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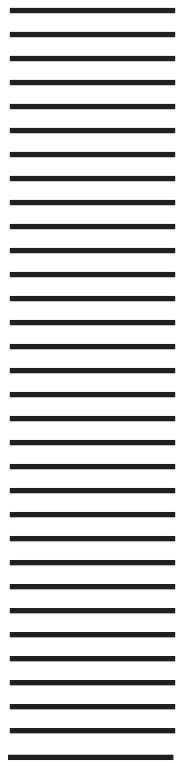

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1.1 Flowsheet Symbols and P&I Diagrams*

G. PLATT (1982) **B. G. LIPTÁK** (1995) **J. E. JAMISON, A. ROHR** (2003)

The purpose of this section is to help the reader establish a uniform means of depicting and identifying all classes of instruments, instrumentation systems, and functions used for measurement, monitoring, and control. It is done by presenting a designation system of graphic symbols and identification codes.

It must be noted that a significant part of this section has been extracted from the revision work of the ISA** SP5.1 subcommittee, and much of it has been based on draft working documents being utilized at the time of this writing, documents with which one of the authors has been actively involved. Other portions of this section, dealing with certain symbols, graphics, and practical tips, are based on the authors' experience in industry and are not part of the SP5.1 subcommittee's proposed forthcoming revision.

A disclaimer to any future ISA standards documents is hereby stated: The reader is cautioned that the draft ISA document that provided much of the information in this section has not been approved as of the time of this writing. It cannot be presumed to reflect the position of ISA or any other committee, society, or group. The intent is to pass along to the reader the best and latest thinking on this subject at this point in time, although many items are contentious and are ultimately subject to change in the continuously evolving fields of digital control systems and digital data buses.

Another view of flowsheet and piping and instrument diagram (P&ID) symbols and diagrams covered in this section is in terms of practical aspects and practices used by instrumentation and control practitioners in the engineering, procurement, and construction (EPC) industry.

SCOPE**

General

The procedural needs of various users are different, and these differences are recognized, when they are consistent with the objectives of this standard, by providing alternative symbol and identification methods.

A limited number of examples are provided later that illustrate (with the emphasis on digital systems/loops) how to accomplish the following:

a) Design an identification system and construct an identification number
b) Use graphic symbols to construct the following:
   1) Schematic diagrams of instrument devices and functions in monitoring and control loops
   2) Schematic and ladder diagrams of electrical circuits
c) Add information and simplify diagrams

Examples of symbol applications are generally shown as applied in the oil and chemical processing industries as in the original version of this standard, but the principles shown are applicable to most other industries.

Specific applications are to be addressed in greater detail and will be forthcoming in the planned S5.1 (now ANSI/ISA-5.01.01) series of Technical Reports dedicated to the various processing, generating, and manufacturing industries. These will include processes such as continuous and batch chemical, oil, and metal refining, pulp and paper, water and waste treatment, power generation and distribution, and discrete parts manufacturing.

Application to Industries

The proposed revised ISA S5.1 (now ANSI/ISA-5.01.01) standard will be suitable for use in the above-mentioned process industries and in discrete parts manufacturing where the use of control system schematic and functional diagramming is required to describe the relationship with processing equipment and the functionality of measurement and control equipment.

Certain fields, such as astronomy, navigation, and medicine, use very specialized instruments that are different from conventional industrial process instruments. No specific effort was made to have the ISA standard meet the requirements of those fields. However, it is expected that, in certain areas such as control functional diagrams, they will prove applicable for such specialized fields.

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**Formerly called the Instrument Society of America.

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Application to Work Activities

The proposed revised ISA S5.1 (now ANSI/ISA-5.01.01) standard will be suitable for use whenever reference to measurement and control instrumentation, control device functions, or software applications functions is required for the purposes of symbolization and identification. Such references may be required for the following uses as well as others:

a) Design sketches
b) Teaching examples
c) Technical papers, literature, and discussions
d) Instrumentation system diagrams, loop diagrams, logic diagrams, and functional diagrams
e) Functional descriptions
f) Conceptual drawings: process flow diagrams (PFDs) and utility flow diagrams (UFDs)
g) Construction drawings: engineering flow diagrams (EFDs), mechanical flow diagrams (MFDs), piping and instrument diagrams (P&IDs), and system flow diagrams (SFDs)
h) Specifications, purchase orders, manifests, and other lists
i) Identification and tag numbering of instruments and control functions
j) Installation, operating, and maintenance instructions, drawings, and records

The standard is intended to provide sufficient information to enable anyone with a reasonable amount of process and instrumentation knowledge to understand the methods of measurement and process control.

It is not necessary to possess the detailed knowledge of a specialist in instrumentation and control systems to understand the standard.

Application to Classes of Instrumentation and to Instrument Functions

The symbolism and identification methods provided in the standard are applicable to all classes and types of measurement and control instruments and functions.

The methods can be used for, but are not limited to, describing and identifying the following:

a) Discrete (individual) instruments and their functions
b) Shared display and control functions
c) Distributed control functions
d) Computer control functions
e) Programmable logic controller display and control functions
f) Application software display and control functions

Extent of Loop and Functional Identification

The ISA S5.1 standard (now ANSI/ISA-5.01.01) provides identification codes and methods for the alphanumeric identification of monitoring and controlling loops, instruments, and functions. The user is free to apply additional identification by serial, equipment, unit, area, or plant number or any other additional means required for the unique identification of a loop, instrument, or function.

A unique function identification number shall identify each instrument, its inherent functions, and each configurable function that requires or allows a user-assigned, unique microprocessor or computer address required by a loop.

Extent of Symbolization

The standard provides symbol sets for the graphic depiction of limited or total functionality for instruments and other devices, entire monitor/control loops, or control circuits. The amount of detail to be shown by the use of symbols depends on the purpose and audience for which the document is being prepared.

A sufficient number of symbols should be used to show the functionality of the instrumentation and control loop being depicted. However, it is not considered necessary to provide a symbol for each instrument device and each function within a loop.

Additional construction, fabrication, installation, and operation details of an instrument are better described in a suitable specification, data sheet, drawing, sketch, or other document intended for individuals who require such details.

Inclusion of the New S5.1 Standard (now ANSI/ISA-5.01.01) in User/Owner Documents

This is a new concept in ISA standards at this point in time. Mandatory use of the standard is required by users/owners based on the following statements.

When the latest issue of the standard is included in user/owner's engineering and/or design guidelines or standards by reference and

a) "Without exception," then the standard in its entirety shall be mandatory.
b) "With exceptions," then the parts of the standard:
   1) "Excepted to" shall be fully described and detailed.
   2) "Not excepted to" shall be mandatory.

When a previous issue of the standard is included by reference with or without exception in user/owner's engineering and design guidelines or standards, that standard in part or in its entirety shall be mandatory until such time as the user/owner's guidelines or standards are revised. When the new issue is used as a guide in the preparation of user/owner's guidelines or standards, symbols and letter and symbol meanings different from those in the standard shall be fully described and detailed.

Symbols and the meanings of letters and symbols from previous issues of the S5.1 standard (now ANSI/ISA-5.01.01) that are different from those contained in this new issue may continue to be used, provided that they are fully described and detailed.

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DEFINITIONS RELATED TO FLOWCHART DIAGRAM SYMBOLOGY

See statement of permission on page 4.

General

For the purpose of understanding the ISA S5.1 standard (now ANSI/ISA-5.01.01), the following definitions and terminology apply. For a more complete treatment, see ISA-S51.1 and the ISA-S75 series of standards. Terms italicized within a definition are also defined in this clause.

Definitions Related to Flowsheet Symbology

Accessible A feature of a discrete device function or feature of an interactive shared system function or feature that can be used or seen by an operator for the purpose of performing control operations, such as setpoint changes, auto-manual transfer, or on–off operations.

Alarm An indicating instrument that provides a visible and/or audible indication if and when the value (or rate of change value) of a measured or initiating variable is out of limits, has changed from a safe to an unsafe condition, and/or has changed from a normal to an abnormal operating state or condition.

a) Actuation may be by binary switch or function or analog transmitter or function.
b) Indication may be by annunciator panel, flashing light, printer, buzzer, bell, horn, siren, and/or shared graphic display systems.

Analog A signal or device that has no discrete positions or states and changes value as its input changes value. When used in its simplest form, as in "analog signal" as opposed to "binary signal," the term denotes a continuously varying quantity.

Application software Software specific to a user application that is configurable and in general contains logic sequences, permissive and limit expressions, control algorithms, and other code required to control the appropriate input, output, calculations, and decisions. See also *software*.

Assignable A system feature permitting channeling or directing of a signal from one device to another without the need for changes in wiring either by means of patching, switching, or via keyboard commands to the system.

Auto-manual station A manual loading station or control station that also provides switching between manual and automatic control modes of a control loop. See also *manual loading station.*

Balloon An alternative term for the circular symbol used to denote and identify the purpose of an instrument or function that may contain a tag number. See preferred term, *bubble.*

Behind the panel A location that, in a broad sense, means "not normally accessible to an operator," such as the rear of an instrument or control panel, an enclosed instrument rack or cabinet, or an instrument rack room within an area that contains a panel.

Binary A signal or device that has only two discrete positions/states and, when used in its simplest form, as in "binary signal" as opposed to "analog signal," the term denotes an "on–off" or "high–low" state.

Board A freestanding structure consisting of one or more sections, cubicles, or consoles that has groups of discrete (individual) instruments mounted on it, houses the operator–process interface, and is chosen to have a unique designation. See *panel.*

Bubble The preferred term for the circular symbol used to denote and identify the purpose of an instrument or function that may contain a tag number. See alternative term, *balloon.*

Communication link A wire, cable, or transmitter network or bus system that connects dedicated microprocessor-based and computer-based systems so that they share a common database and communicate according to a rigid protocol in a hierarchical and/or peer-to-peer relationship. See also *data link.*

a) Wires or cables may be of twisted pair, coaxial, telephone, or fiber optic construction.
b) Transmitters may be radio, telephone, and/or microwave devices.

Computer control system A system in which all control action takes place within a control computer, such as a mainframe computer or minicomputer, which may be single or redundant.

Computing device Preferred term for a device that performs one or more calculations or logic operations, or both, and transmits one or more resultant output signals. See also *computing relay.*

Computing function A hardware or software function that performs one or more calculations or logic operations, or both, and transmits one or more resultant output signals.

Computing relay Alternative term for a device that performs one or more calculations or logic operations, or both, and transmits one or more resultant output signals. See also *computing device.*

Configurable A term for devices or systems whose functional or communication characteristics can be selected or rearranged through setting of program switches, application software, fill-in-the-blank forms, pull-down menus, entered values or text, or other methods other than rewiring as a means of altering the configuration.

Controller A device having an output that varies to regulate a controlled variable in a specified manner that may be a self-contained analog or digital instrument or may be the equivalent of such an instrument in a shared-control system.

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a) An automatic controller varies its output automatically in response to a direct or indirect input of a measured process variable.
b) A manual controller, or manual loading station, varies its output in response to a manual adjustment; it is not dependent on a measured process variable.
c) A controller may be an integral element of other functional elements of a control loop.

Control station A manual loading station that also provides switching between manual and automatic control modes of a control loop. See also *auto-manual station.*
a) The operator interface of a distributed control system may be referred to as a *control station*.

Control valve A device, other than a common, hand-actuated process block valve or self-actuated check valve, that directly manipulates the flow of one or more fluid process streams.
a) The designation "hand control valve" shall be limited to hand-actuated valves that, when used for process throttling, require identification as an instrument or control device.

Converter A device that receives information as one form of an instrument signal and transmits an output signal as another form, such as a current to pneumatic signal converter.
a) An instrument that changes a sensor's output to a standard signal is properly designated as a transmitter and not a converter. Typically, a temperature element (TE) connects to a transmitter (TT) and not to a converter (TY).
b) A converter is sometimes referred to as a *transducer,* a completely general term not recommended for signal conversion.

Data link A wire, cable, or transmitter network or bus system that connects field located devices with dedicated microprocessors so that they share a common database and communicate according to a rigid protocol in a hierarchical or peer-to-peer relationship to other such devices and/or compatible microprocessor-based systems. See also *communication link.*
a) Wire or cable may be of twisted-pair, coaxial, telephone, or fiber optic construction.
b) Transmitters may be radio, telephone, or microwave devices.

