An Introduction to Piping & Instrumentation Drawings (P&IDs)

Part 1: What is a P&ID?

Presented by: ETTA, OSH Division, 919-807-2875

What are P&IDs?

- For thousands of years, pictures have been used to convey information

- P&IDs are no different

What are P&IDs used for?

- Act as the definition of the process from which all engineering, fabrication, construction and operation is based.

- Serve as reference for Process Safety Information (PSI) in Process Safety Management (PSM).

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P&IDs should do the following:

- Provide a clear and concise illustration of all equipment, pipes, valves, instruments, sensors, etc.

- Provide information to assist in analyzing process hazards, safeguards and potential faults so that all kinds of errors are minimized, ideally eliminated.

P&IDs should do the following:

- Support development of operating and maintenance procedures.

- Serve as an as-built record of the process so that changes can be planned safely and effectively using Management of Change (MOC).

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What do P&IDs cover?

- P&IDs can cover the following:

  - Major and minor equipment
  - Valves
  - Instrumentation
  - Stand-alone controllers
  - Buttons
  - Motors and drives
  - Limit and point devices
  - Piping
  - Virtual devices

Lead Sheets

- Comparable to a Legend on a map

- The lead sheets of the company's P&IDs, allow you to quickly track down the meaning of a pipe service label or some other obscure symbol.
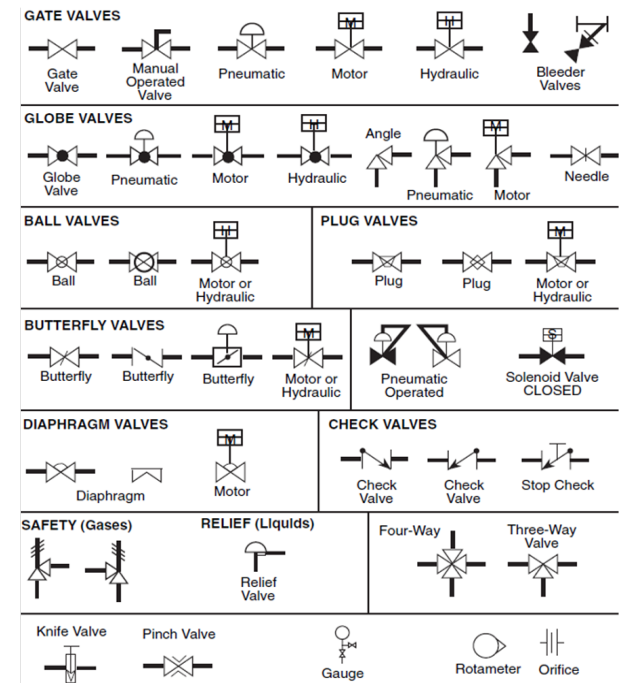
Support Documents

- Common documents that serve vital support functions to P&IDs include:

  – Process Flow Drawings

  – Piping and material specifications

  – Equipment and instrumentation specifications

  – Functional/process control documents

Process Flow Drawings

- Root of all P&IDs

- Typically the first drawings when developing a process

- Illustrate the general plant streams, major equipment and key control loops

- Provide detailed mass/energy balance data along with stream composition and physical properties

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Piping and material specifications

