Data Transmission

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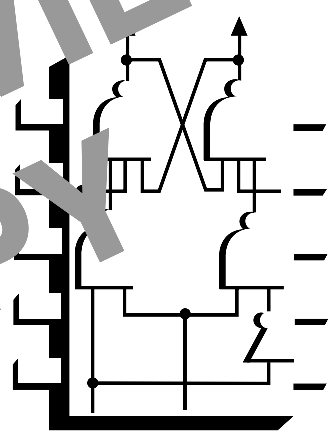
DATA TRANSMISSION

Lesson One

Process Data Transmission Methods



TPC Training Systems

28301

Lesson

1 Process Data Transmission Methods

TOPICS

Data Handling
Open-Loop and Closed-Loop Control
Local Indicators
Remote Indicators
Analog, Digital, and Discrete Control
Environmental Conditions
Process Transmission Methods
Mechanical Data Transmission
Hydraulic Data Transmission
Pneumatic Data Transmission
Electronic Data Transmission
Optical Data Transmission
Telemetric Data Transmission

OBJECTIVES

After studying this Lesson, you should be able to…

- Describe the differences between data transmission in open- and closed-loop systems and with local and remote indicators.
- Discuss the differences among analog, digital, and discrete control.
- Discuss the use of intrinsically safe and explosion-proof equipment.
- List the advantages and disadvantages of mechanical, hydraulic, and pneumatic data transmission.
- Compare voltage-loop and current-loop transmission for analog data and explain the importance of resolution for digital data transmission.
- List the advantages and disadvantages of optical and telemetric data transmission.

KEY TECHNICAL TERMS

Process diagnostics 1.08 data transmission that allows the operator to determine if and where a process problem exists

Local indicator 1.12 a device that senses and displays a process variable value at the site of the variable

Remote indicator 1.14 a device that includes a sensor and transmitter for display of a process variable value at a distance from the sensing point

Intrinsically safe 1.24 incapable of igniting a hazardous atmosphere

EMI 1.57 electromagnetic interference

Modern plants and factories use complex and widely separated processes to produce a variety of products. The ability to transmit process data is essential to effective process monitoring and control. This Lesson describes applications of various process data transmission methods, from simple mechanical systems to complex telemetry, and discusses the advantages and disadvantages of each.

Data Handling

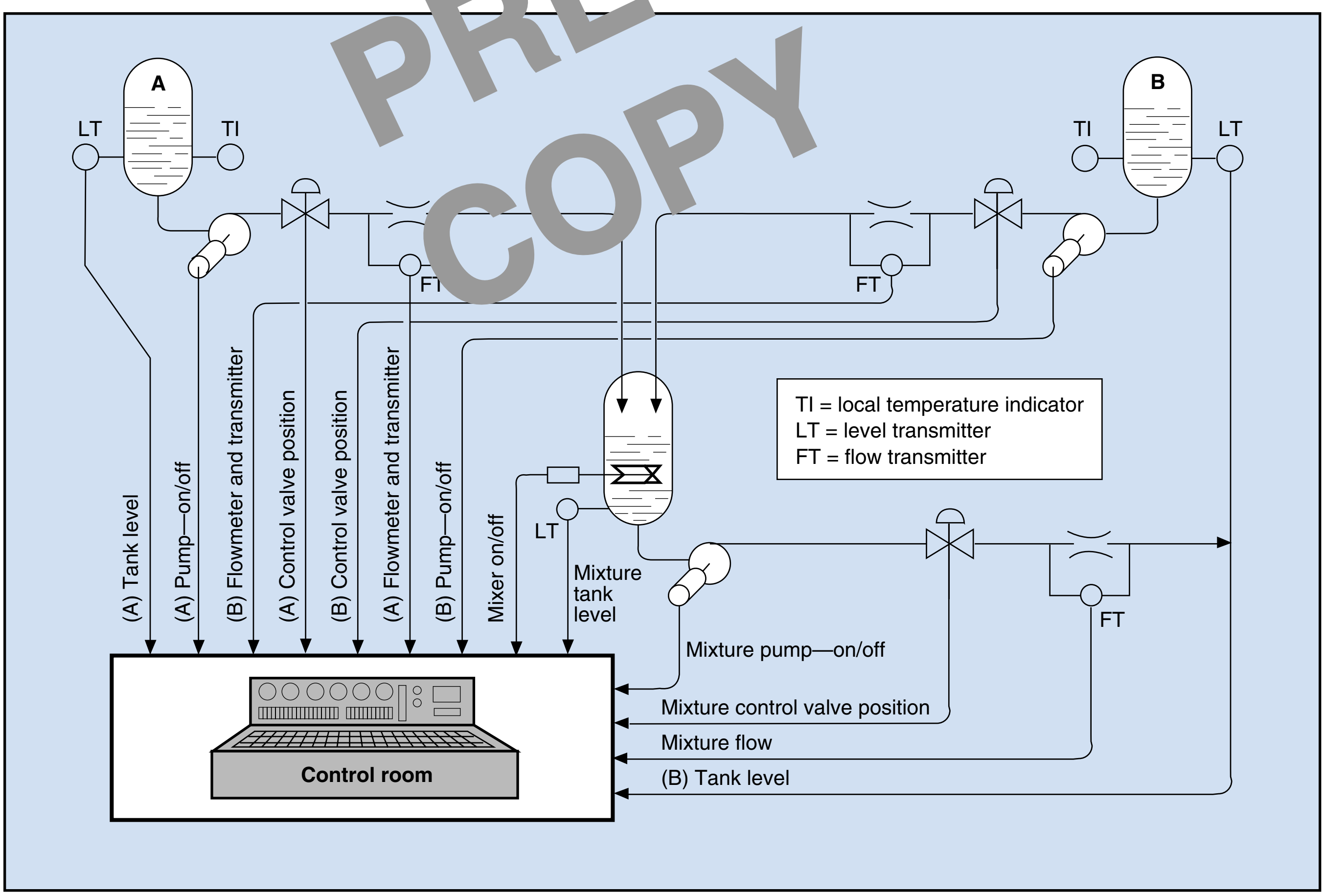
1.01 In a typical plant or factory, hundreds or even thousands of process variables can affect the condition of the process and, ultimately, the quality of the final product. A wide variety of variables, for example, pressure, temperature, flow rate, level, conductivity, pH, and concentration, may be measured at points hundreds to thousands of feet apart.

