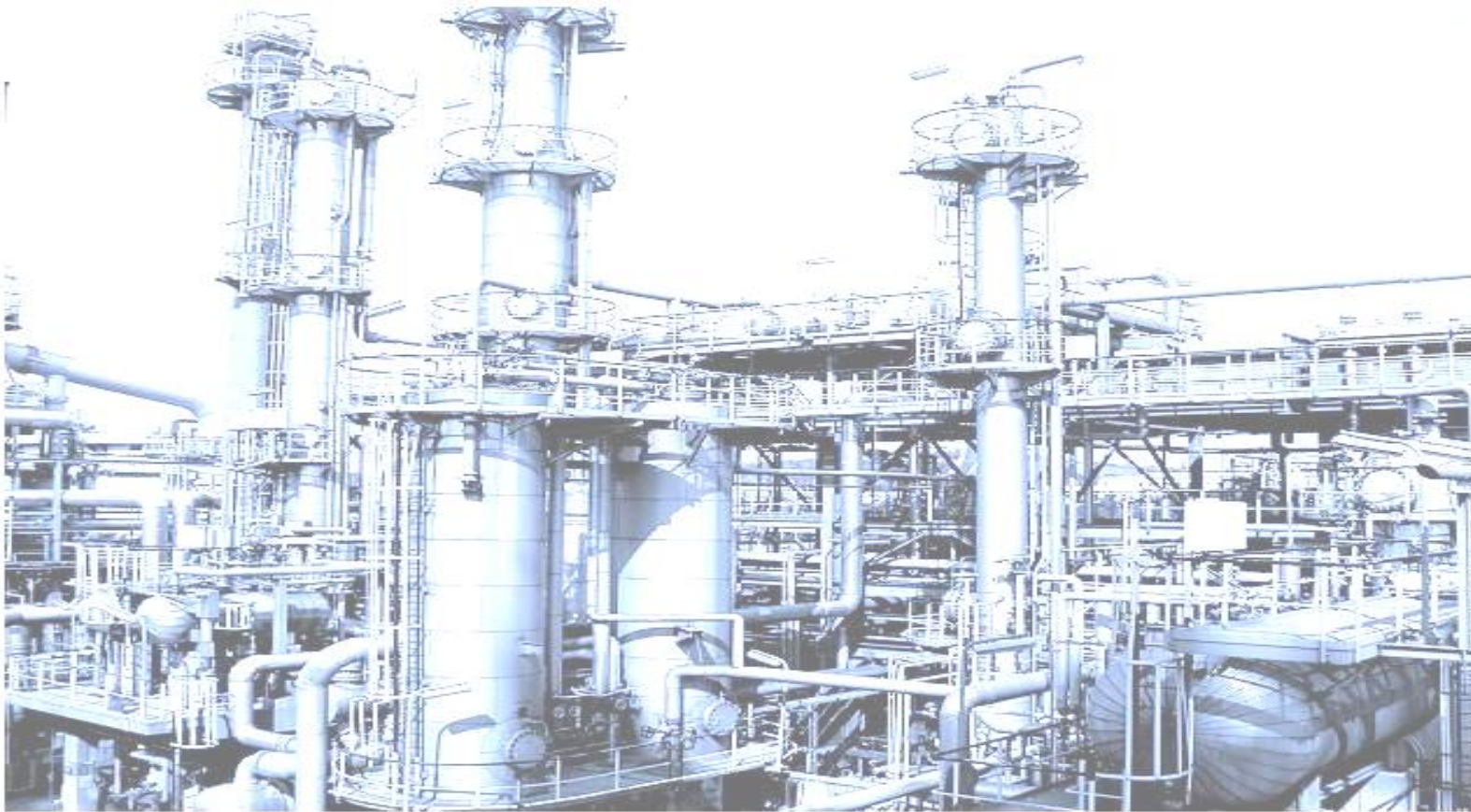


Process & Instrumentation Diagram (P&ID)



