

Transmission Systems

API RECOMMENDED PRACTICE 552
FIRST EDITION, OCTOBER 1994

REAFFIRMED, NOVEMBER 2022



American
Petroleum
Institute

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FOREWORD

This publication reflects the current practices in the transmission of instrument measurement and control signals in a refinery.

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Suggested revisions are invited and should be submitted to the director of the Manufacturing, Distribution, and Marketing Department, American Petroleum Institute, 200 Massachusetts Avenue, NW, Washington, DC 20001.

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Transmission Systems

1 Scope

This document reviews the recommended practices for the installation of electronic and pneumatic measurement and control-signal transmission systems. It does not discuss leased wire, radio, and telemetering transmission. The methods described are generally used throughout the United States. These methods are based on the assumption that the field devices, such as measuring transmitters, transducers, valve positioners, control valves, and other devices are properly installed. It is also assumed that the wiring, piping, and tubing at the control panel or Distributed Control System are properly installed. See the other appropriate API Recommended Practices and standards as needed.

2 References

The following publications are cited in this recommended practice:

API

- RP 500 *Classification of Areas for Electrical Installations at Petroleum Facilities*
- RP 540 *Electrical Installations in Petroleum Processing Plants*

ASTM¹

- A 123 *Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*
- A 525 *Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process*

ISA²

- RP 12.6 *Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations* (ANSI/ISA RP 12.6)
- S7.4 *Air Pressures for Pneumatic Controllers, Transmitters, and Transmission Systems* (ANSI/ISA S7.4)
- S7.7 *Recommended Practice for Producing Quality Instrument Air* (ANSI/ISA S7.7)
- S12.4 *Instrument Purging for Reduction of Hazardous Area Classification*
- S50.1 *Compatibility of Analog Signals for Electronic Industrial Process Instruments* (ANSI/ISA S50.1)

NEMA⁴

- 250 *Enclosures for Electrical Equipment* (ANSI/NEMA 250)

¹American Society of Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

²Instrument Society of America, P.O. Box 12277, Research Triangle Park, NC 27709.

³American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

NFPA⁵

- 70 *National Electric Code (NEC)* (ANSI/NFPA 70)
- 78 *Lightning Protection Code* (ANSI/NFPA 78)
- 493 *Intrinsically Safe Apparatus in Division 1 Hazardous Locations*
- 496 *Purged and Pressurized Enclosures for Electrical Equipment* (ANSI/NFPA 496)

3 General

3.1 ADVANTAGES OF TRANSMITTED SIGNALS

Transmission systems permit operation of one or more large or small process units from a remote control center.

3.2 DESIGN CONSIDERATIONS FOR TRANSMISSION SYSTEMS

The following major factors should be considered in the design of transmission systems:

- a. The relationship of time constants among process, transmission, and control lines, since this relationship may influence a control loop's actual performance. This problem is primarily associated with pneumatic transmission.
- b. The reliability of air and electric power supplies.
- c. The routing and installation of tubing, wiring, and piping to maintain circuit integrity; to reduce the possibility of damage from fire, overheating from hot process lines or equipment, and mechanical abuse; and to ensure immunity from electrical and radio-frequency interference.
- d. The resistance of material and construction to corrosion caused by chemicals in the atmosphere or splatter from new construction or maintenance.
- e. Provisions for manual control, testing, and ready access to instruments for maintenance.
- f. Safety requirements and the effect of federal, state, and local regulations and of national and local codes.

3.3 ELECTRONIC

The preferred signal transmission today is electronic. Electronic methods and needs are discussed in depth in this document, starting with Section 4.

3.4 PNEUMATIC

Pneumatic signals are used today primarily in older plants and where there is a special advantage to pneumatics. The

⁴National Electrical Manufacturers Association, 2101 L Street, N.W., Washington, DC 20032.

⁵National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

advantages, needs, and recommended methods are discussed in this document, starting with Section 21.