1.02 In some processes, the control area may be only a few feet from the process. In other processes, for example, those in petrochemical plants, the control room may be miles from the actual process. Despite the distances involved, the measurements of these variables must be available to an operator or control system at a central location.

1.03 Figure 1-1 shows an example of a process that requires data transmission. In this example, two fluids, fluid A and fluid B, are mixed in a continuous process. Each fluid is part of a separate fluid-handling system that includes a tank, pump, flow control valve, flowmeter, and transmitter. The two fluids are pumped into a mixing tank. From the tank the mixed fluids are pumped through a control valve and flowmeter.

1.04 This process requires careful control to obtain the correct mixture of fluids A and B and also to prevent overfilling or underfilling the mixing

Fig. 1-1. Mixing process requiring data transmission



tank. This process may be controlled locally by an operator observing the tank levels and manually operating the flow control valves to maintain proper levels and mixtures. Or, the process may be controlled manually by an operator in a remote control room or by an automatic control system. In either of the latter two arrangements, a significant amount of control and display data must be transmitted between the control room and the process point.

1.05 The following information is required for the process shown in Fig. 1-1:

- fluid levels in tanks A and B
- on/off control indication for pumps A and B
- positions of flow control valves A and B
- flow rates for fluids A and B
- level in mixing tank
- on/off control indication for mixing motor
- on/off control indication for mixture pump
- position of mixture flow control valve
- flow rate for mixture.

With this information, the operator or the control system can monitor the process to maintain the correct mixture of fluids A and B and the correct flow rates.

1.06 Locating all of the process indicators in a central control room gives the operator better control of the process. He or she can observe all of the indicators together, rather than walking around the plant to obtain readings and make process corrections.

1.07 In some critical processes, it is difficult for an operator to make corrections accurately enough or often enough to maintain optimum process operation, even when the displays are located in the control room. In this case, control is provided by an automatic control system, into which the optimum process values are programmed, in the central control room. The automatic control system sends data back to the process points in the form of control signals to open and close valves and to turn pumps on and off, for example. Most modern process control systems are automatic.

1.08 Data transmission also can provide information for safety considerations and process diagnostics. In this example, safety considerations include protecting the process and personnel from tank overfills and underfills, dangerous pressures, and unsafe temperatures. *Process diagnostics* refers to the operator's determining if a problem exists in the process or control system and, if so, where. For example, a zero flow rate in a flow loop could indicate a failed pump or closed control valve.

Open-Loop and Closed-Loop Control

1.09 In an open-loop system, the process control setpoints (SPs), if maintained, allow the process to operate properly. The process variable (PV) values are monitored to verify that the process is operating as desired. For example, if the fluid level in a tank becomes too high or too low, an operator must correct a flow rate, usually by changing a valve setting, to return the tank contents to the proper level. This kind of control is used only if the process values change very slowly and the values are not critical.

1.10 In a modern closed-loop system, a computer-based controller adjusts the process automatically to maintain the PVs at the desired values. For example, in the system in Fig. 1-1, the mixture ratio of products from tank A and tank B is important. The control computer sets the valves so that flow from each tank is correct. Suppose the flow deviates from that needed to maintain the proper ratio. The control computer senses the difference by reading the flow rate transmitters and, in turn, sends a correcting signal to the flow control valves. The computer continuously monitors the process values and adjusts the actuators to maintain the desired values.

Local Indicators

1.11 Various systems can be used to transmit the process information. The kind of transmission system used depends on the distance, industrial environment, kinds of signals, and other considerations. Most processes include some variables that need to be monitored only periodically. These variables are not involved in the direct control of the process, which requires continuously updated information.

1.12 Two temperature indicators, labeled TI, are shown on tanks A and B in Fig. 1-1. These indicators are of the kind shown in Fig. 1-2 and are referred to as *local indicators*. This means that the process variable (in this case, the fluid temperature in each tank) is sensed and displayed in engineering units at the tank. If the process operator needs to know the temperature of the fluid in either tank, he or she must walk to the tank and read the indicator dial. Local indicators are widely used, but they cannot transmit the measured PV value.

1.13 Local indicators are sometimes used in an automatic process control system as a backup to the automatic readings. They also permit operators to monitor critical values locally to verify that the process is operating properly and to check for system problems.

Remote Indicators

1.14 A *remote indicator* requires two devices:

- a sensor, which can detect the value of the process variable
- a transmitter, which converts the output of the sensing element to a process signal.

Many kinds of sensing instruments are available. The output signal is in some form of energy that can be transmitted over long distances and that represents the process variable.

1.15 Typical process signals are in the following forms:

- air pressure (pneumatic)
- liquid pressure (hydraulic)
- voltage or current (electrical or electronic)
- light (fiber optical).

