SCADA, P&ID, PLC, VFD and more

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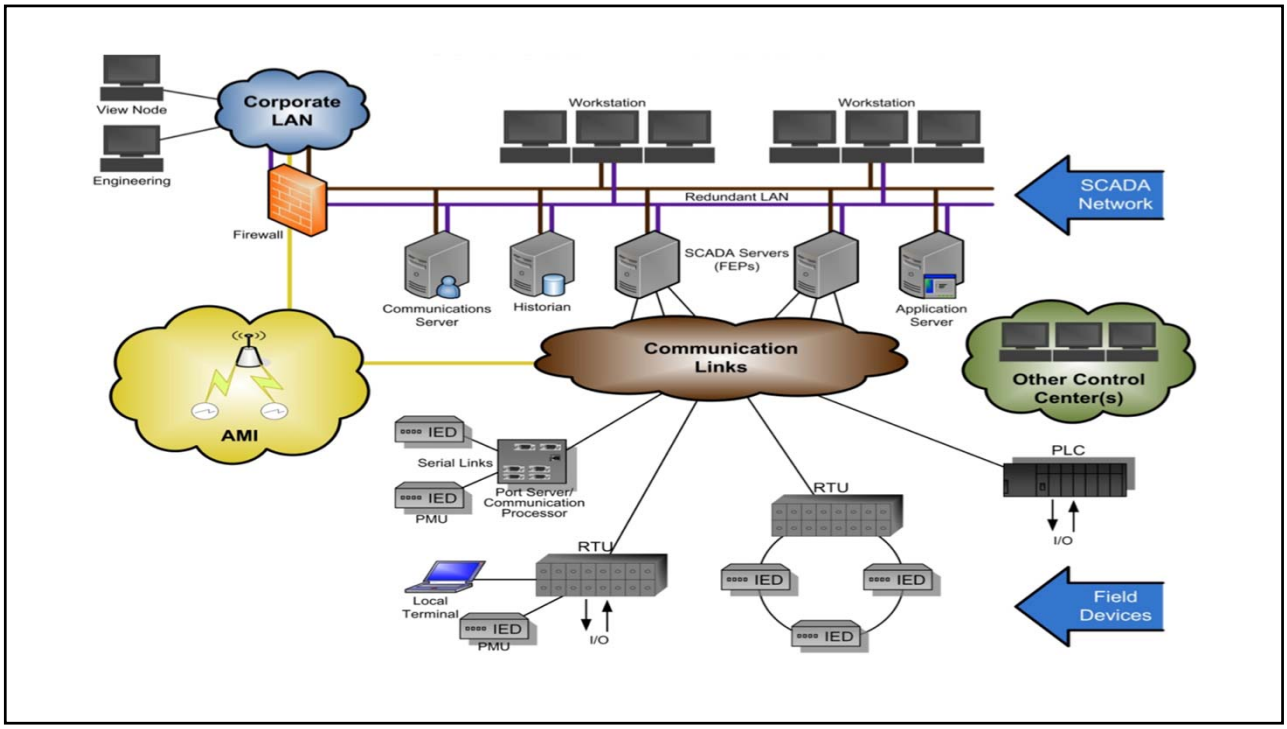
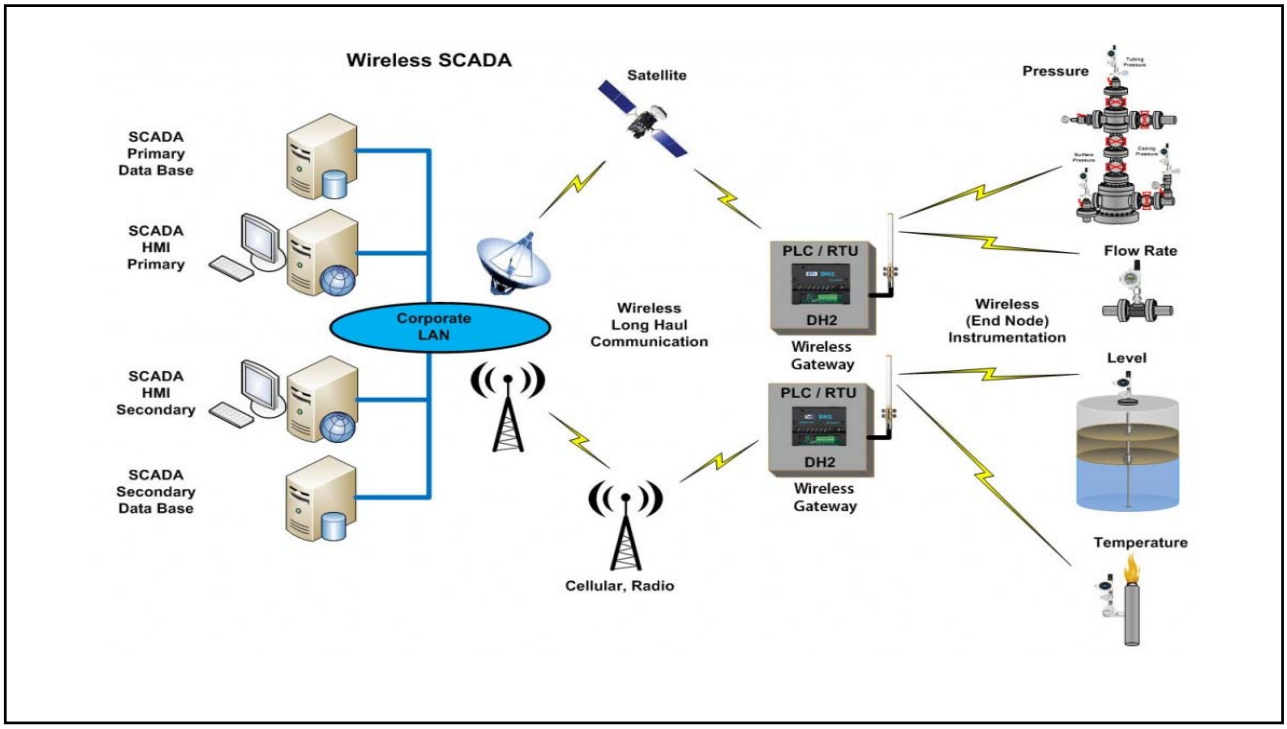
1

Scada Control Room

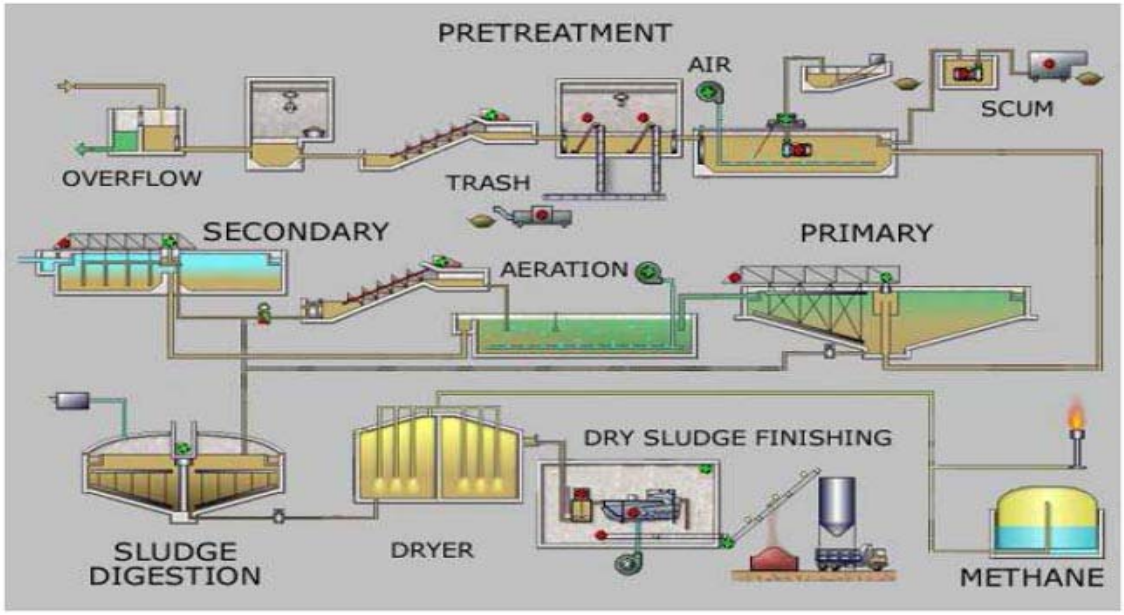
2


View Node
Engineering
Corporate LAN
Firewall
Workstation
Workstation
Redundant LAN
SCADA Network
Communications Server
Historian
SCADA Servers (FEPs)
Application Server
Communication Links
Other Control Center(s)
AMI
IED
Serial Links
Port Server/ Communication Processor
IED
PMU
PLC
I/O
RTU
IED
IED
IED
Local Terminal
RTU
IED
PMU
I/O
Field Devices

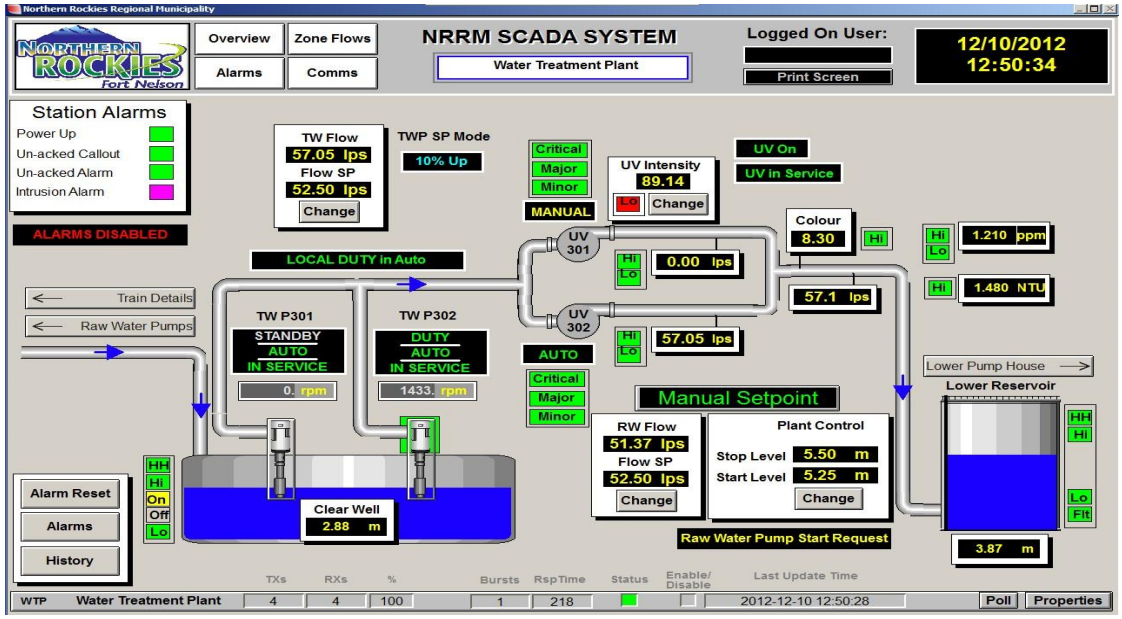
3


Wireless SCADA
Satellite
Pressure
SCADA Primary Data Base
SCADA HMI Primary
Corporate LAN
Wireless Long Haul Communication
PLC / RTU
DH2
Wireless Gateway
Wireless (End Node) Instrumentation
Flow Rate
SCADA HMI Secondary
SCADA Secondary Data Base
PLC / RTU
DH2
Wireless Gateway
Level
Temperature
Cellular, Radio

