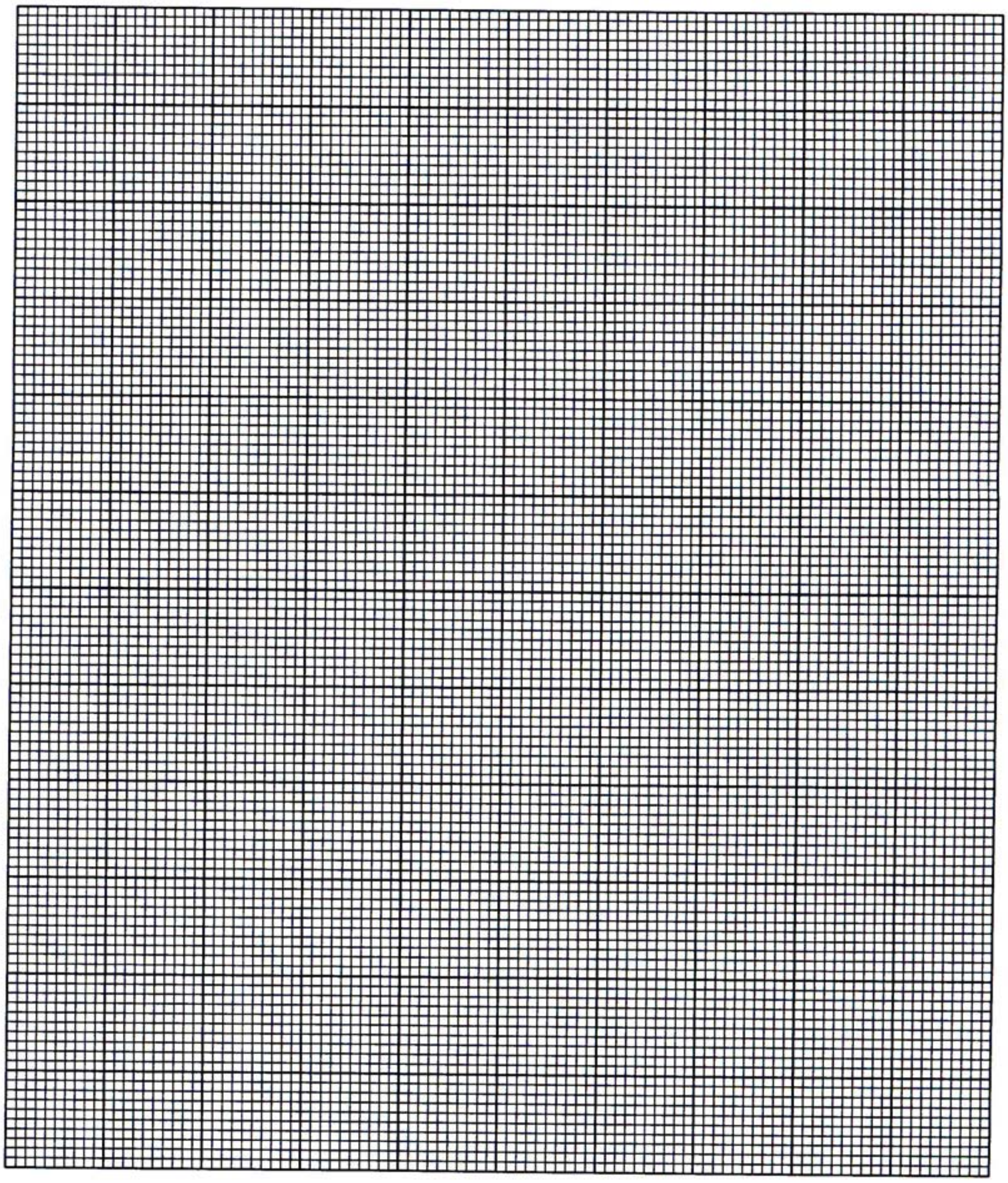


Figure 3-3. Differential pressure transmitter calibration curve.

Exercise 4

Calibration of a Temperature Transmitter

OBJECTIVES

At the completion of this laboratory exercise, you will be able to calibrate a thermocouple transmitter to a specified pressure range.

DISCUSSION

In 1821, Thomas Seebeck discovered that when two wires of dissimilar metals are joined at both ends and one end is heated, a continuous current flows in the circuit. When this circuit is broken, the open circuit voltage is a function of the temperature at the junction of the two wires, and the composition of the two metals. This type of junction is also known as a thermocouple junction.

Standard configurations of thermocouples using specific metals have been adopted and given letter designations. Each type has its own characteristics, such as range, linearity, sensitivity and so on. For instance, type J and K thermocouples are noted for their high sensitivity, while type R and S offer a much larger possible range of measurement at a lower sensitivity. Voltage versus temperature tables are available for many types of thermocouples. In this exercise you will calibrate a temperature transmitter using a type J thermocouple.

As for most transmitters, this thermocouple transmitter has two adjustments that relate the output signal to the sensed temperature. These adjustments are the zero and span or range. Calibration of the transmitter is the process of matching the lower and upper output values of the transmitter to the minimum and maximum temperatures to be measured.

The Thermocouple Transmitter mounted on your Temperature Process Station is factory calibrated at -18-204°C (0-400°F) to be compatible with the range of the oven. For this exercise we will calibrate the transmitter from 0 to 100°C (32 to 212°F) so that we may check the calibration using an ice bath and boiling water bath.

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart in Appendix E to obtain the list of equipment required for this exercise.

PROCEDURE

CAUTION!

Water and electric power are present in this laboratory exercise. Be careful of possible electrical shock hazard.

☐ 1. Remove the Thermocouple Transmitter from the Temperature Process Station and mount it to the pipe stand at the Calibration Bench.

☐ 2. If the thermocouple is already installed on the transmitter, note the manner in which the leads are connected so as to ensure proper reconnection. Remove the thermocouple leads from the transmitter.

Note: *For a J type thermocouple, the white wire is positive (+) and the red wire negative (-).*

☐ 3. Set the digital calibrator of the Calibration Bench for a millivolt output. Connect the leads to the thermocouple input on the transmitter. Connect the output of the transmitter in series with the 24 V dc Power Supply and the digital multimeter (DMM) of the Calibration Bench (placed in ammeter mode). Note the circuit polarity as shown in Figure 4-1.

☐ 4. From the type J thermocouple data table provided in Appendix B, determine the millivolt readings for 0°C (32°F) and 100°C (212°F). Record them on the Calibration Data Sheet.

☐ 5. Open the access cover on the transmitter. Set switch S6 to OFF for a 4-20 mA output. Set switches 1 to 5 for a type J thermocouple, 100°C (212°F) span (S1, S3, S4: ON; S2, S5: OFF).

Note: *The Thermocouple Transmitter on the Temperature Process Station is more complex than the standard transmitter described in the previous discussion. The zero and span/range adjustments are located behind the central plate and are accessible by loosening the two thumbscrews and pulling forward. The dip switches set the type of thermocouple and the desired range. In addition, there are coarse and fine adjustments screws for both zero and span/range. Consult your Temperature Process Station Instruction Manual (75944-D0) for further information.*

☐ 6. Turn on the Thermocouple Transmitter and digital calibrator. Set the calibrator output to the millivolt value corresponding to 0°C (32°F) and adjust the coarse zero to obtain approximately 4 mA on the DMM. Adjust the fine zero to obtain exactly 4 mA.

☐ 7. Set the calibrator output to the millivolt value corresponding to 100°C (212°F) and adjust the coarse and fine span to obtain a reading of 20 mA on the DMM.

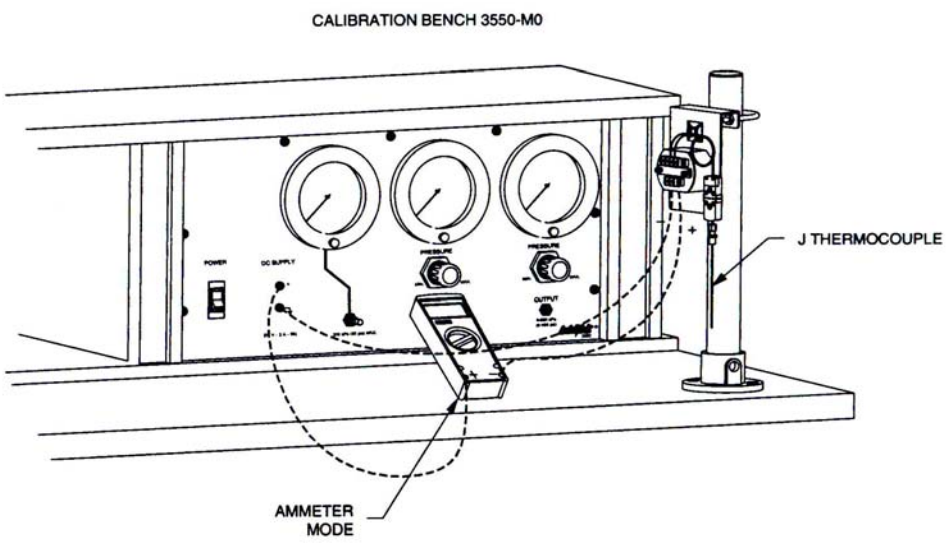


Figure 4-1. Calibration of a Thermocouple Transmitter.

☐ 8. It may be necessary to repeat steps 6 and 7 several times due to interaction between the zero and span/range adjustments.

☐ 9. From the type J thermocouple data table provided in Appendix B, determine the thermocouple input voltage corresponding to each of the percentages listed in the % SPAN column in the Calibration Data Sheet.

☐ 10. Calculate the values of the desired transmitter output that correspond to the % SPAN values listed on the Calibration Data Sheet. Record these values in the DESIRED OUTPUT column of the Calibration Data Sheet.

☐ 11. Adjust the digital calibrator to each of the Thermocouple Input Voltage values recorded in the INPUT column of the Calibration Data Sheet. Record the corresponding transmitter output signal in the ACTUAL OUTPUT column of the Calibration Data Sheet.

Note: *The Temperature Transmitter output at each input temperature must be accurate to within ±2% of span. If a difference greater than these accuracy limits exists at any data point, contact your instructor.*

☐ 12. Turn the Transmitter and digital calibrator OFF and reconnect the thermocouple leads to the proper terminals inside the Thermocouple Transmitter.

☐ 13. Turn the Thermocouple Transmitter power ON and use the ice bath and boiling water bath to check your calibration. Allow time for readings to stabilize and record the values obtained.

☐ 14. Turn the Transmitter Power Supply OFF and disassemble the calibration circuit.

CONCLUSION

In this exercise, your learned to calibrate a thermocouple transmitter for measuring temperatures. You learned that the millivolt output of the thermocouple rises in proportion to the temperature applied. This signal is then converted to a standard output range by the transmitter. You then set up a test circuit to check your calibration. It was found that your test was very close to your calibration and that any differences were dues to the inability to produce the ideal lower and upper temperatures for comparison.