- Details of construction, gaskets, bolts, fittings, etc.
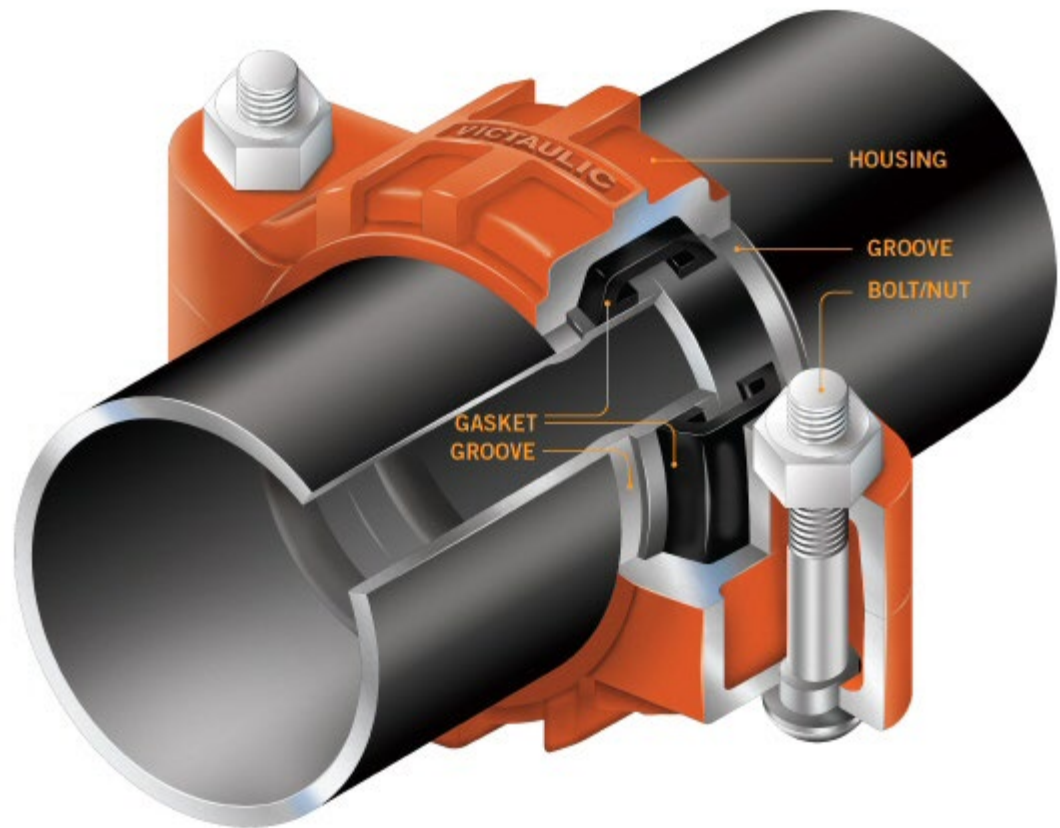
Equipment and instrumentation specifications

- CAD software used to produce P&IDs can create "smart" drawings

- They can incorporate specifications, standards and details that go into the design

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Functional/process control documents

- Describes plant operations

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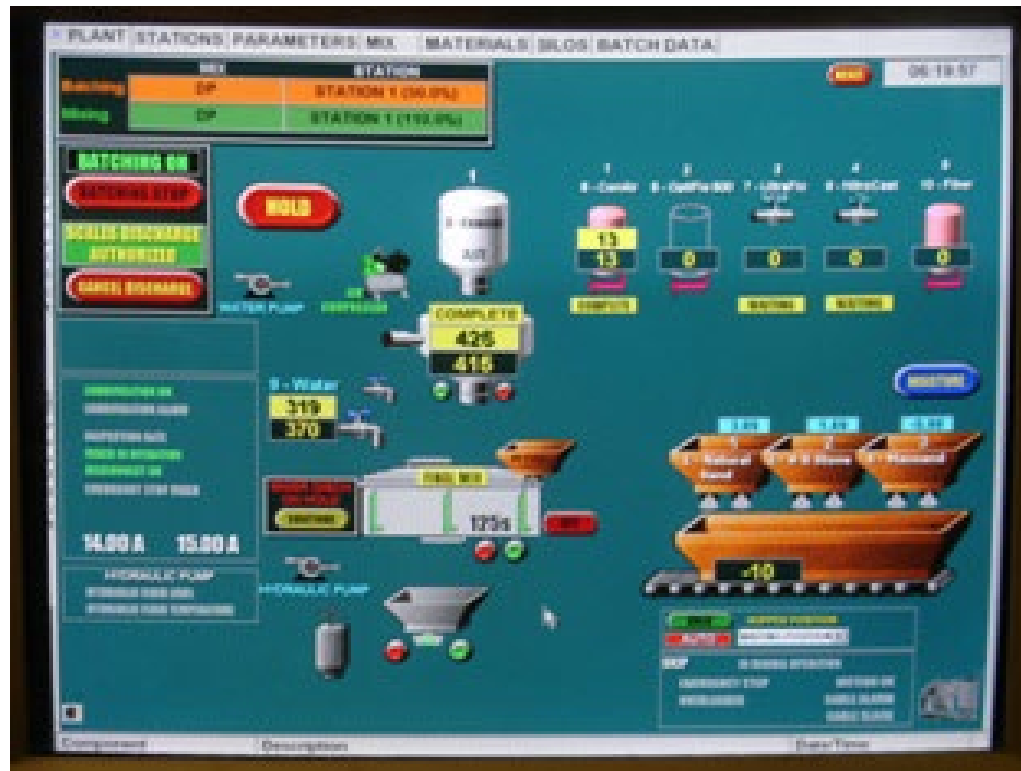
How are P&IDs organized?

