General Considerations

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1.1 Flowsheet Symbols and P&I Diagrams*

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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.

* Used with permission of the Instrument, Systems and Automation Society.
**Formerly called the Instrument Society of America.

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.

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)

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)

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)

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)

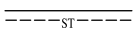
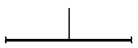
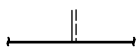
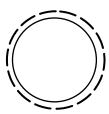
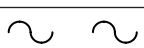
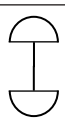
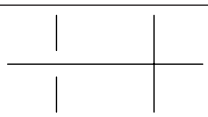
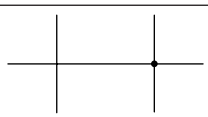
No.	*Symbol*	*Application*
01		Instrument impulse line from process Instrument impulse line from equipment Analyzer sample line from process Functional instrument diagram signal lines
02		Heat (cool) traced instrument impulse line from process Heat (cool) traced instrument impulse line from equipment 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)

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

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

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.