3.5 FIBER OPTICS

Fiber optics is the phrase applied to the use of transparent glass or plastic fibers to carry light signals between devices. Fiber optics is a maturing technology and will find more use in the future. At present, use is usually limited to dedicated cables between portions of control systems, and for some special applications. Cables, connectors, and matching electronics are available. The user is cautioned to verify that the cable selected is appropriate for the application in strength and mechanical makeup, and that the electronics are appropriate. If the signal power is limited to Light Emitting Diode (LED), sources, rather than a Laser source, there is little concern of ignition of hazardous vapors. If the cable has no metal components which could carry electrical currents, then fiber optics provides complete electrical, *galvanic*, isolation between the connected devices, thus eliminating concerns of ground currents.

3.6 DIGITAL FIELD BUS

Several proprietary digital communications schemes are available today for field instruments, and standards are under development to permit convenient interconnection. Digital communications between microcomputer-based devices can utilize the intelligence of the devices to improve accuracy, to

improve utility, to reduce check-out costs, and to facilitate further advances in control and control systems. These techniques also allow multiple devices to share one wire pair to reduce wiring costs. Where metallic wiring is used, the usual concerns of grounding, electrical surge, and electrical safety all apply.

4 General Information On Electronic Systems

4.1 GENERAL

This section includes practices for classified and non-classified areas. The discussion of electric signal transmission necessarily includes signals, analog or digital, that are used in measurement and control systems. The instruments include sensing elements, transmitters, analyzers, controllers, and display devices.

The installation of signal wiring requires practices that will prevent excessive distortion of the signal. Signal wiring is only part of an electronic signal transmission system. The design and installation of the wiring, transmitter, and receiver must result in a system that is suitably accurate for the application. Factors that must be considered include regulatory codes, requirements of a specific set of equipment, and electrical characteristics of the environment through which the wiring passes. This document describes frequently encountered instruments and associated equip-

Table 1—Specific Applications with Wiring Requirements, Wire Type, and Environment

Application	Normal	Strong Magnetic Field	Strong Electrostatic Field	Reduce Noise over 10 Hertz	Remarks
IP controls, maDC, signal (see 6.1)	I, IV ^a	II, IV	III, V, VI	No need	Constant current source; maximum resistance load is limited
Low energy low voltage sensors (see 6.6)	III, VI	III, VI	III, VI		Type V for short runs; RTDs may require triads
Turbine meter (see 6.7)	III	III	III		Manufacturer's suggestions
Magnetic flow transmitter (see 6.8)	Note ^b				Manufacturer's suggestions
IP controls, voltage signal (see 6.2)	I, IV ^a	II, IV	III, V, VI	No need	Constant voltage source; receiver impedance 100 times source impedance
IP controls distributed control system (see 6.1.1)	I, IV ^a	II, IV ^a	III, V, VI ^a	No need	Verify wiring needs with manufacturer

Note: IP = Industrial Process; for wire types, see Table 4.

^aAcceptable, but not recommended; it is not possible to guarantee no electric fields.

^bSpecial Type III between magnetic flowmeter body and 4-20 maDC transmitter, as above for 4-20 maDC.

ment, along with the reasons for using them. Table 1 lists the types of wire suggested for use in the various measurement and control systems. Table 1 also cites sections of the text that contain more detailed information about each application. The specifications for equipment, enclosures, wiring, and installation methods should fully conform to the regulations of all authorities with jurisdiction at the job site.

4.2 STANDARD ELECTRONIC SIGNAL RANGES

The wide variety of applications makes standardization of signal ranges difficult. Although the signal range of 4–20 milliamperes DC (mA DC) has become the standard for process instruments, not all makes of electronic instruments with the same signal range can be intermixed. Electronic instruments designed to use the same input or output signal may not be compatible because of differences in signal voltages, load impedances, wiring techniques required, intrinsic safety, or other characteristics. ANSI/ISA S50.1, *Compatibility of Analog Signals for Electronic Industrial Process Instruments*, can be referenced for details on compatibility.

4.3 REGULATORY CODES AND RECOMMENDED PRACTICES

It is essential that those responsible for electrical design and installation in processing plants be thoroughly familiar with the current edition of ANSI/NFPA 70 *National Electrical Code (NEC)*; the ISA S12 series of standards; API Recommended Practice 500, *Classification of Areas for Electrical Installations at Petroleum Facilities*; and API Recommended Practice 540, *Electrical Installations in Petroleum Processing Plants*.