- Can vary greatly from company to company

- Usually broken down into logical segments

  – Easier to develop

  – Easier to understand

  – Easier to change

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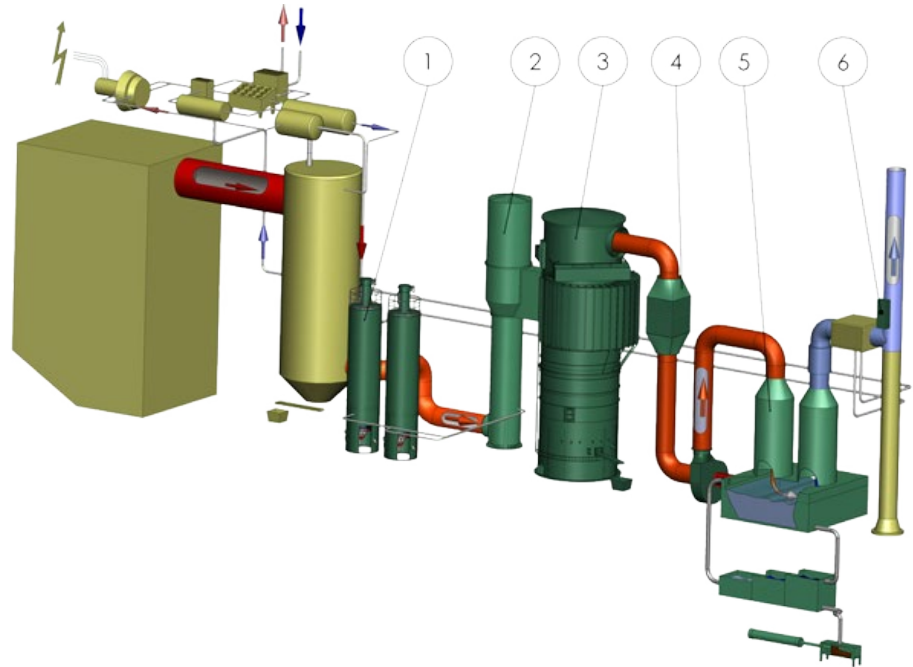
Some weaknesses with P&IDs

- Not to Scale

- Not Geometrically Accurate

- Color Blind

- Not Definitive

- Not Drawn Consistently

P&IDs as a Relational Database

- Contains collections of similar objects with unique tags for easy identification

- Structure lends itself to additions, deletions, changes, etc

- Contains metadata that can provide much more detail

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P&IDs as a Living Document

- Constant change in the form of:

  – Operational changes

  – Capacity/Production changes

  – PSM Audit Review
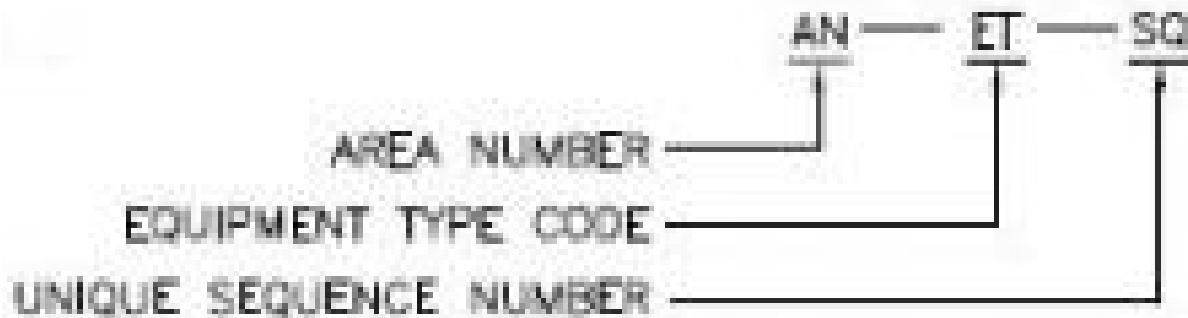
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An Introduction to Piping & Instrumentation Drawings (P&IDs)

Part 2: Reading a P&ID?

Presented by: ETTA, OSH Division, 919-807-2875

Tag Numbering System

EQUIPMENT TAG FORMAT

AN — ET — SQ

AREA NUMBER

EQUIPMENT TYPE CODE

UNIQUE SEQUENCE NUMBER

NOTE: HYPHENS ARE NOT A PART OF EQUIPMENT TAG INSTANCES.

Note: These should always be prominently displayed.