Detector A device that is used to detect the presence of something, such as flammable or toxic gases or discrete parts. See also *primary element* and *sensor.*

Device A piece of instrument hardware that is designed to perform a specific action or function, such as a controller, indicator, transmitter, annunciator, or control valve.

Digital A signal or device that generates or uses binary digit signals to represent continuous values or discrete states.

Discrete A term used to describe the following:
a) Signals that have any number of noncontinuous distinct or defined states or positions. Binary signals are a subset. See *binary.*
b) Instruments or devices that have separate or individual entities, such as a single-case controller or recorder.

Distributed control system Instrumentation, input/output devices, control devices, and operator interface devices that, in addition to executing stated control and indication functions, permits transmission of control, measurement, and operating information to and from single- or multiple-user specifiable locations, connected by single or multiple communication links.

Field instrument An instrument that is not mounted on a panel or console or in a control room but commonly in the vicinity of its primary element or final control element. See *local instrument*.

Final control element A device, such as a control valve, that directly controls the value of the manipulated variable of a control loop.

Function The purpose of, or the action performed by, a device or application software.

Identification The sequence of letters or digits, or both, used to designate an individual instrument, function, or loop.

Instrument A device used for direct or indirect measurement, monitoring, or control of a variable.
a) Includes primary elements, indicators, controllers, final control elements, computing devices, and electrical devices such as annunciators, switches, and pushbuttons.
b) Does not apply to an instrument's internal components or parts, such as receiver bellows or resistors.

Instrumentation A collection of instruments or functions or their application for the purpose of measuring, monitoring, controlling, or any combination of these.

Local instrument An instrument that is not mounted on a panel or console or in a control room but commonly is in the vicinity of its primary element or final control element. See *field instrument.*

Local panel A panel that is not a central or main panel and is commonly located in the vicinity of plant subsystems or subareas (sometimes called a *local instrument panel*).
a) The term *local panel instrument* should not be confused with *local instrument* or *local instrument panel*.

Loop A combination of two or more instruments or control functions arranged so that signals pass from one to another for the purpose of measurement indication or control of a process variable.

Manual loading station A device or function that has a manually adjustable output and may also have indicators, lights, and/or other functions that are used

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to actuate or modulate one or more devices. It does not provide switching between auto-manual modes of a control loop.

Measurement The determination of the existence or magnitude of a process variable.

Monitor A general term for an instrument or instrument system used to measure or sense the status or magnitude of one or more variables for the purpose of deriving useful information. This sometimes means an analyzer, indicator, or alarm.

Monitor light A light that indicates which of a number of normal (but not abnormal) conditions of a system or device exists. See also *pilot light.*

Multifunction devices Devices (controllers) that receive one or more input signals and send out two or more output signals or perform two or more functions. See *multipoint* and *multivariable devices*.

Multipoint devices Indicators or recorders that may be single or multivariable type and that receive input signals from two or more primary elements or transmitters. See *multifunction devices* and *multivariable devices*.

Multivariable devices Devices (indicators, recorders, or controllers) that receive two or more input signals and send one output signal. See *multifunction* and *multipoint devices*.

Panel A freestanding or built-in structure, consisting of one or more sections, cubicles, consoles, or desks, in which groups of instrument hardware are mounted. It could house the operator–process interface and is given a unique designation.

Panel-mounted An instrument or other device that is mounted in a panel or console and is accessible for an operator's normal use.

a) A function that is normally accessible to an operator in a shared-display system is the equivalent of a discrete panel-mounted device.

Pilot light A light that indicates which of a number of normal conditions of a system or device exists. It is not an alarm light that indicates an abnormal condition. See also *monitor light.*

Primary element An external or internal instrument, or a system element, that quantitatively converts the measured variable into a form suitable for measurement. See also *detector* and *sensor*:

a) An orifice plate is an external primary element.
b) The sensing portion of a transmitter is an internal primary element.

Process Any operation or sequence of operations involving a change of energy, state, composition, dimension, or other properties that may be defined with respect to zero or some other defined initial value.

Process variable Any measurable property of a process. Used in this standard to apply to all variables other than instrument signals between devices in a loop.

Program A repeatable sequence of actions that defines the state of outputs as a fixed relationship to the state of inputs.

Programmable logic controller A controller, usually with multiple inputs and outputs, that contains an alterable program that is

a) Typically used to control binary and/or discrete logic or sequencing functions.
b) Also used to provide continuous control functions.

Relay A device whose function is to pass on information in an unchanged form or in some modified form; often used to mean the preferred term, *computing device.*

a) *Relay* is a term applied specifically to an electric, pneumatic, or hydraulic switching device that is actuated by a signal, and to functions performed by a relay.

Scan To sample or multiplex, in a predetermined manner, each of a number of variables periodically and/or intermittently.

a) A scanning or multiplexing device is often used to ascertain the state or value of a group of variables and may be associated with other functions such as recording and alarming.

Sensor A separate or integral part, or function, of a loop or an instrument that first senses the value of a process variable. It assumes a corresponding predetermined and intelligible state and/or generates an output signal indicative of or proportional to the process variable. See also *detector* and *primary element*.

Setpoint An input variable that sets the desired value of the controlled variable manually, automatically, or by means of a program in the same units as the controlled variable.

Shared control A feature of a control device or function that contains a number of preprogrammed algorithms that are user retrievable, configurable, and connectable. It allows user-defined control strategies or functions to be implemented and is often used to describe the control features of a distributed control system.

a) Control of multiple process variables can be implemented by sharing the capabilities of a single device of this kind.

Shared display The operator interface device (such as video, light emitting diode, liquid crystal, or other display unit) used to display process control information from a number of sources at the command of the operator. It is often used to describe the visual features of a distributed control system.

Software The programs, codes, procedures, algorithms, patterns, rules, and associated documentation required for the operation or maintenance of a microprocessor- or computer-based system. See also *application software*.

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Software link The interconnection of system components via communications networks or functions via software or keyboard instruction.

Supervisory setpoint control system The generation of setpoint or other control information by a computer control system for use by shared control, shared display, or other regulatory control devices.

Switch A device that connects, disconnects, selects, or transfers one or more circuits and is not designated as a controller, relay, or control valve. As a verb, the term is also applied to a function performed by a switch.

Test point A process connection to which no instrument is permanently connected; it is intended for the temporary or intermittent connection of an instrument.

Transducer A general term for a device, which can be a primary element, transmitter, relay, converter, or other device, that receives information in the form of one or more physical quantities, modifies the information or its form if required, and produces a resultant output signal.

Transmitter A device that senses a process variable through the medium of a sensor or measuring element and has an output whose steady-state value varies only as a predetermined function of the process variable. The sensor can be an integral part, as in a direct connected pressure transmitter, or a separate part, as in a thermocouple-actuated temperature transmitter.

IDENTIFICATION SYSTEM GUIDELINES

See statement of permission on page 4.

General

This subsection establishes an identification system for instrument loop devices and functions. It is logical, unique, and consistent in application with a minimum of exceptions, special uses, and requirements. The identification system is used to identify instrumentation in text, sketches, and drawings when used with graphic symbols as described in the subsection titled "Graphic Symbol System Guidelines."

The identification system provides methods for identifying instrumentation required to monitor, control, and operate a processing plant, unit operation, boiler, machine, or any other system that requires measurement, indication, control, modulation, and/or switching of variables.

Primary instrumentation, hardware and software devices, and functions that measure, monitor, control, and calculate, and application software functions that require or allow user-assigned identities, shall be assigned both loop and functional identification.

Secondary instrumentation, such as hardware devices that measure and monitor, as well as level glasses, pressure gauges, and thermometers, shall be assigned only a functional identification.

Loop and functional identification shall be assigned in accordance with the guidelines in the standard or with modified guidelines based on the standard, established by the user or owner of the plant, unit, or facility in which the instrumentation is to be installed.

A unique loop identification number shall be assigned to identify each monitoring and control loop. A unique instrument identification/tag number based on the loop identification number shall be assigned for each monitoring or control loop to identify each of the following:

a) Hardware device and integral functions
b) Application software functions that require or allow a user-assigned unique microprocessor or computer address

A monitor or control loop consists of some or all of the following (as indicated):

a) Measurement of the process variable (monitor and control):
   1) Measuring element device, such as an orifice plate or thermocouple
   2) Measurement transmitter, with an integral measuring element, such as a pressure transmitter or without an integral measuring element, such as a temperature transmitter and thermocouple
b) Conditioning of the measurement or input signal (monitor and control):
   1) Calculating devices
   2) Calculating functions
   3) Safety barriers
c) Monitoring of the process variable (monitor):
   1) Indicating or recording device
   2) Application software display function
d) Controlling of the process variable (control):
   1) Indicating or recording control device
   2) Application software control function
e) Conditioning of the controller or output signal (control):
   1) Calculating devices
   2) Calculating functions
f) Modulation of the manipulated variable (control):
   1) Control valve modulation or on–off action
   2) Manipulation of another control loop setpoint
   3) Limiting another control loop output signal

Secondary instrumentation shall be assigned instrument identification/tag numbers or other forms of identification in accordance with the guidelines established in the ISA standard or with modified guidelines based on the standard established by the user/owner of the plant, unit, or facility in which the instrumentation is to be installed.

Examples of instrument identification systems will be found in a future series of S5.1 (now ANSI/ISA-5.01.01) Technical Reports.

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Instrument Index

Loop identification numbers and instrument identification/tag numbers shall be recorded in an instrument index (either manually generated or computerized instrument database), which shall be maintained for the life of the facility for the recording and control of all documents and records pertaining to the loops and their instrumentation and functions.

An instrument index shall contain references to all instrumentation data required by owner or government regulatory agency management-of-change requirements. It should contain, as a minimum, for each loop:

a) Loop identification number
b) Service description
c) Instrument identification/tag numbers
d) Piping and instrument (P&ID) drawing numbers
e) Instrument data sheet numbers
f) Location plan numbers
g) Installation detail drawing numbers

Guideline Modifications

These guidelines may be modified to suit the requirements of the following:

a) Existing user-designed identification and numbering schemes that are not included in this standard
b) Computer databases used for record keeping
c) Microprocessor-based monitoring or control systems

When modified guidelines are adopted, they shall be fully described and detailed in the user/owner's engineering or design standards.

Multipoint, Multivariable, and Multifunction Devices

Input and output devices and functions that are components of a multipoint device shall have tag suffixes that delineate between the different components.

Multivariable devices that receive two or more input signals, transmit one output signal, and have been assigned measured/initiating variable multivariable [U], shall have the following indicators:

a) Each different input shall be assigned its own loop identification number, and each output indicating, recording, switching, alarming, or other device and function that is actuated solely by a single variable, shall be assigned an instrument/tag number that identifies it as part of these loops.
b) Each indicating, recording, switching, alarming, or other device or function that is actuated by more than one of the multivariables shall be assigned an instrument/tag number that identifies it as part of the multivariable loop.

Multifunction devices that receive two or more input signals, send out two or more output signals, or perform two or more functions may be assigned readout/passive or output/active function multifunction [U] and shall have a loop number assigned according to the measured/initiating variable.

Loops that perform two or more functions from a single measured/initiating variable may have the following:

a) Each function assigned a unique instrument/tag number and shown on diagrams as multiple tangent bubbles for the integral functions and multiple individual bubbles for the nonintegral functions.
b) One readout/passive and/or output/active function designated by succeeding letter [U], for the integral functions and multiple individual bubbles for the nonintegral functions, and, if necessary, a note or comment defining the integral functions.

Graphic symbol examples of these loops are given later in this section.

System Identification

Instrumentation is often assembled into systems for various reasons including ease of purchase, ease of application, compatibility, and so on. These systems may need to be identified on drawings and in text.