4.3.1 Classified Areas and Listed Equipment

The presence of flammable liquids or vapors in an area necessitates classification of that area for the purpose of installing electrical equipment. API Recommended Practice 500 is a guide for determining classification. The three common classifications in a Refinery are as follows: Class I, Division 1; Class I, Division 2; and Unclassified. The criterion for a Division 1 area is that a flammable gas or vapor is likely to exist under normal operating conditions. The criterion for a Division 2 area is that a flammable gas or vapor is likely to exist only during an abnormal operating condition, such as failure or rupture of equipment. Locations that are not classified as Division 1 or 2 are unclassified. Unclassified areas are frequently referred to as nonhazardous areas.

Electrical equipment for a Division 1 location is normally designed to be explosion proof. This term means that the equipment enclosure is strong enough to withstand an internal explosion, and the enclosure joints are wide enough and clearances small enough so that flame will be quenched and will not propagate from the interior of the equipment to the surrounding atmosphere. The NEC specifically accepts pressurization in lieu

of an explosion-proof enclosure. For guidance on how to provide approved purged and pressurized enclosures see ANSI/NFPA 496 “Purged and Pressurized Enclosures for Electrical Equipment” and ISA-S12.4 “Instrument Purging for Reduction of Hazardous Area Classification.”

Another alternative to explosion proof equipment is Intrinsically Safe electrical equipment and wiring. Intrinsically Safe equipment is incapable of releasing sufficient energy, under normal or abnormal conditions, to cause ignition of a specific explosive atmosphere. The NEC also specifically mentions that Intrinsically Safe equipment and wiring can be installed in any hazardous location for which they are approved without regard to the NEC requirements for hazardous locations. For guidance in using Intrinsically Safe equipment, see NFPA 493, “Intrinsically Safe Apparatus in Division 1 Hazardous Locations” and ANSI/ISA-RP12.6 “Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations.”

Equipment designed for Division 2 areas has no installed sparking contacts or parts hot enough to be a hazard, or has sparking contacts immersed in oil or contained in hermetically sealed chambers. When such equipment is not available, non-incendive or explosion-proof equipment is generally used.

For Class I Division 2 areas, “Non-Incendive” practices are acceptable. See ANSI/ISA S12.12 “Electrical Equipment for Use in Class I, Division 2 Hazardous (Classified) Locations.”

4.3.2 Grounding of Equipment Cases and Circuits

Grounding practices in instrumentation are of two types: those concerned with personnel safety and those concerned with signal accuracy and dependability. Both types must conform to the NEC and the regulations of any local governing bodies. Details of grounding installations are discussed in Section 20.

5 Reducing Electrical Interference In Electronic Systems

Electrical interference is any spurious voltage or current from external sources that appears in the signal transmission circuit. When these voltages are excessive, signals are changed or cannot be detected.

5.1 SOURCES OF ELECTRICAL INTERFERENCE

Unwanted voltages enter an electronic signal transmission system by the following means:

- Inductive pickup from alternating-current (AC) fields and/or radio-frequency (RF) interference.
- Electrostatic or capacitive coupling with other circuits.
- Direct coupling with other circuits by means of leakage current paths, ground current loops, or a common return lead for more than one circuit.



5.2 MINIMIZING UNWANTED VOLTAGES IN SIGNAL TRANSMISSION CIRCUITS

5.2.1 Electromagnetic Coupling

Spurious signals from inductive pickup may be eliminated by five methods:

- Using twisted pair wires. See the wire specifications.
- Routing signal wires away from strong AC field (see Section 5.2.6).
- Eliminating or reducing the source. One way to do this is by reducing the interference from power wiring by transposing or twisting the power conductors to cancel out or reduce the AC field that is normally produced by parallel power wires.
- Installing signal wiring in steel conduit or covered trays.
- Shielding the power line if this is known to be the source of interference or by installing the power line in steel conduit.

5.2.2 Electrostatic or Capacitive Coupling

The most effective way of reducing voltages from capacitive coupling is to break the coupling between the external voltage source and the transmission circuit. The coupling is broken by putting a grounded and electrically conductive shield around the signal wires. With a grounded shield around the wires, the external voltage couples strongly with the shield and only weakly with the wires. Only one ground should be established. Multiple grounds on shields will create ground loop interference problems.