Area Number (AN)

AREA NUMERS
(PROJECT SPECIFIC)
1—TANK FARM
2—TRAIN 1
3—SOLIDS DEWATERING
4—TRAIN 2
5—VAPOR HANDLING SYSTEM

Equipment Types (ET)

EQUIPMENT TYPE CODES

1— FLUID TRANSPORT (BLOWERS, COMPRESSORS AND ALL TYPES OF PUMPS

2— SOLIDS TRANSPORT (BELT AND SCREW CONVEYORS, FEEDERS, ETC.)

3— PYSICAL SEPARATION (PHASE SEPARATION EQUIPMENT, FILTERS, SCREENS, GRAVITY SEPARATORS, CENTRIFUGES, MICRO/ULTRAFILTERS, ETC.)

4— MIXERS (AGITATORS, IN-LINE MIXERS, SHREDDERS, BLENDERS, ETC.)

5— HEAT TRANSFER (HEAT EXCHANGERS, HEATERS, COOLING TOWERS, BURNERS, ETC.)

6— MASS TRANSFER (AD/ABSORBERS, ION EXCHANGE, SCRUBBERS, STRIPPERS, COLUMNS, EVAPORATORS, ETC.)

7— CONTAINMENT (TANKS, VESSELS, PITS, SUMPS, SILOS, ETC.)

8— REACTORS (CHEMICAL REACTORS OR PRECIPITATORS, CRYSTALLIZERS, ETC.)

9— VENDOR PACKAGES & MISC. (PREFABRICATED SYSTEMS FROM 3RD PARY SUPPLIERS, SPECIALTY EQUIPMENT UNCLASSIFIED ELSEWHERE)

Sequence Numbering (SQ)

EQUIPMENT TAG FORMAT

AN — ET — SQ

AREA NUMBER

EQUIPMENT TYPE CODE

UNIQUE SEQUENCE NUMBER
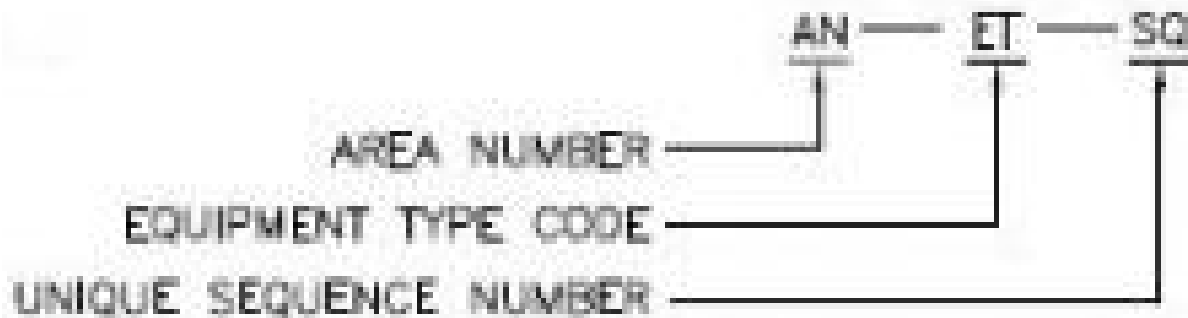
NOTE: HYPHENS ARE NOT A PART OF EQUIPMENT TAG INSTANCES.

Tag Number Examples:

- 1101 –
  - The first pump in the tank farm area.

- 1701 –
  - The first tank in the tank farm area.

- 1405 –
  - The fifth mixer in the tank farm area.

- 2901 –
  - A vendor package in the Train 1 area.

Instrument Loop Numbers

INSTRUMENT/DEVICE TAGS

PX — EQ — SX

DEVICE PREFIX
EQUIPMENT TAG
REDUNDANT/MULTIPLE SUFFIX
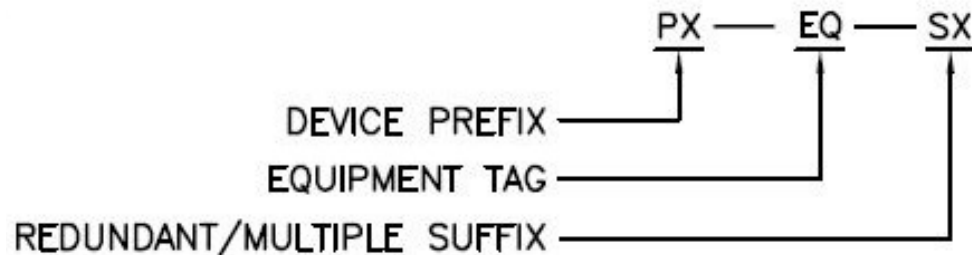
NOTE: HYPHENS ARE NOT RQD BETWEEN PX AND EQ.

