Getting Started

Before you begin...

Fundamentals of Process Instrumentation is designed to be an introduction level course. Before beginning, however, it is important that the student have the following experience and skills in order to receive the maximum benefit from taking this course:

- Be familiar with the basic principles of physics that apply to the function and use of process instrumentation in the workplace. Only a brief overview of such topics as the properties of matter is given in the introduction to this course.
- Have on-the-job experience with process systems sufficient to understand the diagrams and examples used to explain instrument functions and applications.

How instrumentation is used and maintained will vary from site to site. Be sure that you know and follow the specific procedures and safety requirements at your site. Design specifications such as pressure and temperature limits may also vary with each manufacturer and model. **Always refer to the manufacturer's specifications for appropriate and safe use of each device.**

If you have concerns or questions about the instrumentation or control systems in your work area, ask your supervisor or site instrument engineer before proceeding with an operation.

When you finish...

When you have successfully completed this course, you should be able to:

1. Demonstrate an understanding of why the variables temperature, pressure, level, flow, and weight are important in managing process systems.
2. Identify the basic elements of a control loop and the functions of each element.
3. Describe the function and use of examples of instruments typically used to measure and/or control temperature, pressure, level, flow, and weight.
4. Describe the operation of four types of control loops—single element, cascade, feedforward, and ratio control.

Course Design

Fundamentals of Process Instrumentation is divided into three parts, each contained in a separate workbook:

Part I—Introduction (Sections 1-4)
Part II—Sensors (Sections 5-9)
Part III—Control Loops & Their Elements (Sections 10-14)

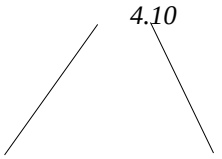
When using the workbooks, you may work at your own pace. Read each unit of information and answer the questions that immediately follow. Note that questions in the workbook may have more than one correct answer. If the answer to a true/false question is false, make a note of the correct information in the margin. At the end of each workbook, a Review Exercise is included to help you review and evaluate how well you understand the main concepts discussed in each section. The course also includes three Completion Exercises, one for each workbook, which will be administered by your supervisor or trainer to determine that you have satisfactorily mastered the course objectives. The final step is a Demonstration Exercise in which you will be asked to identify and answer questions about instrumentation in your work area.

✓

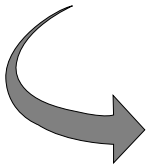
The beginning of each series of questions is indicated by a check mark in the margin next to the first question.

The set of workbooks comes with a complete answer sheet for all sections and Review Exercises in the course. Use it! You may choose to finish a section and then check your answers, or you may want to check each answer immediately. When doing the Review Exercises, however, you should finish the entire exercise before checking your answers. If you miss any questions, go back and review the information in the workbook again. Make a note of any questions you may still have, and go over them with your supervisor or the person designated at your site. **Be sure that all of your questions are answered before you take your Completion Exercises.**

The answers on the sheet that comes with the workbook have numbers that match the question numbers in each section. The questions and answers are numbered as follows:



Pay close attention to the information in the margins. It is given to emphasize or explain further material in the text or in a figure. A bold arrow such as the one in the margin on the left also means the information given beside it is especially important.



This symbol indicates important information.

Your supervisor or trainer will give you a Completion Exercise after you have completed each workbook. The Completion Exercise questions will be similar to those throughout the workbook and in the Review Exercise. The purpose of the Completion Exercises is to determine if you have achieved the course objectives.

After completing the course, you will perform a Skills Demonstration with a supervisor or designated instructor. You will be asked to identify the process instrumentation in your work area and describe its purpose and proper function in the process system.

Electronic Transmitters

Adjusting Electronic Transmitters

The electronic transmitter provides the same general function in a control loop as the pneumatic transmitter, except that it sends a standard electric current output signal instead of a standard air pressure signal. **As with the pneumatic transmitter, the output signal from an electronic transmitter is proportional to the input from the measured process variable.**

The standard electronic transmitter output signal usually ranges in value from 4-20 milliamperes (mA) of direct current (DC). The transmitter is calibrated so that:

- An output signal of 4 mA corresponds to the lowest value in the desired measured range.
- An output of 20 mA corresponds to the highest value of the process variable in the measured range.

Zero and **range** adjustments are used to calibrate the scale within the limits of the instrument. As with a pneumatic transmitter, a standard minimum output value above zero is maintained. A failure or malfunction, which may send a 0 mA output signal, is easily differentiated from a low value for the process variable measurement.

10.16

✓ Electronic transmitters typically send out signals in the range of...