Crosstalk can affect the performance of digital field instruments, but can be minimized by the following:

- Eliminating resistances common to multiple circuits, such as common return leads, power supply output fuses, and diodes used to switch between redundant power supplies. In some cases these elements can be effectively bypassed with the use of appropriate capacitors.
- Using Type III or Type VI cable.
- Using individually isolated (floating) circuits when Type IV or Type V cable is used. If intrinsically safe barriers are used, avoid the type which connects one side of the circuit directly to the ground.

5.2.3 Direct Coupling by Leakage Paths

Spurious signals from current leaking from one circuit to another are commonly caused by moisture and may be reduced or eliminated by using properly insulated wire, terminal strips, and dry air purges. High quality insulation should be used in all circuits.

5.2.4 Direct Coupling by Ground Current Loop

Unwanted voltages from ground current flowing through a transmission circuit may be eliminated by removing multiple grounds from the circuits. Only one ground should be established. Multiple grounds on shields can create similar interference problems.

5.2.5 Direct Coupling by Common Return Lead

Use of a single wire as a return lead for several signal circuits to conduct currents for each circuit is not recommended because each current causes a resistive voltage drop

Table 2—Power Level Classification

Level 1 (Low Level Signals)	Level 2 (Medium Level Signals)	Level 3 (High Level Signals)	Level 4 (Power)	Level 5 (High Power)
Thermocouple	Analog signal, DC electronic instruments	DC switching circuits with voltages greater than 28	AC and DC buses with voltages of 0–800 and amperages of 20–800	AC and DC buses with voltages above 800 or amperages above 800
Pulse signals	Resistance temperature devices	AC circuits with amperages less than 28 (lighting circuits, convenience outlets, back-of-panel lights)		
Strain gauge bridge outputs	Lighting and switching circuits with DC voltages of 28 or less	DC control buses with voltages of 250 or less		
	Circuits to lights and relay input buffers with DC voltages of 28 or less	DC relay and contactor coils with voltages of 250 or less		
		Ground detection circuits		

that appears in all the other circuits as an unwanted voltage. These unwanted voltages may be eliminated by providing a separate pair of wires for each signal generator. It is especially important to eliminate these unwanted voltages when digital signals are used.

5.2.6 Separation of Instrument and Power Circuits

Power circuits of different power levels should be installed with proper spacing to avoid interference and to ensure proper operation. (see Section 9). Table 2 describes the five classes of power levels. The minimum separation for circuits in each level class is shown in Table 3.

5.3 INSTRUMENTS TO BE INTERCONNECTED

When an electronic signal transmission system is designed, the level and type of signal and the kinds of signal

generators and receivers must be considered. The instruments can be the following:

- a. Process control instruments.
- b. Sensors with electrical outputs.
- c. Digital Data Transmission.

For wiring purposes, the difference between the first two groups is the frequency response of the equipment. Process control equipment usually has a cut-off frequency on or near 5 Hertz, while computer input circuits may respond to much higher frequencies.

The signals involved are the following:

- a. Process analog, conventional, 4–20 maDC.
- b. Special and low energy/voltage, eg. sensors.
- c. Switches and solenoid valves, other discrete, 120AC, 24VDC or VAC with inductive loads.
- d. Digital data.

Table 3—Wire Separation

Power and signal run in separate steel conduit; signal: individual shielded twisted pairs with overall cable shield, (API Type III and VI)^a

Power Cable(s)	Low Level (millivolts)	maDC (4-20 or 10-50)
Up to 125V @20A	4"	None Req'd
125V to 500V @200A	12"	6"
Over 500V	36"	18"

Power and signal run in separate steel conduit; signal: twisted pair (API II and V)^b

Power Cable(s)	Low Level (millivolts)	maDC (4-20 or 10-50)
Up to 125V @20A	8"	4"
125V to 500V @200A	15"	8"
Over 500V	48"	24"

Power and signal in tray; signal: shielded twisted pair (API III and VI)
OR

Power and signal in tray with metallic barrier; signal twisted pair (API II and V)^c

Power Cable(s)	Low Level (millivolts)	maDC (4-20 or 10-50)
Up to 125V @20A	30"	15"
125V to 500V @200A	60"	30"
Over 500V	180"	96"

Power: steel conduit; signal: tray shielded twisted pair (API III and VI)
OR

Power in tray; signal in steel conduit, shielded twisted pairs (API III and VI)^d

Power Cable(s)	Low Level (millivolts)	maDC (4-20 or 10-50)
Up to 125V @20A	30"	15"
125V to 500V @200A	30"	15"
Over 500V	60"	30"

Notes: mA = milliampere ; DC = direct current; A = ampere.