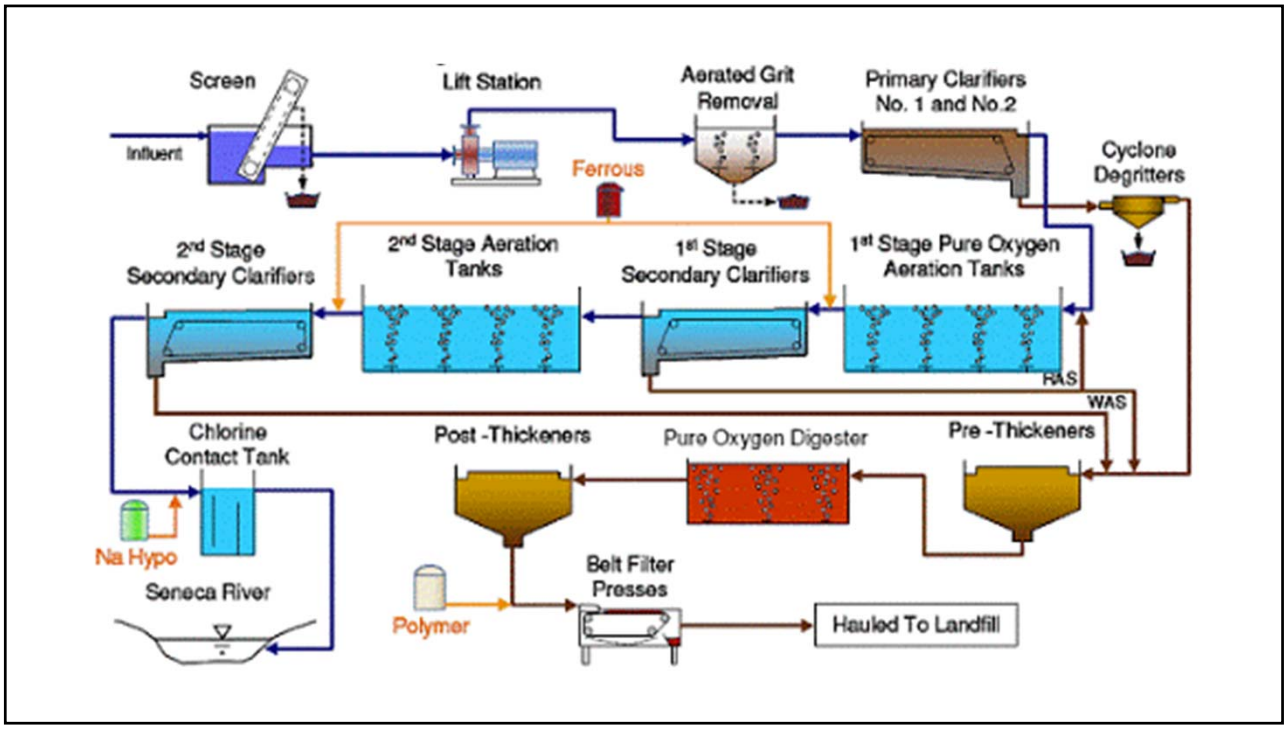
4


PRETREATMENT
AIR
SCUM
OVERFLOW
TRASH
SECONDARY
PRIMARY
AERATION
DRY SLUDGE FINISHING
SLUDGE DIGESTION
DRYER
METHANE

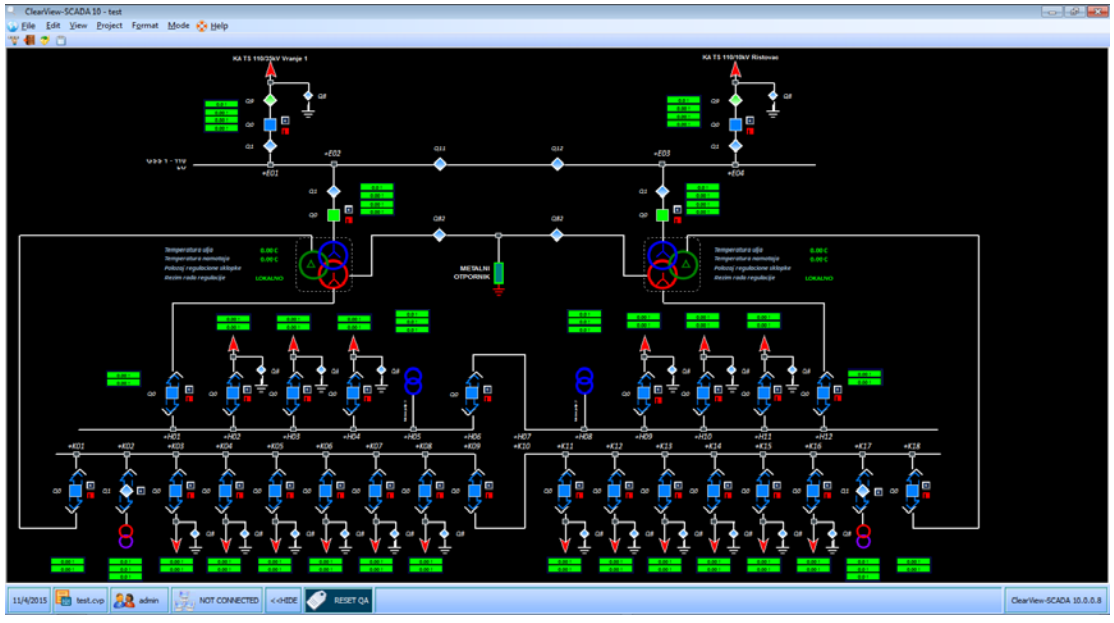
5


Northern Rockies Regional Municipality
NORTHERN ROCKIES Fort Nelson
Overview
Zone Flows
Alarms
Comms
NRRM SCADA SYSTEM
Water Treatment Plant
Logged On User:
Print Screen
12/10/2012 12:50:34
Station Alarms
Power Up
Un-acked Callout
Un-acked Alarm
Intrusion Alarm
ALARMS DISABLED
TW Flow
57.05 lps
Flow SP
52.50 lps
Change
TWP SP Mode
10% Up
Critical
Major
Minor
MANUAL
UV Intensity
89.14
Lo
Change
UV On
UV in Service
Colour
8.30
Hi
Hi
Lo
1.210 ppm
Hi
1.480 NTU
LOCAL DUTY in Auto
UV 301
Hi
Lo
0.00 lps
57.1 lps
UV 302
Hi
Lo
57.05 lps
Train Details
Raw Water Pumps
TW P301
STANDBY
AUTO
IN SERVICE
0. rpm
TW P302
DUTY
AUTO
IN SERVICE
1433. rpm
AUTO
Critical
Major
Minor
Manual Setpoint
Lower Pump House
Lower Reservoir
RW Flow
51.37 lps
Flow SP
52.50 lps
Change
Plant Control
Stop Level
5.50 m
Start Level
5.25 m
Change
Raw Water Pump Start Request
HH
Hi
On
Off
Lo
Clear Well
2.88 m
HH
Hi
Lo
Fit
3.87 m
Alarm Reset
Alarms
History
TXs
RXs
%
Bursts
RspTime
Status
Enable/ Disable
Last Update Time
WTP
Water Treatment Plant
4
4
100
1
218
2012-12-10 12:50:28
Poll
Properties

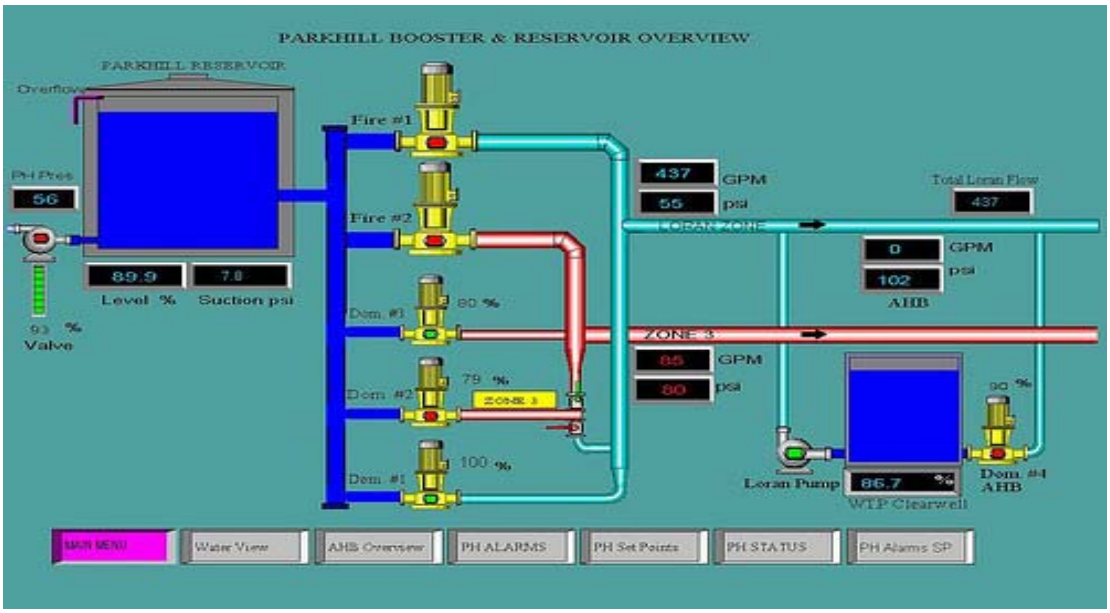
6


Screen
Influent
Lift Station
Ferrous
Aerated Grit Removal
Primary Clarifiers No. 1 and No.2
Cyclone Degritters
2nd Stage Secondary Clarifiers
2nd Stage Aeration Tanks
1st Stage Secondary Clarifiers
1st Stage Pure Oxygen Aeration Tanks
RAS
WAS
Chlorine Contact Tank
Post -Thickeners
Puro Oxygen Digester
Pre -Thickeners
Na Hypo
Seneca River
Polymer
Belt Filter Presses
Hauled To Landfill

7



8



9

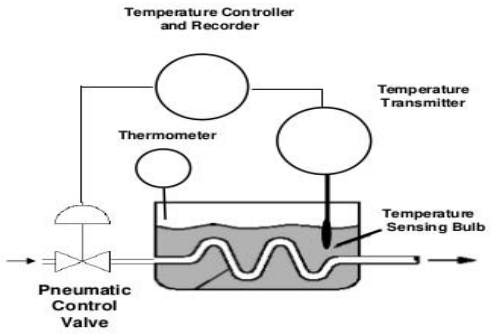
P & ID

BASICS

10

Building the P&ID

The P&ID will use symbols and circles to represent each instrument and how they are inter-connected in the process.



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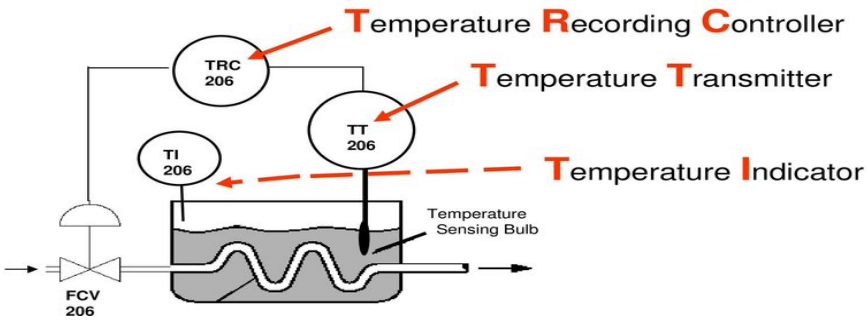
Tag Numbers

Tag "numbers" are letters and numbers placed within or near the instrument to identify the type and function of the device.