REDUNDANT/MULTIPLE SUFFIX RULES:

1. UTILIZE SEQUENTIAL NON−HYPHENATIED ALPHABETIC SUFFIXES FOR REDUNDANT DEVICES.
2. FOR MULTIPLE ITEMS OF SAME TYPE, EMPLOY A SEQUENTIAL, HYPHENATED NUMERIC SUFFIX.

Example Loop Tags

PI1101

A pressure indicator on the discharge of the first pump in the tank farm area.

LT1701

A level transmitter on the first tank in the tank farm area.

IT1405

A current transmitter (for the motor) on the fifth agitator in the tank farm area.

AE1701A

A redundant analyzers on the first tank in the tank farm.

XV1701-1

An actuated valve on the first tank in the tank farm area.

Line Numbers

LINE NUMBERS

LINE SIZE
SERVICE CODE
X" — SVC — DNSQ — LS
LINE (PIPING) SPEC
SEQUENTIAL NUMBER
LAST TWO DIGITS OF DRAWING FILE NAME
LABEL COLOR = BLACK
EXAMPLE

EQI
UNIQUE

VALVE TAGS

MANUAL VALVES   CONTROL VALVES

MANUAL VALVE SIZE → 100
GREEN=OPEN RED=CLOSED
N4
HV0001
VALVE SPEC
HAND VALVE TAG
CONTROL VALVE BUBBLE
CONTROL VALVE SIZE

2"-IFD-0001-LS1

FCV ####
##

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Line Numbers

X"--SVC--ET:SQ--LS

X" - the nominal size of the pipe

SVC - the service code for the material that normally flows in the line

ET:SQ - a unique line tag that includes two parts, the equipment tag from which the line originates followed by a unique sequential number

LS -line specification for the pipe, including class and material type, valves etc.

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Fluid Service Codes (SVC)

FLUID SERVICE CODES

ALM — ALUMINUM SULFATE	NAG — NATURAL GAS
AMN — AMMONIUM NITRATE	NIA — NITRIC ACID
AMH — AMMONIUM HYDROXIDE	N2 — NITROGEN
ABF — AMMONIUM (BI)FLUORIDE	OIL — OIL (GENERAL USE)
AMS — AMMONIUM SULFATE	PAR — PROCESS AIR
ASO — ACID SOLUBLE ORGANICS	PFD — POLYMER FEED
BAR — BACKWASH AIR	PHA — PHOSPHORIC ACID
CAF — CALCIUM FLUORIDE	KF — POTASSIUM FLUORIDE
CAR — COMPRESSED AIR	KOH — POTASSIUM HYDROXIDE
CBW — CLEAN BACKWASH WATER	PSL — PROCESS SLURRY/SLUDGE
CFD — CAUSTIC RAW FEED (GEN. USE)	PVP — PROCESS VAPOR
CO2 — CARBON DIOXIDE	PWR — POTABLE WATER
CHC — CALCIUM HYPOCHLORITE	SAH — SULFURIC ACID, >75%
CL2 — CHLORINE	SAL — SULFURIC ACID, <75%
DBW — DIRTY BACKWASH WATER	SHC — SODIUM HYPOCHLORITE
DRN — PROCESS DRAIN	SOC — SODIUM CARBONATE
DSL — DIESEL FUEL	SOH — SODIUM HYDROXIDE
EFF — EFFLUENT (GENERAL USE)	SLP — STEAM, <125#
FEC — FERRIC CHLORIDE	SMB — SODIUM METABISULFITE
FEW — FILTER EFFLUENT WATER	STM — STEAM, 125—220 #
FIW — FILTER INFLUENT WATER	SNY — SANITARY SEWER
FOL — FUEL OIL	STO — STORM DRAIN
HCL — HYDROCHLORIC ACID	SWR — SERVICE WATER
HF — HYDROFLUORIC ACID	TFL — THERMAL FLUID
HPX — HYDROGEN PEROXIDE	UAR — UTILITY AIR
IAR — INSTRUMENT AIR	UWR — UTILITY WATER
IFD — INDUSTRIAL RAW FEED	VNT — VENT (GENERAL USE)
LSY — LIME SLURRY	WOL — WASTE OIL
MEL — METHANOL	WWR — WASTEWATER (GENERAL USE)

Line Specifications (LS)

- Line specifications cover all the details related to the piping system used to handle the fluid for the line.