REVIEW QUESTIONS

1. What type of signal is generated by the thermocouple itself?

____

____

____

2. The thermocouple transmitter is, in a sense, a dual purpose instrument. What two functions does it perform?

____

____

____

3. What effect would a change in reference junction temperature have on the transmitter output current? Explain.

____

____

____

4. Assuming an ice bath was not used to calibrate the transmitter, how would the thermocouple input voltage be compensated for the temperature of the reference junction?

____

____

____

Calibration of a Temperature Transmitter

Calibration of a Temperature Transmitter

CALIBRATION DATA SHEET

APPLICATION DATA

INSTRUMENT NUMBER: ______________

FUNCTION: ______________

LOCATION: ______________

INPUT RANGE: ______________

REQUIRED ACCURACY: ______________

DATE OF CALIBRATION: ______________

INSTRUMENT NAMEPLATE DATA

MANUFACTURERS NAME: ______________

MODEL NUMBER: ______________

SERIAL NUMBER: ______________

OUTPUT RANGE: ______________

INPUT	% SPAN	DESIRED OUTPUT	ACTUAL OUTPUT	REMARKS
	0			
	25			
	50			
	75			
	100			
	75			
	50			
	25			
	0			

ALARMS

ALARM FUNCTION : ______________

ALARM SETTINGS:

LOW SETPOINT	ACTUAL TRIP POINT	HIGH SETPOINT	ACTUAL TRIP POINT

Calibration of a Temperature Transmitter

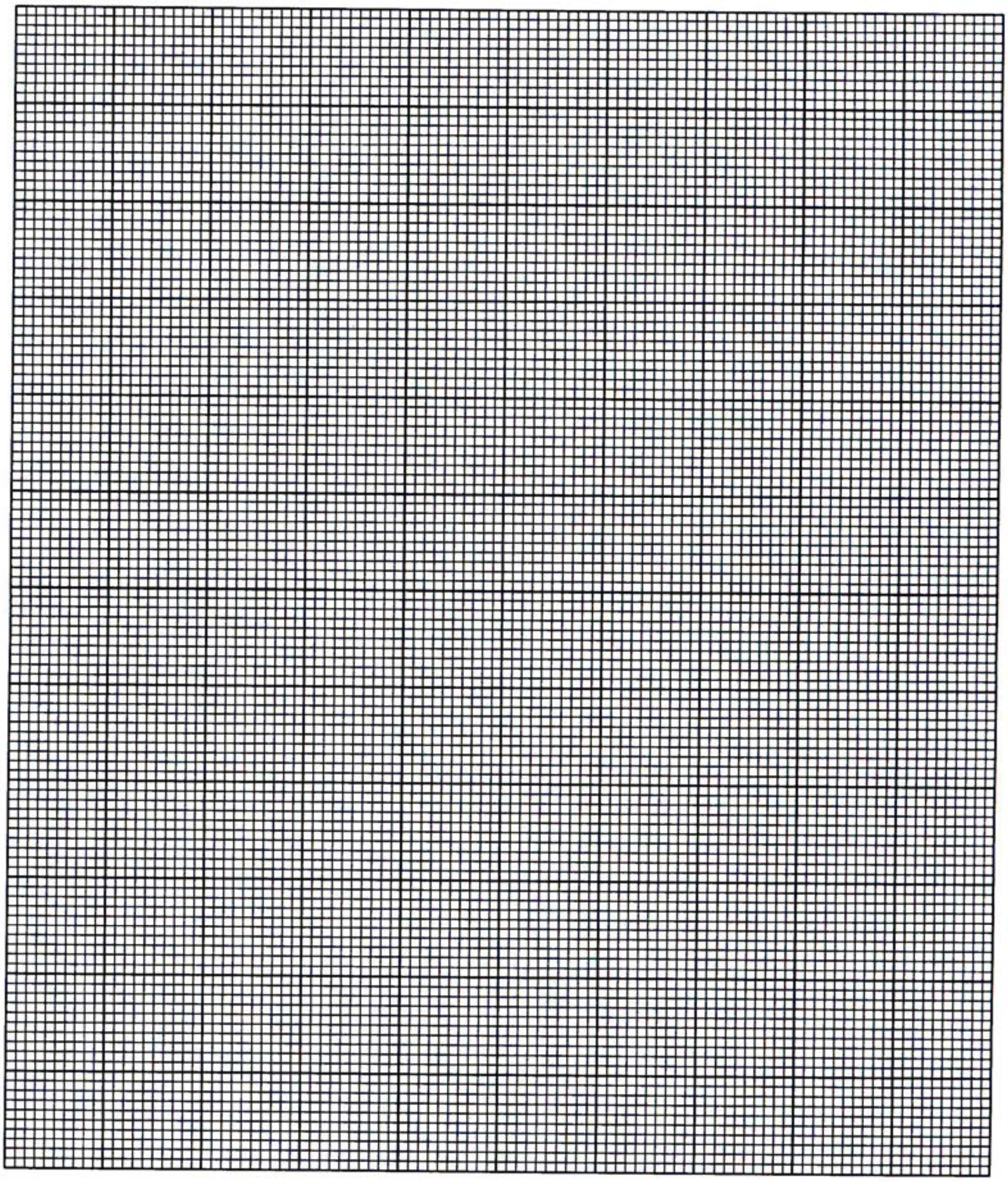


Figure 4-2. Temperature Transmitter Calibration Curve.

Exercise 5

Calibration of a Current to Pressure Converter

OBJECTIVES

At the completion of this laboratory exercise, you will be able to calibrate a current to pressure converter.

DISCUSSION

Current to pressure converters, or simply I/P converters, are used in a number of measurement and control applications. This converter linearly translates a 4 to 20 mA current into a 20 to 102 kPa (3 to 15 psi) signal. They are most frequently used to convert the output of an electronic controller to the pneumatic signal necessary to operate diaphragm actuated control valves. They are also found in pneumatic control systems where long distances between components are found. The pneumatic signal is changed to an electrical signal for transmission, and then converted back to pneumatic signal at the receiver. This reduces transmission lag, which is the major concern in pneumatic instrument loops.

There are many designs for these detectors, but the basic principle almost always involves the use of a nozzle/flapper system. The nozzle/flapper, shown in Figure 5-1, is a subassembly used to convert a mechanical motion into a pressure change. When a current flows through the coil, a force is produced which tends to pull the flapper down and reduce the gap between the flapper and the nozzle. Typically, if the flapper/nozzle clearance changes from 0.0038 cm (0.0015 inch) to 0.0025 cm (0.0010 inch), the nozzle back pressure changes from 20 kPa (gage) (3 psig) to 102 kPa (gage) (15 psig). The result of the increase in signal current, therefore, is an increase in air output pressure.

Two adjustment are available for calibration on the I/P converter. These adjustments are the zero, and span or range. The zero adjustment simply moves the armature bar up or down by adjusting the applied spring force. The range adjustment screw shunts a portion of the magnetic flux away from the permanent magnet. When the screw is turned in, the repulsion force produced by the interaction of the coil and the permanent magnet is less for the same input signal current. Calibration of the converter is the process of matching the lower and upper output values of the converter to the minimum and maximum signal current applied.

Calibration of a Current to Pressure Converter

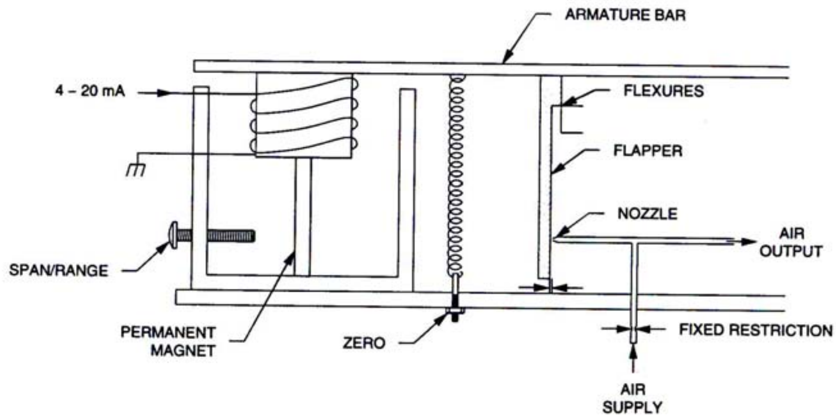


Figure 5-1. Simple Current to Pressure Converter.

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart in Appendix E to obtain the list of equipment required for this exercise.

PROCEDURE

☐ 1. Move the Pressure Process Station (3501-M0) next to the Calibration Bench. If this is not possible, or a Pressure Process Station is not available, an I/P converter can also be found on the Level Process Station, Model 3503.

☐ 2. Connect 0.64 cm (¼ inch) tubing from the I/P Converter output port to the 0 to 205 kPa (0 to 30 psi) gauge on the Calibration Bench. Refer to Figure 5-2.

☐ 3. Connect 0.64 cm (¼ inch) tubing from the 0 to 205 kPa (0 to 30 psi) regulator port on the Calibration Bench to the I/P Converter supply. Attach a male "Eastman" fitting to the end of the tubing which connects to the regulator port. Set the regulator for minimum pressure.

☐ 4. Set the digital calibrator of the Calibration Bench for a current output. Connect the leads to the 4-20 mA current input on the converter.

Calibration of a Current to Pressure Converter

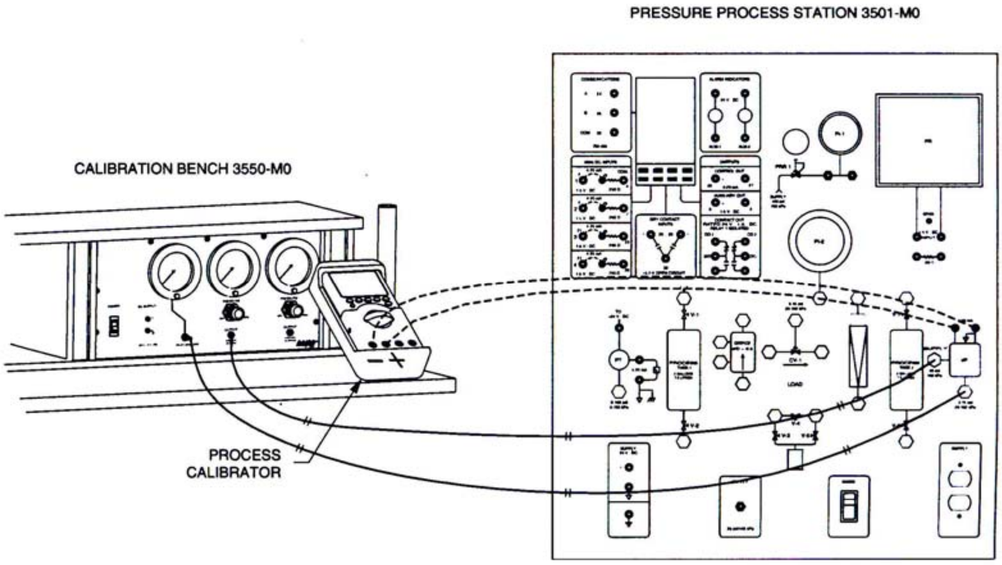


Figure 5-2. Calibration of a I/P Converter.

☐ 5. Turn on the Calibration Bench and digital calibrator. Adjust the 0 to 205 kPa (0 to 30 psi) regulator for an output pressure of 138 kPa (20 psi) to the I/P converter supply.