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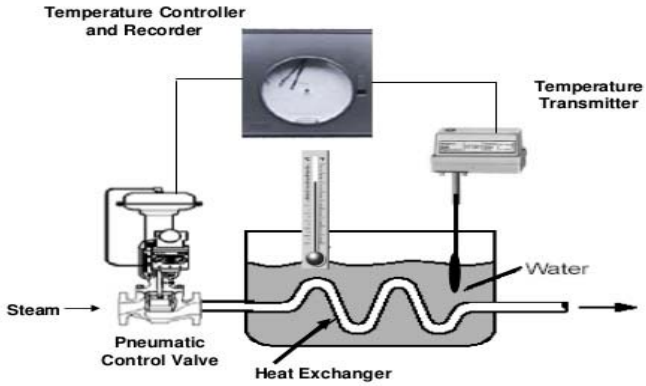
Temperature Process

Using pictorial diagrams may be informative however it is not practical or CAD friendly especially in a multi-loop process.



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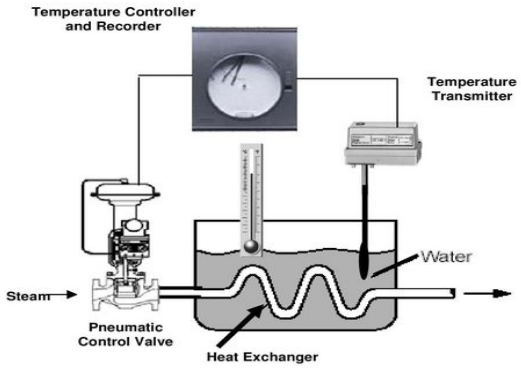
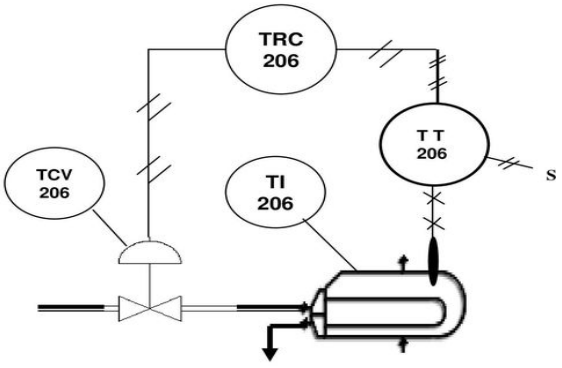
P&ID Example





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ISA S5.1 Identification Letters

	First-letter		Succeeding- Letters		
	Measured or Initiating variable	Modifier	Readout function	Output function	Modifier
A	Analysis				
C				Control	
D		Differential			
F	Flow Rate	Ratio			
H	Hand				High
I	Current		Indicate		
L	Level				Low
P	Pressure, vacuum				
Q	Quantity	Totalizer			
S		Safety		Switch	
T	Temperature			Transmit	
V	Vibration			Valve, Damper	
z	Position			Actuator	

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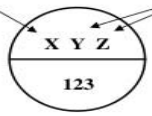
Tag Descriptors

*The first letter is used to designate the **measured variable***

*The succeeding letter(s) are used to designate the **function** of the component, or to **modify** the meaning of the first letter.*



Pressure

Level

Flow

Temperature

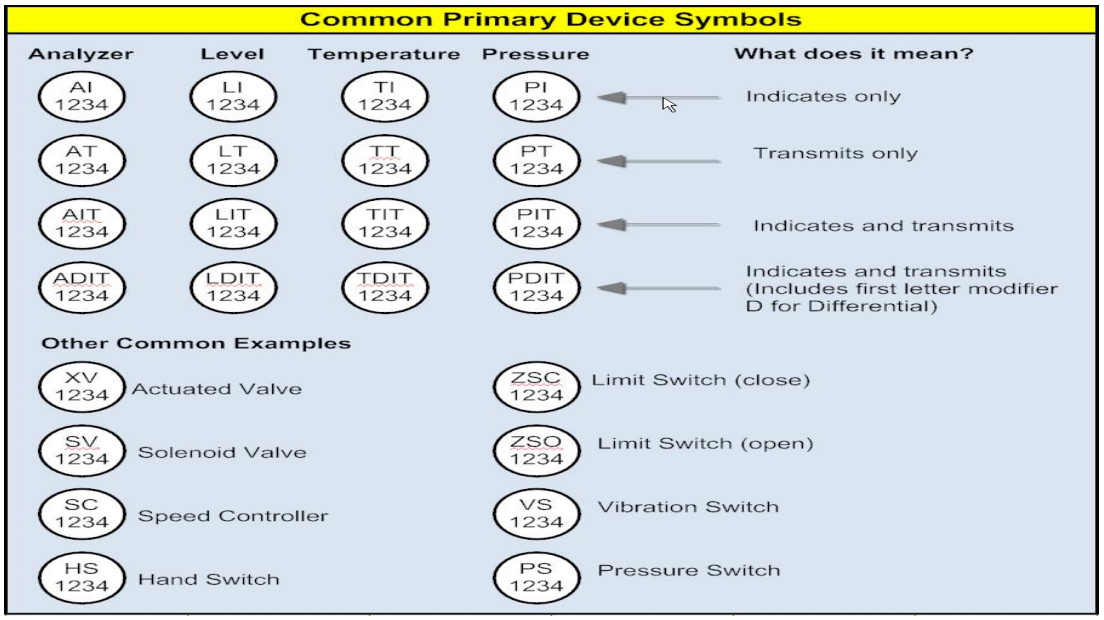
Indicator

Recorder

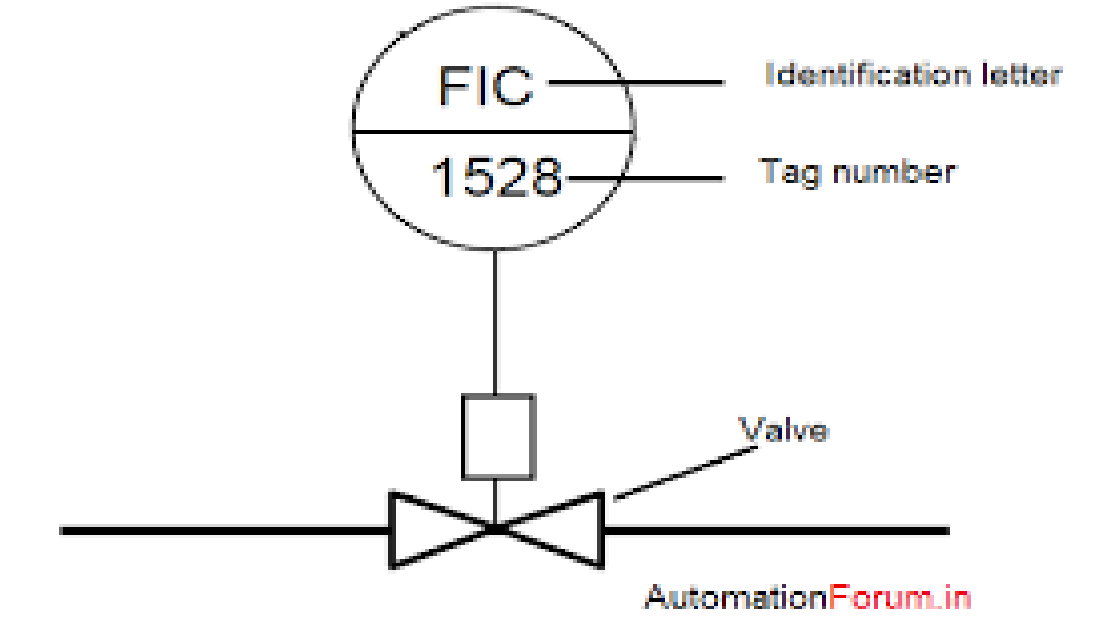
Controller

Transmitter

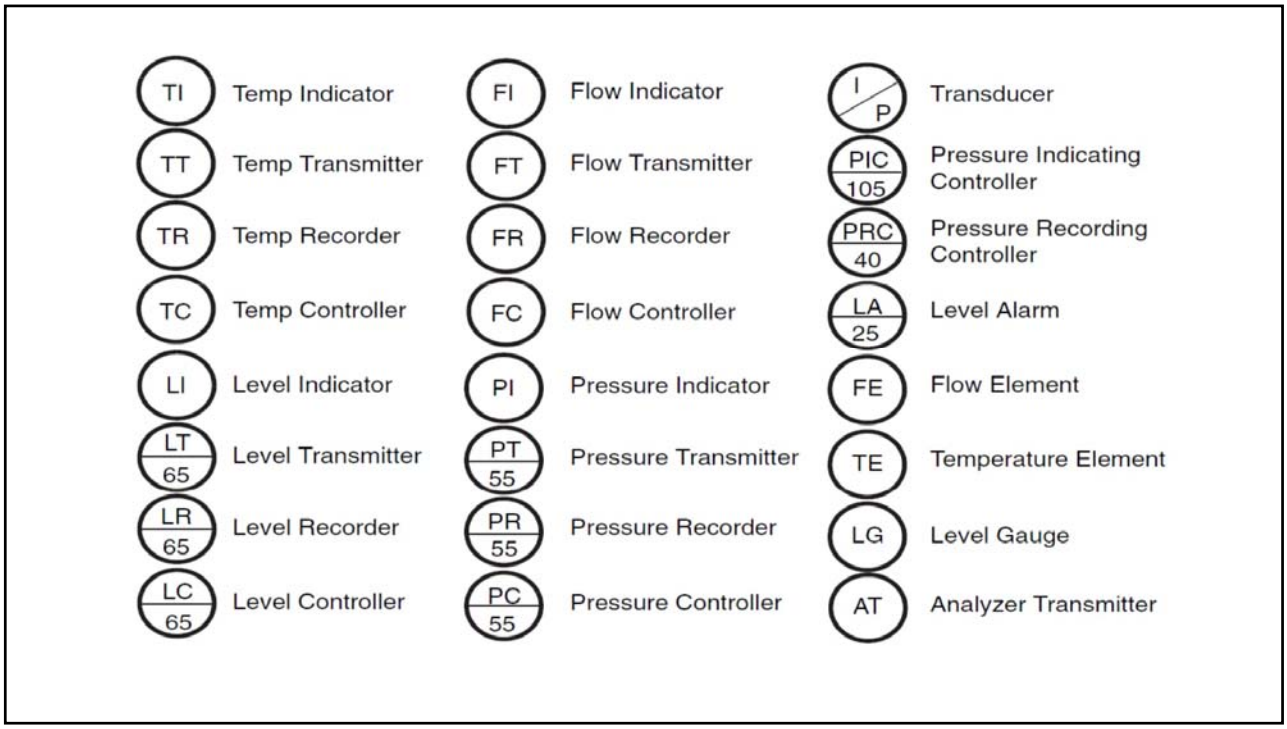
16


Common Primary Device Symbols
Analyzer
Level
Temperature
Pressure
What does it mean?
AI 1234
LI 1234
TI 1234
PI 1234
Indicates only
AT 1234
LT 1234
TT 1234
PT 1234
Transmits only
AIT 1234
LIT 1234
TIT 1234
PIT 1234
Indicates and transmits
ADIT 1234
LDIT 1234
TDIT 1234
PDIT 1234
Indicates and transmits (Includes first letter modifier D for Differential)
Other Common Examples
XV 1234
Actuated Valve
SV 1234
Solenoid Valve
SC 1234
Speed Controller
HS 1234
Hand Switch
ZSC 1234
Limit Switch (close)
ZSO 1234
Limit Switch (open)
VS 1234
Vibration Switch
PS 1234
Pressure Switch