Some of the more common instrumentation systems and the system codes for identifying them are the following:

ACS = Analyzer control system
BMS = Burner management system
CCS = Computer control system
CEMS = Continuous emissions monitoring system
DCS = Distributed control system
FDS = Flame detection system
MMS = Machine monitoring system
PCCS = Personal computer control system
PLC = Programmable logic controller
SIS = Safety instrumented system
VMS = Vibration monitoring system

Suffixes may be added to the instrumentation system codes [SC] when required as follows:

a) [SC] 1, [SC] 2, and so forth, when more than one system is used in a complex
b) [SC]-M, [SC]-L, when main and local systems are used in a unit
c) [SC]-[unit identifier]

Loop Identification Number

A loop identification number is a unique combination of letters and numbers that is assigned to each monitoring and control loop in a facility to identify the process or machine variable that is being measured for monitoring or control (see Table 1.1a).

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TABLE 1.1a
Typical Loop Identification Number

					Measured/Initiating Variable			
10	-	P		-	*01	A		Loop identification number
10								Optional loop number prefix
	-							Optional punctuation
		P						Measured/initiating variable
				-				Optional punctuation
					*01			Loop number
						A		Optional loop number suffix
					First Letters			
10	-	P	D	-		*01	A	Loop identification number
10								Optional loop number prefix
	-							Optional punctuation
		P	D					First letters
		P						Measured/initiating variable
			D					Variable modifier
				-				Optional punctuation
						*01		Loop number
							A	Optional loop number suffix

See statement of permission on page 4.

Loop identification numbers are assigned as follows:

a) Numerals in parallel, serial, or parallel/serial sequences
b) Letters or letter combinations selected from Table 1.1c, Identification Letters (column 1, Measured/Initiating Variables and column 2, Variable Modifiers)

Loop identification number numerals shall be assigned to loop variables letters according to one of the following sequencing methods:

a) Parallel: duplicated numerical sequences for each loop variable letter or letter combination
b) Serial: the same numerical sequence regardless of loop variable letter or letter combination
c) Parallel/serial: parallel sequences for selected loop variable letters or letter combinations and a serial sequence for the remainder

Loop number numerical sequences are normally three or more digits, -*01, -*001, -*0001, and so on, where

a) -* can be any digit from 0 to 9
b) Coded digits are related to drawing numbers or equipment numbers
c) *00, *000, *0000, and so on are not used

Gaps may be left in any sequence to allow for the addition of future loops. (See Tables 1.1c through 1.1f for various combinations of allowable instrumentation identification/tag numbers.)

TABLE 1.1b
Typical Instrument Identification/Tag Number

10	-	P	D	A	L	-	*01	A	-	A	-	1			Loop identification number
10															Optional loop number prefix
	-														Optional punctuation
		P					*01	A							Loop number, measured variable
		P	D				*01	A							Loop number, first letters
						-									Optional punctuation
							*01								Loop number
								A							Optional loop number suffix
		P	D	A	L										Functional identification letters
		P	D												First letters
		P													Measured/initiating variable
			D												Variable modifier
				A	L										Succeeding letters
				A											Function identifier
					L										Function modifier
									-						Optional punctuation
										A					Tag number suffix
											-				Optional punctuation
												1			Tag number suffix

See statement of permission on page 4.

IDENTIFICATION LETTER TABLES

See statement of permission on page 4.

General

This clause provides in tabular form the alphabetic building blocks of the Instrument and Function Identification System in a concise, easily referenced manner.

Table 1.1c, Identification Letters, defines and explains the individual letter designators to be used as loop and functional identifiers in accordance with the guidelines of the subsection titled “Identification System Guidelines.”

The letters in Table 1.1c shall have the mandatory meanings as given in the table except as follows:

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TABLE 1.1c

Identification Letters (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

	First Letters (1)		*Succeeding Letters (15)*		
	Column 1 Measured/Initiating Variable	*Column 2 Variable Modifier*	*Column 3 Readout/Passive Function*	*Column 4 Output/Active Function*	*Column 5 Function Modifier*
A	Analysis		Alarm		
B	Burner, combustion		User's choice	User's choice	User's Choice
C	User's choice			Control	Close
D	User's choice	Differential, deviation			Deviation
E	Voltage		Sensor, primary element		
F	Flow, flow rate	Ratio			
G	User's choice		Glass, gauge, viewing device		
H	Hand				High
I	Current		Indicate		
J	Power		Scan		
K	Time, schedule	Time rate of change		Control station	
L	Level		Light		Low
M	User's choice				Middle, intermediate
N	User's choice		User's choice	User's choice	User's Choice
O	User's choice		Orifice, restriction		Open
P	Pressure		Point (test connection)		
Q	Quantity	Integrate, totalize	Integrate, totalize		
R	Radiation		Record		
S	Speed, frequency	Safety		Switch	
T	Temperature			Transmit	
U	Multivariable		Multifunction	Multifunction	
V	Vibration, mechanical analysis			Valve, damper, louver	
W	Weight, force		Well		
X	Unclassified	X-axis	Unclassified	Unclassified	Unclassified
Y	Event, state, presence	Y-axis		Auxiliary devices	
Z	Position, dimension	Z-axis		Driver, actuator, unclassified final control element	

See statement of permission on page 4.

a) The user shall assign a variable name to the user's choice letters in column 1 and a function name to the user's choice letters in columns 3 through 5 when such letters are used.
b) The user may assign meanings to the blanks in columns 2 through 5 if needed.

Table 1.1d, Allowable Loop Identification Letter Schemes, provides the allowable loop identification letters and combinations according to the loop identification number construction schemes.

The letters and combinations shall have the mandatory meanings as given in the table except as follows:

a) The user shall assign a variable name to the user's choice letters in the "First Letter" column.

Tables 1.1e and 1.1f, Allowable Function Identification Letter Combinations, provide allowable combinations of function identifying letters.

The letter combinations shall have the meanings given in the table, except as follows:

a) The user shall assign a variable and/or function to user's choice letters if used.
b) The user may assign a meaning to blanks if needed.
c) Cells marked N/A are combinations that shall not be allowed.

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TABLE 1.1d

Allowable Loop Identification Letter Schemes

First Letters	Measured/Initiating Variable	Scheme 1	Scheme 2	Scheme 3	Scheme 4	Scheme 5	Scheme 6	Scheme 7(1)		Scheme 8(1)		Scheme 9(1)	
								Parallel	Serial	Parallel	Serial	Parallel	Serial
		Parallel Meas./Init. Var.	Parallel Meas./Init. Var. w/Var. Mod.	Parallel First Letters	Serial Meas./Init. Var.	Serial Meas./Init. Var. w/Var. Mod.	Serial First Letters	Measured/Initiating Variable		Measured/Initiating Variable w/Variable Modifier		First Letters	
A	Analysis	A-*01	A-*01	A-*01	A-*01	A-*01	A-*01	A-*01		A-*01		A-*01	
B	Burner, combustion	B-*01	B-*01	B-*01	B-*02	B-*02	B-*02		B-*01		B-*01		B-*01
C	User's choice	C-*01	C-*01	C-*01	C-*03	C-*03	C-*03		C-*02		C-*02		C-*02
D	User's choice	D-*01	D-*01	D-*01	D-*04	D-*04	D-*04		D-*03		D-*03		D-*03
E	Voltage	E-*01	E-*01	E-*01	E-*05	E-*05	E-*05		E-*04		E-*04		E-*04
F	Flow, flow rate		F-*01	F-*01		F-*06	F-*06			F-*01		F-*01	
FF	Flow ratio	F-*01	FF-*02		F-*06	FF-*07		F-*01		FF-*02			
FQ	Flow total		FQ-*03	FQ-*01		FQ-*08	FQ-*07			FQ-*03		FQ-*01	
G	User's choice	G-*01	G-*01	G-*01	G-*07	G-*09	G-*08		G-*05		G-*05		G-*05
H	Hand	H-*01	H-*01	H-*01	H-*08	H-*10	H-*09		H-*06		H-*06		H-*06
I	Current	I-*01	I-*01	I-*01	I-*09	I-*11	I-*10		I-*07		I-*07		I-*07
J	Power	J-*01	J-*01	J-*01	J-*10	J-*12	J-*11		J-*08		J-*08		J-*08
K	Time	K-*01	K-*01	K-*01	K-*11	K-*13	K-*12		K-*09		K-*09		K-*09
L	Level	L-*01	L-*01	L-*01	L-*12	L-*14	L-*13	L-*01		L-*01		L-*01	
M	User's choice	M-*01	M-*01	M-*01	M-*13	M-*15	M-*14		M-*10		M-*10		M-*10
N	User's choice	N-*01	N-*01	N-*01	N-*14	N-*16	N-*15		N-*11		N-*11		N-*11
O	User's choice	O-*01	O-*01	O-*01	O-*15	O-*17	O-*16		O-*12		O-*12		O-*12
P	Pressure		P-*01			P-*18				P-*01		P-*01	
PF	Pressure ratio	P-*01	PF-*02	P-*01	P-*16	PF-*19	P-*17	P-*01		PF-*02			
PK	Pressure schedule		PK-*03			PK-*20				PK-*03		PK-*03	
PD	Pressure difference		PD-*04	PD-*01		PD-*21	PD-*18			PD-*04			
Q	Quantity	Q-*01	Q-*01	Q-*01	Q-*17	Q-*22	Q-*19		Q-*13		Q-*13		Q-*13

(Continued)

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TABLE 1.1d Continued

Allowable Loop Identification Letter Schemes

First Letters	Measured/Initiating Variable	Scheme 1	Scheme 2	Scheme 3	Scheme 4	Scheme 5	Scheme 6	Scheme 7(1)		Scheme 8(1)		Scheme 9(1)	
								Parallel	Serial	Parallel	Serial	Parallel	Serial
		Parallel Meas./Init. Var.	Parallel Meas./Init. Var. w/Var. Mod.	Parallel First Letters	Serial Meas./Init. Var.	Serial Meas./Init. Var. w/Var. Mod.	Serial First Letters	Measured/Initiating Variable		Measured/Initiating Variable w/Variable Modifier		First Letters	
R	Radiation	R-*01	R-*01	R-*01	R-*18	R-*23	R-*20		R-*14		R-*14		R-*14
S	Speed	S-*01	S-*01	S-*01	S-*19	S-*24	S-*21		S-*15		S-*15		S-*15
T	Temperature		T-*01			T-*25				T-*01		T-*01	
TF	Temperature ratio	T-*01	TF-*02	T-*01	T-*20	TF-*26	T-*22	T-*01		TF-*02			
TK	Temperature schedule		TK-*03			TK-*27				TK-*03		TD-*01	
TD	Temperature difference		TD-*04	TD-*01		TD-*28	TD-*23			TD-*04			
U	Multivariable	U-*01	U-*01	U-*01	U-*21	U-*29	U-*24		U-*16		U-*16		U-*16
V	Vibration, machine analysis	V-*01	V-*01	V-*01	V-*22	V-*30	V-*25		V-*17		V-*17		V-*17
W	Weight, force		W-*01			W-*31					W-*18		W-*18
WD	Weight difference		WD-*02			WD-*32					WD-*19		WD-*19
WF	Weight ratio	W-*01	WF-*03	W-*01	W-*23	WF-*33	W-*26		W-*18		WF-*20		WF-*20
WK	Weight loss (gain)		WK-*04			WK-*34					WK-*21		WK-*21
WQ	Weight total		WQ-*05			WQ-*35					WQ-*22		WQ-*22
X	Unclassified	X-*01	X-*01	X-*01	X-*24	X-*36	X-*27		X-*19		X-*23		X-*23
Y	Event, state, presence	Y-*01	Y-*01	Y-*01	Y-*25	Y-*37	Y-*28		Y-*20		Y-*24		Y-*24
Z	Position, dimension		Z-*01	Z-*01		Z-*38	Z-*29				Z-*25		Z-*25
ZX	Position, X-axis		ZX-*02	ZX-*01		ZX-*39	ZX-*30				ZX-*26		ZX-*26
ZY	Position, Y-axis		ZY-*03	ZY-*01		ZY-*40	ZY-*31				ZY-*27		ZY-*27
ZZ	Position, Z-axis	Z-*01	ZZ-*04	ZZ-*01	Z-*26	ZZ-*41	ZZ-*32		Z-*21		ZZ-*28		ZZ-*28
ZD	Gauge deviation		ZD-*01	ZD-*01		ZD-*42	ZD-*33				ZD-*29		ZD-*29
ZDX	Gauge X-axis deviation		ZDX-*02	ZDX-*01		ZDX-*43	ZDX-*34				ZDX-*30		ZDX-*30
ZDY	Gauge Y-axis deviation		ZDY-*03	ZDY-*01		ZDY-*44	ZDY-*35				ZDY-*31		ZDY-*31
ZDZ	Gauge Z-axis deviation		ZDZ-*04	ZDZ-*01		ZDZ-*45	ZDZ-*36				ZDZ-*32		ZDZ-*32

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Note (1): Assignment shown is one of many possibilities.