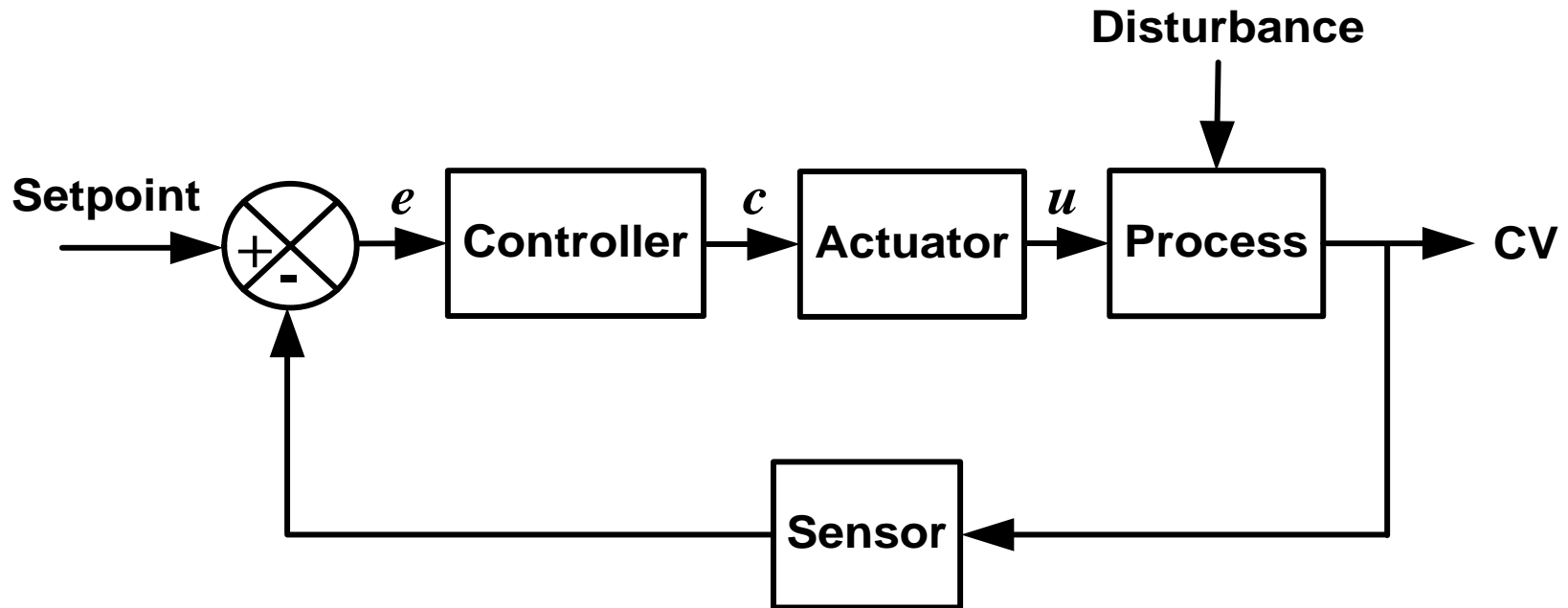
By

DR. RAMESH

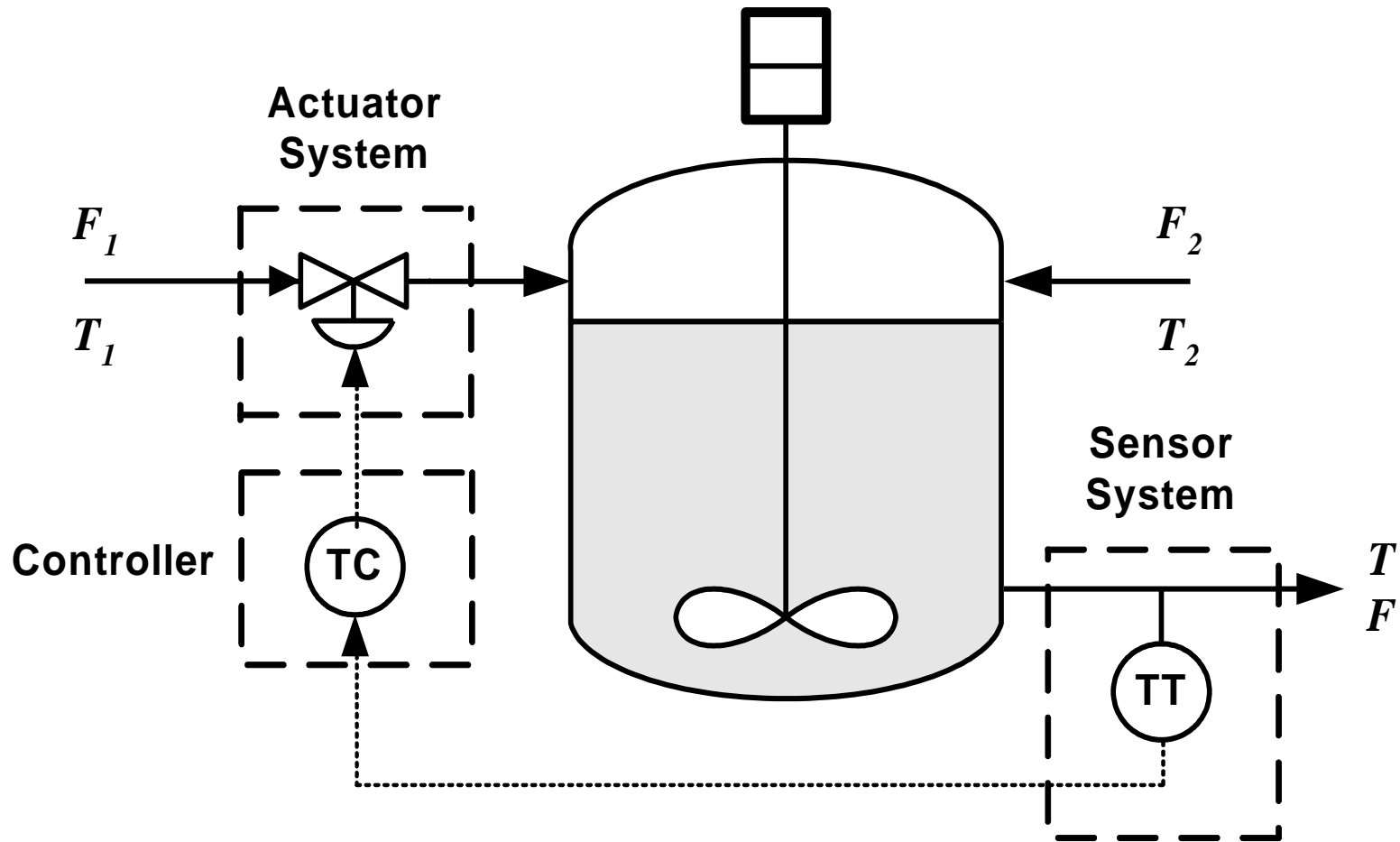
Some Basic Control

Aspects.....

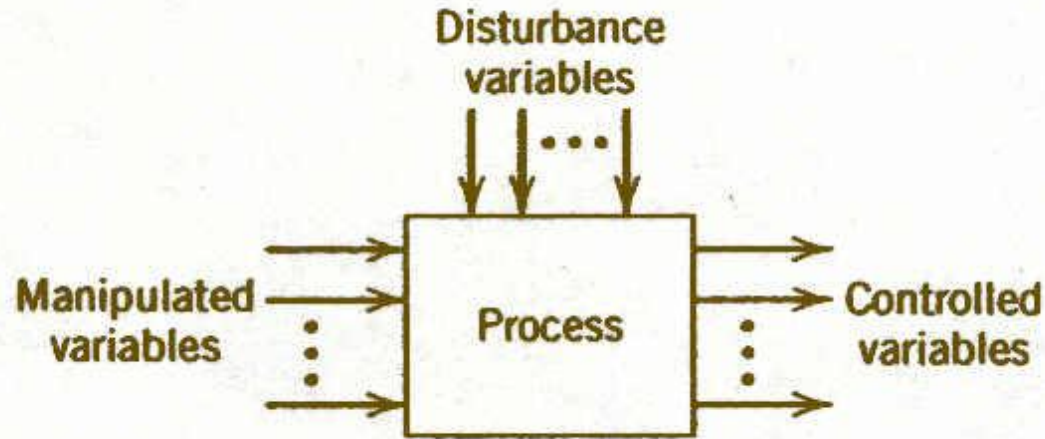
Flow Diagram for a Feedback Control Loop



Control Diagram of a Typical Control Loop (Blending Process)



Selection of Controlled Variables



Guideline 1.

All variables that are not self-regulating must be controlled.

Guideline 2.

Choose output variables that must be kept within equipment and operating constraints (e.g., temperatures, pressures, and compositions).

Selection of Controlled Variables

Guideline 3.