17


FIC
1528
Identification letter
Tag number
Valve
AutomationForum.in

18



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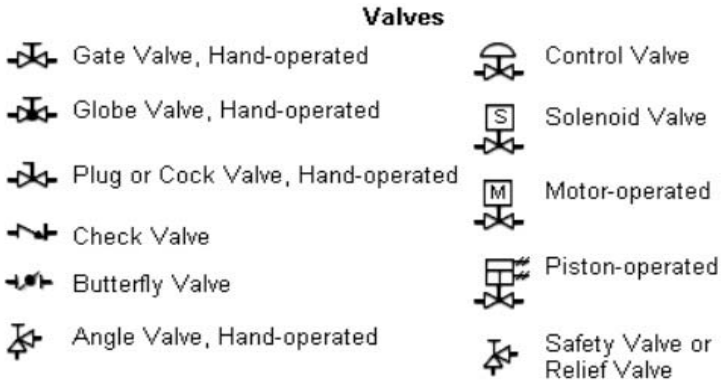
Valve Symbols



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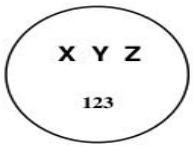
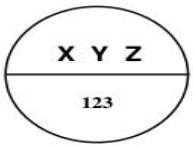
Instrument Location

*The presence or absence of a line determines the location of the physical device. For example **no line** means the instrument is installed in the field near the process.*



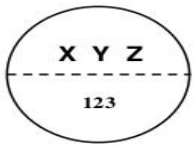
No Line

The instrument is mounted in the field near the process, (close to the operator)



Solid Line

The instrument is mounted in the control room (accessible to the operator)



No Line

The instrument is mounted out of sight (not accessible to the operator)

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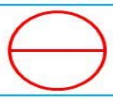
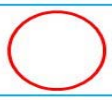
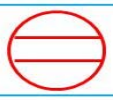
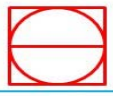
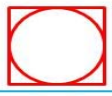
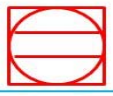
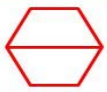
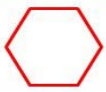
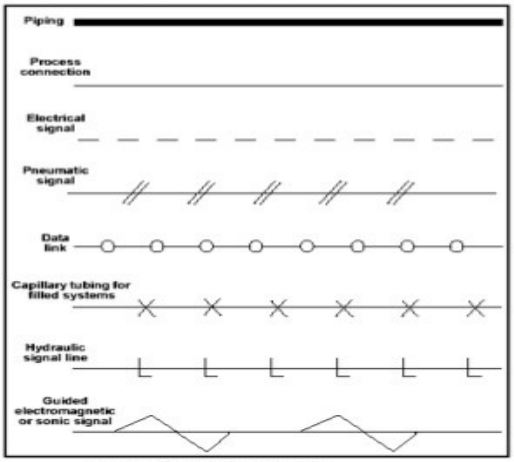
General Instrument or Function Symbols

	Primary Location Normally Accessible to Operator	Field Mounted	Auxiliary Location Normally Accessible to Operator
Discrete Instruments			
Shared Display			
Computer Function			
Programmable Logic Control			

22

Piping and Connection Symbols



Piping and Connection Symbols

These symbols are used to identify how the instruments in the process connect to each other.

And what type of signal is being used. (electrical, pneumatic, data, etc)

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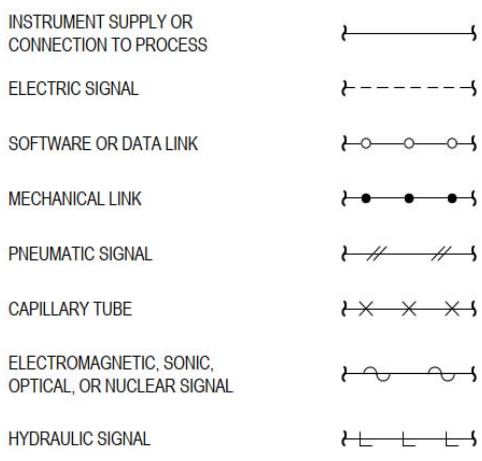
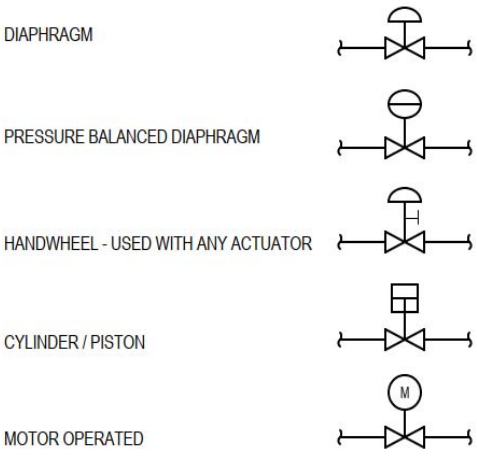


EXAMPLES OF INSTRUMENT SIGNALS



EXAMPLES OF CONTROL VALVE ACTUATORS

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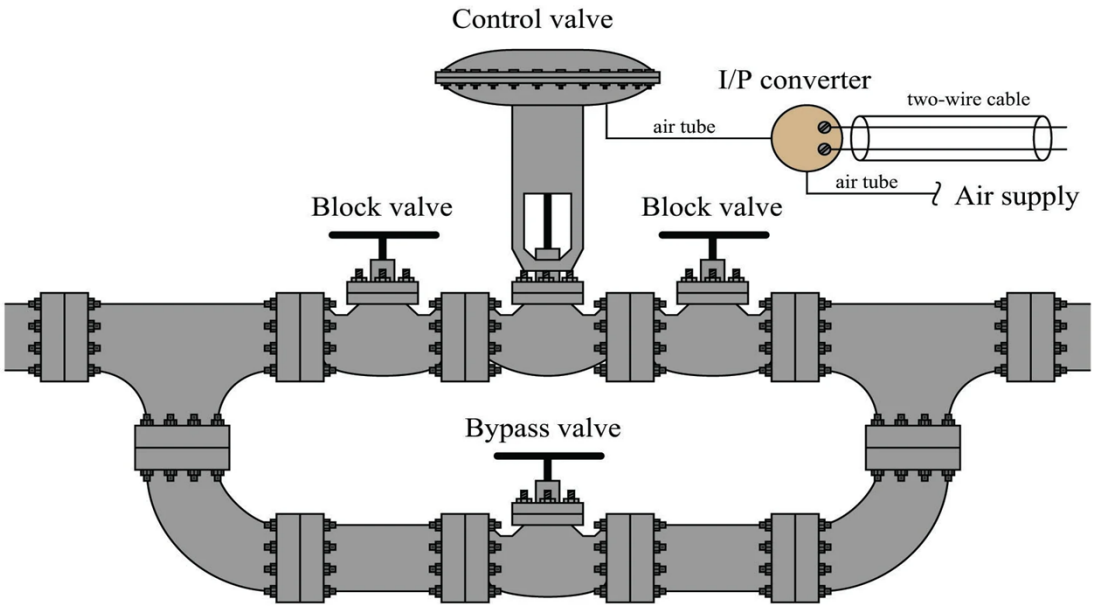
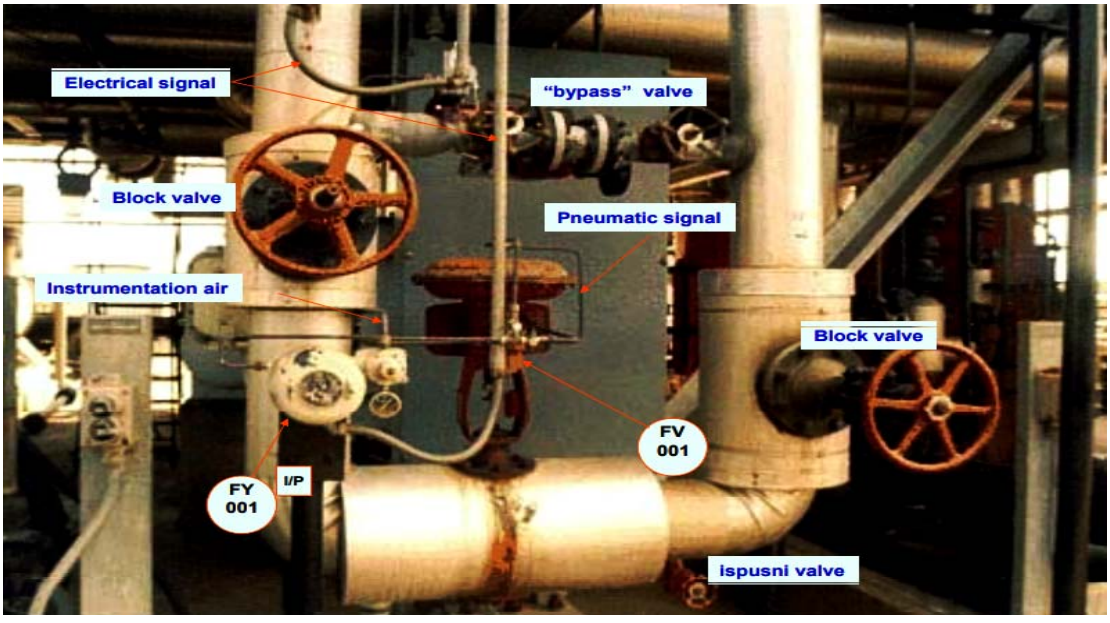

Control valve
I/P converter
two-wire cable
air tube
air tube
Air supply
Block valve
Block valve
Bypass valve

25


Electrical signal
"bypass" valve
Block valve
Pneumatic signal
Instrumentation air
Block valve
FV
001
FY
001
I/P
Ispusni valve

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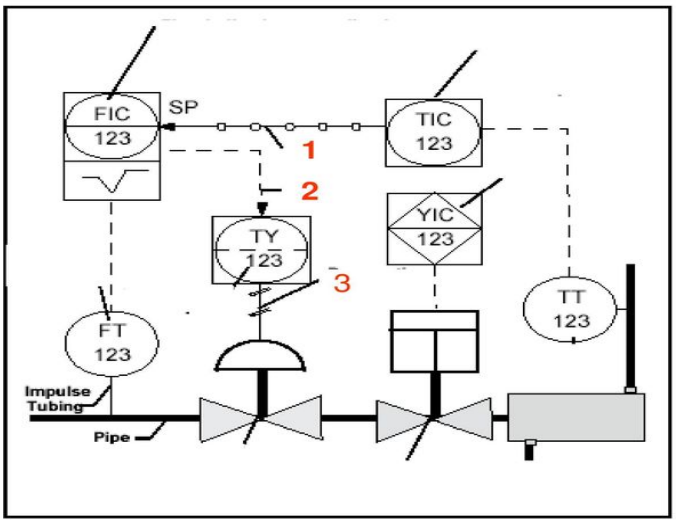
P&ID Exercise



FIC

TIC

YIC

TY

FT

TT

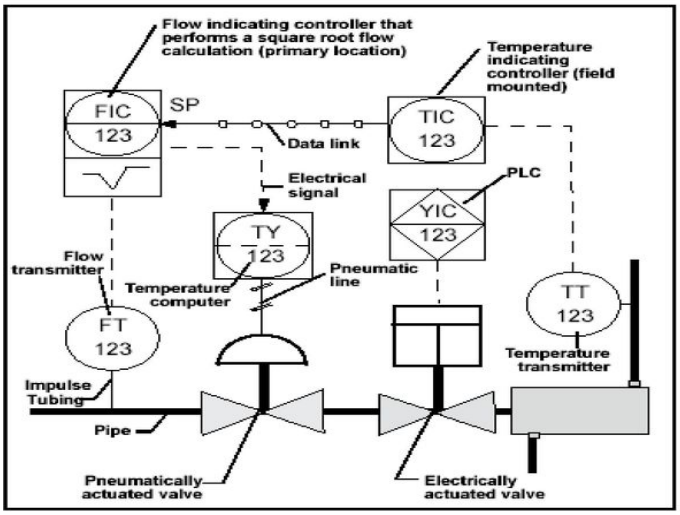
1

2

3

27

P&ID Exercise



FIC –
Flow Indicating Controller

TIC
Temperature Indicating Cont.