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TABLE 1.1e

Allowable Readout/Passive Function Identification Letter Combinations

First Letters	Measured/Initiating Variable	A(1)						B	E	G	I	L	N	O	P	Q	R	W	X
		Absolute Alarms			Deviation Alarms			User's Choice	Sensor, Primary Element	Gauge, Glass (2)	Indicate	Light	User's Choice	Orifice Restrict	Point (Test Conn.)	Integrate Totalize	Record	Well	Unclassified
		H	M	L	D	DH	DL												
A	Analysis	AAH	AAM	AAL	AAD	AADH	AADL		AE	N/A	AI			N/A	AP	N/A	AR	N/A	
B	Burner, combustion	BAH	BAM	BAL	BAD	BADH	BADL		BE	BG	BI	BL		N/A	N/A	N/A	BR	N/A	
C	User's choice	CAH	CAM	CAL	CAD	CADH	CADL		CE	CG	CI	CL					CR		
D	User's choice	DAH	DAM	DAL	DAD	DADH	DADL		DE	DG	DI	DL					DR		
E	Voltage	EAH	EAM	EAL	EAD	EADL	EADL		EE	EG	EI	EL		N/A	EP	N/A	ER	N/A	
F	Flow, flow rate	FAH	FAM	FAL	FAD	FADH	FADL		FE	FG	FI	FL		FO	FP	FQ	FR	N/A	
FF	Flow ratio	FFAH	FFAM	FFAL	FFAD	FFADH	FFADL		FE	N/A	FFI	N/A		N/A	N/A	N/A	FFR	N/A	
FQ	Flow total	FQAH	FQAM	FQAL	FQAD	FQADH	FQADL		N/A	N/A	FQI	N/A		N/A	N/A	N/A	FQR	N/A	
G	User's choice	GAH	GAM	GAL	EAD	GADH	GADL				GI						GR		
H	Hand	N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A	HI	N/A		N/A	N/A	N/A	HR	N/A	
I	Current	IAH	IAH	IAL	IAD	IADH	IADL		IE	N/A	II	IL		N/A	IP	N/A	IR	N/A	
J	Power	JAH	JAM	JAL	JAD	JADH	JADL		JE	N/A	JI	JL		N/A	JP	JQ	JR	N/A	
K	Time	N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A	KI	KL		N/A	N/A	KQ	KR	N/A	
L	Level	LAH	LAM	LAL	LAD	LADH	LADL		LE	LG	LI	LL		N/A	LP	N/A	LR	N/A	
M	User's choice	MAH	MAM	MAL	MAD	MADH	MADL				MI						MR		
N	User's choice	NAH	NAM	NAL	NAD	NADH	NADL				NI						NR		
O	User's choice	OAH	OAM	OAL	OAD	OADH	OADL				OI						OR		
P	Pressure	PAH	PAM	PAL	PAD	PADH	PADL		PE	PG	PI	PL		N/A	PP	N/A	PR	N/A	
PD	Pressure differential	PDAH	PDAM	PDAL	PDAD	PDADH	PDADL		PDE	PDG	PDI	PDL		N/A	PDP	N/A	PDR	N/A	
PF	Pressure ratio	PFAH	PFAM	PFAL	PFAD	PFADH	PFADL		N/A		PFI	N/A		N/A	N/A	N/A	PFR	N/A	
PK	Pressure schedule	PKAH	PKAM	PKAL	PKAD	PKADH	PKADL		N/A		PKI	PKL		N/A	N/A	N/A	PKR	N/A	
Q	Quantity	QAH	QAM	QAL	QAD	QADH	QADL		N/A		QI	QL		N/A	N/A	N/A	QR	N/A	
R	Radiation	RAH	RAM	RAL	RAD	RADH	RADL		RE	RG	RI	RL		N/A	RP	RQ	RR	N/A	
S	Speed	SAH	SAM	SAL	SAD	SADH	SADL		SE	SG	SI	N/A		N/A	SP	N/A	SR	N/A	
T	Temperature	TAH	TAM	TAL	TAD	TADH	TADL		TE	TG	TI	TL		N/A	TP	N/A	TR	TW	
TD	Temperature differential	TDAH	TDAM	TDAL	TDAD	TDADH	TDADL		TE	TDG	TDI	TDL		N/A	N/A	N/A	TDR	N/A	

(Continued)

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TABLE 1.1e Continued

Allowable Readout/Passive Function Identification Letter Combinations

First Letters	Measured/Initiating Variable	A(1)						B	E	G	I	L	N	O	P	Q	R	W	X
		Absolute Alarms			Deviation Alarms			User's Choice	Sensor, Primary Element	Gauge, Glass (2)	Indicate	Light	User's Choice	Orifice Restrict	Point (Test Conn.)	Integrate Totalize	Record	Well	Unclassified
		H	M	L	D	DH	DL												
TF	Temperature ratio	TFAH	TFAM	TFAL	TFAD	TFADH	TFADL		N/A	N/A	TFI	N/A		N/A	N/A	N/A	TFR	N/A	
TK	Temperature schedule	TKAH	TKAM	TKAL	TKAD	TKADH	TKADL		N/A	N/A	TKI	TKL		N/A	N/A	N/A	TKR	N/A	
U	Multivariable	N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	
V	Vibration, machine analysis	VAH	N/A	VAL	VAD	VADH	VADL		VE	VG	VI	N/A		N/A	VP	N/A	VR	N/A	
W	Weight, force	WAH	WAM	WAL	WAD	WAD	WADL		WE	N/A	WI	WL		N/A	N/A	N/A	WR	N/A	
WD	Weight difference	WDAH	WDAM	WDAL	WDAD	WDAD	WDADL		WE	N/A	WDI	WDL		N/A	N/A	N/A	WDR	N/A	
WF	Weight ratio	WFAH	WFAM	WFAL	WFAD	WFAD	WFADL		WE	N/A	WFI	N/A		N/A	N/A	N/A	WFR	N/A	
WK	Weight loss (gain)	WKAH	WKAM	WKAL	WKAD	WKAD	WKADL		N/A	N/A	WKI	WKL		N/A	N/A	N/A	WKR	N/A	
WQ	Weight total	WQAH	WQAM	WQAL	WQAD	WQAD	WQADL		N/A	N/A	WQI	WQL		N/A	N/A	N/A	WQR	N/A	
X	Unclassified	XAH	XAM	XAL	XAD	XAD	XADL		XE	XG	XI	XL		N/A	N/A	N/A	XR	N/A	
Y	Event, state, presence	YSAH	N/A	YAL	N/A	N/A	N/A		N/A	YG	YI	YL		N/A	N/A	N/A	YR	N/A	
Z	Position, dimension	ZAH	ZAM	ZAL	ZAD	ZADH	ZADL		ZE	ZG	ZI	ZL		N/A	N/A	N/A	ZR	N/A	
ZX	Position, X-axis	ZXAH	ZXAM	ZXAL	ZXAD	ZXADH	ZXADL		ZXE	ZXG	ZXI	ZXL		N/A	N/A	N/A	ZXR	N/A	
ZY	Position, Y-axis	ZYAH	ZYAM	ZYAL	ZYAD	ZYADH	ZYADL		ZYE	ZYG	ZYI	ZYL		N/A	N/A	N/A	ZYR	N/A	
ZZ	Position, Z-axis	ZZAH	ZZAM	ZZAL	ZZAD	ZZADH	ZZADL		ZZE	ZZG	ZZI	ZZL		N/A	N/A	N/A	ZZR	N/A	
ZD	Gauge deviation	ZDAH	ZDAM	ZDAL	ZDAD	ZDADH	ZDADL		ZDE	ZDG	ZDI	N/A		N/A	N/A	N/A	ZDR	N/A	
ZDX	Gauge X-axis deviation	ZDXAH	ZDXAM	ZDXAL	ZDXAD	ZDXADH	ZDXADL		ZDXE	ZDXG	ZDXI	N/A		N/A	N/A	N/A	ZDXR	N/A	
ZDY	Gauge Y-axis deviation	ZDYAH	ZDYAM	ZDYAL	ZDYAD	ZDYADH	ZDYADL		ZDYE	ZDYG	ZDYI	N/A		N/A	N/A	N/A	ZDYR	N/A	
ZDZ	Gauge Z-axis deviation	ZDZAH	ZDZAM	ZDZAL	ZDZAD	ZDZADH	ZDZADL		ZDZE	ZDZG	ZDZI	N/A		N/A	N/A	N/A	ZDZR	N/A	

See statement of permission on page 4.

N/A = not allowed.

Note (1): Alarm combinations are given with Function Modifiers for deviation from set point and absolute values. Adding [H] or [L] forms low–low and high–high alarm Functional Identifications.

Note (2): Readout/Passive Function [G] (glass, gauge) is shown for local direct connected devices, such as flow sight glasses, level glasses, pressure gauges, and thermometers, and also for weigh scales and position indicators. These devices provide a simple view of a process condition. The Readout/Passive Function [I] (indicate) may continue to be used in facilities where it is currently used.

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TABLE 1.1f

Allowable Output/Active Function Identification Letter Combinations

First Letters	Measured/ Initiating Variable	C				K	S			T			U	V	X	Y	Z
		Controller				Control Station	Switch			Transmitter			Multi-function	Valve Damper Louver	Unclassified	Compute Convert Relay	Actuator Drive
		C(4)(5)	IC(3)	RC(3)	CV(6)		H	M	L	T	IT	RT					
A	Analysis	AC	AIC	ARC	N/A	AK	ASH	ASM	ASL	AT	AIT	ART	AU	AV	AX	AY	
B	Burner, combustion	BC	BIC	BRC	N/A	BK	BSH	BSM	BSL	BT	BIT	BRT	BU	BV	BX	BY	BZ
C	User's choice	CC	CIC	CRC		CK	CSH	CSM	CSL	CT	CIT	CRT	CU	CV	CX	CY	
D	User's choice	DC	DIC	DRC		DK	DSH	DSM	DSL	DT	DIT	DRT	DU	DV	DX	DY	
E	Voltage	EC	EIC	ERC	N/A	EK	ESH	ESM	ESL	ET	EIT	ERT	EU	N/A	EX	EY	EZ
F	Flow, flow rate	FC	FIC	FRC	FCV	FK	FSH	FSM	FSL	FT	FIT	FRT	FU	FV	FX	FY	
FF	Flow ratio	FFC	FFIC	FFRC	N/A	FFK	FFSH	FFSM	FFSL	N/A	N/A	N/A	N/A	N/A	FFX	FFY	
FQ	Flow total	FQC	FQIC	FQRC	FQCV	FQK	FQSH	FQSM	FQSL	FQT	FQIT	FQRT	N/A	FQV	FQX	FQY	
G	User's choice	GC	GIC	GRC		GK	GSH	GSM	GSL	GT	GIT	GRT	GU	GV	GX	GY	
H	Hand	HC	HIC	N/A	HCV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	HV	HX	HY	
I	Current	IC	IIC	IRC	N/A	IK	ISH	ISM	ISL	IT	IIT	IRT	IU	N/A	IX	IY	IZ
J	Power	JC	JIC	JRC	N/A	JK	JSH	JSM	JSL	JT	JIT	JRT	JU	N/A	JX	JY	JZ
K	Time	KC	KIC	KRC	N/A	N/A	KSH	KSM	KSL	N/A	N/A	N/A	N/A	N/A	KX	KY	
L	Level	LC	LIC	LRC	LCV	LK	LSH	LSM	LSL	LT	LIT	LRT	LU	LV	LX	LY	
M	User's choice	MC	MIC	MRC		MK	MSH	MSM	MSL	MT	MIT	MRT	MU	MV	MX	MY	
N	User's choice	NC	NIC	NRC		NK	NSH	NSM	NSL	NT	NIT	ORT	NU	NV	NX	NY	
O	User's choice	OC	OIC	ORC		OK	OSH	OSM	OSL	OT	OIT	BRT	OU	OV	OX	OY	
P	Pressure	PC	PIC	PRC	PCV	PK	PSH	PSM	PSL	PT	PIT	PRT	PU	PV	PX	PY	
PD	Pressure differential	PDC	PDIC	PDRC	PDCV	PDK	PDSH	PDSM	PDSL	PDT	PDIT	PDRT	PDU	PDV	PDX	PDY	
PF	Pressure ratio	PFC	PFIC	PFRC	N/A	PFK	PFSH	PFSM	PFSL	N/A	N/A	N/A	N/A	N/A	PFX	PFY	
PK	Pressure schedule	PKC	PKIC	PKRC	N/A	PKADH	PKSH	PKSM	PKSL	N/A	N/A	N/A	N/A	N/A	PKX	PKY	
Q	Quantity	QC	QIC	QRC	QCV	QADH	QSH	QSM	QSL	QT	QIT	QRT	QU	N/A	QX	QY	
R	Radiation	RC	RIC	RRC	N/A	RADH	RSH	RSM	RSL	RT	RIT	RRT	RU	RV	RX	RY	
S	Speed	SC	SIC	SRC	SCV	SADH	SSH	SSM	SSL	ST	SIT	SRT	SU	SV	SX	SY	
T	Temperature	TC	TIC	TRC	TCV	TADH	TSH	TSM	TSL	TT	TIT	TRT	TU	TV	TX	TY	
TD	Temperature differential	TDC	TDIC	TDRC	N/A	TDADH	TDSH	TDSM	TDSL	TDT	TDIT	TDRT	TDU	TDV	TDX	TDY	