Select output variables that are a direct measure of product quality (e.g., composition, refractive index) or that strongly affect it (e.g., temperature or pressure).

Guideline 4.

Choose output variables that seriously interact with other controlled variables.

Guideline 5.

Choose output variables that have favorable dynamic and static characteristics.

Selection of Manipulated Variables

Guideline 6.

Select inputs that have large effects on controlled variables.

Guideline 7.

Choose inputs that rapidly affect the controlled variables.

Guideline 8.

The manipulated variables should affect the controlled variables directly rather than indirectly.

Guideline 9.

Avoid recycling of disturbances.

Selection of Measured Variables

Guideline 10.

Reliable, accurate measurements are essential for good control.

Guideline 11.

Select measurement points that have an adequate degree of sensitivity.

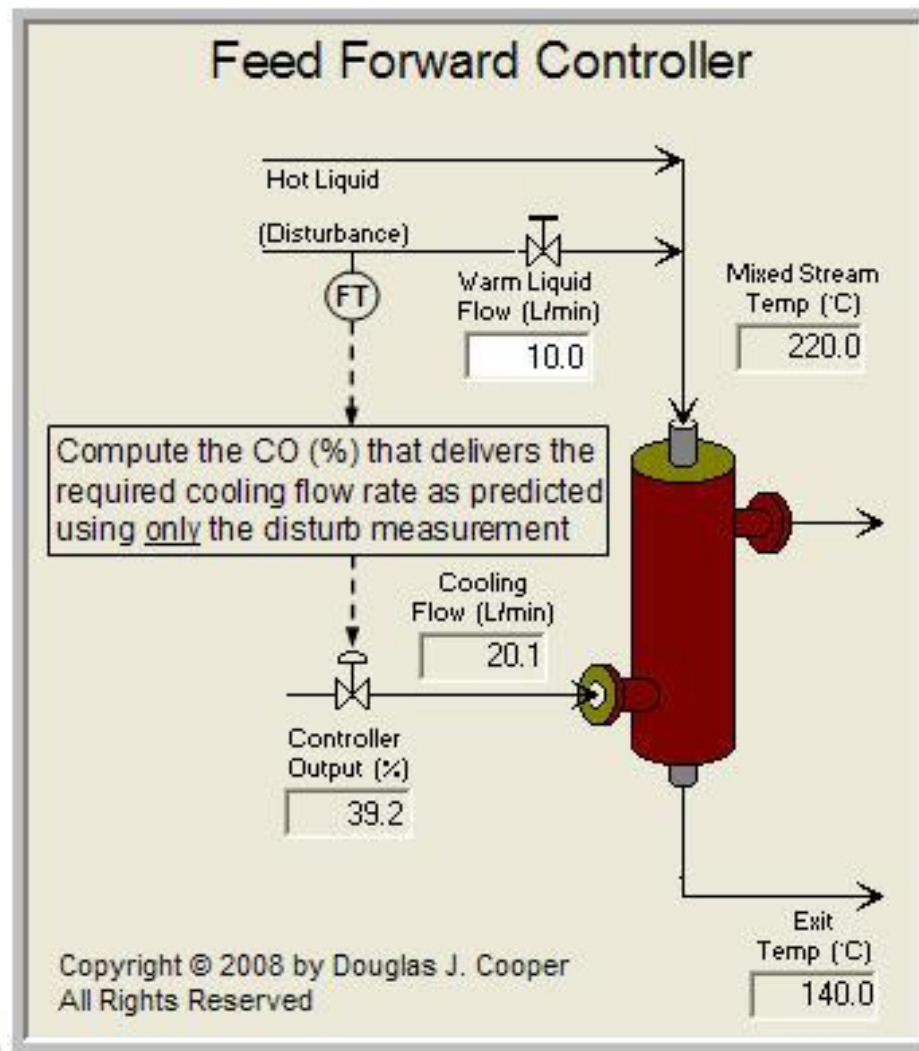
Guideline 12.