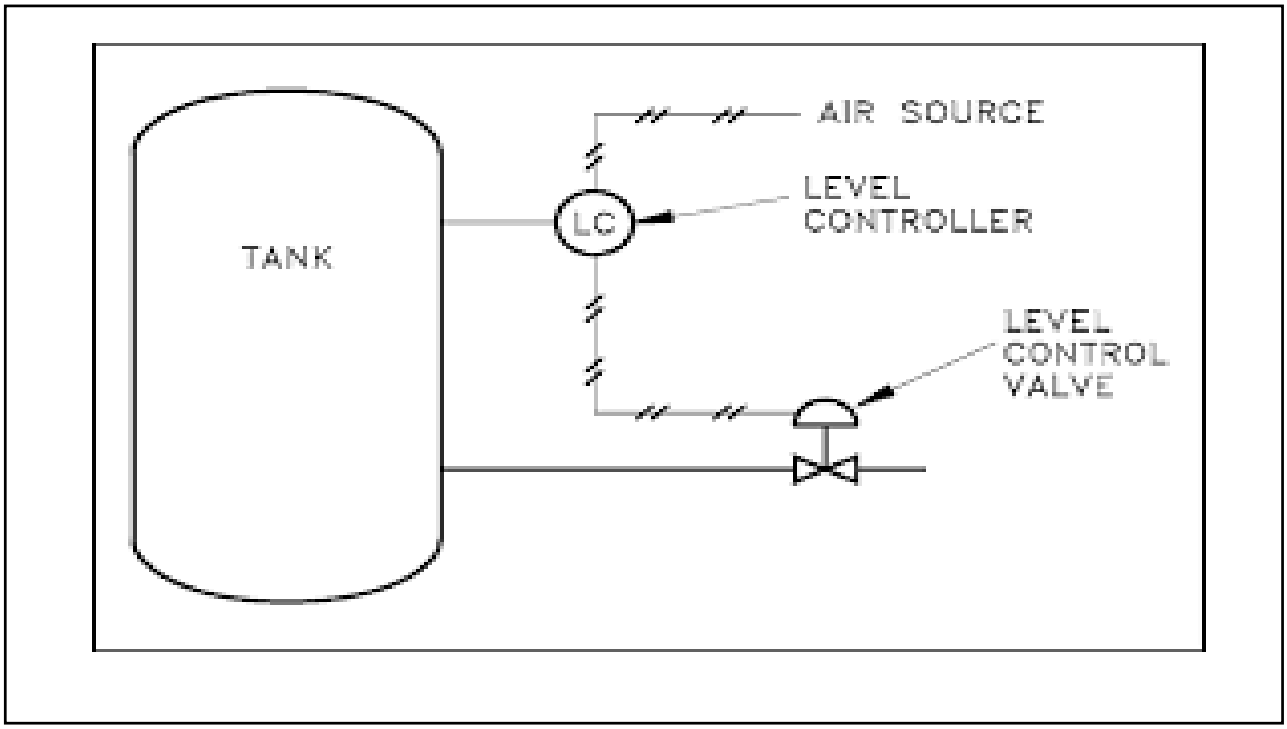
YIC
PLC Indicating Controller

TY
Temperature Computer Output

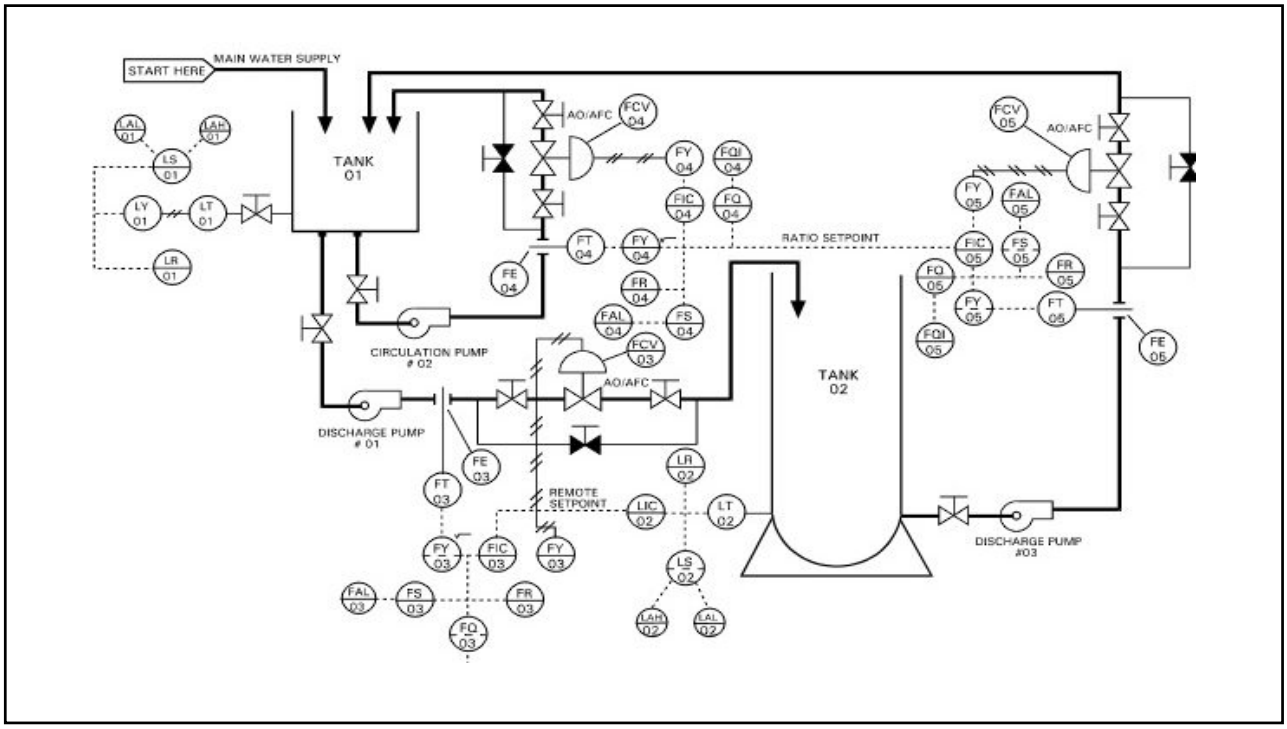
FT
Flow Transmitter

TT
Temperature Transmitter

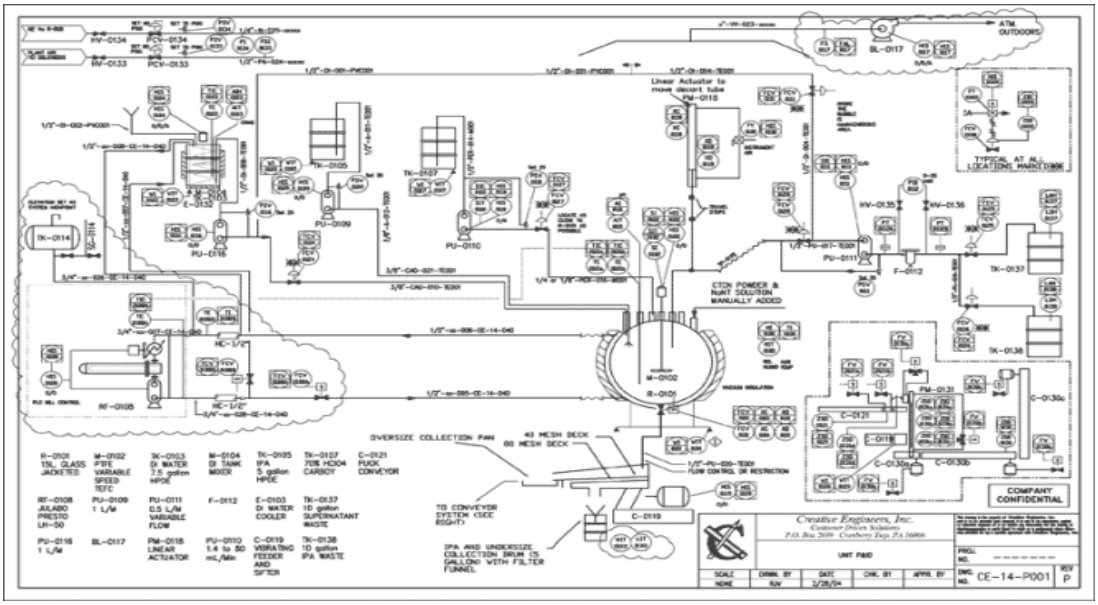
28


AIR SOURCE
LEVEL
CONTROLLER
LC
TANK
LEVEL
CONTROL
VALVE

29


START HERE
MAIN WATER SUPPLY
TANK
01
AO/AFC
FCV
04
FY
04
FQI
04
FIC
04
FQ
04
FT
04
FE
04
RATIO SETPOINT
FR
04
FAL
04
FS
04
FCV
03
AO/AFC
CIRCULATION PUMP
02
DISCHARGE PUMP
01
TANK
02
FCV
05
AO/AFC
FY
05
FAL
05
FIC
05
FS
05
FR
05
FQ
05
FY
06
FT
06
FQI
05
FE
05
FE
03
FT
03
REMOTE
SETPOINT
LIC
02
LT
02
LR
02
LS
02
LAH
02
LAL
02
FY
03
FIC
03
FY
03
FAL
03
FS
03
FR
03
FQ
03
DISCHARGE PUMP
#03

30



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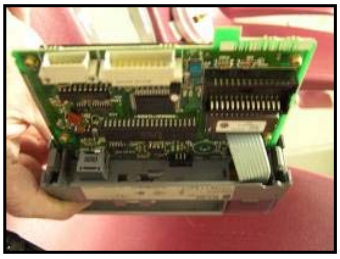
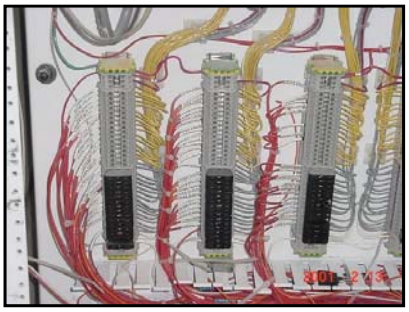
PLC



A-B SLC 500



Typical associated wiring

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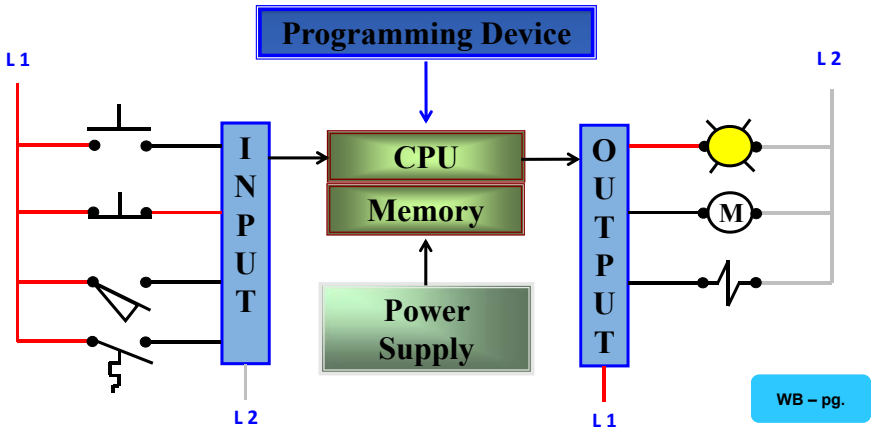
What is a PLC?