☐ 6. Remove the protective plastic plugs from the zero and span/range access holes.

☐ 7. Set the calibrator output to 4 mA and adjust the zero adjusting screw to obtain a reading of 20 kPa (3 psi) on the pressure gauge of the Calibration Bench.

> **Note:** *Turn the zero adjusting screw, located in the zero access hole, counterclockwise to increase the pressure or clockwise to decrease the pressure at the I/P output port.*

☐ 8. Set the calibrator output to 20 mA and adjust the span/range adjusting screw, located in the range access hole, to obtain a reading of 102 kPa (15 psi) on the pressure gauge of the Calibration Bench.

☐ 9. It may be necessary to repeat steps 7 and 8 several times due to interaction between the zero and span/range adjustments.

☐ 10. Complete the Calibration Data Sheet and verify your calibration. Graph your results.

☐ 11. Adjust the 0 to 205 kPa (0 to 30 psi) regulator of the Calibration Bench for an output pressure of 205 kPa (30 psi).

☐ 12. Without changing your calibration, record the I/P Converter output pressure for the following input current signal:

INPUT CURRENT (mA)	I/P OUTPUT PRESSURE (kPa (psi))
4	
20	

Table 5-1. I/P pressure versus input current.

☐ 13. Turn the Calibration Bench and digital calibrator OFF. Replace the protective plastic plugs in the zero and range access holes. Disassemble the calibration circuit.

CONCLUSION

In this exercise, you learned to calibrate a current to pressure converter. You also learned that I/P converters are frequently used in process control systems. Their design is based on a flapper/nozzle system which converts a mechanical motion into a pressure change.

REVIEW QUESTIONS

1. What is one of the main disadvantages of the I/P Converter design of Figure 5-1?

____

____

____

2. From the data recorded at step 12, calculate the effect that variation in the supply pressure would have on the I/P outlet pressure. Express your result in percentage of full scale per 6.9 kPa (1 psi) change in supply pressure.

3. For the typical I/P converter specified in the discussion, how much should the flapper move with respect to the nozzle to create a 5 kPa (0.5 psi) change in output?

Calibration of a Current to Pressure Converter

Calibration of a Current to Pressure Converter

CALIBRATION DATA SHEET

APPLICATION DATA

INSTRUMENT NUMBER: ______________

FUNCTION: ______________

LOCATION: ______________

INPUT RANGE: ______________

REQUIRED ACCURACY: ______________

DATE OF CALIBRATION: ______________

INSTRUMENT NAMEPLATE DATA

MANUFACTURERS NAME: ______________

MODEL NUMBER: ______________

SERIAL NUMBER: ______________

OUTPUT RANGE: ______________

INPUT	% SPAN	DESIRED OUTPUT	ACTUAL OUTPUT	REMARKS
	0			
	25			
	50			
	75			
	100			
	75			
	50			
	25			
	0			

ALARMS

ALARM FUNCTION : ______________

ALARM SETTINGS:

LOW SETPOINT	ACTUAL TRIP POINT	HIGH SETPOINT	ACTUAL TRIP POINT

Calibration of a Current to Pressure Converter

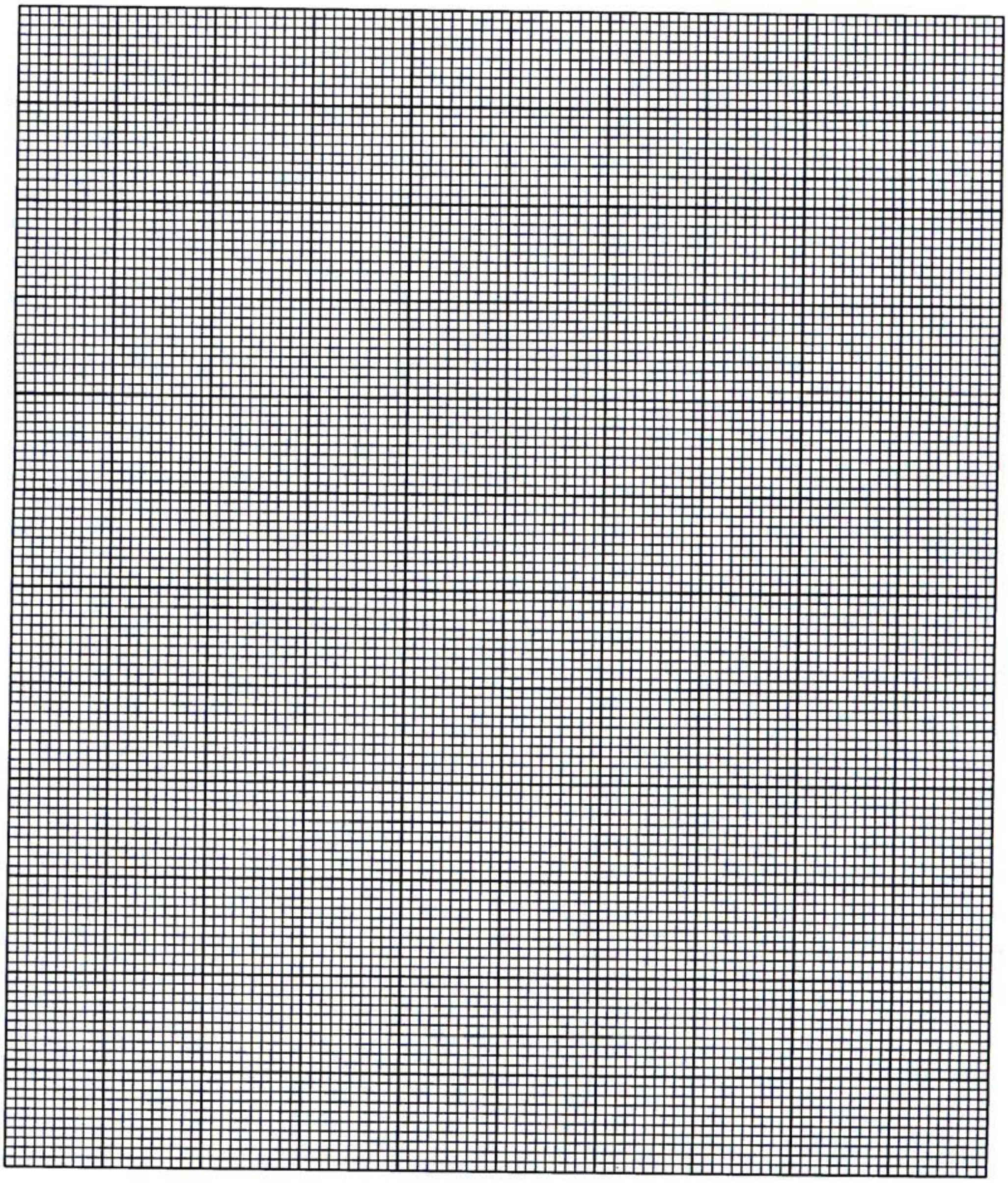


Figure 5-3. Current-to-Pressure Converter Calibration.

Exercise 6

Calibration of a Strip Chart Recorder

OBJECTIVES

At the completion of this laboratory exercise, you will be able to calibrate an Electronic Chart Recorder for use as an indicating device.

DISCUSSION

The strip chart recorder is a device that is used extensively in the process industry. It is used to provide indication and to record the magnitude and changes in magnitude of a process variable with respect to time. This recording can be a continuous trace made by a pen, or it can be made up of a series of printed characters or dots. The strip chart recorder that you will be calibrating uses a pen to provide a continuous trace recording of the magnitude of the input signal.

The recorder operates on the automatic null balance principle using a high gain, narrow band servo amplifier as shown in Figure 6-1. A reversing servo motor and a mechanical linkage is used to drive the cursor of a calibrated variable resistor. This method is used to produce a variable reference voltage (V_R) which, when compared with the signal input voltage (V_I) creates an error signal. Any non-zero error signal will drive the servo motor in the proper direction to bring the system back to a null position called balance. To record the signal input voltage only requires a mechanical linkage between the variable resistor cursor and in ink pen.

A zero adjust on the strip chart recorder front panel allows the pen to be set at any position on the chart, while the span adjustment calibrates the full scale deflection.

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart in Appendix E to obtain the list of equipment required for this exercise.

Calibration of a Strip Chart Recorder

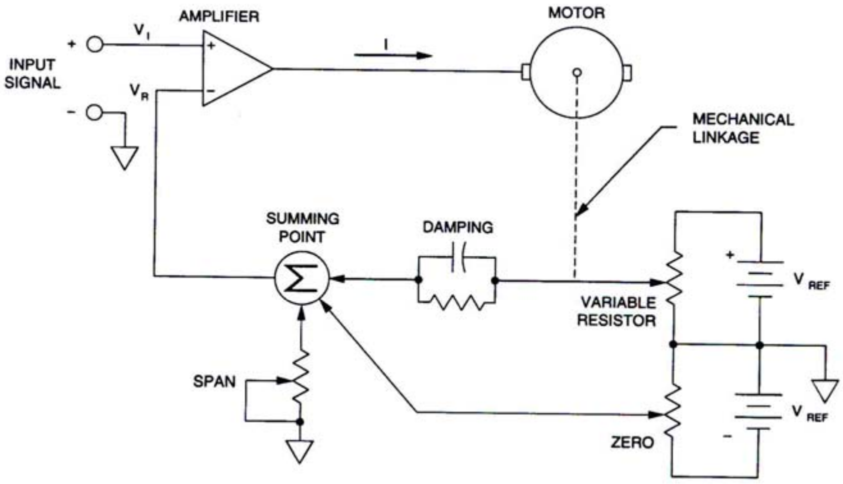


Figure 6-1. Chart Recorder functional schematic.

PROCEDURE

☐ 1. Move the Level Process Station next to the Calibration Bench. If a Level Process Station is not available, a Strip Chart Recorder can also be found on any other Mobile Process Station.

☐ 2. Set the digital calibrator of the Calibration Bench for a voltage output. Connect the leads to the 15 V dc input on the recorder as shown in Figure 6-2.

☐ 3. Turn the Level Process Station MAINS switch to ON. Open the Strip Chart Recorder protective cover. Set the recorder chart speed selector to OFF and turn the power switch to ON.

☐ 4. Turn the digital calibrator power ON.