- Should include all details regarding
  - material of construction
  - valves and trim
  - Gaskets
  - Fittings
  - T/P limits

Hand Valves (HV)

MANUAL VALVES

MANUAL VALVE SIZE ⟶ 100

N4
HV0001

VALVE SPEC
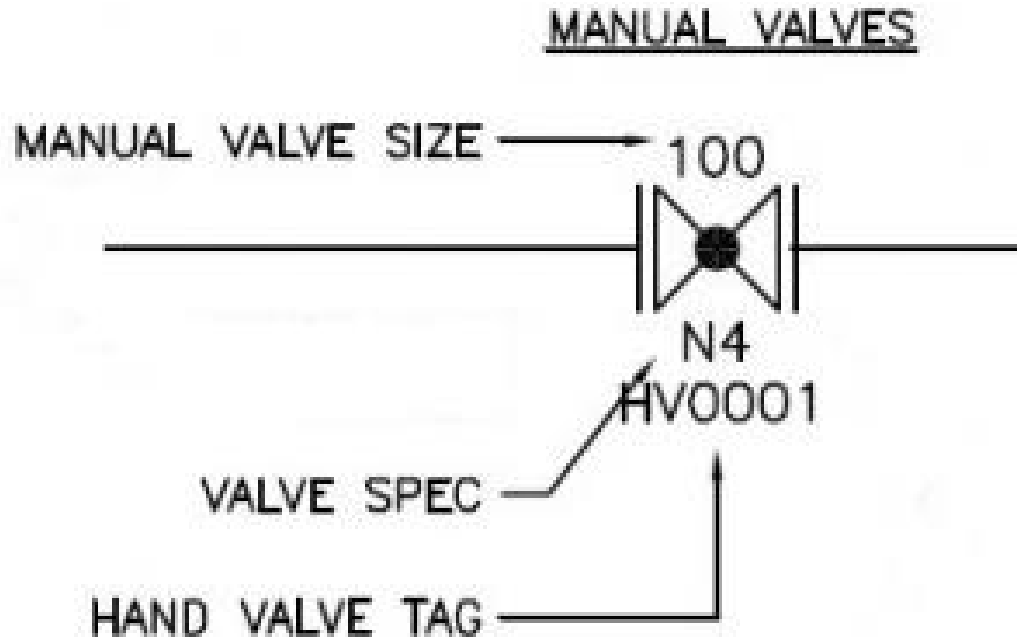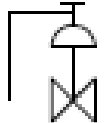
HAND VALVE TAG

Examples:
V0001 - The first hand valve on P&ID D100
V1205 - The fifth hand valve on P&ID D102

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Valve Symbols

VALVE SYMBOLS

|O| — BALL

|∕| — BUTTERFLY

|∕| — CHECK, GENERAL

|◁| — CHECK, SPLIT DISK

⊠ — DIAPHRAGM

⋈ — GATE

⋈ — GLOBE

|‖| — KNIFE GATE

⋈ — NEEDLE

⋈ — PINCH

|◇| — PLUG

— ANGLE

|O| — THREE−WAY
(Ball type shown)

— PRESSURE RELIEF

— PRESSURE REDUCING
(EXTERNAL SENSOR)

— PRESSURE REDUCING
(INTERNAL SENSOR)
HAND WHEEL ADJ.
SETPOINT

— PRESSURE RELIEF
VACUUM VENT

NOTE: VALVE COLOR DURING TYPICAL OPERATION IS
GREEN=OPEN AND RED=CLOSED.

Line Symbols

LINE SYMBOLS

————————————	MAJOR PROCESS PIPING
———————————	MINOR/INSTRUMENT PIPING
—— —— ——	EXISTING PIPING
— — — — — —	ELECTRICAL SIGNAL
—×——×——×—	CAPILLARY TUBING
——o——o——	SOFTWARE OR DATA LINK
—•——•——•—	MECHANICAL LINK
——//————//—	PNEUMATIC SIGNAL/PIPING
—L——L——L—	HYDRAULIC SIGNAL
——~————~—	GUIDED WAVE
~ ~ ~	UNGUIDED WAVE

NOTE: PROCESS LINES ARE COLOR—KEYED
      IN ACCORDANCE WITH THE PFD LINE
      COLOR KEY TABLE.