(Continued)

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TABLE 1.1f Continued

Allowable Output/Active Function Identification Letter Combinations

First Letters	Measured/ Initiating Variable	C				K	S			T			U	V	X	Y	Z
		Controller				Control Station	Switch			Transmitter			Multi-function	Valve Damper Louver	Unclassified	Compute Convert Relay	Actuator Drive
		C(4)(5)	IC(3)	RC(3)	CV(6)		H	M	L	T	IT	RT					
TF	Temperature ratio	TFC	TFIC	TFRC	N/A	TFADH	TFSH	TFSM	TFSL	N/A	N/A	N/A	N/A	N/A	TFX	TFY	
TK	Temperature schedule	TKC	TKIC	TKRC	N/A	TKADH	TKSH	TKSM	TKSL	N/A	N/A	N/A	N/A	N/A	TKX	TKY	
U	Multivariable	UC	UIC	URC	N/A	N/A	USH	USM	USL	UT	N/A	N/A	N/A	N/A	UX	UY	
V	Vibration, machine analysis	VC	VIC	VRC	N/A	VADH	VSH	VSM	VSL	VT	VIT	VRT	N/A	N/A	VX	VY	
W	Weight, force	WC	WIC	WRC	WCV	WAD	WSH	WSM	WSL	WT	WIT	WRT	WU	WV	WX	WY	
WD	Weight difference	WDC	WDIC	WDRC	N/A	WDAD	WDSH	WDSM	WDSL	WDT	WDIT	WDRT	WDU	N/A	WDX	WDY	
WF	Weight ratio	WFC	WFIC	WFRC	N/A	WFAD	WFSH	WFSM	WFSL	N/A	N/A	N/A	N/A	N/A	WFX	WFY	
WK	Weight loss (gain)	WKC	WKIC	WKRC	N/A	WKAD	WKSH	WKSM	WKSL	N/A	N/A	N/A	N/A	N/A	WKX	WKY	
WQ	Weight total	WQC	WQIC	WQRC	N/A	WQAD	WQSH	WQSM	WQSL	N/A	N/A	N/A	N/A	N/A	WQX	WQY	
X	Unclassified	XC	XIC	XRC	N/A	XAD	XSH	XSM	XSL	XT	XIT	XRT	XU	XV	XX	XY	XZ
Y	Event, state, presence	YC	YIC	YRC	N/A	N/A	YSH	YSM	YSL	YT	YIT	YRT	YU	N/A	YX	YY	YZ
Z	Position, dimension	ZC	ZIC	ZRC	N/A	ZADH	ZSH	ZSM	ZSL	ZT	ZIT	ZRT	ZU	ZV	ZX	ZY	ZZ
ZX	Position, X-axis	ZXC	ZXIC	ZXRC	N/A	ZXADH	ZXSH	ZXSM	ZXSL	ZXT	ZXIT	ZXRT	N/A	ZXV	ZXX	ZXY	ZXZ
ZY	Position, Y-axis	ZYC	ZYIC	ZYRC	N/A	ZYADH	ZYSH	ZYSM	ZYSL	ZYT	ZYIT	ZYRT	N/A	ZYV	ZYX	ZYY	ZYZ
ZZ	Position, Z-axis	ZZC	ZZIC	ZZRC	N/A	ZZADH	ZZSH	ZZSM	ZZSL	ZZT	ZZIT	ZZRT	N/A	ZZV	ZZX	ZZY	ZZZ
ZD	Gauge deviation	ZDC	ZDIC	ZDRC	N/A	ZDADH	ZDSH	ZDSM	ZDSL	ZDT	ZDIT	ZDRT	N/A	ZDV	ZDX	ZDY	ZDZ
ZDX	Gauge X-axis deviation	ZDXC	ZDXIC	ZDXRC	N/A	ZDXADH	ZDXSH	ZDXSM	ZDXSL	ZDXT	ZDXIT	ZDXRT	N/A	ZDXV	ZDXX	ZDXY	ZDXZ
ZDY	Gauge Y-axis deviation	ZDYC	ZDYIC	ZDYRC	N/A	ZDYADH	ZDYSH	ZDYSM	ZDYSL	ZDYT	ZDYIT	ZDYRT	N/A	ZDYV	ZDYX	ZDYY	ZDYZ
ZDZ	Gauge Z-axis deviation	ZDZC	ZDZIC	ZDZRC	N/A	ZDZADH	ZDZSH	ZDZSM	ZDZSL	ZDZT	ZDZIT	ZDZRT	N/A	ZDZV	ZDZX	ZDZY	ZDZZ

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N/A = not allowed.

Note (3): The combinations in the [IC] and [RC] columns indicate the order to be followed in forming the Functional Identification of a controller device or function that also provides indication or recording.

Note (4): The combinations in the [C] column do not have operator visible indication of measured variable, set point, or output signal, when used with discrete hardware single case instruments.

Note (5): The combinations in the [C] column may also be used for a controller function configured in a shared or distributed control system.

Note (6): The combinations in the [CV] column indicate the order to be followed in forming the Functional Identification for self-actuated control valves.

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GRAPHIC SYMBOL SYSTEM GUIDELINES

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General

The future revised ISA Standard S5.1 (now ANSI/ISA-5.01.01) establishes a graphic symbol system and functional identification for depicting instrument loop devices and functions, application software functions, and the interconnections between them that is logical, unique, and consistent in application with a minimum of exceptions, special uses, and requirements.

The graphic symbol system shall be used to depict instrumentation in text and in sketches and drawings. When used with identification letters and numbers as described in the subsection titled "Identification System Guidelines," it shall identify the functionality of each device and function shown.

The graphic symbol system provides methods for schematic loop diagramming, functional diagramming (see Section 1.2), and electrical schematic diagramming of any process or system that requires measurement, indication, control, modulation, or switching of variables.

Table 1.1g, Instrument Line Symbols, contains lines used to represent process connections and the measurement and control signals that connect instruments and functions to the process and to each other.

Tables 1.1h through 1.1k depict circles, squares, diamonds, hexagons, and lines used to represent the majority of hardware and software instruments and functions as follows:

Table 1.1h, Discrete (Individual) Devices and/or Functions, represents discrete hardware instruments and/or functions that are implemented in nonmicroprocessor-based systems similar or equal to single-case transmitters, controllers, indicators, or recorders.

Table 1.1i, Shared Continuous Devices and/or Functions, represents shared and/or distributed software analog instruments and/or functions that are implemented in microprocessor-based systems similar or equal to distributed control or programmable logic control systems.

Table 1.1j, Shared On–Off Devices and/or Functions, represents shared and/or distributed on–off software instruments and/or functions that are implemented in microprocessor-based control systems similar or equal to a distributed control or programmable logic control systems.

Table 1.1k, Computer Devices and/or Functions, represents shared and/or distributed on–off software instruments and/or functions that are implemented in a computer-based control system.

Figures 1.1l and 1.1m illustrate some practical but not standardized P&ID symbology for a fieldbus system (DeviceNet).

Table 1.1n, Primary Elements—Flow, describes various geometric shapes that represent primary measurement elements, such as orifice plates and thermocouples, that are located in the process piping.

Tables 1.1o through 1.1r, Final Control Elements, consist of various geometric shapes that represent final control elements, such as control valves and their actuators, that are located in the process piping:

Table 1.1o–Control Valve Bodies
Table 1.1p–Control Valve Actuators
Table 1.1q–Self-Actuated Devices (includes such self-actuated elements as pressure control valves and pressure relief valves)
Table 1.1r–Failure Position Indicators for Control Valves (indicates the position which the valve takes when/if the actuating power fails)

Table 1.1s, Electrical Schematic Symbols, represents electrical circuit elements.

Specific industrial application examples of the graphic symbol system will be found in a future series of S5.1 (now ANSI/ISA-5.01.01) Technical Reports. Sketches that are not all inclusive of acceptable methods of depicting instrumentation are included in the following text to illustrate the intent of the standard. However, the individual symbols and their meanings are to be mandatory in the future, imminent standard.

Guideline Modifications

These guidelines may be modified to suit the requirements of existing user-designed graphic symbols that are not included in this standard. When modified symbols are adopted, they shall be fully described and detailed in the user/owner's engineering or design standards.

Instrument Line Symbols

In Table 1.1g, symbols represent the following:

a) Instrument and device connections at process measurement points
b) Connections to instrument power supplies
c) Signals between measurement and control instruments and functions

Lines shall be

a) Fine in relation to process equipment and piping lines
b) As short as possible and consistent with clarity

Measurement and Control Devices and/or Function Symbols

See Table 1.1h, Discrete (Individual) Devices and/or Functions, in which symbols represent discrete devices that perform continuous and/or on–off functions that do not share control or display functions for the following:

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TABLE 1.1g

Instrument Line Symbols (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

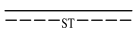
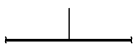
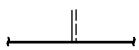
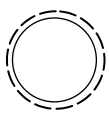
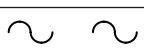
No.	*Symbol*	*Application*
01		Instrument impulse line from process Instrument impulse line from equipment Analyzer sample line from process Functional instrument diagram signal lines
02		Heat (cool) traced instrument impulse line from process Heat (cool) traced instrument impulse line from equipment Heat (cool) traced analyzer sample line from process Type of tracing may be indicated as ET = electrical, RT = refrigerated, ST = steam, etc.
03		Generic instrument impulse line connected to process line Generic instrument impulse line connected to equipment
04		Heat (cool) traced generic instrument impulse line connected to process line Heat (cool) traced generic instrument impulse line connected to equipment Process line or equipment may or may not be traced
05		Heat (cool) traced instrument connected to process impulse line Instrument impulse line may or may not be traced
06		Flanged instrument connection to process line Flanged instrument connection to equipment
07		Threaded instrument connection to process line Threaded instrument connection to equipment
08		Socket welded instrument connection to process line Socket welded instrument connection to equipment
09		Welded instrument connection to process line Welded instrument connection to equipment *Practical industry tip:* Use symbol for both seal weld on threaded connection as well as butt weld on larger sizes
10		Instrument air supply Indicate supply pressure as required: AS-60 psig, AS-400 kPa, etc. IA (instrument air) or PA (plant air) may be used for AS Use as required
11		Instrument electric power supply Indicate voltage and type as required, e.g., ES-24 VDC, ES-120 VAC, etc. Use as required *Practical industry tip:* Add note if it is coming from UPS
12		Undefined signal Use for PFDs Use for discussions or diagrams where type of signal, pneumatic or electronic, is not of concern
13		Pneumatic signal
14		Electric signal Electronic signal Functional instrument diagram signal lines
15		Hydraulic signal
16		Filled thermal element capillary tube
17		Guided electromagnetic signal Fiber optic cable Guided sonic signal
18		Unguided electromagnetic signal Unguided sonic signal Alternate radio communication link (see symbol 22)

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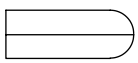
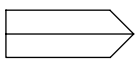
TABLE 1.1g Continued

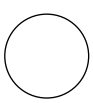
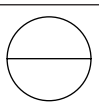
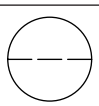
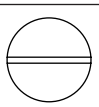
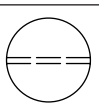
Instrument Line Symbols (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

No.	*Symbol*	*Application*
19	—o——o—	Communication link or system bus, between devices and functions of a microprocessor-based system *Industry tip:* Use this for traditional DCS main data highway systems. System internal software link
20	—•——•—	Shared communication link or bus (not system bus) between two or more independent microprocessor-based systems Shared data link from/between field located microprocessor-based devices and/or functions *Industry tip:* Use for fieldbus field devices
21	--o----o--	Dedicated communications link or bus (not system bus) between two or more independent microprocessor-based systems Dedicated data link from a field located microprocessor-based device and/or function
22	⟋ ⟋	Dedicated radio communications link (not system bus) between radio transmitting and receiving devices and/or systems Unguided radio signal Alternate unguided electromagnetic signal (see symbol 18)
23	—◉——◉—	Mechanical link or connection
24		Signal connector Drawing-to-drawing signal connector Internal signal connector used to avoid long signal lines
25		Signal connector Internal signal connector used to avoid long signal lines Drawing-to-drawing signal connector

See statement of permission on page 4.