- ❍ 3-15 mA
- ❍ 0-20 mA
- ❍ 4-20 mA
- ❍ 20-40 mA

10.17

An output signal from an electronic transmitter of 0 mA might indicate...

- ❍ A range adjustment of the transmitter is needed.
- ❍ No adjustment is needed.
- ❍ The process should be scaled back.
- ❍ The transmitter is malfunctioning.

Power Supply

The electric power supply for the transmitter typically comes from one of two sources:

- From a separate power supply (usually 110 volt) or
- Through the signal wire coming from the controller

When the transmitter has a separate power supply, the transmitter is called a four-wire device; two wires are used to supply power to the transmitter, and two wires are used to send the output signal to the controller or other parts of the control loop. A diagram of a four-wire transmitter is shown in Figure 10.8.

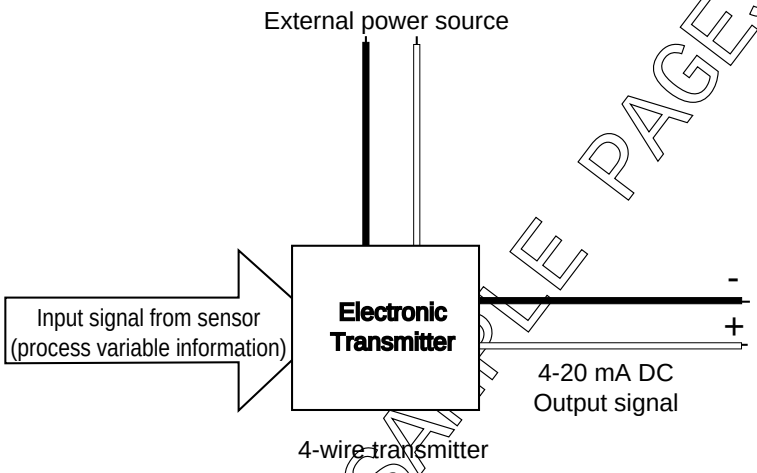


Figure 10.8

When the power source is the signal wires between the controller and the transmitter it is called a two-wire device. (See Figure 10.9.)

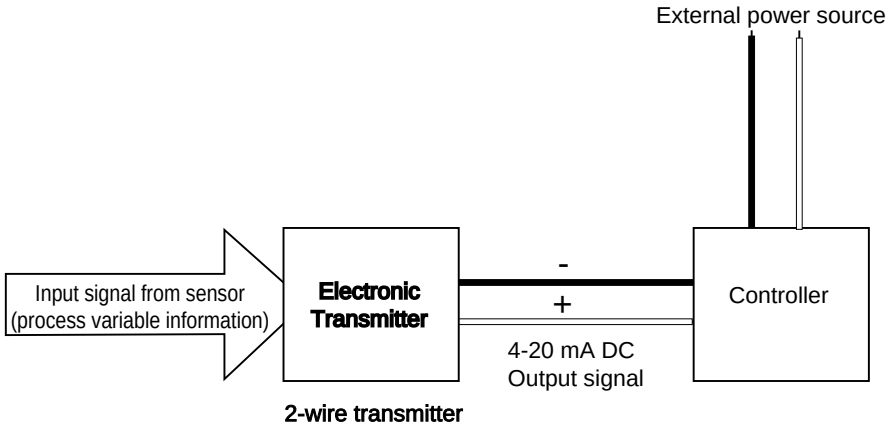


Figure 10.9

Controllers will always have their own power source. Typically, controllers can be used with either two-or four-wire transmitters. The controller will have appropriate connection terminals for both types of transmitters.

When a control loop uses a two-wire transmitter, the controller knows the value of the monitored variable by the amount of current the transmitter draws from the controller.

✓ 10.18

A two-wire electronic transmitter's power is supplied by...

- ❍ The process system
- ❍ Separate power supply wires
- ❍ The same wires it uses to send its signal
- ❍ Another transmitter

The signal input to an electronic transmitter is usually either an electronic (voltage or current) or mechanical signal from the sensing element. Like pneumatic transmitters, the sensing element is often combined with the transmitter in the same unit.

Many types of electronic transmitters are available, and their design will vary with each manufacturer and system requirements. However, when the sensor and the transmitter are combined in a single unit, all electronic transmitters have components which provide the following necessary functions:

- ■ A primary element that senses a change in the measured variable
- ■ A detection mechanism that recognizes the sensor's output and generates an electronic signal
- ■ Electronics that convert the signal from the detection mechanism to a 4-20 mA signal and send it to other control loop elements

✓ 10.19

The input signal to an electronic transmitter may be...