> **Note:** *Remove the protective cap over the pen tip and set the recorder chart drive to HI speed. Attach the resulting trace of your calibration to the Calibration Data Sheet. Always install the protective cap over the pen tip when the recorder is not used.*

Calibration of a Strip Chart Recorder

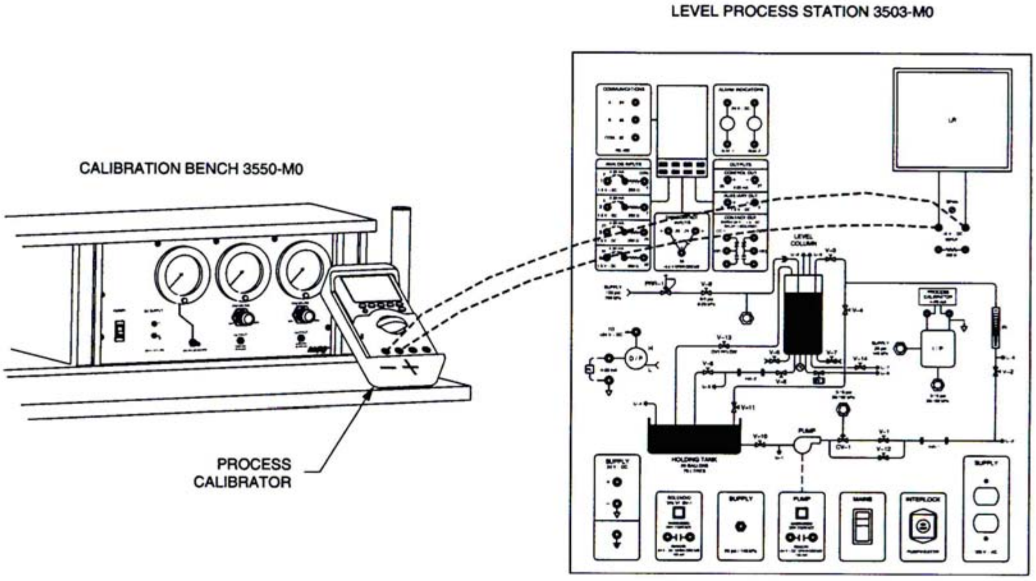


Figure 6-2. Calibration of a Strip Chart Recorder.

☐ 5. Set the calibrator output to 1 V dc and adjust the Strip Chart Recorder zero adjusting screw until the pen tip registers 0% of chart scale indication.

☐ 6. Set the calibrator output to 5 V dc and adjust the Strip Chart Recorder span adjusting screw, located below the recorder, until the pen tip registers 100% of chart scale indication.

☐ 7. It may be necessary to repeat steps 5 and 6 several times due to interaction between the zero and span/range adjustments.

☐ 8. Complete the Calibration Data Sheet and verify your calibration.

☐ 9. Turn the Strip Chart Recorder, Level Process Station, and Digital Calibrator power OFF. Disassemble the calibration circuit.

CONCLUSION

In this exercise you gained experience at calibrating an electronic strip chart recorder.

REVIEW QUESTIONS

1. List two advantages of the strip chart recorder.

____

____

____

2. What type of process could the strip chart recorder be used to monitor?

____

____

____

3. What additional components or modifications would be necessary to use a recorder designed to accept a 1 to 5 V dc input to measure a 4 to 20 mA input current?

____

____

____

Calibration of a Strip Chart Recorder

CALIBRATION DATA SHEET

APPLICATION DATA

INSTRUMENT NUMBER: ______________

FUNCTION: ______________

LOCATION: ______________

INPUT RANGE: ______________

REQUIRED ACCURACY: ______________

DATE OF CALIBRATION: ______________

INSTRUMENT NAMEPLATE DATA

MANUFACTURERS NAME: ______________

MODEL NUMBER: ______________

SERIAL NUMBER: ______________

OUTPUT RANGE: ______________

INPUT	% SPAN	DESIRED OUTPUT	ACTUAL OUTPUT	REMARKS
	0			
	25			
	50			
	75			
	100			
	75			
	50			
	25			
	0			

ALARMS

ALARM FUNCTION : ______________

ALARM SETTINGS:

LOW SETPOINT	ACTUAL TRIP POINT	HIGH SETPOINT	ACTUAL TRIP POINT

Calibration of a Strip Chart Recorder

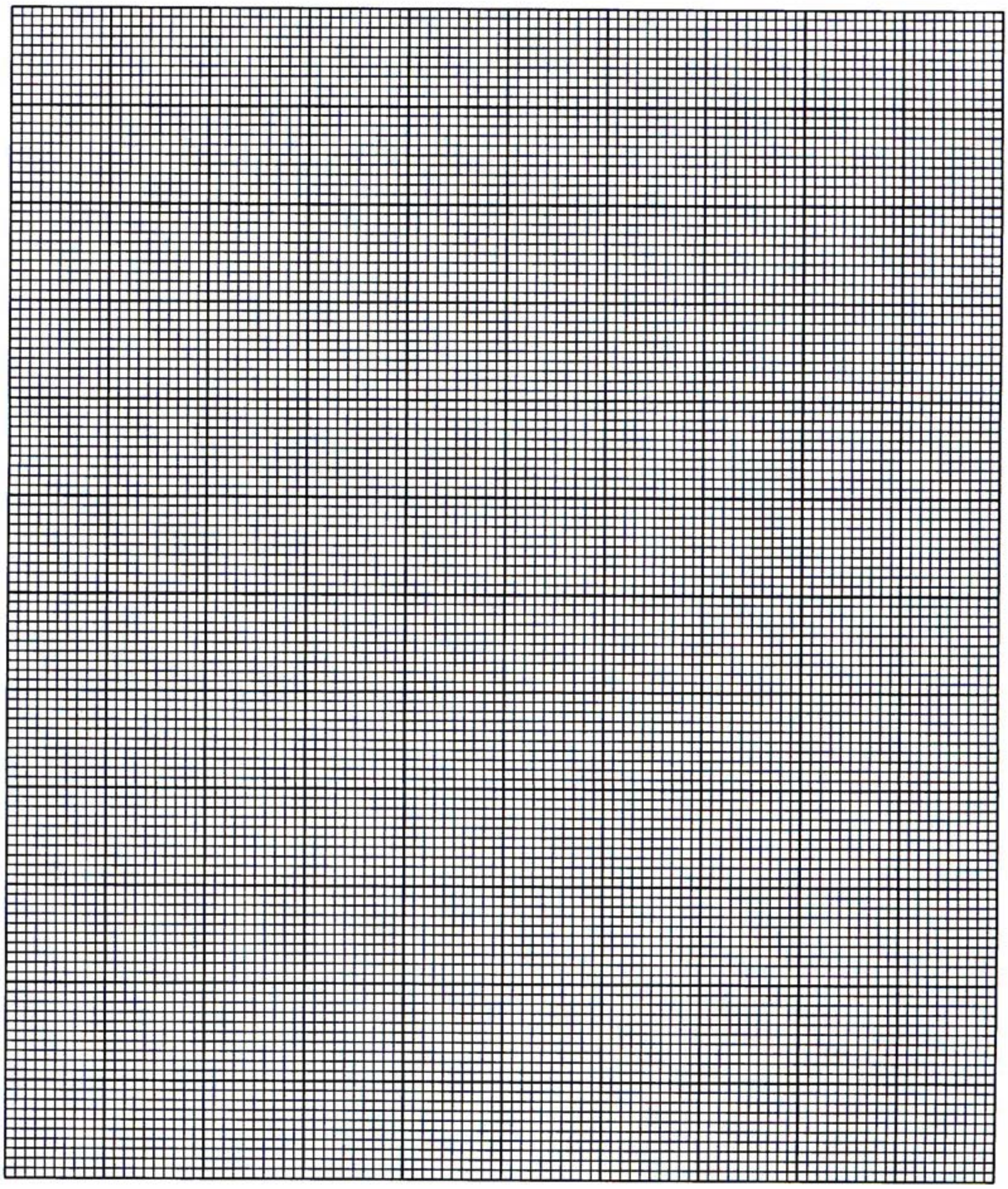


Figure 6-3. Strip Chart Recorder Calibration.

Exercise 7

Alignment of a Control Valve

OBJECTIVES

At the completion of this laboratory exercise, you will be able to align a control valve actuator to a control valve. You will be able to use the nameplate data on the valve, and then set both valve stroke and spring pressure to provide the desired valve characteristics.

DISCUSSION

For a control valve to perform properly, the valve must be capable of being both fully opened and fully closed. Aligning a control valve is simply checking to be sure that with the required range of signal pressure to the control valve actuator that the valve does stroke from fully open to fully closed. The amount of valve travel from open to closed is printed on the nameplate. Other information on the nameplate includes diaphragm pressure range, bench set diaphragm pressure range and valve flow characteristics. The bench set diaphragm pressure range is used to set the valve stroke when the system is depressurized, or when the valve is out of the system. When the valve actuator spring is adjusted under these conditions to the bench set diaphragm pressure range values, the pressure drop in the system may cause the valve to open slightly when the control signal is at the pressure designed to close the valve.

Alignment of a Control Valve

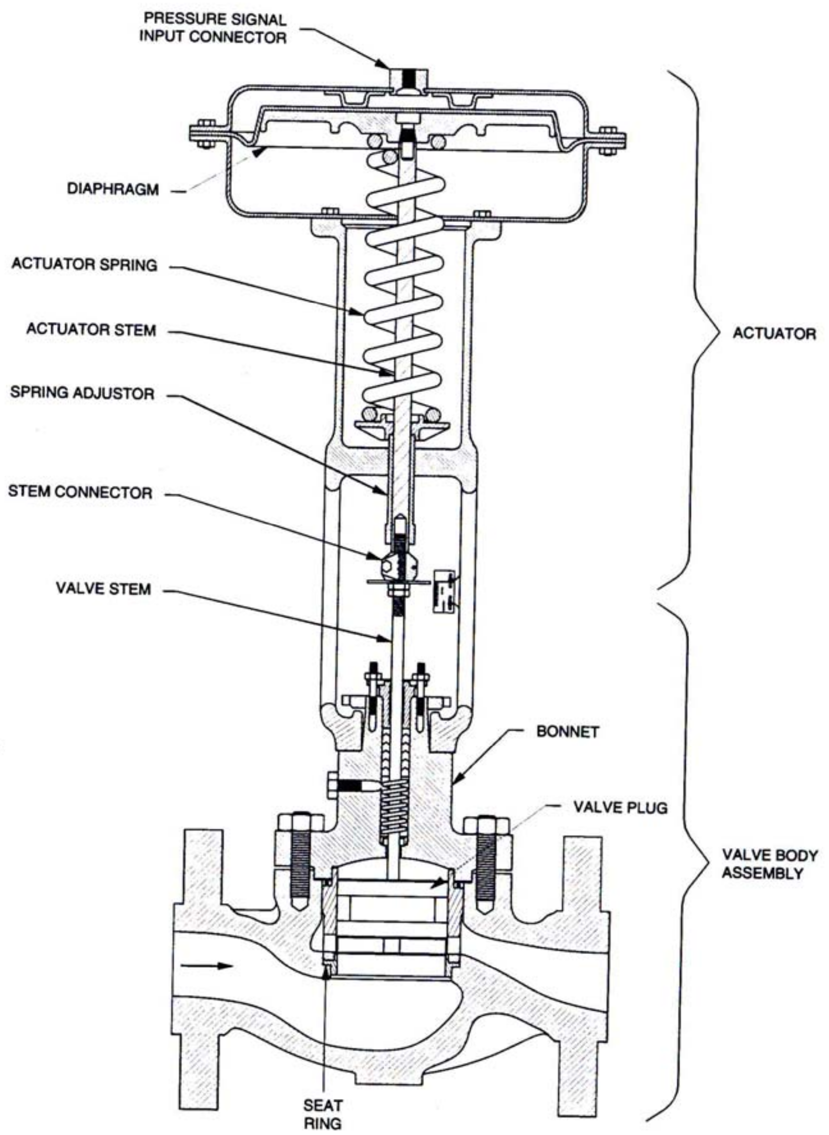


Figure 7-1. Typical Control Valve.