The use of standard output signals enables a plant or process to include transmitters and other devices from a variety of manufacturers. Figure 1-3 shows a typical pressure transducer/transmitter combination. The output is a standard 4 to 20 milliamp (mA) signal that is proportional to differential pressure. This transmitter, which must be mounted close to the process, is designed to withstand a wide range of environmental conditions.

Analog, Digital, and Discrete Control

1.16 The sensors and transmitters referred to in these examples are *analog* measuring devices. That is, an output value exists for the entire range of values of the process variable. For example, suppose a process pressure varies over a range of 0 to 1000psig. An analog pressure transducer senses the pressure and sends an output signal of 1 to 5mV or 4 to 20mA. Any voltage between 1 and 5mV or any current between 4 and 20mA represents a specific pressure. For example, 3mV or 12mA represents 500psig. The output signal is proportional to the value of the measured variable.

1.17 The outputs of modern *digital* transducers are proportional to the value of the PV, but are in the form

Fig. 1-2. Local temperature indicators

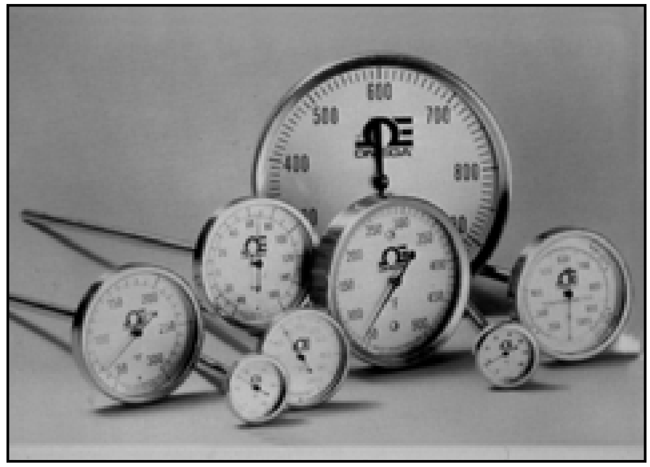


Fig. 1-3. Process transmitter

Fig. 1-4. Discrete pressure switch

of a digital computer word rather than an analog voltage or current. In many applications, process data can be transmitted more accurately in digital form than in analog form. Digital data are discussed briefly later in this Lesson, and digital transmission methods are discussed in detail in a later Lesson in this Unit.

1.18 Discrete two-state (on-off) transmitters used for process control should not be confused with modern digital transducers. *Discrete* process variables and signals have only two states, which represent two extremes. The following list gives some examples of discrete process components and variables:

- relief valves—open or shut
- pumps and motors—on or off
- pressure limits—too high or too low.

1.19 Figure 1-4 shows a typical discrete pressure switch. Its output has only two states, on and off. If the pressure rises above a certain setpoint, the switch changes state. It changes back to its original state when the pressure decreases below the setpoint. The switch may simply turn an indicator lamp on to indicate an overpressure condition, or it may control the pressure by turning a pump on and off. When the pressure increases to the SP pressure, the pump is turned off. When the pressure decreases to a value below the SP, the pump is turned on.

1.20 Analog transducers allow a discrete control system to have *proportional* control of the process, to a limited extent. The controller reads the analog value of the variable to be controlled and can turn pumps, valves, heating coils, and other final control elements (FCEs) on and off a proportional amount of time to keep any variable at a specific value in its range.

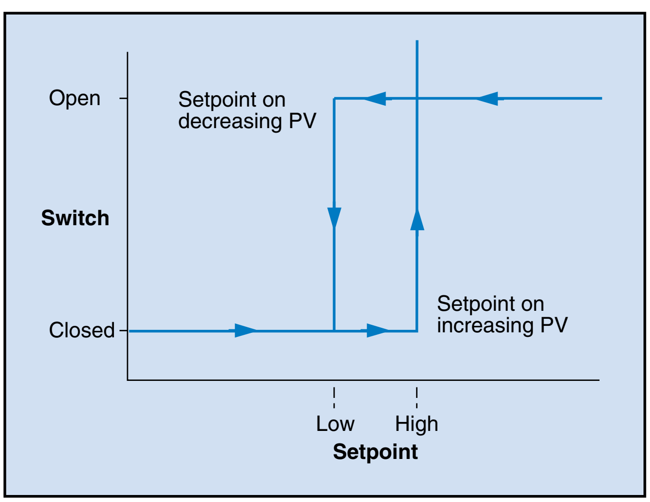
1.21 Discrete switches used to control a process usually include some deadband. That is, the turn-on and the turn-off values are different. The switch point is higher on an increase in PV and lower on a decrease in PV, as shown in Fig. 1-5. When the PV increases to the high SP, the switch opens. When the PV decreases to the low SP, the switch closes. Without deadband, the controlled device would chatter by cycling on and off rapidly as the PV varied a small amount around the SP.

Environmental Conditions

1.22 A plant may include many kinds of environments. Some may involve only moderate temperature and humidity changes. Others may include one or more of the following difficult conditions:

- outdoor weather
- dusts from coal, grain, and other substances

Fig. 1-5. Deadband in discrete switch



- oil spray
- water spray
- chemical solvents and fumes
- extremely high or low temperatures.

1.23 Process equipment manufacturers have developed a variety of equipment that can work reliably in these environments. However, safety to personnel must also be considered. In some environments, there is a real danger of fire and/or explosion. In these hazardous locations, the methods of process variable measurement and process signal transmission must conform strictly to various established standards, including the National Electrical Code.