Select measurement points that minimize time delays and time constants

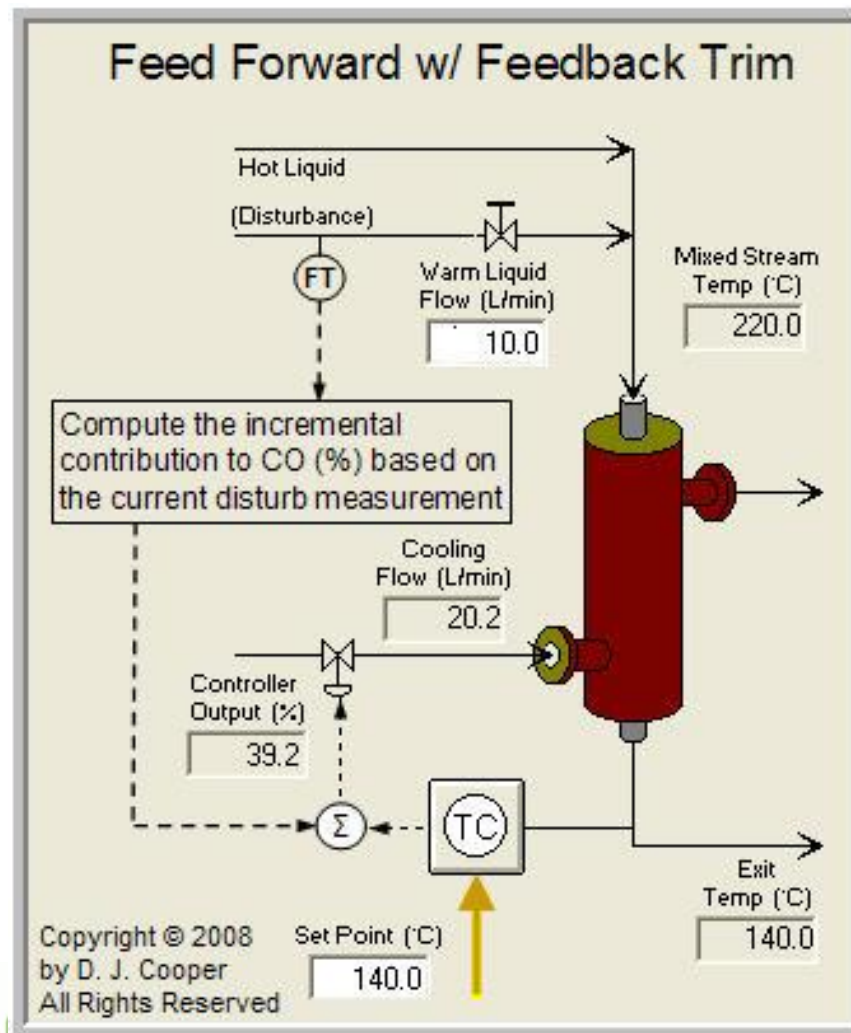
Feedforward Control

- In some cases, the major disturbance to a process is measured and utilized to adjust the manipulated variable
- The advantage feedforward control is that corrective action is taken for a change in a disturbance input *before* it affects the control parameter
- Feedforward control is used in conjunction with feedback control to provide multiple-input single output (MISO) control