^aThe above tables are for parallel runs up to 500 feet long; for longer runs increase spacing proportionately to the parallel length.

^b120-volt instrument circuits for alarms, solenoids, and similar circuits should be treated as power circuits in the above tables.

^cGroup wiring by type and level: low level signals to the farthest from power, next maDC circuits, next alarms; next 120V alarms; closest are 120 V solenoid valves and limit switches.

^dThis information is based partly on data and partly on accepted and proven experience.

6 Engineering Factors In Selection Of Wire Types For Electronic Systems

This section describes wiring practices for signal transmission systems for instruments commonly used. For each typical application, one type of wire or signal conductor is suggested. The wire types are identified with Roman Numerals and are defined in Table 4.

Table 4—Types of Wire or Cable for Signal Transmission

Type	Description
I	Untwisted copper wire
II	Single, unshielded twisted-pair copper wire
III	Single, shielded twisted-pair copper wire
IV	Multipair cable of Type II wire
V	Multipair, overall shielded cable of Type II wire
VI	Multipair, overall shielded cable of Type III wire

Note: In the above, replace the word *pair* with *triple* or *triad* for wiring certain items such as some resistance bulb sensors (RTD), or strain gauges, and others like these.

6.1 PROCESS CONTROLS WITH MILLIAMPERE SIGNALS

Most process control instruments use DC milliamper current signals in wiring that goes from a transmitter to a display station, or a control system, a controller, and/or other receivers, and from the controller to a final control element. The standard signal is 4–20 milliamper DC.

6.1.1 Wire Type

Although a pair of untwisted, unshielded, stranded copper wires (Type I) may be used to interconnect most industrial process control equipment, such use is not recommended. For installations where the possibility of magnetic-field interference exists, single, unshielded twisted-pair wires (Type II) can be used. In runs of three or more pairs, multipair cable (Type IV) should be considered for economic reasons. Where excessive interference is due to electrostatic coupling, shielded (Type III, V, or VI) should be used. Type VI is more expensive and might not be justified.

These wires or cables can be enclosed in conduits or laid in trays, but DC signal wiring should not be mixed with AC signal wiring or power wires.

6.1.2 Mixing Signals

It is considered poor practice to mix wiring of significantly different signal levels. In other words, wiring with low energy/voltage should not be mixed with wiring carrying AC signals, DC pulses, or any power. Wiring with

4–20 maDC signals should be separated from 120 VAC to solenoids, 120 VAC alarms and power wiring, and power signals. See Table 5.

Table 5—Guidelines for Grouping Wires Bearing Signals of the Same Magnitude

Type of Signal	Suggested Range
<u>DC Voltage</u>	
Low	0 millivolts < Signal < 100 millivolts
Medium	100 millivolts < Signal < 5 volts
High	5 volts < Signal < 75 volts
<u>AC Voltage</u>	
Low	0 millivolts < Signal < 100 millivolts
Medium	100 millivolts < Signal < 5 volts
High	5 volts < Signal < 75 volts
<u>DC Current</u>	
	0 milliamperes < Signal < 50 milliamperes

6.1.3 Resistive Loading

Instrument manufacturers publish limits on the resistive load that can be put on each signal generator for specified supply voltages.

Installations should be in accordance with the manufacturers' recommendations. The maximum transmission distance for a loop can be determined by using data from Table 6, the input resistance of the various receivers, power supply voltage, and the maximum resistive loading. This is rarely a problem except for Intrinsically Safe applications.

Table 6—Resistance of Copper Wire-Per Conductor

AWG	Diameter, inches	Ohm/1000 ft	Ohm/mile
10	0.1019	0.9989	1.588
12	0.08081	1.588	8.384
14	0.06408	2.525	13.33
16	0.05082	4.016	21.20
18	0.04030	6.385	33.71
19	0.03589	8.051	42.50
20	0.03196	10.15	53.59
22	0.02535	16.14	85.21
24	0.02010	25.67	135.5

Note: ft = feet; AWG = American Wire Gauge.