Do you know the 5 parts to a PLC?



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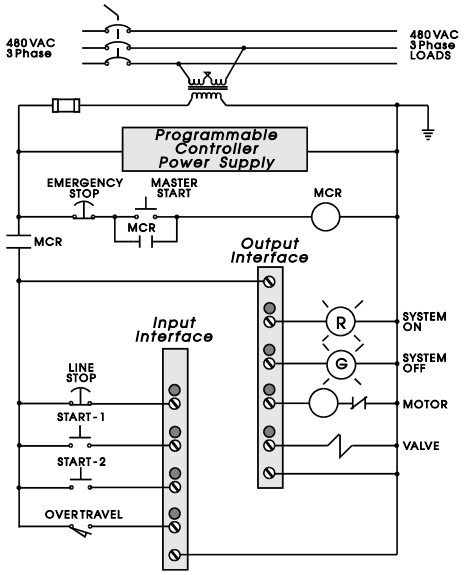
Typical Installation of PLCs



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PLC Ladder Diagram

- PLC's utilize microprocessors to replace relays
- Different "languages" are used to program
- Ladder logic commonly used because of similarity to relay logic
- Similarity makes it easy to transition from Relay Ladder Logic to PLC Ladder Logic

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The PLC Ladder Diagram is similar to Relay Logic

- Sets of "PLC Instructions" are used by the PLC to examine inputs
- PLC then makes a decision whether or not to provide some type of output based on this input
- Interpreting the PLC Ladder tells you:
  - What inputs the PLC is looking at
  - What values the PLC is looking for
  - What action (output) PLC will decide upon based on the input values received

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The PLC Ladder Diagram

- The PLC Ladder Diagram is prepared by PLC Programmers
- Typically requires adjustments in the field during startup and maintenance
- Must be familiar with programming and programming software to make changes to the ladder diagram and effect PLC Operation

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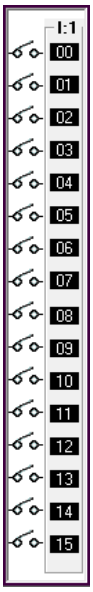
PLC Addressing

What is the address for this point on the I/O module?



I:01/06

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PLC Addressing

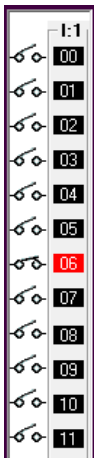
Software Addressing

Input switch is *CLOSED*

Input is *HIGH*

Address I:01/06 is *ONE*

I:01/06



15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

16 Bit *WORD*

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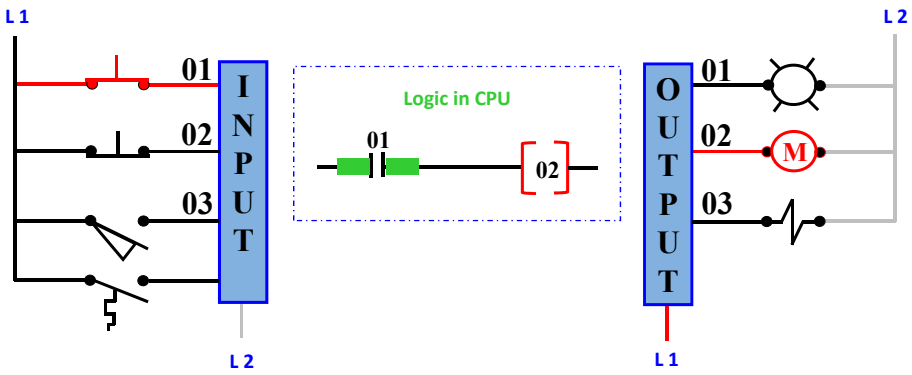
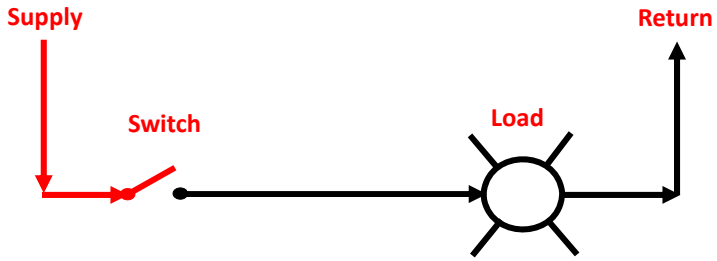
The PLC program has its own ladder diagram



40

The 5 Basic Principles of Successful Control Circuit Interpretation



1. Know your basic symbols and have a handy reference.
2. Read top-to-bottom; left-to-right.
3. Current is just looking for a path to return to source.
4. If the control elements allow current flow through a load; the load operates.
5. Follow the print to see what actions the load performs when it operates.

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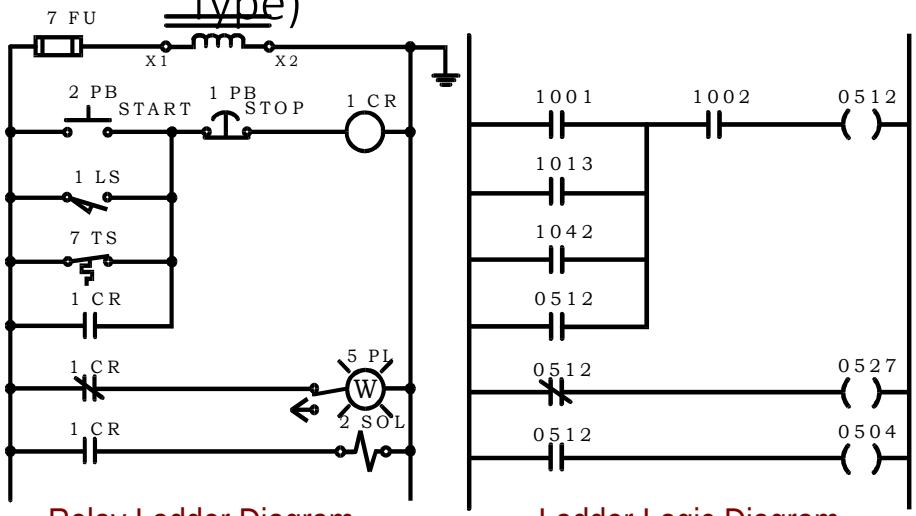
Bit Instructions – (Relay Type)



Relay Ladder Diagram

Ladder Logic Diagram

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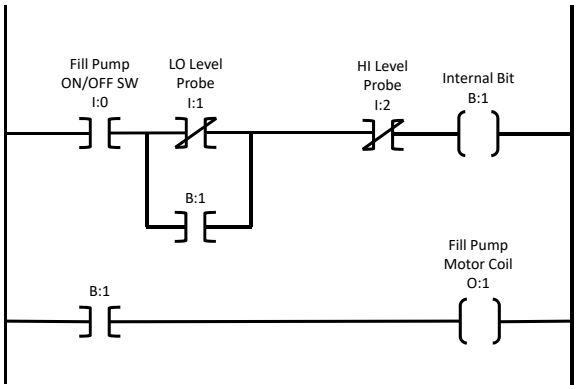
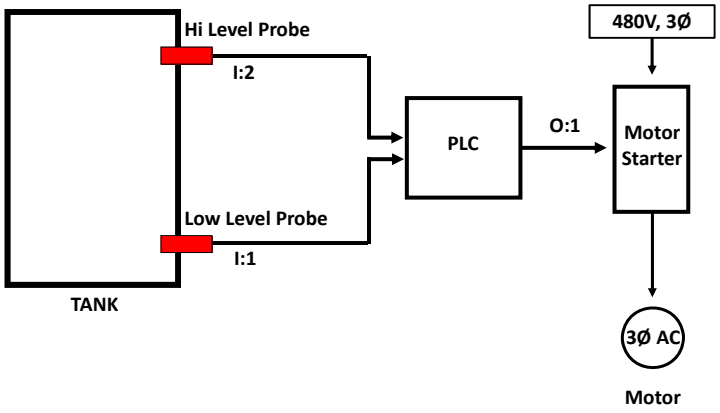
Pump Cycles to Maintain Tank Level



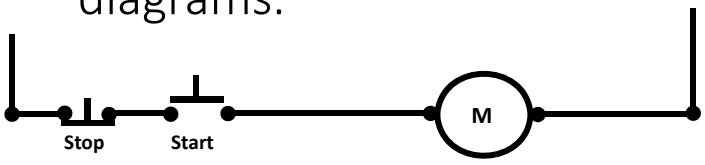
43

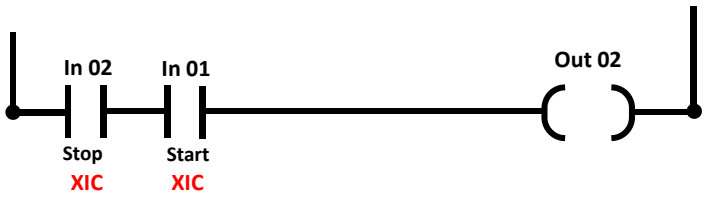
Pump Cycles to Maintain Tank Level



44

Reading and interpreting basic PLC ladder diagrams.

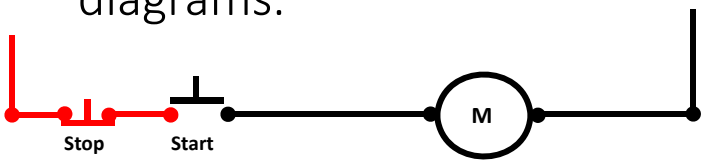


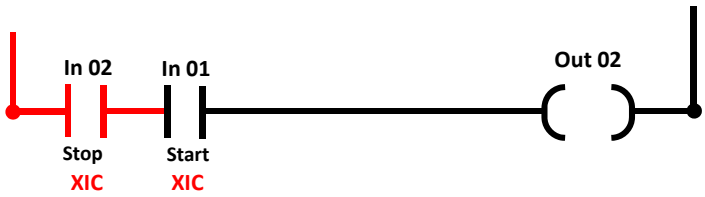


XIC = Examine if CLOSED
XIO = Examine if OPEN

45

Reading and interpreting basic PLC ladder diagrams.

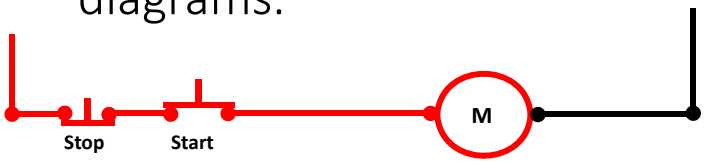


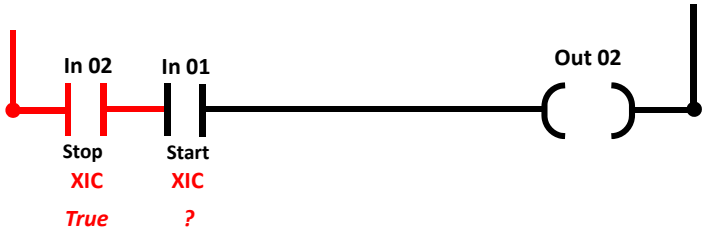


XIC = Examine if CLOSED
XIO = Examine if OPEN

46

Reading and interpreting basic PLC ladder diagrams.