TABLE 1.1h

Discrete (Individual) Devices and/or Functions (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

No.	*Symbol*	*Location and Accessibility*
01		Field or locally mounted Not panel or cabinet mounted Normally accessible to an operator
02		Central or main control room Front of main panel mounted Normally accessible to an operator
03		Central or main control room Rear of main panel mounted Not normally accessible to an operator
04		Secondary or local control room Field or local control panel Front of secondary or local panel mounted Normally accessible to an operator
05		Secondary or local control room Field or local control panel Rear of secondary or local panel or cabinet mounted Not normally accessible to an operator
06		Signal processor identifier located in upper right or left quadrant of symbols above Signal processor identifier attached to symbols where affected signals are connected

See statement of permission on page 4.

a) Measurement (transmitters, primary elements)
b) Indication (indicators, annunciators)
c) Control (controllers, control valves, switches, solenoids)

Limited operator accessibility (setpoint changes, control mode transfers, etc.) and unlimited engineer or technician accessibility through location and enclosure methods are shown.

Table 1.1i covers analog, digital, and/or discrete shared control devices and/or functions for continuous control, indication, calculation, and so forth that are microprocessor based and configurable. They communicate with each other and share control or display functions in applications such as distributed control and programmable logic systems.

Limited operator accessibility (setpoint changes, control mode transfers, and so forth) and unlimited engineer accessibility is through local or wide area communications networks, keyboards, and video displays as shown.

Table 1.1j deals with analog, digital, and discrete control devices and functions for on–off or binary control, indication, calculation, and so forth that are microprocessor based and configurable. They communicate with each other and share control or display in distributed control and programmable logic systems.

Limited operator accessibility (setpoint changes, control mode transfers, and so on) and unlimited engineer accessibility is through local or wide area communications networks, keyboards, and video displays as shown.

The devices and functions in Table 1.1k include process plant computer-implemented regulatory and/or advanced control analog/digital/discrete (individual) control and indication functions that are mainframe computer or minicomputer based.

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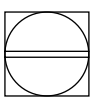
TABLE 1.1i

Shared Continuous Devices and/or Functions (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

No.	Symbol	Location and Accessibility
01		Dedicated single function device Field or locally mounted Not panel or cabinet mounted Normally accessible to an operator at device
02		Central or main console Visible on video display Normally accessible to an operator at console
03		Central or main console Not visible on video display Not normally accessible to an operator at console
04		Secondary or local console Field or local control panel Visible on video display Normally accessible to an operator at console
05		Secondary or local console Field or local control panel Not visible on video display Not normally accessible to an operator at console
06		Mathematical function located in upper right or left quadrant of symbols above Mathematical function attached to symbols where affected signals are connected

See statement of permission on page 4.

Limited operator accessibility (setpoint changes, control mode transfers, etc.), and unlimited engineer accessibility is through local or wide area communications networks, keyboards, and video displays as shown.

Fieldbus P&ID Examples: DeviceNet Figures 1.1l and 1.1m show the practical methods used by one EPCM company in establishing a P&ID detail and markup for a low-voltage motor control plus a VFD motor control implemented with DeviceNet as the fieldbus. It should be pointed out that these figures do not completely conform to the ISA S5.1 (now ANSI/ISA-5.01.01) proposed standard and are a compromise born of necessity.

In Table 1.1n, symbols are pictorial representations of primary flow elements that generate a measurement or signal equal to, or a signal proportional to, a fluid flow rate or total flow.

In Table 1.1o, valve body symbols, when combined with valve actuator symbols, shall be used to represent control valves and solenoid valves as follows:

Symbols 01 through 05 may be used as generic symbols to represent control and solenoid valve bodies.

The remaining symbols may be used when it is desired to more clearly indicate a specific valve body type.

TABLE 1.1j

Shared on–off devices and/or Functions (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

No.	Symbol	Location and Accessibility
01		Field or locally mounted Not panel or cabinet mounted Normally accessible to an operator at device
02		Central or main console Visible on video display Normally accessible to an operator at console
03		Central or main console Not visible on video display Not normally accessible to an operator at console
04		Secondary or local console Field or local control panel Visible on video display Accessible to an operator at console
05		Secondary or local console Field or local control panel Not visible on video display Not normally accessible to an operator at console
06		Mathematical function located in upper right or left quadrant of symbols above Mathematical function attached to symbols where affected signals are connected

See statement of permission on page 4.

TABLE 1.1k

Computer Devices and/or Functions (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

No.	Symbol	Location and Accessibility
01		Undefined location Undefined visibility Undefined accessibility
02		Central or main computer Visible on video display Normally accessible to an operator at console or computer terminal
03		Central or main computer Not visible on video display Not normally accessible to an operator at console or computer terminal
04		Secondary or local computer Visible on video display Normally accessible to an operator at console or computer terminal
05		Secondary or local computer Not visible on video display Not normally accessible to an operator at console or computer terminal

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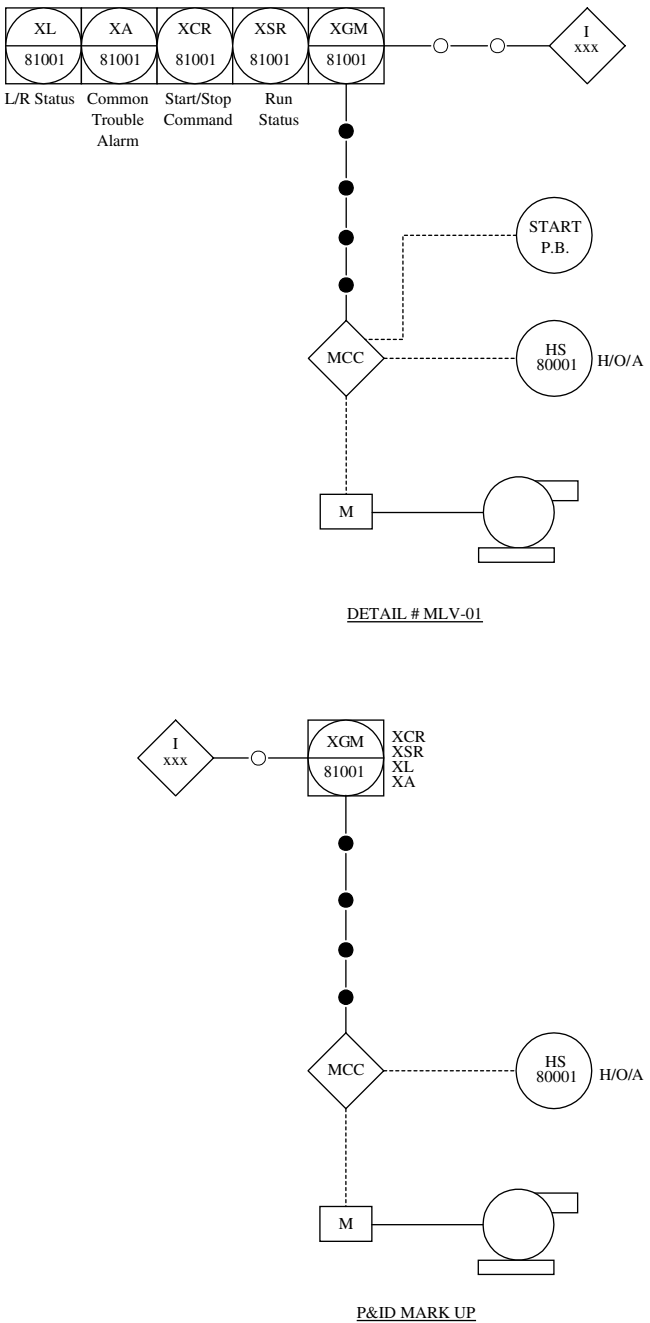

FIG. 1.1l
Low voltage motor control on DeviceNet (detail and P&ID mark up).

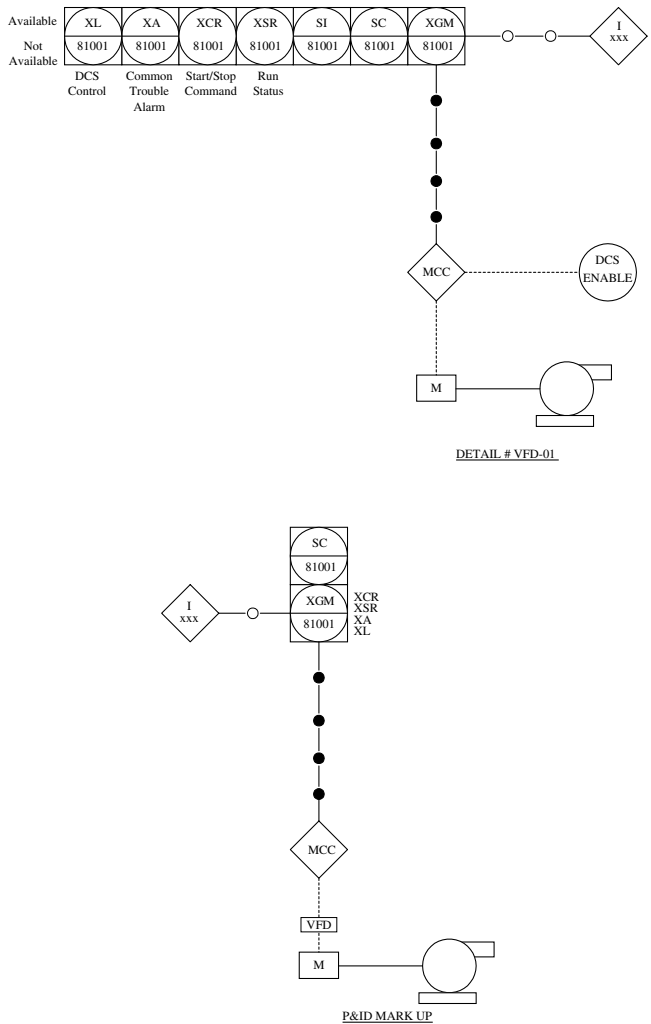

FIG. 1.1m
VFD motor control on DeviceNet (detail and P&ID mark up).

In Table 1.1s, contacts shall be shown in shelf condition. Rising switch actuator will cause contacts to switch.

Multipoint, Multifunction, and Multivariable Devices and Loops

Multipoint devices are indicators or recorders that may be single or multivariable and receive input signals from two or more primary elements or transmitters.

Multivariable devices are indicators, recorders, and controllers that receive input signals from two or more primary elements or transmitters and control one manipulated variable.