1.24 **Intrinsically safe equipment.** Process equipment manufacturers use intrinsically safe designs in making equipment for use in hazardous locations. *Intrinsically safe* equipment, by its design, cannot ignite a hazardous atmosphere. Even accidental damage, incorrect adjustment, faulty installation, or failed components will not cause ignition.

1.25 Pneumatic, hydraulic, or fiber optic transmission techniques are often used for intrinsically safe data transmission in hazardous locations, because the mechanisms in these systems are incapable of generating sparks. It is possible to make intrinsically safe electrical transmission systems as well, but it is much more difficult. Intrinsically safe electrical transmission is discussed in a later Lesson in this Unit.

1.26 **Explosion-proof equipment.** It is always desirable to use intrinsically safe equipment, but it is not always possible or economical. Electrical process equipment is built with housings that are sufficiently tight and strong enough to prevent a spark or explosion inside the housing from igniting an external explosive atmosphere. These housings are referred to as *explosion-proof*. Explosion-proof equipment usually incorporates heavy, thick-walled enclosures with precisely machined sealing surfaces. Both general-purpose and explosion-proof housings may be used to enclose similar electrical equipment, depending on the environment in which it is operated.

1.27 It is very important that you understand the safety implications of hazardous locations. Something as simple as a cover left off a junction box can create a dangerous situation. You must always follow proper procedures, including replacing and properly tightening all covers. If you are uncertain about a particular maintenance item, be sure to check the manufacturer's technical instructions or ask your supervisor.

Process Transmission Methods

1.28 Various transmission methods and techniques are used in industry. The following are among the most common:

- mechanical
- hydraulic
- pneumatic
- electrical/electronic
- optical
- telemetric.

Each method has its own advantages over the other methods for particular applications, and each has its own disadvantages.

The Programmed Exercises on the following page will tell you how well you understand the material you have just read. Before starting the exercises, remove the Reveal Key from the back of your Book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

1-1. In a(n) ________-loop computer-based system, the computer automatically adjusts the process to maintain the PVs at the proper values.	1-1. CLOSED Ref: 1.10
1-2. In addition to a sensing element, a remote indicator requires a(n) ________.	1-2. TRANSMITTER Ref: 1.14
1-3. The outputs of modern digital transducers are in the form of digital ________.	1-3. COMPUTER WORDS Ref: 1.17
1-4. Transducers with analog outputs allow a discrete control system to have limited ________ control of the process.	1-4. PROPORTIONAL Ref: 1.20
1-5. The ________ in a two-state discrete switch prevents chatter in the controlled device.	1-5. DEADBAND Ref: 1.21
1-6. Equipment that is incapable of igniting a hazardous atmosphere is referred to as _________.	1-6. INTRINSICALLY SAFE Ref: 1.24
1-7. Is it easier to achieve intrinsically safe data transmission with pneumatic or electrical equipment?	1-7. PNEUMATIC Ref: 1.25
1-8. It is especially important to replace all ________ on explosion-proof equipment.	1-8. COVERS Ref: 1.27

Mechanical Data Transmission

1.29 The simplest way to transmit data is to use mechanical couplings and linkages. Using mechanical means to measure process variables is both inexpensive and efficient. One example of mechanical data transmission is a tank in which liquid level is monitored by a float attached to an indicator. Another example is the automobile speedometer cable, which monitors the rotational speed of the transmission.

1.30 The primary advantages of mechanical data transmission are simplicity, reliability, and the fact that it requires no external power. Disadvantages include the inability to transmit data for more than a few feet and the need for maintenance. Mechanical data transmission requires the use of pulleys, cables, and linkages for remote display over long distances. The longer the distance, the less accurate is the transmission. The system also requires frequent lubrication and adjustment.

1.31 Mechanical data transmission systems are not useful for systems that require automatic computer-based control and monitoring of the process. Computers require electronic input signals for operation. Therefore, mechanical data transmission is limited to small, simple processes.

Hydraulic Data Transmission

1.32 In processes involving liquids, hydraulic techniques are sometimes used for transmitting process information. In its simplest form, hydraulics can be used to monitor the process by simply extending the piping to the monitoring area. For example, monitoring the pressure in a tank at a remote location requires a small access hole in the tank. The hole, called an *instrument tap*, is linked to a small-diameter tube routed to the control area. A standard pressure gauge is mounted at the end.

1.33 This data transmission method is similar to the mechanical method, because both methods are very simple and neither requires external power. However, hydraulic data transmission has the advantage of not requiring mechanical linkages. Only small-diameter, relatively flexible tubing is needed to transmit the process information. The remote indicator can be located farther away from the equipment than with mechanical methods.

1.34 Most of the disadvantages of hydraulic data transmission are related to the plumbing aspects of the systems. Leaks can develop, and dirt can clog the small-diameter sensing lines. You must flush the sensing lines periodically to remove dirt. You also must vent the lines to remove air bubbles. If the installation is exposed to the weather, you may need to insulate the lines or wrap them with heater tape. In addition, the static head of the liquid in the sensing line can affect accuracy. In pressure measurement, the indicator must be at tank level to prevent the static head from producing a measurement error.

1.35 Like mechanical ones, hydraulic transmission methods are limited in those applications that require computer-based closed-loop control. A hydraulic transmission line cannot send electronic signals to the control computer unless a pressure transmitter with an electronic signal output is connected to the transmission line at the control room.