Alignment of a Control Valve

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart in Appendix E to obtain the list of equipment required for this exercise.

PROCEDURE

Alignment of the Control valve

☐ 1. Remove the Control Valve from the Pressure Process Station. You are going to align it for 20 to 102 kPa (3 to 15 psi) input signals.

☐ 2. From the nameplate on the Control Valve, list the following parameters:

Total Valve Stroke . . . . : ________________
Flow Characteristics . . . . : ________________
Diaphragm Pressure Range . . . . : ________________
Bench Set Diaphragm Pressure Range . . . . . : ________________

☐ 3. Make the instrument connections shown in Figure 7-2.

☐ 4. Adjust the pressure regulator on the Calibration Bench to fully open the valve. Using two open-end wrenches, disconnect the actuator stem from the valve stem.

> **Note:** *Refer to the Control Valve Instruction Manual for disassembly and reassembly procedures.*

☐ 5. By pushing down on the valve stem, close the valve.

☐ 6. While using a ruler to estimate actuator stem travel, slowly decrease the pressure applied to the actuator. Stop decreasing pressure when actuator has moved the same distance as the valve stroke.

☐ 7. Attach the stem connector block to the actuator stem and the valve stem.

Alignment of a Control Valve

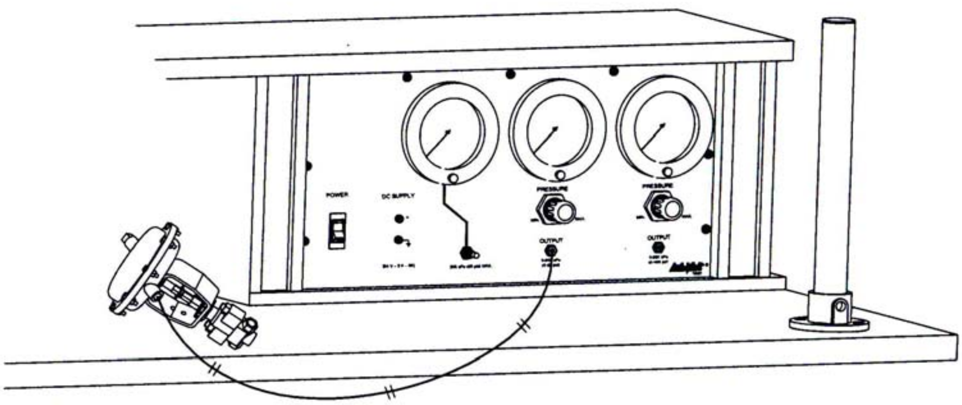


Figure 7-2. Alignment of a Control Valve.

☐ 8. Reposition the travel indicator disc to indicate 0 valve travel. Tighten the indicator in position with the lock nuts.

☐ 9. While noting the pressure that valve travel starts at, increase the applied pressure to the actuator to the maximum diaphragm pressure valve. The position indicator should be at 100%.

☐ 10. If the pressure noted in step 9 is less than the minimum diaphragm pressure from the nameplate, turn the spring adjuster nut clockwise. Repeat steps 9 and 10 until the starting pressure is correct.

☐ 11. If the pressure noted in step 9 is greater than the minimum diaphragm pressure from the nameplate, turn the spring adjuster nut counterclockwise. Repeat steps 9 and 10 until the starting pressure is correct.

☐ 12. Reduce applied actuator pressure to 0 kPa (0 psi).

Alignment Check of the Control Valve

☐ 13. If available, mount a dial indicator on the valve body so that it will measure the valve stem travel. If not use a ruler.

☐ 14. Increase the diaphragm pressure in steps of 20 kPa (3 psi) and complete the OPENING columns of Table 7-1.

☐ 15. Starting at 120 kPa (18 psi), decrease the diaphragm pressure in 20 kPa (3 psi) steps and complete the CLOSING columns of Table 7-1.

Note: *The difference in readings at the same pressure, on the opening and closing, is due to an effect called hysteresis.*

APPLIED PRESSURE		OPENING		CLOSING	
(kPa)	(psi)	DIAL INDICATOR	POSITION INDICATION	DIAL INDICATOR	POSITION INDICATION
0	0				
20	3				
40	6				
60	9				
80	12				
100	15				
120	18				

Table 7-1. Alignment check of the Control Valve.

CONCLUSION

During the laboratory exercise you have learned how to align a control valve and its diaphragm actuator. A known position that makes a good starting and reference point is the valve in the fully closed position. With the actuator stroke already set to the correct value, and at its lowest point of travel, the valve stem and actuator stem are coupled together. The full stroke upward then results in fully opening the valve.

REVIEW QUESTIONS

1. Why is the valve pushed to its closed seat prior to connecting the valve stem to the actuator stem?

____

____

____

2. What effect does turning the spring adjustment nut clockwise have on the spring compression?

3. What could be done to remove the hysteresis shown by the Station's Control Valve?

4. What would be the effect on the operation of the Station's Control Valve if flow through the valve was reversed?

Appendix A

Venturi Tube Flow Curve

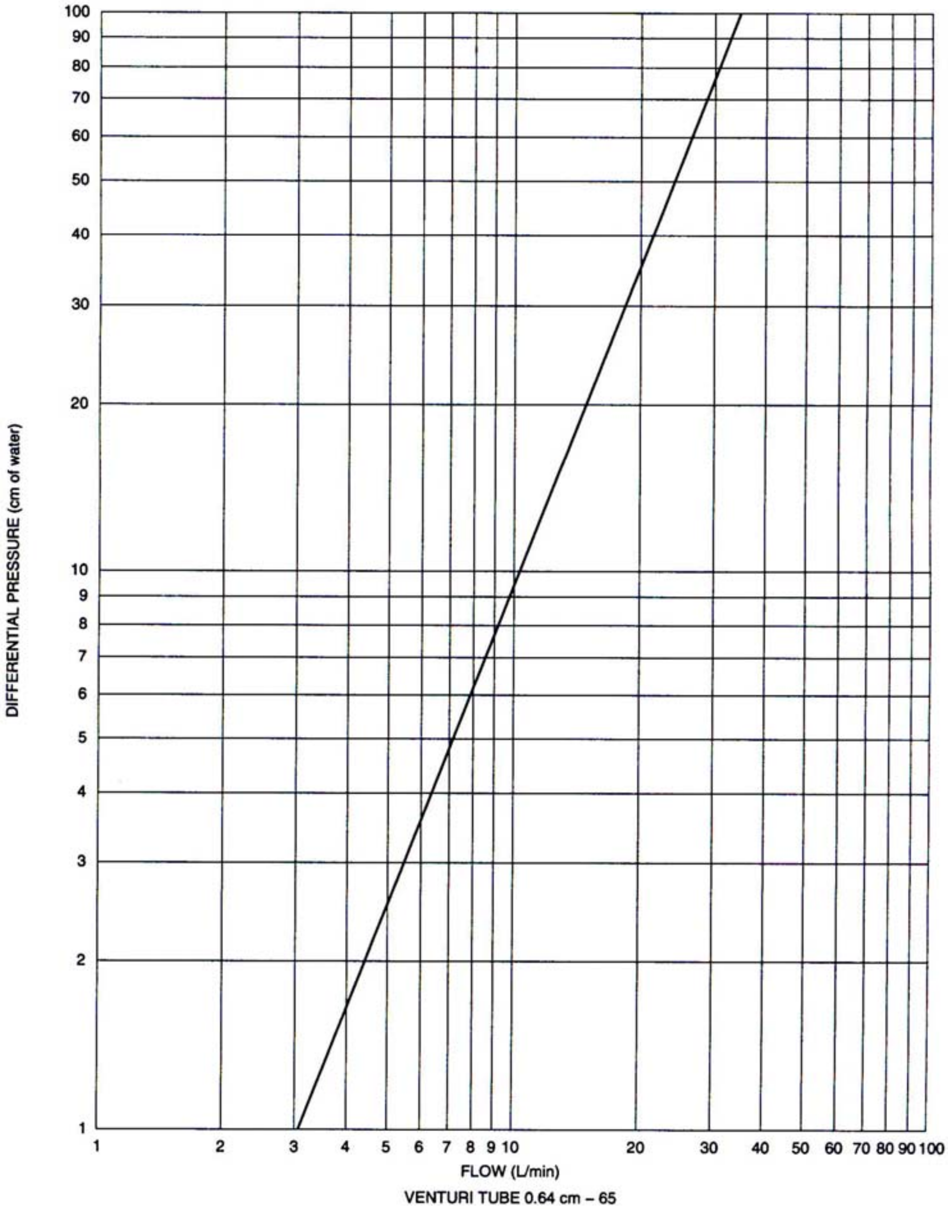


Figure A-1. Venturi Tube Flow Curve.

Venturi Tube Flow Curve

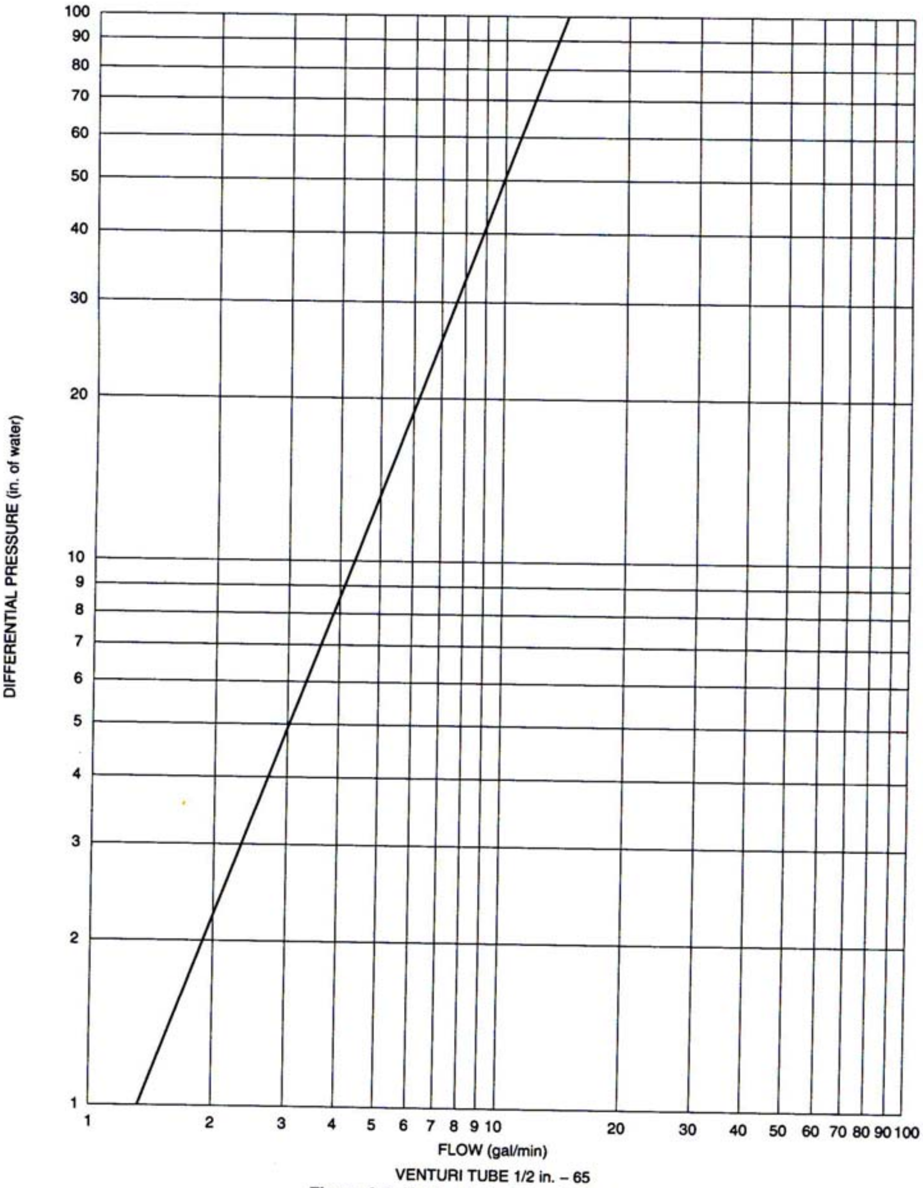


Figure A-2. Venturi Tube Flow Curve.