Feedforward Temperature Control



Feedforward and Feedback Temperature Control

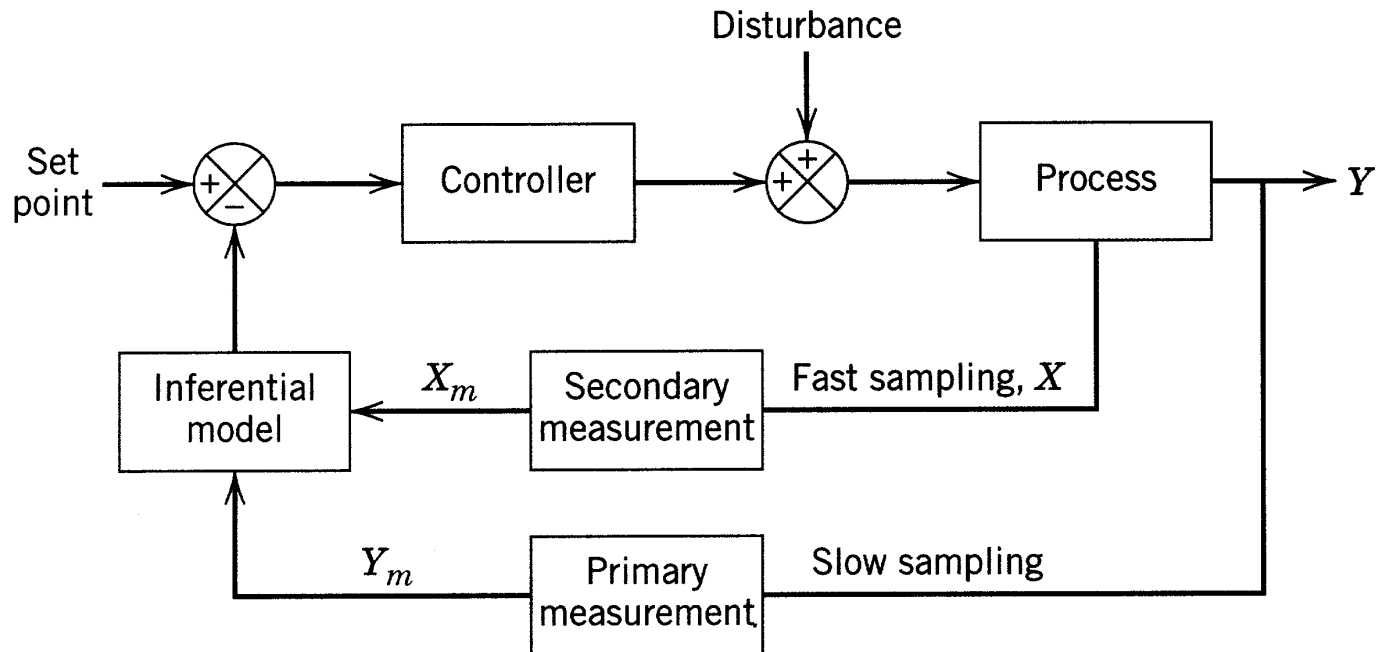


Analysis of Feedforward and Feedback Temperature Control

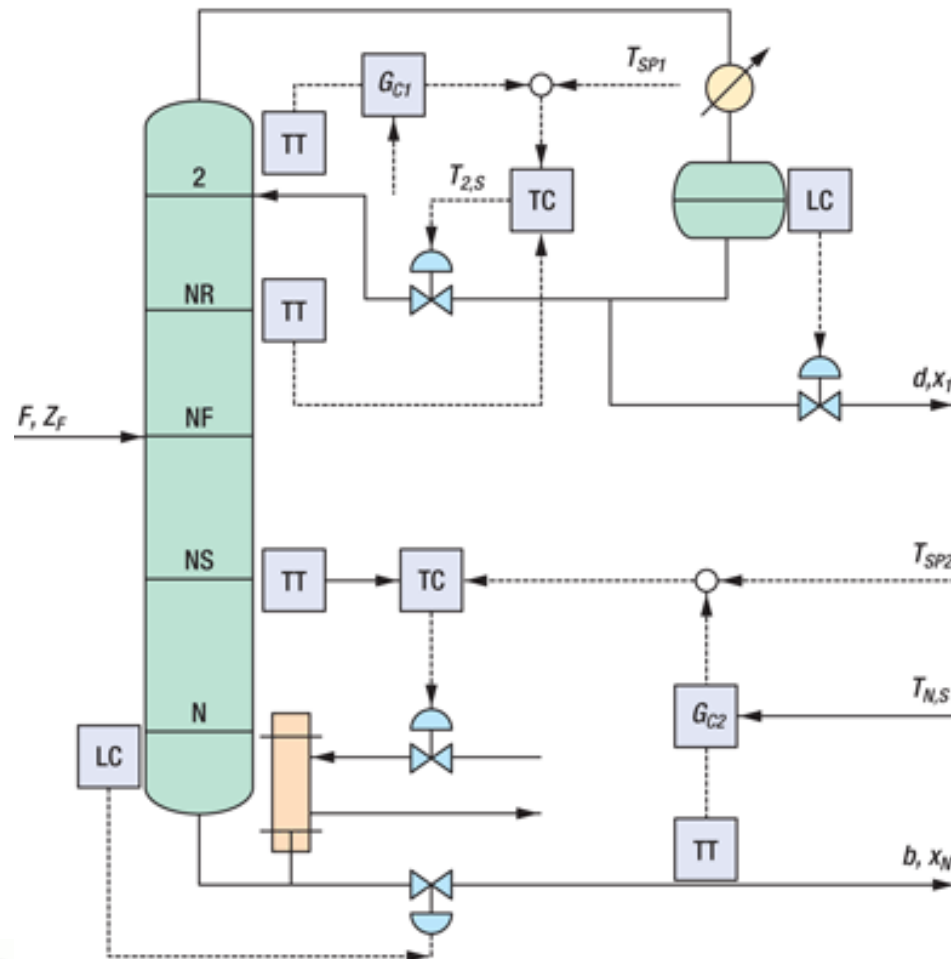
- **Feedback** - only must absorb the variations in exit temperature by feedback action
- **Feedforward** - only handle variation in exit temperature by measuring the warm liquid flow into the tank
- Combined feedforward and feedback has best features of both controllers