Pneumatic Data Transmission

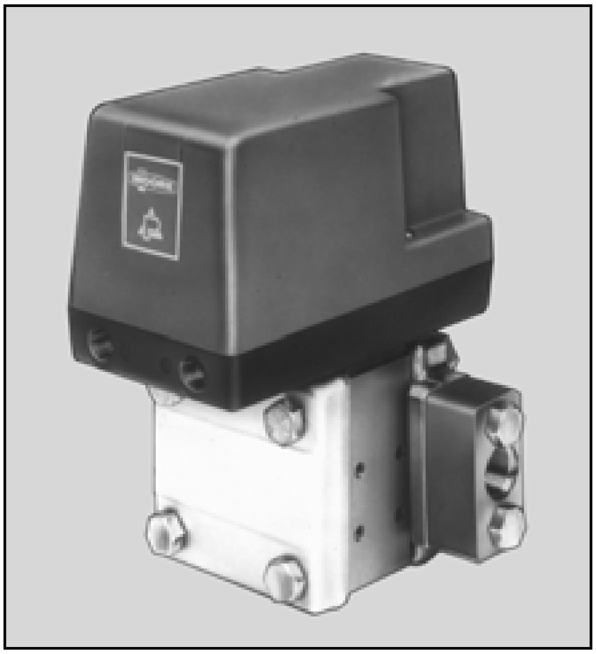
1.36 Pneumatic (air pressure) methods were widely used for process data transmission before low-cost, low-power, reliable electronics became available. In the mid-1960s, pneumatic logic gates were developed for the process industry. However, you will not find many pneumatic logic circuits in factories today. Some pneumatic instrumentation and transmission systems still remain in service, though, especially where intrinsic safety is a major concern.

1.37 Figure 1-6 on the following page shows a typical pneumatic transmitter. This kind of device generates an air-pressure signal proportional to the value of the process variable. The standard industrial pneumatic signal ranges from 3 to 15 psig. A wide variety of pneumatic transmitters is available for monitoring many kinds of process variables.

1.38 The main advantage of pneumatic devices is that they are intrinsically safe. Other advantages include the ability to transmit the air signal over long distances, the absence of the static head errors present in hydraulic systems, and the fact that pneumatic systems can be designed to be relatively insensitive to electrical power failures.

1.39 Pneumatic systems require clean, well-filtered dry air. Tiny particles of dirt can lodge in the many

Fig. 1-6. Pneumatic transmitter



small orifices and ports of the equipment and block the pneumatic signal. Moisture in the system also can block the signals or freeze in cold weather. Maintenance of a pneumatic transmission system requires regular cleaning of the system to flush out dirt or moisture that has collected in the equipment. Fittings and hoses must be kept leak-free and free of kinks. Like the other nonelectrical systems, pneumatic systems cannot be directly interfaced to computers or programmable controllers.

Electronic Data Transmission

1.40 Process data are most often transmitted by one of the electronic methods available. Most modern process control systems make use of electronic data processing and programmable controllers. Also, most transducers and sensors are available with some kind of electrical output signal. These devices interface directly to electronic controllers and computers, and the signals can be transmitted reliably over long distances at low cost. Data transmitted between the process points and the control room can be in analog or digital form, as discussed earlier.

1.41 **Analog data.** Recall that for *analog* data, the value of the variable being measured,for example, temperature or pressure, is represented directly by a voltage or current whose value is proportional to the value of the measured PV. A simple analog level transducer is shown in Fig. 1-7. As the level in the tank changes, the float changes the position of the potentiometer (R), creating an analog voltage equivalent of the level. (The gas gauge in most automobiles works this way.) The analog voltage output from the level transducer (V_S) is transmitted by wire directly to the gas gauge on the instrument cluster.

1.42 In the example above, data are transmitted on a *voltage loop*. That is, the analog signal is sent to the receiving device as a voltage value. The signal is *attenuated* (decreased in amplitude or intensity) by the transmission line. The amount of attenuation depends on the resistance of the wire and the impedance of the load.

1.43 The resistance of the wire carrying the signal to the control center depends on the wire size and length. A 24-gauge wire, commonly used for data transmission circuits, has a resistance of about 25 ohms per 1000 ft.

Fig. 1-7. Analog level transducer

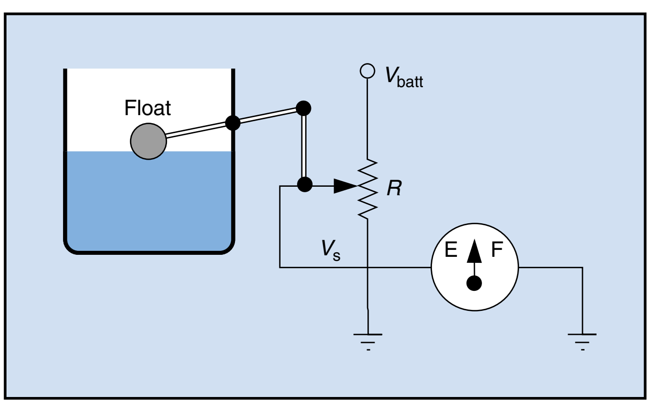
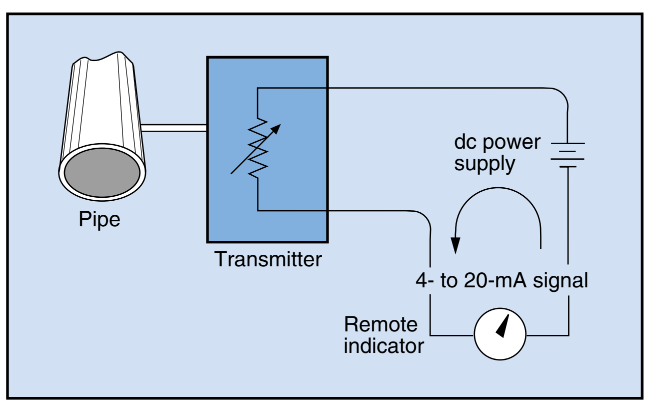


Fig. 1-8. Two-wire current loop



The attenuation may be significant over long distances between process points and the control room. The amount of attenuation can change if wire length or environment changes, perhaps as a result of relocating a control, causing errors in the measurement.