Appendix B

J Type Thermocouple Table

°C	0	1	2	3	4	5	6	7	8	9	10
0	0	0,05	0,101	0,151	0,202	0,253	0,303	0,354	0,405	0,456	0,507
10	0,507	0,558	0,609	0,66	0,762	0,762	0,813	0,865	0,865	0,916	1,019
20	1,019	1,07	1,122	1,174	1,277	1,277	1,329	1,381	1,381	1,432	1,536
30	1,536	1,588	1,64	1,693	1,797	1,797	1,849	1,901	1,901	1,954	2,058
40	2,058	2,111	2,163	2,216	2,321	2,321	2,374	2,426	2,426	2,479	2,585
50	2,585	2,638	2,691	2,743	2,796	2,849	2,902	2,956	3,009	3,062	3,115
60	3,115	3,168	3,221	3,275	3,328	3,381	3,435	3,488	3,542	3,595	3,649
70	3,649	3,702	3,756	3,809	3,863	3,917	3,971	4,024	4,078	4,132	4,186
80	4,186	4,239	4,293	4,347	4,401	4,455	4,509	4,563	4,617	4,671	4,725
90	4,725	4,78	4,834	4,888	4,942	4,996	5,05	5,105	5,159	5,213	5,268
100	5,268	5,322	5,376	5,431	5,485	5,54	5,594	5,649	5,703	5,758	5,812
110	5,812	5,867	5,921	5,976	6,031	6,085	6,14	6,195	6,249	6,304	6,359
120	6,359	6,414	6,468	6,523	6,578	6,633	6,638	6,742	6,797	6,852	6,907
130	6,907	6,962	7,017	7,072	7,127	7,182	7,237	7,292	7,347	7,402	7,457
140	7,457	7,512	7,567	7,622	7,677	7,732	7,787	7,843	7,898	7,953	8,0085
150	8,008	8,063	8,118	8,174	8,229	8,254	8,339	8,394	8,45	8,505	8,336
160	8,56	8,616	8,671	8,726	8,781	8,837	8,892	8,947	9,003	9,058	9,113
170	9,113	9,169	9,224	9,279	9,335	9,39	9,446	9,501	9,556	9,612	9,667
180	9,667	9,723	9,778	9,834	9,889	9,944	10	10,055	10,111	10,166	10,222
190	10,222	10,277	10,333	10,388	10,444	10,499	10,555	10,61	10,666	10,721	10,777

Table B-1. Temperature-versus-millivolt conversion table for a J-type thermocouple.

J Type Thermocouple Table

°F	0	1	2	3	4	5	6	7	8	9	10
0	-0.886	-0.858	-0.831	-0.803	-0.776	-0.749	-0.721	-0.694	-0.666	-0.639	-0.611
10	-0.611	-0.583	-0.556	-0.528	-0.501	-0.473	-0.445	-0.418	-0.390	-0.362	-0.334
20	-0.334	-0.307	-0.279	-0.251	-0.223	-0.195	-0.168	-0.140	-0.112	-0.084	-0.056
30	-0.056	-0.028	0.000	0.028	0.056	0.084	0.112	0.140	0.168	0.196	0.225
40	0.225	0.253	0.281	0.309	0.337	0.365	0.394	0.422	0.450	0.478	0.507
50	0.507	0.535	0.563	0.592	0.620	0.649	0.677	0.705	0.734	0.762	0.791
60	0.791	0.819	0.848	0.876	0.905	0.933	0.962	0.991	1.019	1.048	1.076
70	1.076	1.105	1.134	1.162	1.191	1.220	1.249	1.277	1.306	1.335	1.364
80	1.364	1.392	1.421	1.450	1.479	1.508	1.537	1.566	1.594	1.623	1.652
90	1.652	1.681	1.710	1.739	1.768	1.797	1.826	1.855	1.884	1.913	1.942
100	1.942	1.972	2.001	2.030	2.059	2.088	2.117	2.146	2.175	2.205	2.234
110	2.234	2.263	2.292	2.322	2.351	2.380	2.409	2.439	2.468	2.497	2.527
120	2.527	2.556	2.585	2.615	2.644	2.673	2.703	2.732	2.762	2.791	2.821
130	2.821	2.850	2.880	2.909	2.938	2.968	2.997	3.027	3.057	3.086	3.116
140	3.116	3.145	3.175	3.204	3.234	3.264	3.293	3.323	3.353	3.382	3.412
150	3.412	3.442	3.471	3.501	3.531	3.560	3.590	3.620	3.650	3.679	3.709
160	3.709	3.739	3.769	3.798	3.828	3.858	3.888	3.918	3.948	3.977	4.007
170	4.007	4.037	4.067	4.097	4.127	4.157	4.187	4.217	4.246	4.276	4.306
180	4.306	4.336	4.366	4.396	4.426	4.456	4.486	4.516	4.546	4.576	4.606
190	4.606	4.636	4.666	4.696	4.726	4.757	4.787	4.817	4.847	4.877	4.907

Table B-2. Temperature-versus-millivolt conversion table for a J-type thermocouple.

Appendix C

Foxboro IGP10-A Pressure Transmitter Configuration and Calibration Diagrams

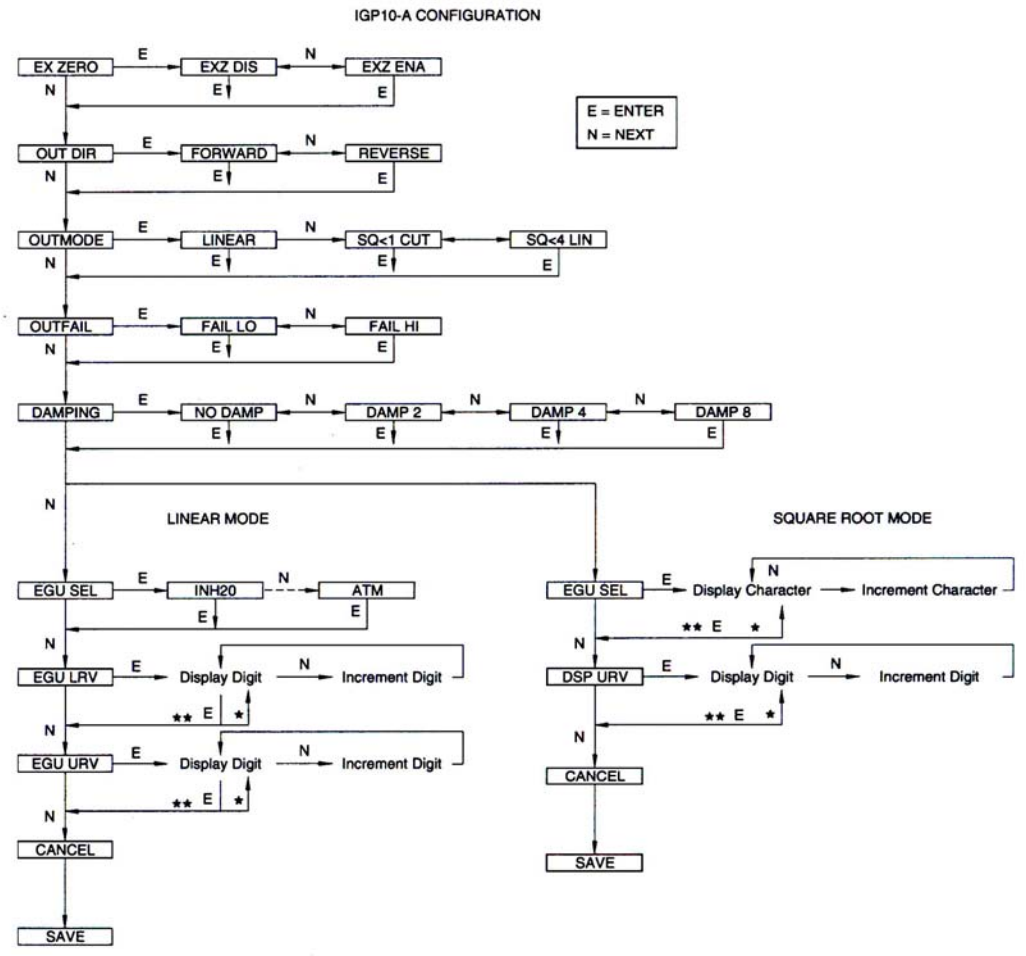


Figure C-1. IGP10-A Pressure Transmitter Configuration.

Foxboro IGP10-A Pressure Transmitter Configuration and Calibration Diagrams

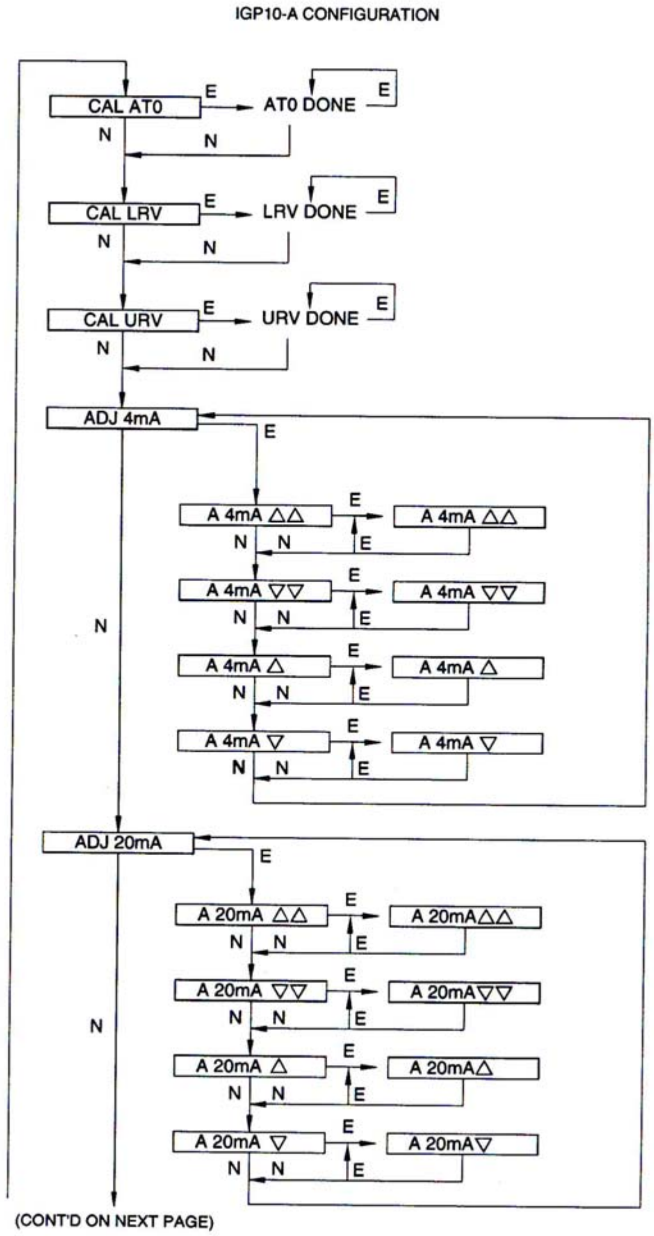


Figure C-2. IGP10-A Pressure Transmitter Calibration (cont'd).