Inferential Control

Inferential control is the one where the primary variables are difficult to measure or slow sampling then the fast sampling secondary variables are measured and using a mathematical model (soft sensor) to infer the value of the controlled variable.



Inferential Control

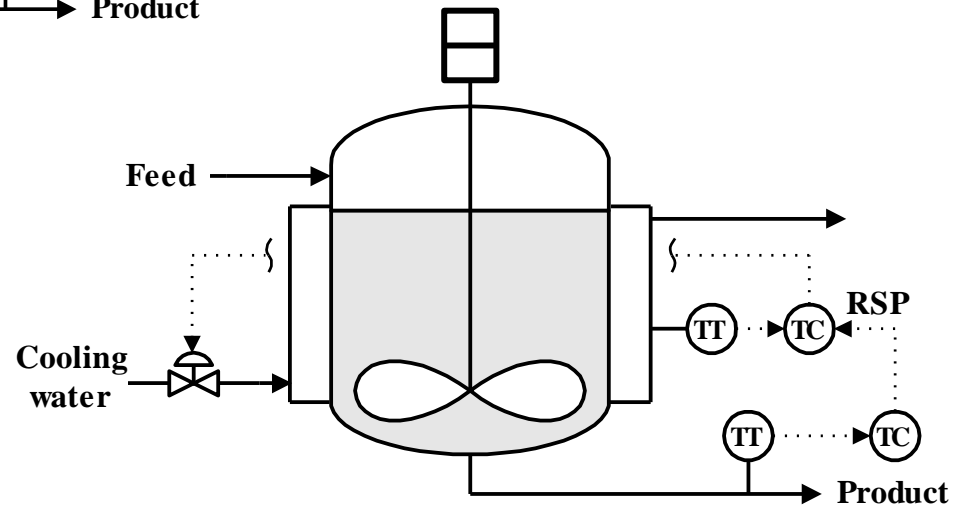
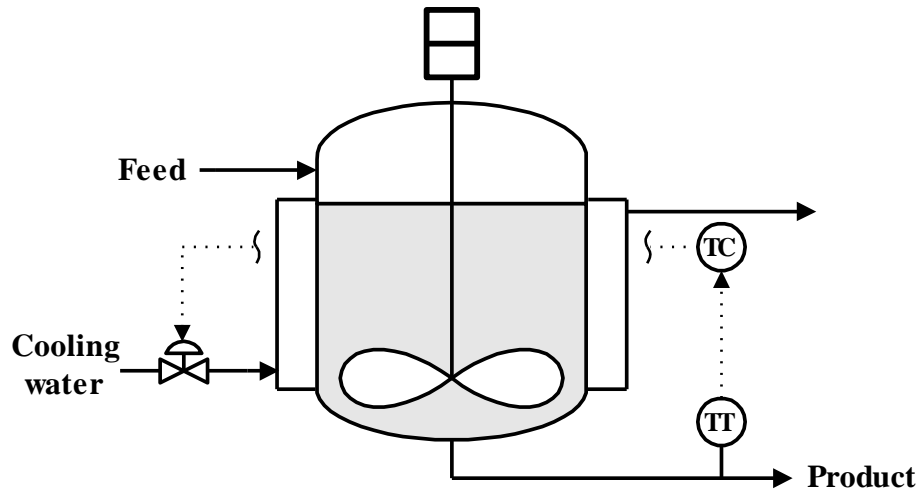


Cascade control

Cascade Control Systems contain integrated sets of control loops

- **Primary Loop:** Monitors the control variable and uses deviation from its setpoint to provide an output to the secondary loop.
- **Secondary Loop:** Receives its setpoint from the primary loop and controls the reference variable accordingly.