XIC = Examine if CLOSED
XIO = Examine if OPEN

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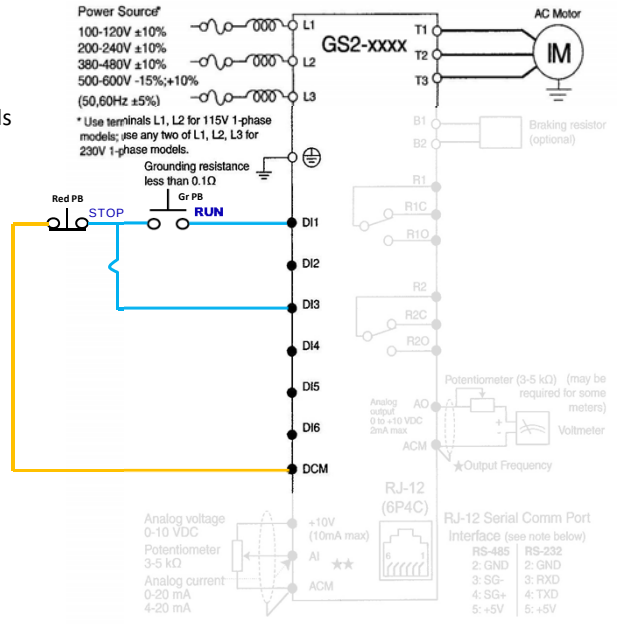
P3.01
Multi-function Input Terminals (DI1-DI2)

Settings		
	00	DI1 - FWD/STOP DI2 - REV/STOP
	01	DI1 - RUN/STOP DI2 - REV/FWD
	02	DI1 - RUN (N.O. latching input) DI2 - REV/FWD DI3 - STOP (N.C. latching input)



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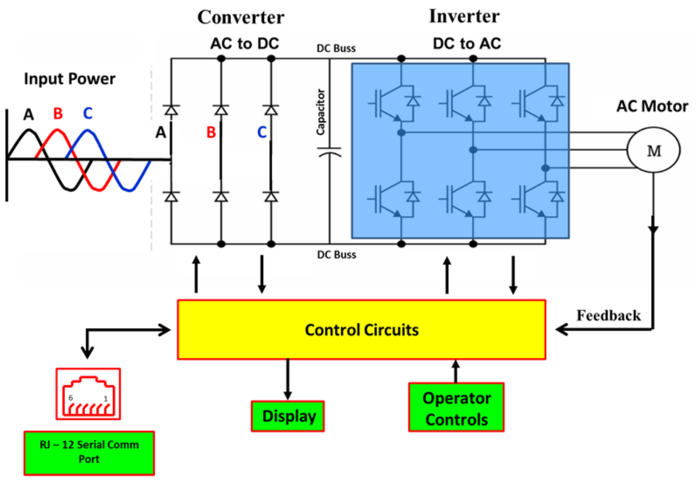
Basic Variable Frequency Drives



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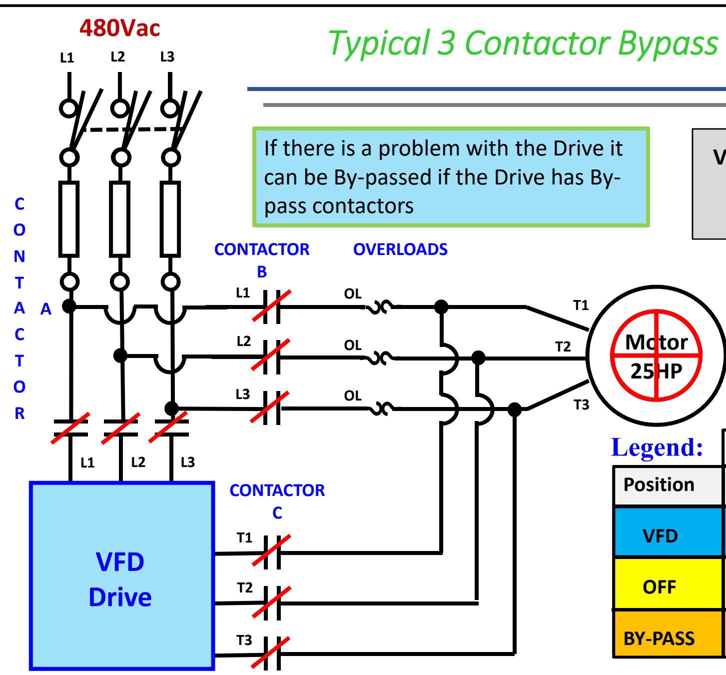
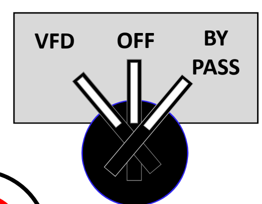
Typical 3 Contactor Bypass Option



If there is a problem with the Drive it can be By-passed if the Drive has By-pass contactors



Legend:

	Contactor		
Position	A	B	C
VFD	X		X
OFF			
BY-PASS	X		

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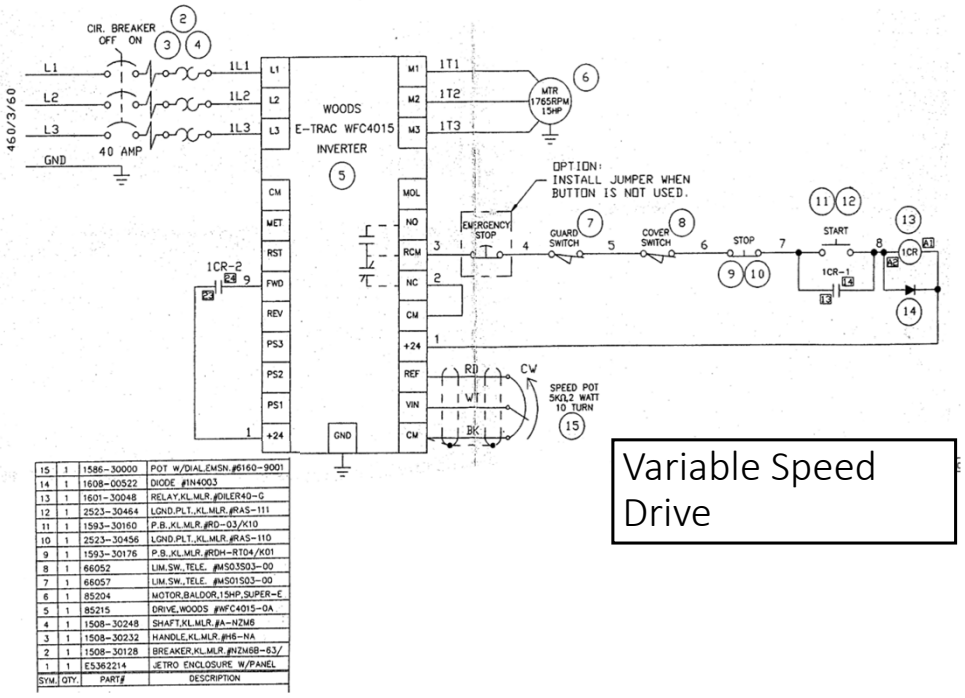

SYM.	QTY.	PART#	DESCRIPTION
15	1	1586-30000	POT W/DIAL,EMSN.#6160-9001
14	1	1608-00522	DIODE #1N4003
13	1	1601-30048	RELAY,KL,MLR.#DILER40-G
12	1	2523-30464	LGND,PLT.,KL,MLR.#RAS-111
11	1	1593-30160	P.B.,KL,MLR.#RD-03/K10
10	1	2523-30456	LGND,PLT.,KL,MLR.#RAS-110
9	1	1593-30176	P.B.,KL,MLR.#RDH-RT04/K01
8	1	66052	LIM.SW.,TELE. #MS03S03-00
7	1	66057	LIM.SW.,TELE. #MS01S03-00
6	1	85204	MOTOR,BALDOR,15HP,SUPER-E
5	1	85215	DRIVE,WOODS #WFC4015-0A
4	1	1508-30248	SHAFT,KL,MLR.#A-NZM6
3	1	1508-30232	HANDLE,KL,MLR.#H6-NA
2	1	1508-30128	BREAKER,KL,MLR.#NZM6B-63/
1	1	E5362214	JETRO ENCLOSURE W/PANEL

Variable Speed Drive

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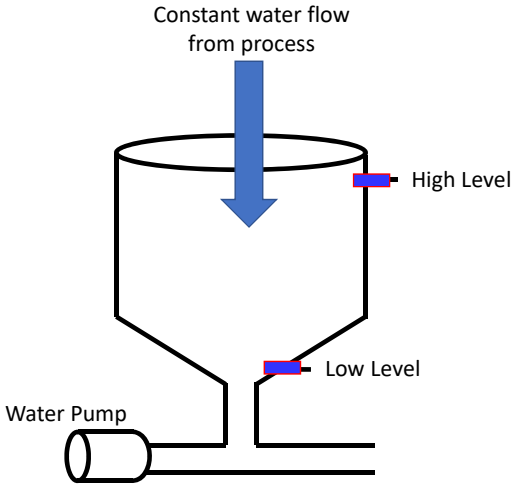
Activity: Draw your own Ladder Diagram



Goal:

- **Turn on the pump to drain the tank when we reach the high level.**
- **Turn off the pump when we reach the low level.**
- **Automatic operation, no start/stop buttons needed.**
- **E-Stop button in case of emergencies.**

Can you draw a ladder diagram to do this job?

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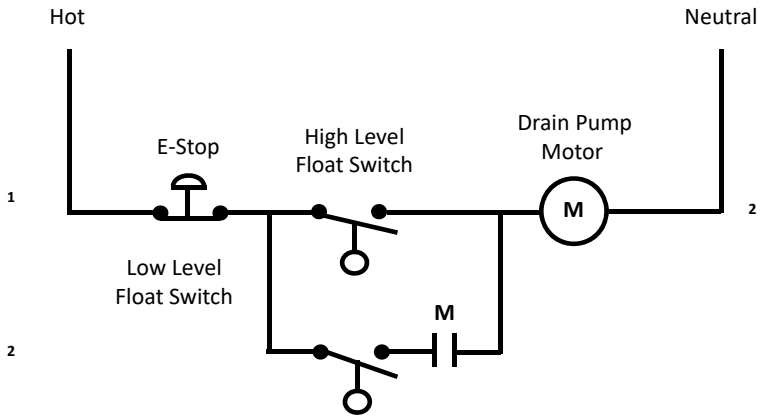
A Possible Solution



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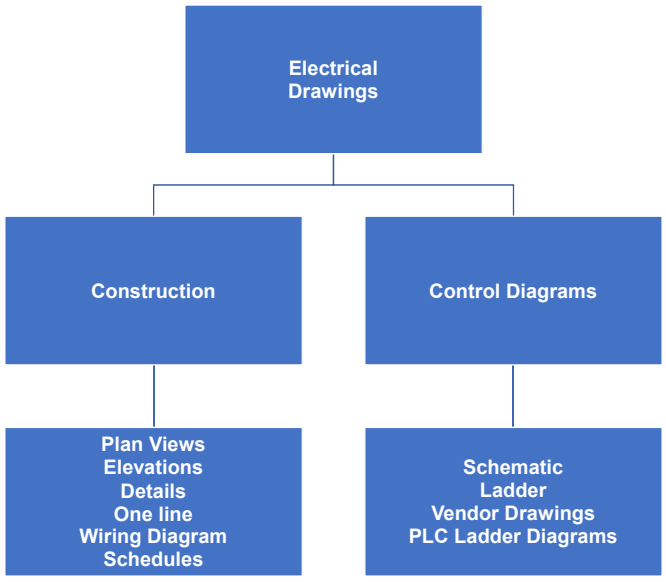

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Why Electrical Fundamentals for Print Reading?