Foxboro IGP10-A Pressure Transmitter Configuration and Calibration Diagrams

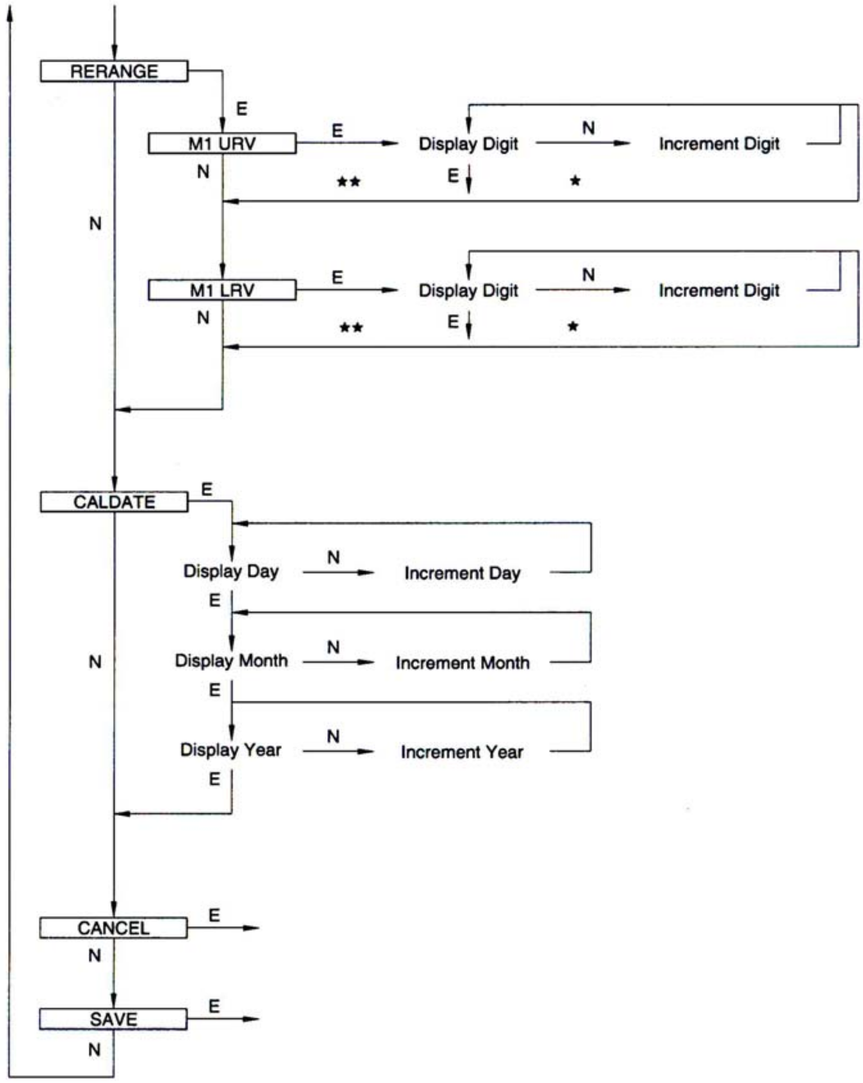


Figure C-3. IGP10-A Pressure Transmitter Calibration (cont'd).

Appendix D

Foxboro IDP10-D Pressure Transmitter Configuration and Calibration Diagrams

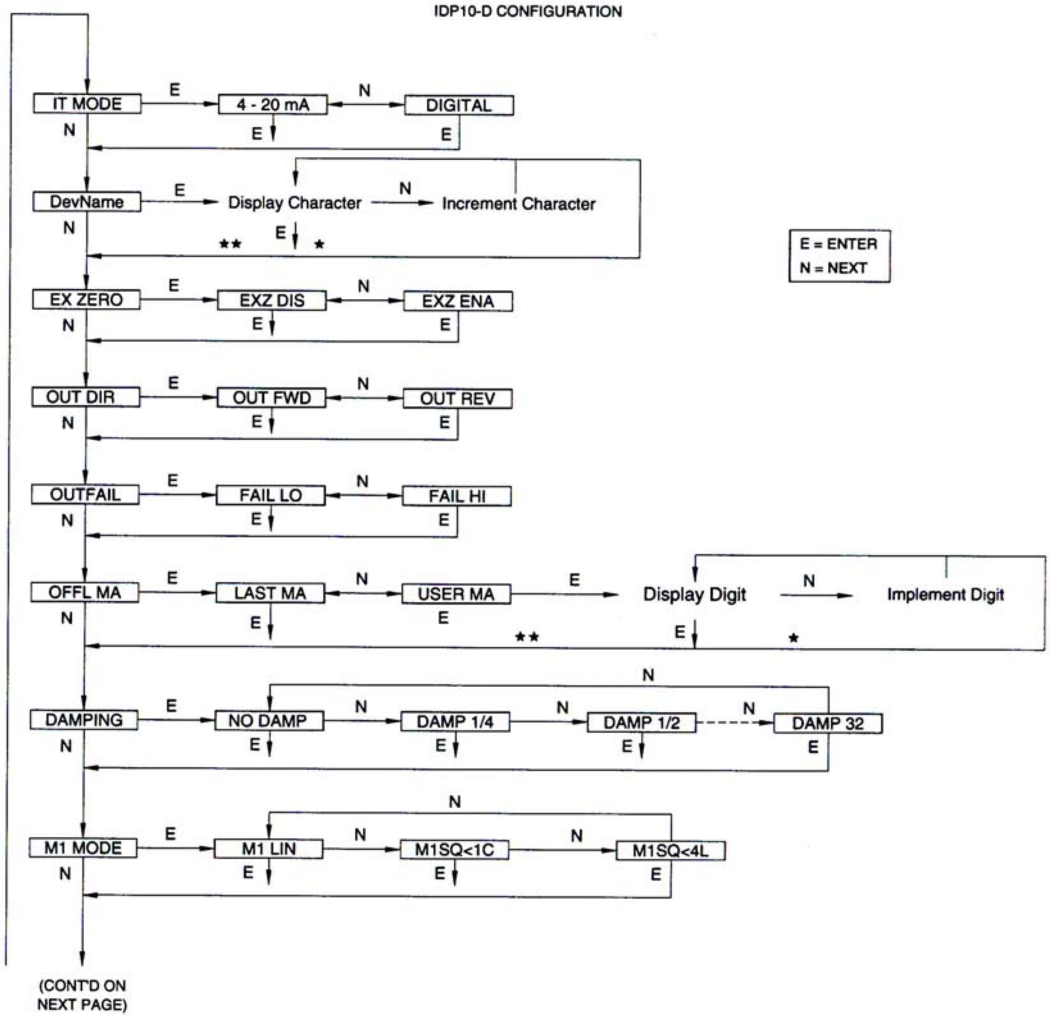


Figure D-1. IDP10-D Pressure Transmitter Configuration.

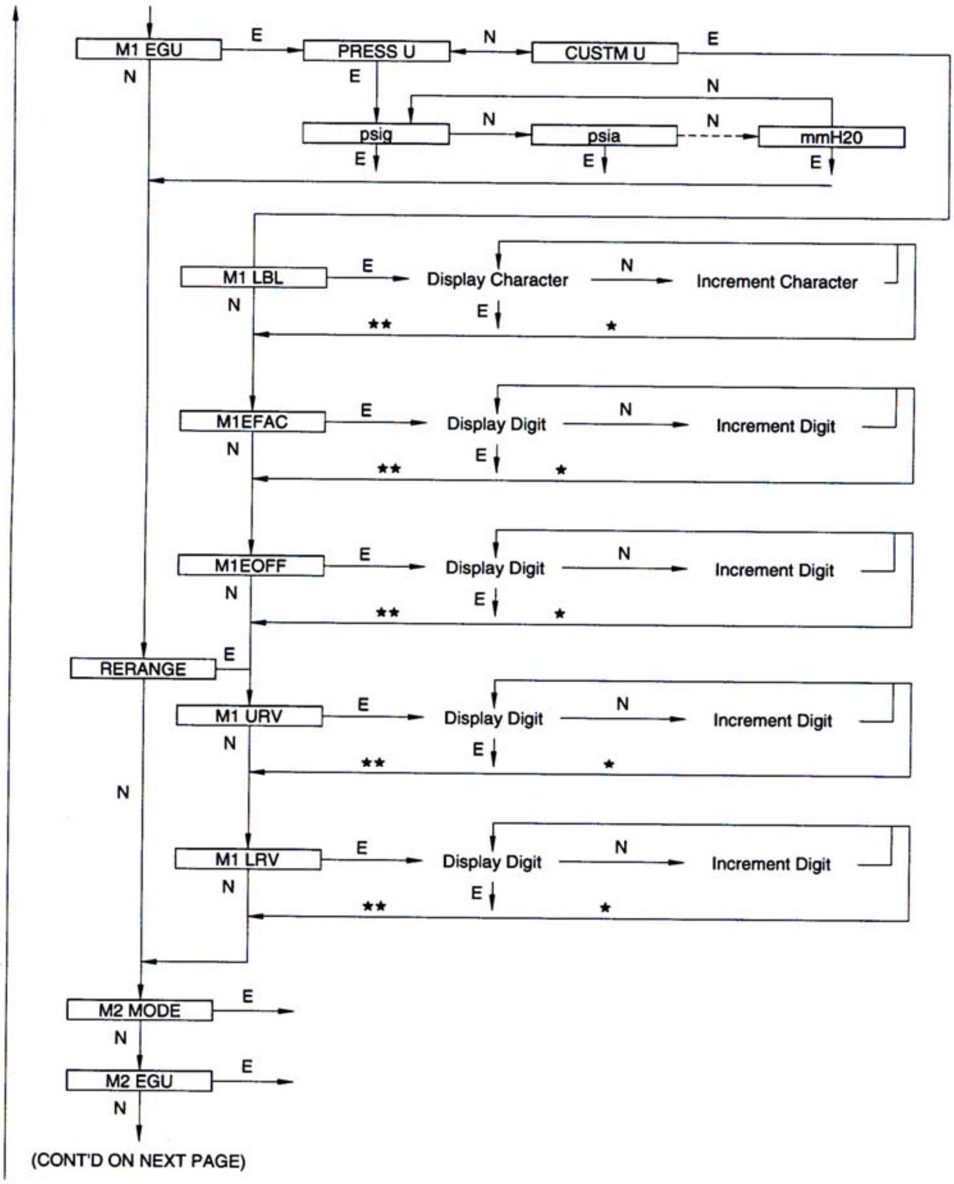


Figure D-2. IDP10-D Pressure Transmitter Configuration (cont'd).