6.1.4 Grounding

Noise from ground loops can be avoided by limiting grounds to only one ground point per circuit (see also Section 20).

6.2 PROCESS CONTROLS WITH VOLTAGE SIGNALS

Voltage signals are seldom used for long-distance transmission because of voltage-drop considerations. One exception is vibration monitoring systems.



When a voltage signal is used, precautions must be taken to ensure that the transmission system does not degrade the measurement signal.

6.3 DIGITAL COMMUNICATIONS SIGNALS

Digital Communications Signals (DCS) are normally interconnected with data-highway cables. The control system manufacturer specifies the cable and recommends the installation details.

6.4 PROCESS CONTROL LOW ENERGY/ VOLTAGE SENSORS

Low energy/voltage sensors include thermocouples. Resistance temperature detectors (RTDs) and strain gauges generate low DC voltages when energized with a DC power supply.

6.4.1 Grounding

Circuits that contain resistance temperature detectors and strain gauges should not be grounded at more than one point. The preferred location is near the source of power and on the lower voltage wire. Grounded thermocouples should have no other grounded point than that in the primary sensor. Sneak circuits can easily occur because the extent of isolation and grounding within instruments varies with their function and make. The selection of grounded-junction or ungrounded-junction is beyond the scope of this standards (also see Section 20).

6.4.2 Thermocouple Burnout Circuit

Frequently the electronics used with a thermocouple will include provision for *upscale (downscale) burnout*. This provision is typically accomplished by imposing a small circulating current on the thermocouple circuit. If the thermocouple or the connecting wiring is broken, the output signal is driven to the maximum (minimum). It is necessary to consider this current in any special thermocouple circuits which would put electronic devices in parallel, since the burnout circuits may interfere with each other.

6.5 PROCESS CONTROL WITH PULSE OUTPUT METERS

Pulse output meters are usually connected to devices that have a relatively high input impedance.

The recommendations of the manufacturer concerning the preamplifier and the wiring should be carefully considered.

Power wires and other types of signal wires should not be mixed with pulse signal wiring. The wire type and the grounding of the signal circuit should follow the manufacturer's recommendations.

6.6 LOW-IMPEDANCE SENSORS TO COMPUTERS

Low-impedance sensors to computers are the same as those listed in 6.4.

Shielded twisted pair wires (Types III and VI) should be used. A multipair cable with only an overall shield (Type V) can normally be used if the distance is less than 100 feet (30 meters) and common-mode interference is small. Individual shielding (Type III or VI) may not be needed, depending on the design of the receiver. For thermocouples, the extension lead wire should consist of shielded, twisted pairs. This wire should comply with ANSI MC96.1

6.7 TURBINE METERS

The suggestions of the manufacturer concerning the preamplifier and the wiring should be carefully considered.

Most turbine meters are supplied with integral converters to amplify the pulses or to convert for transmission of 4–20 milliamperes DC. Wiring for integral or field converters may require more than two wires (see 6.5).

6.8 MAGNETIC-FLOW TRANSMITTERS

The electric signal from magnetic flow electrodes is generally less than 50 millivolts. The low signal level requires that the electrical interference be minimized. Minimizing is done by using a two-conductor, shielded, twisted-pair cable whose length is limited by the manufacturer's recommendations. The recommended cable length is a function of the measured fluid's conductivity and the grade of the cable.

The recommendations of the manufacturer should be followed. The transmitter, cable, and receiving instrument are designed and sold as a unit. The spacing requirements given in Table 3 should be followed. Alternatively, an integral amplifier/converter may be used.

7 Specifications For Wires And Cables In Electronic Systems

General wiring requirements, such as those for twisted-pair, shielded, and other types of wire, are given in Section 6. The frequently used wires can be classified into one of the six types that are described in Table 4.

7.1 WIRE SIZE

The smallest wire size that will not cause an excessive voltage drop and that has sufficient strength and workability should be selected. Normally, the size used for single conductor wire is 14 gauge, that for single twisted-pair wire is 16 gauge, and that for multipair cable is 20 gauge. Other wire gauges may be selected for reasons of economy, space, or application.