- ❍ A voltage signal
- ❍ A mechanical signal
- ❍ A controller
- ❍ A primary signal

Input and Output

An electronic and/or a pneumatic transmitter often can be used to send the same information about a measured process variable. In Figure 10.10, a tank contains water at varying levels. The level is measured in duplicate by both a pneumatic and an electronic pressure transmitter located at a level one foot below the bottom of the tank. The pressure sensors are in the transmitters. The output signals are 3 to 15 psi from the pneumatic transmitter and 4 to 20 mA from the electronic transmitter. Their output increases

Pressure sensors are sometimes used to measure liquid level.

with the level in the tank. In Figure 10.10, the liquid level is shown at maximum operating level or 100% the level range. This level would correspond to a transmitter output signal of 15 psi or 20 mA —the maximum output values. This level is indicated on the pressure gauge at 132 inches of water pressure.

132 inches of water pressure =
+ $\mathbf{H_o}$ Operating range (120 inches or 10 feet)
+ $\mathbf{H_s}$ Distance sensor located below bottom of tank (12 inches or 1 foot)

132 inches of water pressure at the transmitter corresponds to the maximum operating level of 10 feet (120 inches) of water in the tank.

12 inches of water pressure at the transmitter is equal to 0 feet of water in the tank (minimum operating level) since the transmitter is located 12 inches below the bottom of the tank.

Inches of water pressure and level in the tank can be calculated in this way for this example because the liquid in the tank is water. If the liquid were something else, pressure values would have to be calculated taking into account the density of the liquid.

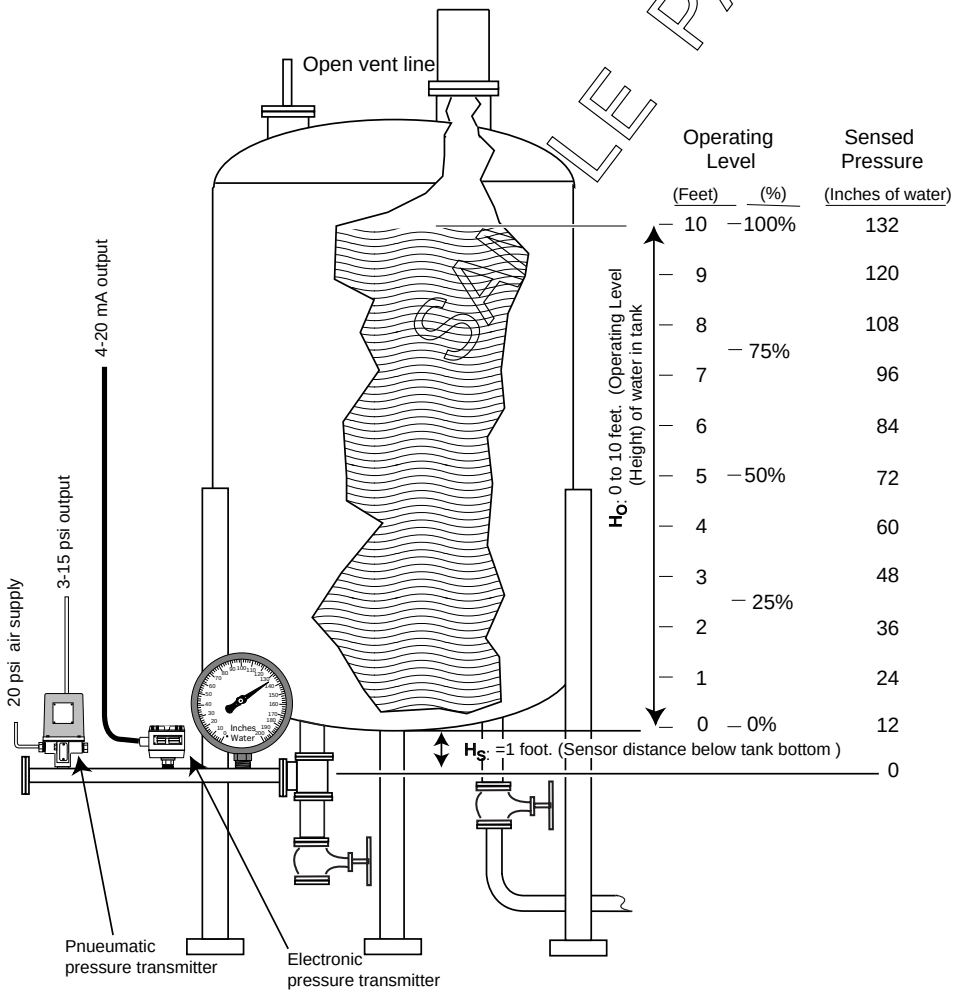


Figure 10.10