Control Valve ID

CONTROL VALVE ACTUATORS

PISTON WITH SPRING RETURN

FAIL OPEN

PISTON

FAIL CLOSED

ELECTRIC FAIL INDETERMINATE

LY — VALVE MOUNTED I/P CONVERTER

DIAPHRAGM ACTUATOR

SOLENOID

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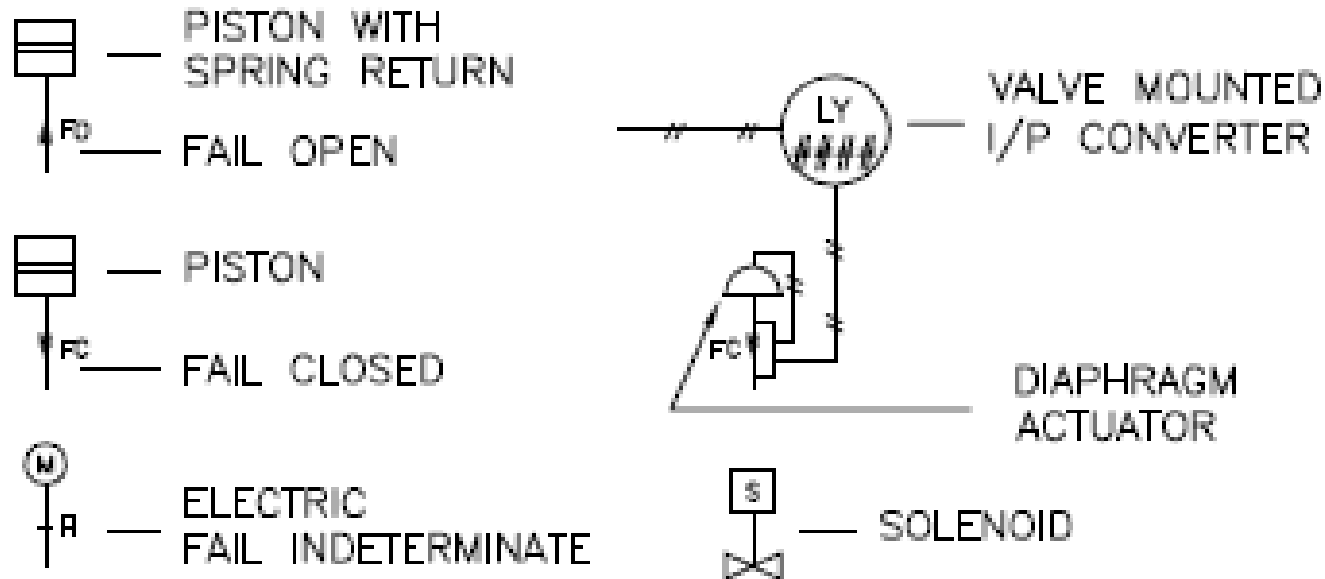
Primary Flow Elements

PRIMARY FLOW ELEMENTS

ORIFICE PLATE WITH FLANGE PIPE TAPS OR VENA CONTRACTA

ORIFICE PLATE IN QUICK-CHANGE FITTING

AVERAGING PITOT TUBE

TURBINE OR PROPELLER TYPE

PITOT TUBE

POSITIVE DISPLACEMENT

VENTURI TUBE

ROTAMETER

VORTEX SENSOR

FLOW NOZZLE

MAGNETIC

WEIR (V-NOTCH SHOWN)

ULTRASONIC (DOPPLER)

CORIOLIS

FLUME

TRANSIT TIME

Instrument Letter ID

INSTRUMENT LETTER IDENTIFICATION

	FIRST−LETTER		SUCCEEDING−LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYZER		ALARM		
B	BURNER		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
C	USER'S CHOICE	CONTROL		CONTROL	CLOSE
D	USER'S CHOICE	DIFFERENTIAL			
E	VOLTAGE		PRIMARY ELEMENT		
F	FLOW	RATIO			
G	USER'S CHOICE		GLASS		
H	HAND				HIGH
I	CURRENT		INDICATE		
J	POWER	SCAN			
K	TIME			CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	USER'S CHOICE	MOMENTARY			MEDIUM
N	USER'S CHOICE		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
O	USER'S CHOICE		ORIFICE		OPEN
P	PRESSURE		POINT TEST CONN.		
Q	QUANTITY	INTEGRATE/TOTALIZE			
R	RADIATION	RELIEF	RECORD		
S	SPEED	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTI−VARIABLE		MULTI−FUNCTION	MULTI−FUNCTION	MULTI−FUNCTION
V	VIBRATION			VALVE, DAMPER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X−AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE	Y−AXIS		RELAY, COMPUTE	
Z	POSITION	Z−AXIS		DRIVER, ACTUATOR UNCLASSIFIED FINAL CONTROL ELEMENT	