1.44 If high-impedance receiving devices are used to reduce the attenuation caused by wire resistance, the voltage transmissions are susceptible to electrical noise. Devices near the loop—for example, arc welders and dc motors—introduce noise signals that can interfere with the measurement. Thermocouple and strain-gauge sensors, which generate signals of only a few millivolts, are especially affected.

1.45 Many of the analog output transducers used in process control and factory automation systems transmit data on a *current loop* in which the current is proportional to the measured PV. Many standard industrial transducers provide an output range of 4 to 20mA as the PV changes from its minimum to its maximum value. Standard industrial display devices and recorders operate over this range as well. This standard allows many off-the-shelf transducers and display devices to operate together.

1.46 Figure 1-8 shows a simple current transducer and current-loop transmission circuit. Basically, the transmitter functions as a variable resistor that allows a current to flow in proportion to the PV value. This is accomplished by a small electronic circuit assembly within the transmitter. Notice that there are no separate power leads to the transmitter. The pair of wires that carries the process information also provides power to the transmitter. The power supply is a simple dc source. The transmitter is designed to work over a wide range of power supply voltages. The remote indicator is simply a dc ammeter that closes the loop.

Application 1-1

A manufacturer of quality silver-plated tableware used a manual system to control the silver-plating process. The thickness of the silver plate depended on the plating current and the amount of time in the plating tank. As the silver content changed, the plating current changed, because the impedance of the bath changed. The control console displayed current and time, and the operator adjusted the current and conveyor speed accordingly to maintain the correct current-times-time factor for a proper plate thickness.

Because the plant produced a quality product, the thickness of the plate was important. When silver was inexpensive, quality was maintained by ensuring that the plating thickness exceeded the minimum. As silver became more expensive, this method became impractical. The plant needed to plate just the right amount of silver, and never too little.

The solution was a computer-controlled plating line that measured a number of variables, including line speed, time, plating-bath concentration, and plating current. These values were transmitted to a central control computer. The computer automatically adjusted speed and current to obtain a close plating tolerance according to its calculations for the measured silver-bath concentrate. The savings in previously lost silver were calculated to pay back the control system investment in less than one year.

1.47 Most electrical noise problems are eliminated by the low impedance of the current loop and by the use of shielded twisted pairs of wires between the transmitter and the indicator and power supply. Figure 1-9 on the following page shows a typical electronic transmitter. The sensing element and electronic circuit assembly work together to provide the signal.

1.48 Electronic data transmission depends on an external source of electrical power. If power is lost, all indication of the process variable is also lost. However, critical applications use redundant components and backup power supplies. Another disadvantage is that electrical noise, radiated or conducted on the power line, can induce operational problems. In addition, electrical transducers are not intrinsically safe. However, this disadvantage can be overcome with the use of explosion-proof housings and with intrinsically safe couplers between the transducer and its power source.

1.49 **Digital data.** In addition to analog voltage or current representations, a PV value may be rep-

Fig. 1-9. Current-loop electronic transmitter

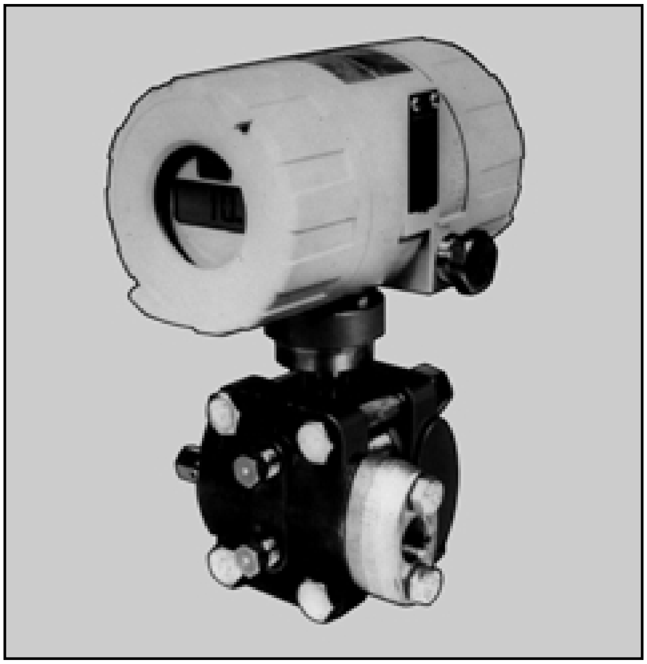
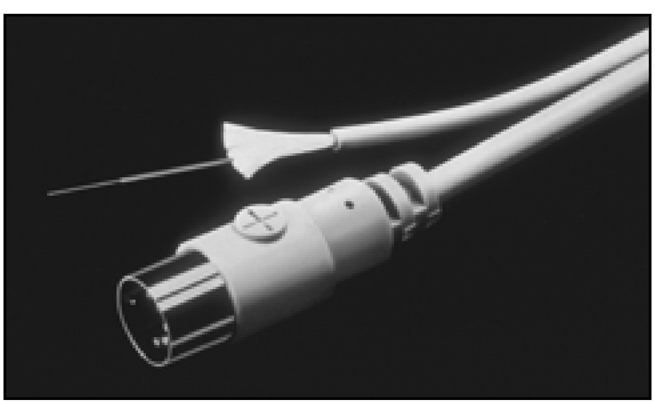


Fig. 1-10. I/P transducer

resented in *digital* form. In this case, the value of the measured PV or SP is converted to a *binary* number and communicated as a series of data *bits*. Any number of data bits can be used to represent the value of the measured PV or SP. In most data acquisition and control (DAC) systems, either 8 or 16 bits are used to represent the signal.