Multifunction devices are controllers or switches that receive input signals from two or more primary elements or transmitters and control two or more manipulated variables.

Single variable or multivariable multipoint indicators and recorders for two or three points shall be drawn with bubbles either

a) Tangent to each other in the same order, left to right, as the pen or pointer assignments:

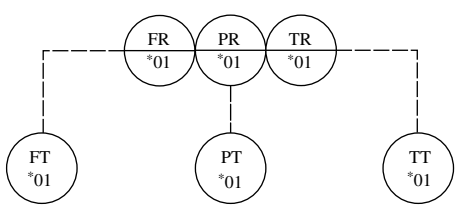

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TABLE 1.1n

Primary Elements—Flow (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

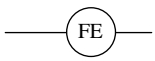
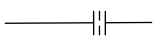
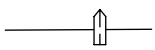
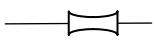
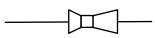
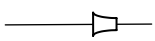
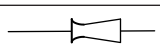
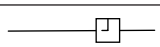
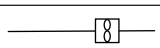
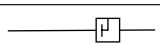
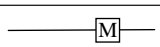
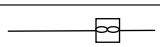
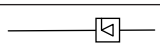
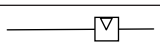
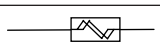
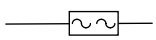
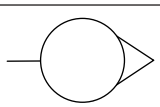
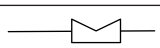
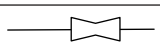
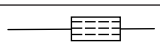
No.	Symbol	Description
01		Generic flow element
02		Standard orifice plate Restriction orifice
03		Orifice plate in quick change fitting
04		Generic venturi tube, flow nozzle, or flow tube Notation required if used for more than one type
05		Venturi tube
06		Flow nozzle
07		Flow tube
08		Standard pitot tube
09		Averaging pitot tube
10		Turbine flowmeter Propeller flowmeter
11		Vortex shedding flowmeter
12		Target flowmeter
13		Magnetic flowmeter
14		Positive displacement flowmeter
15		Cone meter Annular orifice meter
16		Wedge meter
17		Coriolis flowmeter
18		Sonic flowmeter Ultrasonic flowmeter
19		Variable area flowmeter
20		Open channel weir plate
21		Open channel flume
22		Flow straightening vanes Flow conditioning element

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TABLE 1.1o

Final Control Elements—Control Valve Bodies (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

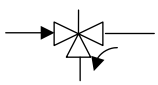
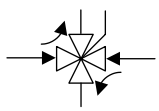
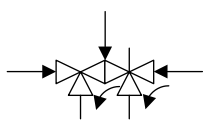
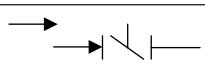
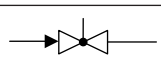
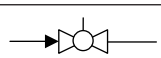
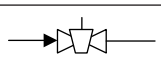
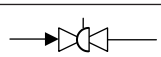
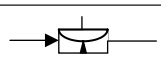
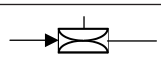
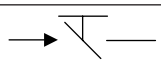
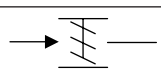
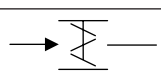
No.	Symbol	Description
01		Generic two-way valve Straight globe control valve Two-way solenoid valve Gate valve
02		Generic two-way angle valve Angle globe control valve Angle solenoid valve
03		Generic three-way valve Three-way globe control valve Three-way solenoid valve Arrow indicates air failure or de-energized flow path
04		Generic four-way valve Four-way plug or ball control valve Four-way four ported on–off valve Arrows indicate air failure or de-energized flow paths
05		Four-way five ported on–off valve Arrows indicate air failure or de-energized flow paths
06		Butterfly valve
07		Two-way globe valve
08		Ball valve
09		Plug valve
10		Eccentric rotary disc valve
11		Diaphragm valve
12		Pinch valve
13		Generic damper Generic louver
14		Parallel blade damper Parallel blade louver
15		Opposed blade damper Opposed blade louver

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TABLE 1.1p

Final Control Elements—Control Valve Actuators (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

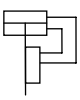
No.	Symbol	Description
01		Generic actuator Spring-opposed diaphragm linear actuator
02		Spring-diaphragm actuator with positioner
03		Pressure-balanced diaphragm linear actuator
04		Generic piston actuator May be linear or rotary
05		Piston actuator, single-acting, spring-opposed, with positioner
06		Piston actuator, double-acting, with positioner
07		Rotary motor-operated actuator May be electric, pneumatic, or hydraulic
08		Automatic reset solenoid actuator Nonlatching solenoid actuator Dual solenoids may be used
09		Manual or remote reset solenoid actuator Latching solenoid actuator
10		Manual and remote-reset solenoid actuator Latching solenoid actuator
11		Manual actuator Hand actuator
12		Spring-, weight-, or pilot-actuated relief or safety actuator
13		Actuator with side-mounted handwheel
14		Actuator with top-mounted handwheel
15		Electrohydraulic actuator May be linear or rotary action

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TABLE 1.1q

Final Control Elements—Self-Actuated Devices (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

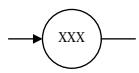
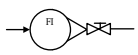
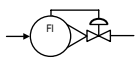
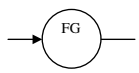
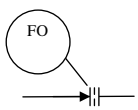
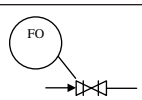
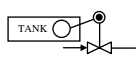
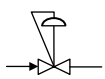
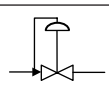
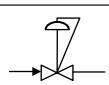
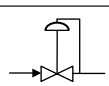
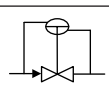
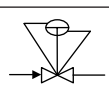
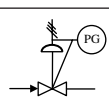
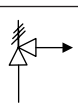
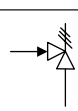
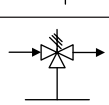
No.	Symbol	Description
01		Automatic flow regulator XXX = FCV w/o indicator XXX = FICV w/integral indicator
02		Variable area flowmeter with a manual regulating valve
03		Constant flow regulator Manual setpoint variable area flowmeter
04		Flow sight glass Type shall be noted if more than one type used
05		Generic flow restriction Single stage orifice plate as shown Note required for multistage or capillary tube types
06		Restriction orifice hole drilled in valve plug Tag number may be omitted if valve is otherwise identified
07		Level regulator Ball float and mechanical linkage
08		Backpressure regulator Internal pressure tap
09		Backpressure regulator External pressure tap
10		Pressure-reducing regulator Internal pressure tap
11		Pressure-reducing regulator External pressure tap
12		Differential-pressure regulator External pressure taps
13		Differential-pressure regulator Internal pressure taps
14		Pressure-reducing regulator w/integral outlet pressure relief and pressure gauge
15		Generic pressure safety valve Pressure relief valve
16		Generic vacuum safety valve Vacuum relief valve
17		Generic pressure and vacuum relief valve Tank pressure and vacuum relief valve

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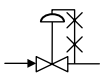
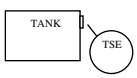
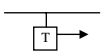
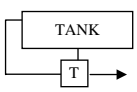
TABLE 1.1q Continued

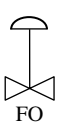
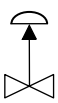
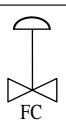
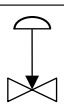
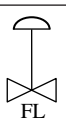
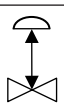
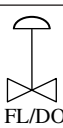
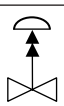
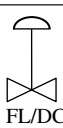
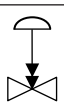
Final Control Elements—Self-Actuated Devices (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

No.	*Symbol*	*Description*
18		Pressure safety element Pressure rupture disk Pressure relief
19		Pressure safety element Vacuum rupture disk Vacuum relief
20		Temperature regulator Filled thermal system
21		Thermal safety element Fusible plug or disk
22		Generic moisture trap Steam trap Note required for other trap types
23		Moisture trap with equalizing line

See statement of permission on page 4.

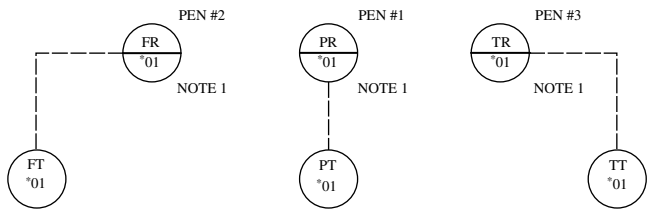
TABLE 1.1r

Final Control Elements—Control Valve Air Failure Position Indication (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

No.	*Method 1*	*Method 2*	*Definition*
01			Fail to open position
02			Fail to closed position
03			Fail locked in last position
04			Fail at last position Drift open
05			Fail at last position Drift closed

See statement of permission on page 4.

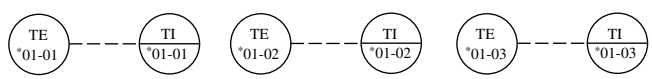
b) Separate from each other, with pen or pointer number indicated preferably in upper right or left quadrant and a note defining instrument or device indicated in preferably lower right or left quadrant:



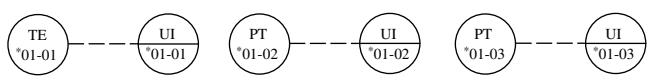
Note 1. Indicated pen in 3-pen Recoder

Multipoint indicators and recorders for four or more points may be drawn with bubbles separate from each other, with point number indicated by adding a suffix to the tag numbers as follows:

a) Single variable:



b) Multivariable:



Multivariable controllers may be drawn with bubbles for each measured variable input and for the output to the final control element; measured variable indicators may be:

a) Shown:

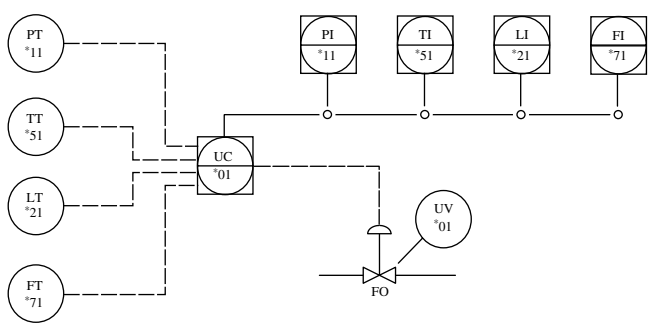


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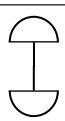
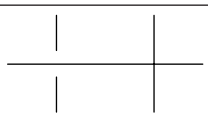
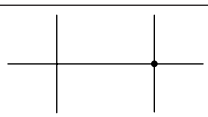
TABLE 1.1s

Electrical Schematic Symbols (proposed for the next revision of ISA S5.1 [now ANSI/ISA-5.01.01] at the time of this writing)

No.	*Symbol*	*Description*
01		Normally open, single-circuit pushbutton switch contact Single-pole, normally open (SPNO) pushbutton switch contact Combine with symbols 06 or 07 to form toggle or rotary-actuated switches
02		Normally closed, single-circuit pushbutton switch contact Single-pole, normally closed (SPNC) pushbutton switch contact Combine with symbols 06 or 07 to form toggle or rotary-actuated switches
03		Normally open, double-circuit pushbutton switch contact Double-pole, normally open (DPNO) pushbutton switch contact Combine with symbols 06 or 07 to form toggle or rotary-actuated switches
04		Normally closed/normally open double-circuit pushbutton switch contact Double-pole, normally open/closed (DPNO/NC) pushbutton switch contact Combine with symbols 06 or 07 to form toggle or rotary-actuated switches
05		Two-position toggle or rotary-maintained position pushbutton switch actuator Combine with symbols 01 through 05 to form single-pole, double-throw (SPDT) or multipole double-throw (DPDT, TPDT, etc.) switches
06		Three-position toggle or rotary-maintained position pushbutton switch actuator Combine with symbols 01 through 05 to form single-pole, triple-throw (SPTT) or multipole, triple-throw (DPTT, TPTT, etc.) switches
07		Single-pole, single-throw (SPST) normally open toggle switch Form A switch contact
08		Single-pole, single-throw (SPST) normally closed toggle switch Form B switch contact
09		Single-pole, double-throw (SPDT) normally closed/normally open toggle switch Form C switch contact
10		Pressure switch actuator
11		Differential-pressure switch actuator
12		Liquid level switch actuator
13		Temperature switch actuator
14		Flow switch actuator
15		Foot switch actuator
16		Relay coil
17		Normally open relay contact
18		Normally closed relay contact
19		Connection convention A: Left = not connected Right = connected
20		Connection convention B: Left = not connected Right = connected