7.2 STRANDED WIRE

Stranded wire is preferred because of its flexibility and resistance to breakage by bending. Where great flexibility is needed, wire with 19 strands is suggested; otherwise, seven-strand wire should be used.

In areas of high corrosion, solid conductors may be preferred. Thermocouple wires and 20-gauge multipair cables are normally solid conductors. Consider using tinned stranded wire for additional protection in high corrosion areas.

7.3 INSULATION

The insulation of signal wire should be adequate for the operating voltage and current. Most electric signals are less than 95 volts to ground and lower than 5 watts. Wire insulated for 300 volts is satisfactory for signals of this low operating level. To meet NEC requirements, wires in the same raceway must have insulation adequate for the highest voltage on any of the wires.

7.4 TEMPERATURE RATING

The wire or cable should have a temperature rating high enough for the anticipated environment. It is suggested that 75°C be specified as a minimum temperature requirement. In very cold localities, the lowest temperature at which the wire or cable is rated is also of interest. High temperature insulation should be used in areas of expected high temperatures, such as furnace areas. When protection from flash fires is required, an arrangement of thermal barriers and/or fire retardants can be provided. Some users prefer to purchase fire-rated cable; it is possible to retain control for a reasonable time, 15-20 minutes of exposure to fire. An alternative is to bury the conductors underground. See also 13.2.6.

7.5 OVERALL JACKET

The overall jacket material should be moisture resistant, abrasion resistant, flame retardant, and compatible with the environment.

7.6 SHIELDING

The preferred shielding is aluminized polyester film with an overall spiral wrap that has 25-percent overlap. The shield should be electrically in contact with a copper drain wire that is as long as the pair of signal wires. The shield should be electrically insulated both inside and outside. For multipair cables, overall shielding should have the same specifications and should also be insulated both inside and outside.

7.7 NUMBER OF CROSSOVERS

Twisted wire should have a minimum of six crossovers per foot (2 inch lay)(20 crossovers per meter). Eight crossovers per foot (26 crossovers per meter) is a typical specification.

7.8 WIRE AND PAIR IDENTIFICATION

Either number coding or color coding is required in multipair wiring.

7.9 COMMUNICATION WIRES

Inclusion of communication wires in any multiple-pair cable is recommended to assist in the checkout of wiring and maintenance using sound-powered headphones.

7.10 LIGHTNING PROTECTION

Refer to Section 16 for information on lightning protection.

8 Typical Applications of Wire Types Used in Electronic Systems

Six common types of wire and cable are described in Table 4. Table 1 provides a quick guide for selecting the minimum type of wire that can be used for a given application. Generally, the following rules of thumb can be applied with good results:

Wiring from a field mounted electronic instrument to a field mounted junction box or multiplexer box should be Type III.

Wiring from the field junction box to the control building or "rack room" can be multi-pair Type V cable for signal levels one volt or greater; but should be Type VI for signal levels less than 1 volt and for thermocouples.

9 Guidelines for Separation of Wires in Electronic Systems

Most industrial plants will require signal transmitting systems of several different types. Guidelines for separating the various systems from each other and from power wiring and equipment are presented below (see also 6.3).

9.1 SIMILAR SIGNAL LEVELS

All the signals in one cable or conduit should be of similar magnitude. Whenever it is necessary to combine different signal levels in a single cable or conduit, each pair should be individually shielded and grounded at a single point. Floating (balanced) wiring is used and minimizes interference in many systems; however, it may be difficult to maintain.

Wiring from some types of sensor should be completely separated from other circuits. Magnetic flow meters, turbine meters, pH electrode wiring, chromatograph detector wiring, and AC-powered bridge circuits are just a few examples. Thermocouple wiring should not be mixed with milliampere signal wiring. Wiring for circuits in which sharp voltage pulses are transmitted (such as relay contact closures, relay coils, and solenoids) should also be segregated from other wiring.

A practical exception to the preceding is the situation of one conduit to a control valve with the wiring for the 4–20 maDC signal for the valve, the 24 VDC for an associated solenoid valve, plus the wiring for the limit switches.

9.2 SIGNAL AND POWER WIRING

Where signal wiring is run along a parallel route with AC power circuits, separation of conduits, cable, and trays