INSTRUMENT SYMBOL IDENTIFICATION

INSTRUMENT FUNCTION (SEE ABOVE TABLE)

LE
123A

DEVICE TAG/LOOP NUMBER (SEE D102 FOR DETAILS)

MAY INDICATE QUANTITY (IF APPLICABLE), TYPE OF DEVICE, APPLICABLE SETTINGS OR OTHER SUPPLEMENTARY DATA

MODIFIER SUFFIX IS REQ'D WHEN REDUNDANT AND/OR MULTIPLE DEVICES PRESENT IN A COMMON LOOP. REFER TO D002 FOR DETAILS.

NOTE:
TABLE IS BASED ON ANSI/ISA−5.1−1984 (R1992).

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Instrument Symbols

INSTRUMENT SYMBOLS

LOCALLY MOUNTED (FIELD)

FRONT OF PANEL MOUNTED

LOCAL PANEL MOUNTED

BACK OF PANEL MOUNTED OR INACCESSIBLE

SHARED DISPLAY FUNCTION NOT NORMALLY ACCESSIBLE TO THE OPERATOR

SHARED DISPLAY FUNCTION NORMALLY ACCESSIBLE TO THE OPERATOR

SHARED DISPLAY FUNCTION REMOTE LOCATION

PLC FUNCTION

INSTRUMENTS SHARING COMMON HOUSING

NOT BY VEOLIA WATER

PILOT LIGHT

HOST COMPUTER NOT NORMALLY ACCESSIBLE TO THE OPERATOR

HOST COMPUTER NORMALLY ACCESSIBLE TO THE OPERATOR

RESET

INTERLOCK

PURGE

Instrument Abbreviations

INSTRUMENT ABBREVIATIONS

|	
AI — ANALOG INPUT	FWD — FORWARD
AO — ANALOG OUTPUT	KT — K-TYPE THERMOCOUPLE
BCD — BINARY CODED DECIMAL	LC — LOCKED CLOSED
C — COMPUTER	LO — LOCKED OPEN
CPT — CONTROL POWER TRANSFORMER	MN — MODBUS NETWORK
DI — DIGITAL INPUT	MS — MOTOR STARTER
DL — DATA LOGGER	NC — NORMALLY CLOSED
DO — DIGITAL OUTPUT	NO — NORMALLY OPEN
FB — FEEDBACK	PLC — PROGRAMMABLE LOGIC CONTROLLER
FC — FAIL CLOSED	PV — PROCESS VARIABLE
FI — FAIL INTERMEDIATE	RSP — REMOTE SETPOINT
FLP — FAIL LAST POSITION	REV — REVERSE
FO — FAIL OPEN	SP — SETPOINT
FP — FILL PORT	EL — ELEVATION
	IAR — INSTRUMENT AIR

CONNECTIONS

—|O|— THREADED (GENERAL)

—|O|— BUTT WELDED

—]O[— SOCKET WELDED

—||O||— FLANGED

Computing Function ID

COMPUTING FUNCTION IDENTIFICATION

Σ	— ADD	$\pm$	— BIAS	V	— VELOCITY LIMITER
Σ/n	— AVERAGE	$\div$	— DIVIDE	$-K$	— NEGATIVE GAIN
Δ	— DIFFERENCE	$>$	— HIGH SELECTOR	K	— PROPORTIONAL GAIN
1:1	— BOOSTER	$<$	— LOW SELECTOR	2:1	— PROPORTIONAL
$>$	— HIGH LIMIT	X	— MULTIPLY	f(t)	— TIME FUNCTION
$<$	— LOW LIMIT	$\int$	— INTEGRATE	$\sqrt{\ }$	— ROOT EXTRACTION
$\frac{d}{dt}$	— RATE OF CHANGE	x^n	— EXPONENTIAL	/	— CONVERT

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I/O Symbols

TYPICAL I/O SYBMOLS

DI ▷ —	DIGITAL INPUT TO PLC
DO ▷ —	DIGITAL OUTPUT FROM PLC
AI ▷ —	ANALOG INPUT TO PLC
AO ▷ —	ANALOG OUTPUT FROM PLC
MB ▷ —	MODBUS COMMUNICATIONS
KT ▷ —	K-TYPE THERMOCOUPLE

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Thank You For Attending!

Final Questions?

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(1-800-625-2267)

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