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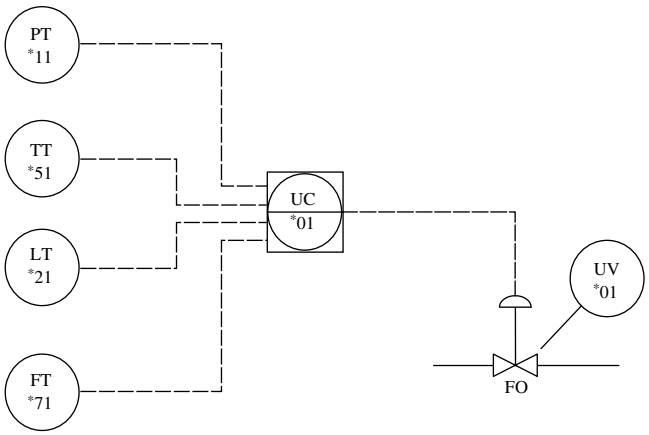
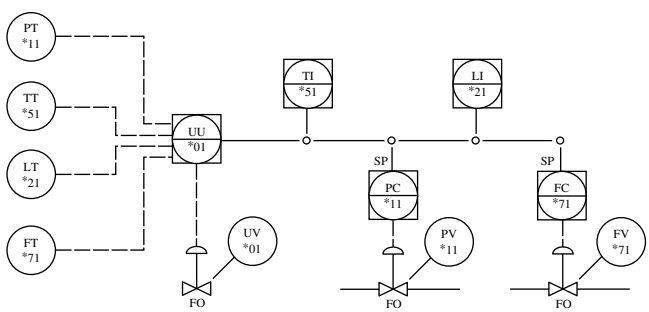
b) Assumed:

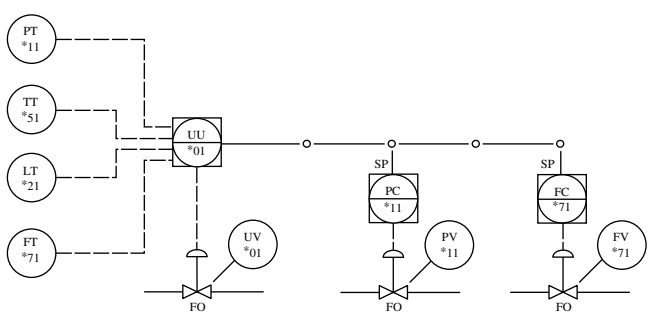


Multifunction controllers shall be drawn with bubbles for each measured variable input and output to final control elements; measured variable indicators may be:

a) Shown:



b) Assumed:



Fieldbus Devices, Loops, and Networks

Comments and Exceptions (Including Non-ISA Industrial Practice) Instrument and control systems staff working at engineering, procurement, and construction management (EPCM) companies had to improvise on P&ID symbols for fieldbus devices, loops, segments, and networks throughout the late 1990s and early 2000s. This has been the case while waiting for the draft standard work outlined in this section to be discussed and approved as the latest revision to ISA S5.1 (now ANSI/ISA-5.01.01). (For specific details on fieldbus technologies, please refer to later chapters and sections in this volume.)

Certain techniques and shortcuts used by several EPCM companies, and how they have handled fieldbus symbology, will be mentioned in this subsection. A few companies have generated their P&IDs using the proposed Instrument Line Symbol no. 20 (Table 1.1g) as the shared data links or FOUNDATION™ fieldbus (FF) segments between field located microprocessor-based devices as well as FF host systems. In this way, it is implicit that the devices connected by that symbol are fieldbus devices and do not need any further symbology or identification on the P&IDs. This symbol also has been used for other fieldbuses such as PROFIBUS PA, PROFIBUS DP, AS-i Bus, and DeviceNet (see Figures 1.1l and 1.1m).

Another symbol used by the EPCM companies for fieldbus has been the Instrument Line Symbol no. 19 (Table 1.1g), which is the current existing symbol (ANSI/ISA S5.1-1984[1992]) and normally the one used for data links and DCS data highways. This has been done occasionally when the EPCM company's client/owner had specific, custom P&ID symbology standards and was reluctant to change a worldwide standard to a new symbol such as no. 20. Once again, any field devices such as transmitters and control valves that are connected together by Symbol no. 19 are now known to be fieldbus-type devices. The disadvantage is that the P&IDs must be studied carefully to determine real communication link, DCS data highway, system bus, or internal software link applications from the fieldbus applications.

Another EPCM company used the conventional analog electronic signal (Symbol no. 14 in Table 1.1g) at the urging of its client but added the suffix "FB" to each fieldbus device bubble on the P&IDs. Once again, this was not a standardized approach, and it led to ambiguity and misunderstanding. It is highly recommended that the proposed draft revision Instrument Line Symbol no. 20 (which we hope will be approved by the time this volume is released) be used for all types of fieldbus segments and networks.

P&IDs: Practical Aspects and Practices in the EPC Industry

Piping and instrument diagrams (P&IDs) are the basic documents describing a plant from mechanical and control point of view. They are sometimes called mechanical flow diagrams (MFDs) by some EPC and operating companies. Process flowsheets/diagrams (PFDs) are used and generated by process design engineering in the very early stage of the front-end engineering phase and do not normally include ISA symbols except in the most elementary fashion. However, they are the starting point for P&ID development.

The P&ID life cycle extends through the feasibility study, project estimate, detailed engineering phase, construction phase, precommissioning, commissioning, and, finally, to exploitation of the plant. According to which phase the

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project is in, the P&IDs show different level of details to suit various needs.

1) During the feasibility study, not all equipment and lines are shown; only the major ones appear, such as used to follow the path of authorizations, obtain of financing, and so on. At this stage, only major equipment is sized, such as to show environmental impact, and effluent systems are studied to comply with the information requested by various environmental authorities. Only major lines are shown, without sizing information. Very few instruments and control loops are shown, and then only in the most simplified manner.
2) During the project estimate, all equipment is shown, but without auxiliary services such as cooling water to machinery. The lines are sized, and their material and rating are shown. All control loops are shown, or at least all transmitters, local instruments, and control valves. All motor-operated valves and safety valves are shown and are sized if possible. Small-bore/diameter piping (<2 in) is not shown unless it is made of an exotic material.
3) Within the detailed engineering phase, the P&IDs are issued several times, incorporating information as it becomes available from vendors or as derived from calculations and finalization of choices. Normally, there are about three or four issues before the issue for construction. At that time, the P&IDs shall show all equipment and all lines including services to machinery, drains, and vents (as far as piping is concerned) and all instruments, control loops, and valves (as far as instrumentation is concerned).

Each line shall be sized, classified, and numbered, meaning that each line is identified with nominal diameter, piping class (which defines the material), rating (unless the piping class covers only one rating), corrosion allowance, and winterization. The control valves shall be shown with their true nominal diameter and flange rating along with block and bypass valves, handwheel, action on air failure, and possibly the pressure drop. If the valve is the angle type, the inlet and outlet shall be shown correctly. The transmitters shall be shown singularly, duplicated, or triplicated, with their pressure taps. If level bridles are used, they shall be shown with correct valving. The flow measurements shall show the correct type of primary element. Magnetic flowmeters that are required to run full should show the indication "low point."

If some devices (such as desuperheaters) require special precautions, such precautions shall be shown to prevent wrong piping design (e.g., minimum unobstructed straight length = X feet). The safety valves shall be shown with size and rating of input and output connections plus the set pressure. All vents, drains, silencers, and so on shall be shown. If many vents use common silencers, this shall be clearly indicated by means of drafting or notes. The control loops shall be shown in complete form. However, in the power industry, some boiler manufacturers show the transmitters (since they are supplied by them) and the control loops in several different documents (vendor package drawings) to be delivered to the DCS supplier or the EPC company responsible for DCS design. To prevent multiple repeats of the same information, some typical sketches should be prepared covering, for instance, the indications and commands related to an on–off motor-operated valve, an inching motor-operated valve, high-voltage motors, low-voltage motors, on–off pneumatic valves, and so forth. The typical sketches shall be numbered and referred to nearby each device on the P&ID to which it applies.

Although the P&ID symbols are normally in accordance with ISA standards, it is recommended that a P&ID symbol key sheet be prepared with a summary of all equipment and instrument symbols used to prevent any misunderstanding. The reader is referred to the previous subsection, "Inclusion of the New S5.1 Standard (now ANSI/ISA-5.01.01) in User/Owner Documents."

The tag numbering of the instruments shall be in accordance with ISA guidelines, standards, and recommended practices previously covered in this section, and all components of a loop shall have the same distinctive number so as to simplify maintenance and understanding of the process. In the case in which an instrument or loop is cancelled, its tag number shall not be used again to prevent the possibility of keeping the old process data that is no longer correct. The tag/loop cancellations must be carefully noted and retained in the instrument index, and especially in the computerized instrument database (IDB) that generates the index. For the same reason, if an instrument or a loop is moved to a different tapping point, it should be renamed—although this depends on different company standards/policies on this subject. In some cases, two pieces of equipment are used (e.g., two pumps, one spare to the other), which are named with the suffix A/B. Their relevant instruments are often tagged with the tag number suffixed with A/B. To avoid misinterpretations when two or three instruments are used in a redundant/voting configuration, it is suggested to attach suffixes to them using the letters X, Y, and Z.

Even though the P&IDs are not representative of the layout of the plant, it is recommended that the equipment be shown as it is to appear; e.g., a horizontal vessel shall be shown as horizontal and not vertical, and a boiler feed water pump with intermediate MP draft should be shown with the nozzles in correct sequence. A distillation column with different sections should be represented not as a constant one but to be roughly representative of the true situation. It is noted that the P&IDs are to be suitable for a take-off of the valves, reducers, branches, and instruments, but not for the take-off of piping and elbows.

The P&IDs depicting utility distribution or fire detection/fighting instead follow the plant plot plan and include some instruments as well.

It is important that all instruments appear on the P&ID and that none is overlooked. If some instruments are supplied

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as an integral part of a machine (e.g., resistance temperature detectors in electric motor windings and vibration probes in a compressor or turbine), it is advisable that the manufacturer's P&ID be numbered with the same system as the project P&IDs, and always from the viewpoint of taking care of all signals that will be connected to a PLC or DCS. In fact, most EPC companies supply the proper compatible tags and loop numbers from the IDB to the vendor after the first vendor document/drawing review and subsequent return to the vendor.

During construction and precommissioning, the P&IDs are used to keep track of the installed piping and instruments. At the precommissioning stage, they are used to verify that the plant has been built according to the P&IDs issued for construction. This is called the *check against P&IDs*. Any discrepancy found during this check shall be resolved and the plant modified or, if acceptable, the P&IDs shall be marked up to prepare the "as-built" issue.

During commissioning, some modifications could be necessary to overcome operational problems that could arise. These modifications could involve additional drains and vents, control strategy changes, and so forth and need to be recorded on the P&IDs to be introduced in the "as-built" issue.

During the life cycle of the plant, the P&IDs can be modified because of different products required, different feedstock, or additional treatment systems. This is even more evident in batch processes that can be modified to obtain different products. Sometimes, it is a concern that the revamping or debottlenecking of the original plant could be so extensive that the original P&IDs need to be redrawn. In this case, it is possible that starting from existing P&IDs could cause the introduction of several errors because they have not been updated.

The P&IDs have also a commercial impact on a project in that a payment is tied to their first issue. In defining the commercial aspects, one should determine to what extent the first issue of the P&IDs shall be complete so as to avoid conflicts between the owner and the supplier. A possible request could be as follows:

- All lines sized, classified, and numbered
- All instruments tagged
- All set values of safety valves shown

To go even farther, the size of control valves could be shown.

The P&IDs are the first step in ensuring the safety of maintenance personnel, which today is based on widely used outsourcing. For example, people should immediately be warned about the risks involved in the case of piping that has a high rating, is made with an exotic material, has high corrosion allowance, has a thick insulation, or belongs to a system with high set values for the safety valves.

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