Foxboro IDP10-D Pressure Transmitter Configuration and Calibration Diagrams

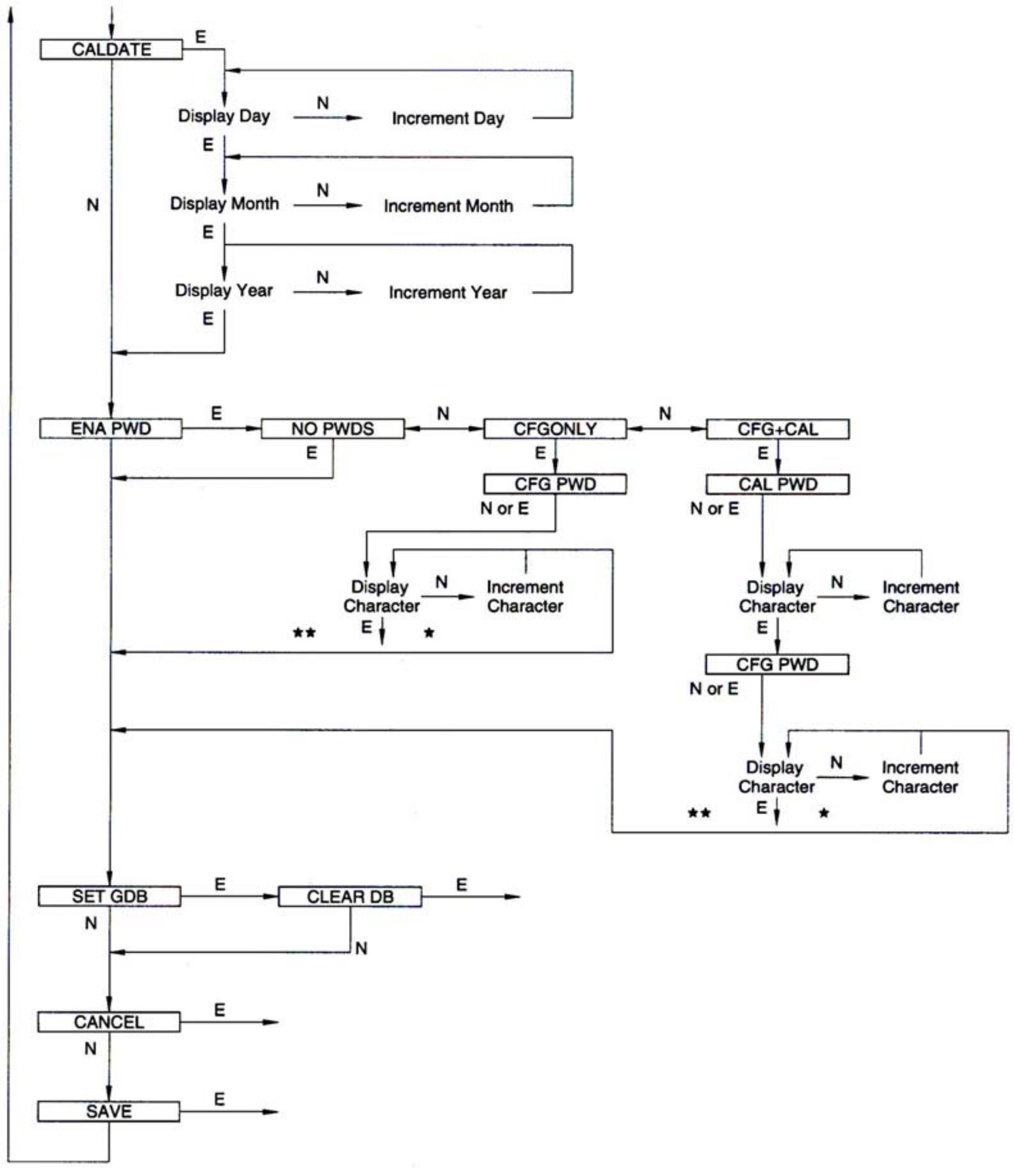


Figure D-3. IDP10-D Pressure Transmitter Configuration (cont'd).

Foxboro IDP10-D Pressure Transmitter Configuration and Calibration Diagrams

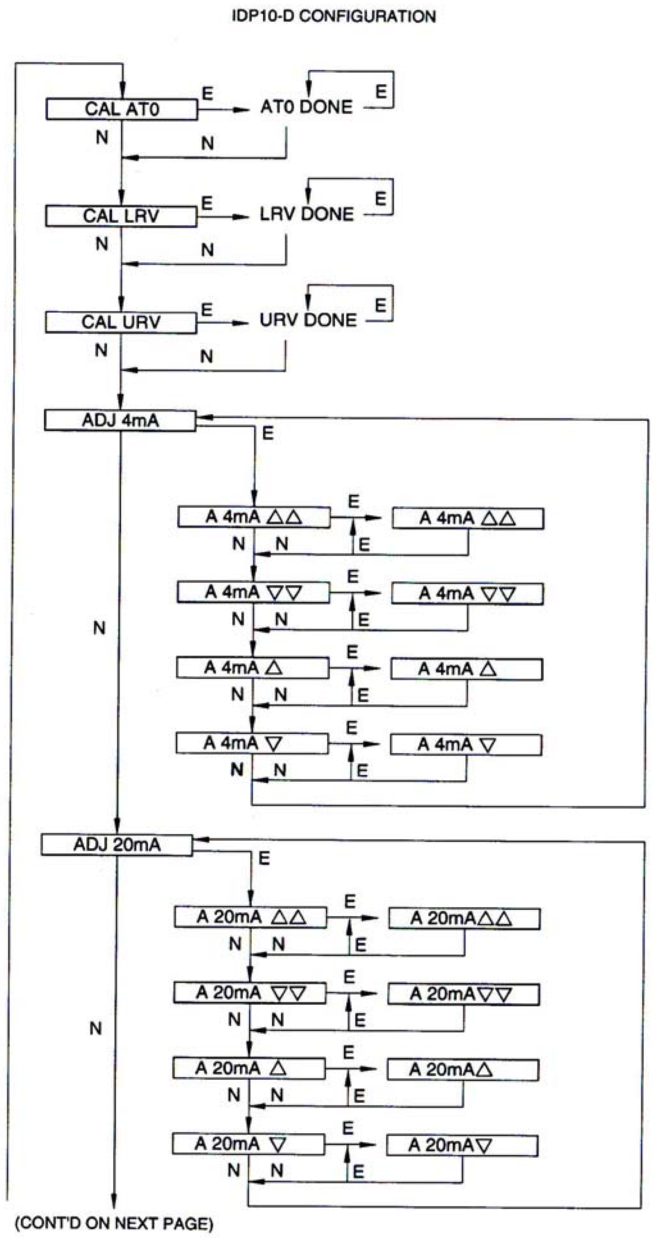


Figure D-4. IDP10-D Pressure Transmitter Calibration (cont'd).

Foxboro IDP10-D Pressure Transmitter Configuration and Calibration Diagrams

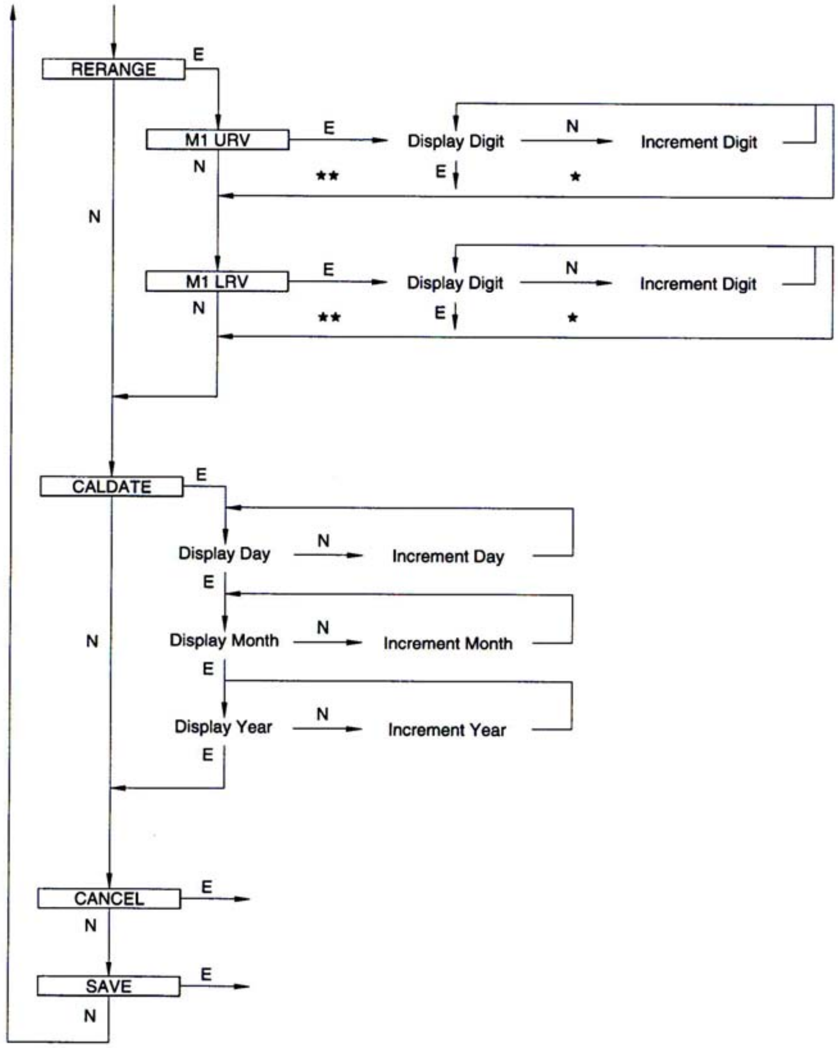


Figure D-5. IDP10-D Pressure Transmitter Calibration (cont'd).

Appendix E

Equipment Utilization Chart

The following Lab-Volt equipment is required to perform the exercises in this manual.

EQUIPMENT		EXERCISE						
MODEL	DESCRIPTION	1	2	3	4[1]	5	6	7[2]
3501	Pressure Process Station	1	1			1		1
3503	Level Process Station			1			1	
3504	Temperature Process Station				1			
3550-M	Calibration Bench	1	1	1	1	1	1	1

[1] An ice bath and boiling water bath are also required.

[2] A dial indicator is also recommended, if available.