1.50 The *resolution* of the digital signal, that is, the number of levels of the full-scale signal that can be represented by the digital signal, is equal to 2^n, where *n* is the number of bits used. For example, if an 8-bit binary number is used to represent a signal, the signal can be resolved into 2^8 (256) levels. Each bit then represents about 0.04% of full scale.

Fig. 1-11. Fiber optic assembly



1.51 Data can be communicated more accurately in digital form than they can in analog form. Degradation of the analog signal along the communications link due to loop impedances, line losses, and noise causes measurement errors. However, a digital signal that is degraded along the communications link can be reconstructed at the receiver end with no loss of accuracy.

1.52 The digital signal on the communications network is degraded just as the analog signal is degraded. The difference is that the digital value of the received signal is precisely the same as that sent by the transmitter, as long as the signal reaching the receiver can still be resolved into its one and zero bit levels. Digital error detection and correction methods (discussed in a later Lesson in this Unit) further improve the accuracy of digital data transmission.

1.53 **Electrical/pneumatic conversion.** Some data transmission applications use a combination of methods to take advantage of each. For example, pneumatic equipment may be used to transmit a signal from a hazardous area, and then electrical equipment may be used to transmit the signal the rest of the way to the control room. Because combination electrical/ pneumatic systems are quite common, it is often necessary to convert a signal from electrical to pneumatic (or pneumatic to electrical) form.

1.54 The device that accomplishes this change is an I/P (or P/I) converter. *I* represents current, usually between 4 and 20mA, and *P* represents a pneumatic air signal, usually between 3 and 15 psig. The *I/P converter* converts a current signal to a pneumatic signal, and the *P/I converter* converts a pneumatic signal to a current signal. Figure 1-10 shows a typical I/P converter, or transducer. A *P/E* or *E/P converter* is used for conversion to or from a voltage signal, with *E* representing voltage.

Optical Data Transmission

1.55 Fiber optics is one of the newer technologies used to transmit process data. Fiber optic cables are thin strands of glass or plastic that can conduct light energy with little loss. Fiber optic data transmission is most often associated with digital data transmission. One of the major advantages of fiber optic data transmission is that it has a very wide bandwidth, which allows each fiber to carry large amounts of data. This feature is important in modern computer-controlled processes, in which vast amounts of data must be transmitted between the process points and the control room.

1.56 Optical fiber does not conduct electricity and, as a result, the remote process transducers and actuators are completely isolated electrically from the control computer. For example, if the remote site is struck by lightning, the computer would be unharmed and the rest of the process would be unaffected. Because a spark cannot be transmitted through the fiber optic cable into a hazardous area, the transmission link is intrinsically safe as well.

1.57 Optical fiber data transmission networks are immune to interference from nearby electrical and magnetic fields, so they can reliably transmit data in the presence of electrical noise. Also, because the fiber cables do not emit any electrical or magnetic energy, they do not cause *electromagnetic interference* (*EMI*) to surrounding systems. EMI is discussed in detail later in this Unit.

1.58 The costs to purchase, install, and maintain fiber optic systems are considerably higher than the costs for wired systems. For this reason, fiber optic systems are used only if their special advantages are important to the application. Another disadvantage is that connection and splicing methods are specialized and more difficult to perform in the field than methods for wired systems. However, improvements are being made, and fiber is becoming more common. Figure 1-11 shows a typical fiber optic assembly.

Telemetric Data Transmission

1.59 *Telemetry*, sometimes called *telemetering*, consists basically of transmitting information over a high-frequency modulated radio wave. The radio wave transmitted in a telemetric system is similar to that from communication transmitters. However, instead of transmitting a human voice, it sends PV information. Telemetry was first widely used in the aerospace industry to monitor the flight performance of aircraft and spacecraft.

1.60 Telemetric systems transmit process data by many different methods. One common system converts analog process variables into a multiplexed signal, which is used to modulate the frequency of a carrier signal. That is, the process information is imposed on a reference frequency. The carrier signal is transmitted from the source of the local process to the receiving station. The receiving station demodulates and demultiplexes the transmitted signal to recover the process information from the reference frequency.

1.61 As an example of how telemetry is used in industry, consider a gas pipeline hundreds of miles long. The pipeline has a number of unmanned pumping stations. A microwave telemetry system transmits performance data—without using any wires—from each pumping station to a central control station.

1.62 The major advantage of telemetry is that it eliminates the need for wires, tubing, and other devices between the process being measured and the remote indicator. However, telemetry is the most complex of the data transmission systems discussed in this Lesson. The complexity of the system lowers reliability. Another disadvantage is that atmospheric disturbances can interrupt the data flow when radio or microwave transmissions are used.