- You may be able to read a diagram, but
- you won't be able to interpret unless you can
  - Explain the terminology
  - Trace the current flow path
  - Understand device and equipment ratings
  - Explain basic code requirements and wiring techniques
  - Understand how one change can effect several drawings

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One-line Diagrams

- Used in larger commercial and industrial installations
- Indicates the flow path of power throughout the facility
- May encompass several sheets
  - Arranged sequentially such that a smooth flow of power throughout the facility can be followed from one sheet to the next.

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One-line Diagrams

- Interpretation requires knowledge of symbols and Device Function Numbers
- first sheet of Electrical Drawings
  - Unique symbols and Device Function Numbers used typically identified
  - Index of Electrical Drawings
  - Numbered as “E-XX” (“E Drawings”)

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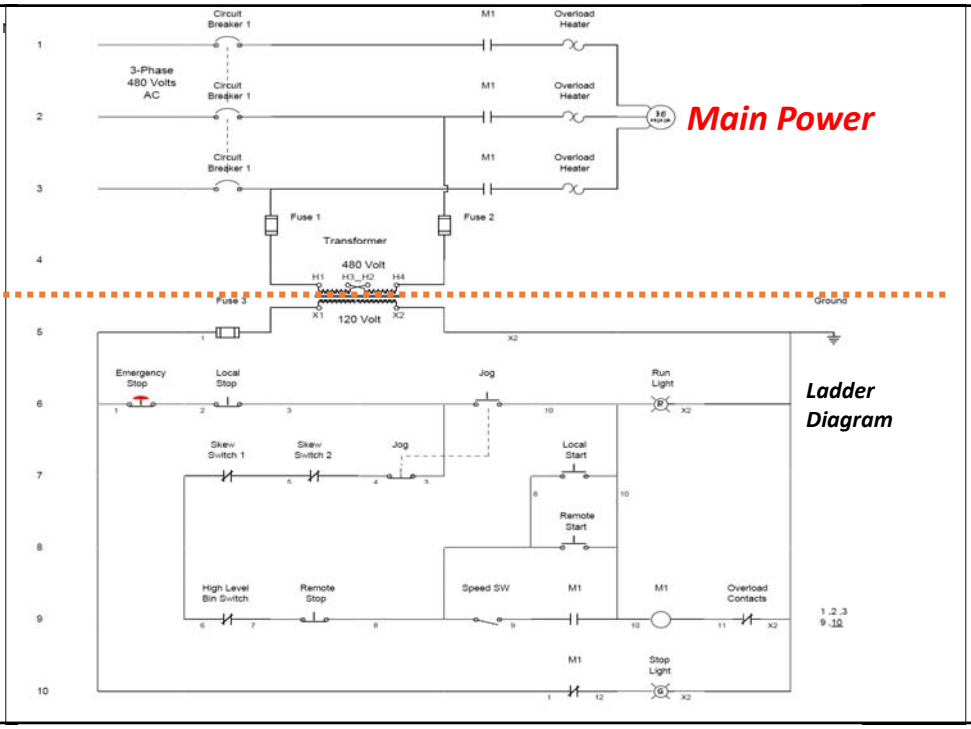
Schematic Diagram Overview



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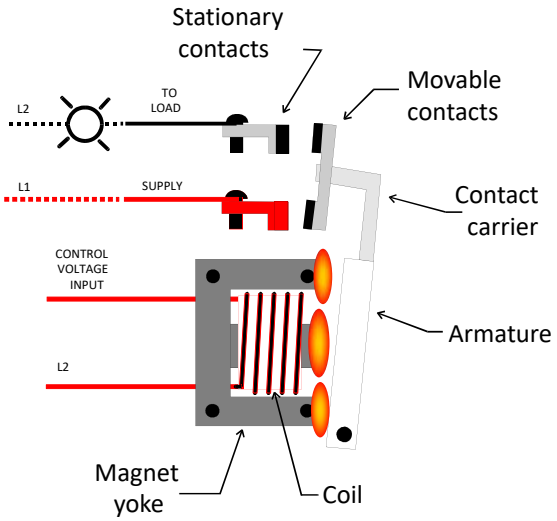
Relay Operation



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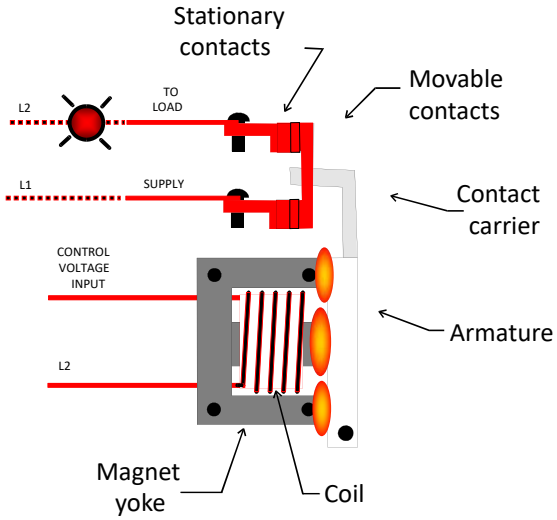
Relay Operation



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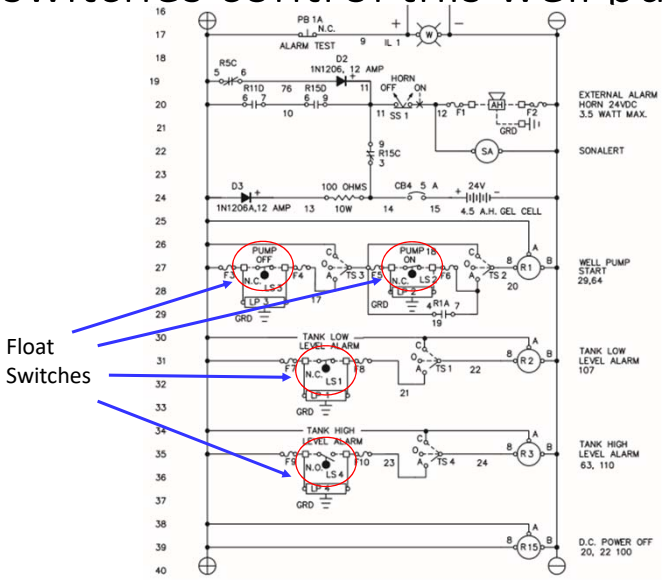
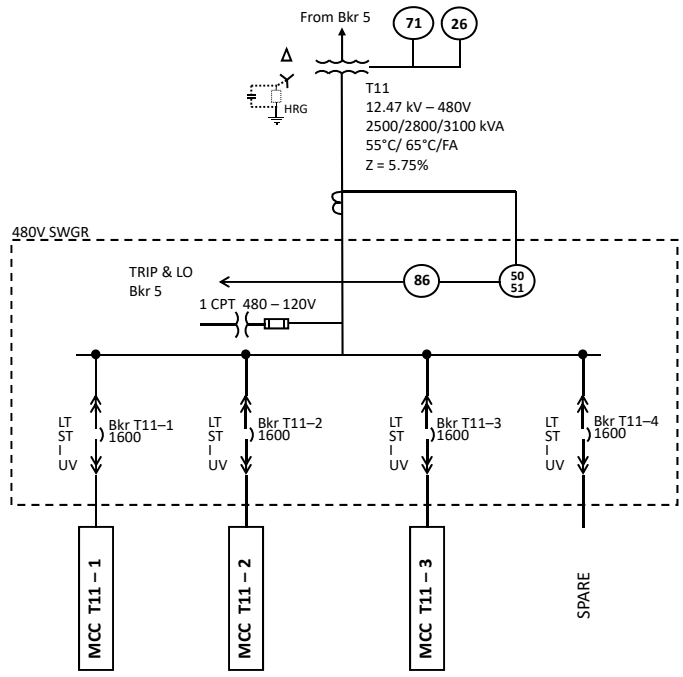
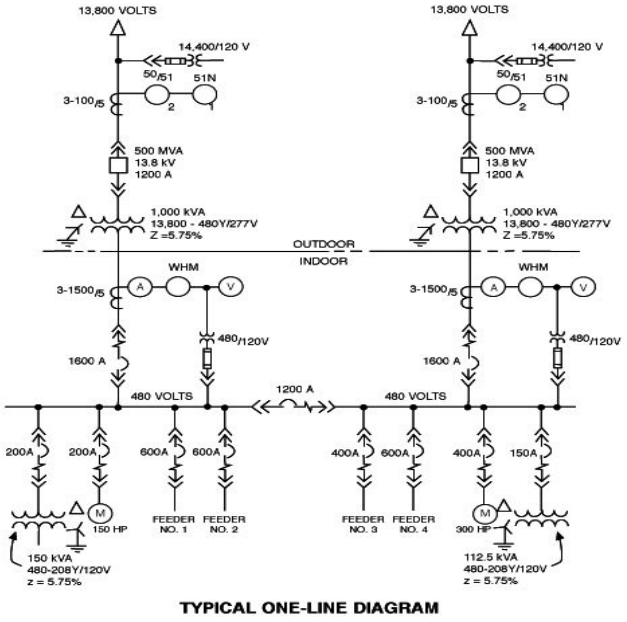
What switches control this well pump?



61



62



TYPICAL ONE-LINE DIAGRAM

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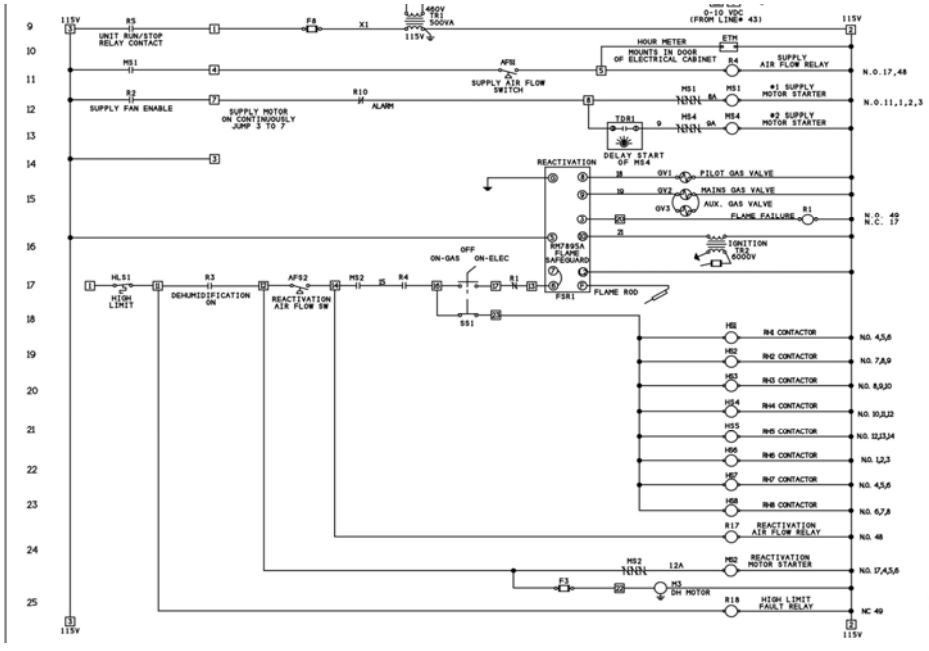
Example Ladder Diagram



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