1-9. Mechanical methods generally are used to transmit process data only over ________ distances.	1-9. SHORT Ref: 1.30
1-10. Hydraulic methods of data transmission are best suited to processes that involve ________.	1-10. LIQUIDS Ref: 1.32
1-11. For transmitting pressure data by hydraulic means, the indicator must be at tank level to prevent errors due to ________.	1-11. STATIC HEAD Ref: 1.34
1-12. The presence of ________ or ________ in an air system can cause blockage of pneumatic signals.	1-12. DIRT; MOISTURE Ref: 1.39
1-13. Process data transmitted by electronic means can be in ________ or ________ form.	1-13. ANALOG; DIGITAL Ref: 1.40
1-14. Electronic signals in a current loop are ________ susceptible to noise interference than those in a voltage loop.	1-14. LESS Ref: 1.47
1-15. The cable for the ________ data transmission method does not conduct electricity and does not cause EMI.	1-15. FIBER OPTIC Ref: 1.56, 1.57
1-16. The ________ data transmission method requires no wires or tubes between the process and the indicator.	1-16. TELEMETRIC Ref: 1.62

Answer the following questions by marking an "X" in the box next to the best answer.

1-1. In a modern closed-loop system, process variables are monitored continuously by a(n)

- ☐ a. computer-based controller
- ☐ b. electronic transducer
- ☐ c. fiber optic cable
- ☐ d. pneumatic transmitter

1-2. A remote indicator always requires a transmitter and a(n)

- ☐ a. amplifier
- ☐ b. controller
- ☐ c. sensor
- ☐ d. transducer

1-3. The outputs of digital transducers are in the form of

- ☐ a. 1 to 5mV
- ☐ b. 4 to 20mA
- ☐ c. digital computer words
- ☐ d. on or off signals

1-4. Which of the following data transmission methods is most difficult to make intrinsically safe?

- ☐ a. Electrical
- ☐ b. Fiber optical
- ☐ c. Hydraulic
- ☐ d. Pneumatic

1-5. A main advantage of mechanical data transmission is that

- ☐ a. data can be transmitted accurately over long distances
- ☐ b. its versatility makes it useful for complex systems
- ☐ c. little maintenance is required
- ☐ d. no external power is required

1-6. Pneumatic data transmitters

- ☐ a. are intrinsically safe
- ☐ b. are limited to short-distance transmissions
- ☐ c. can be interfaced directly to computers
- ☐ d. require no maintenance

1-7. A major advantage of digital over analog data transmission is in

- ☐ a. accuracy
- ☐ b. installation requirements
- ☐ c. maintenance requirements
- ☐ d. space requirements

1-8. Which of the following converts an electrical current signal to a pneumatic signal?

- ☐ a. E/P
- ☐ b. I/P
- ☐ c. P/E
- ☐ d. P/I

1-9. A disadvantage of optical data transmission is that fiber optic cable

- ☐ a. can carry only a small amount of digital data
- ☐ b. emits magnetic energy
- ☐ c. is susceptible to induced electrical transmission
- ☐ d. is very expensive

1-10. A major advantage of telemetric data transmission systems is that they

- ☐ a. are based on very simple technology
- ☐ b. are extremely reliable
- ☐ c. are seldom affected by atmospheric disturbances
- ☐ d. require no wires or tubing between the PV and the indicator

SUMMARY

Process data transmission is the sending of process variable measurements to a control center, which may be quite near the process or many miles away. Data transmission permits the operator to keep the process at optimum operation and also provides information for safety considerations and process diagnostics. Most processes include both local and remote indicators.

Process variables may be in analog or digital form. Analog devices provide proportional control. Outputs from modern digital controllers are in the form of computer words and are proportional to the value of the PV. However, discrete transmitters have two states, on and off.

Intrinsically safe equipment cannot ignite a hazardous atmosphere. Pneumatics, hydraulics, or fiber optics are often used for intrinsically safe data transmission in hazardous locations. Explosion-proof equipment is also widely used. Always follow proper safety procedures in hazardous locations.

Various methods and techniques are used in process data transmission, including mechanical, hydraulic, pneumatic, electrical/electronic, optical, and telemetric. Mechanical and hydraulic transmission methods are simplest and require no external power, and pneumatic devices are intrinsically safe. However, these three methods cannot be directly interfaced to computer-based systems.

Electronic data transmission is most common in process control. Analog data are transmitted on a voltage loop or current loop. Digital data are transmitted as a series of data bits. The number of data bits determines the resolution of the digital signal. Fiber optic networks, which are expensive but intrinsically safe, are also used for digital data transmission. Telemetric systems, the most complex, eliminate the need for wires or tubing, but are subject to interrupted signals due to atmospheric disturbances.

Answers to Self-Check Quiz

1-1. a. Computer-based controller. Ref: 1.10

1-2. c. Sensor. Ref: 1.14

1-3. c. Digital computer words. Ref: 1.17

1-4. a. Electrical. Ref: 1.25

1-5. d. No external power is required. Ref: 1.30

1-6. a. Are intrinsically safe. Ref: 1.38

1-7. a. Accuracy. Ref: 1.51

1-8. b. I/P. Ref: 1.54

1-9. d. Is very expensive. Ref: 1.58

1-10. d. Require no wires or tubing between the PV and the indicator. Ref: 1.62

Contributions from the following are appreciated:

Figure 1-2. Omega Engineering, An Omega Group Co.
Figure 1-3. Taylor Instrument, A Division of Combustion Engineering, Inc.
Figure 1-4. Automatic Switch Co.
Figure 1-6. Moore Products Co.
Figure 1-9. Bailey Controls, div. Babcock & Wilcox
Figure 1-10. Bellofram Corp.
Figure 1-11. Belden Electronic Wire and Cable