Cascade Reactor Temperature Control

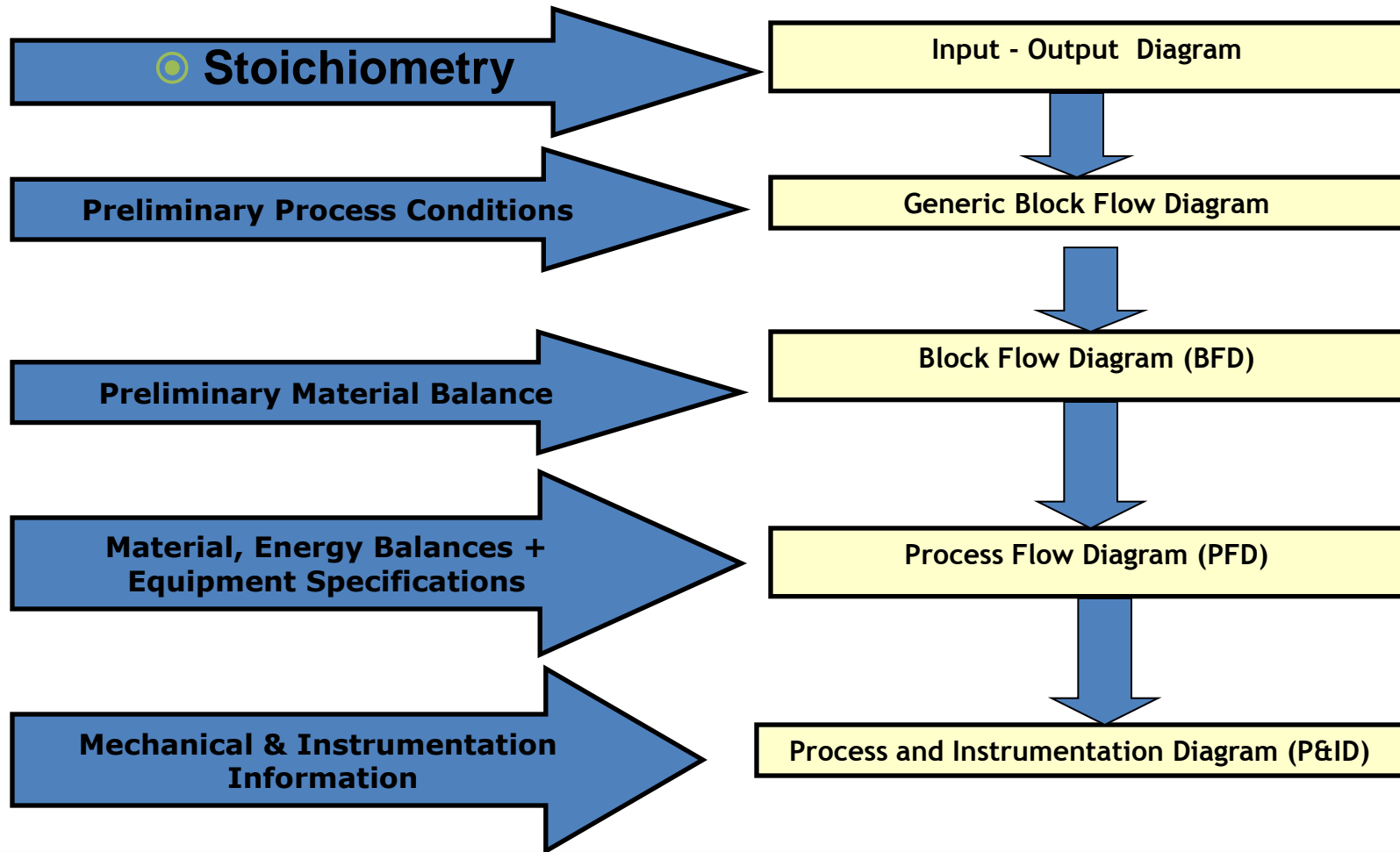


Cascade Reactor Temperature Control

- Without cascade, changes in the cooling water temperature will create a significant upset for the reactor temperature
- With cascade, changes in the cooling water temperature will be absorbed by the slave loop before they can significantly affect the reactor temperature.

Process & Instrumentation Diagram (P&ID)

Sequence of process design



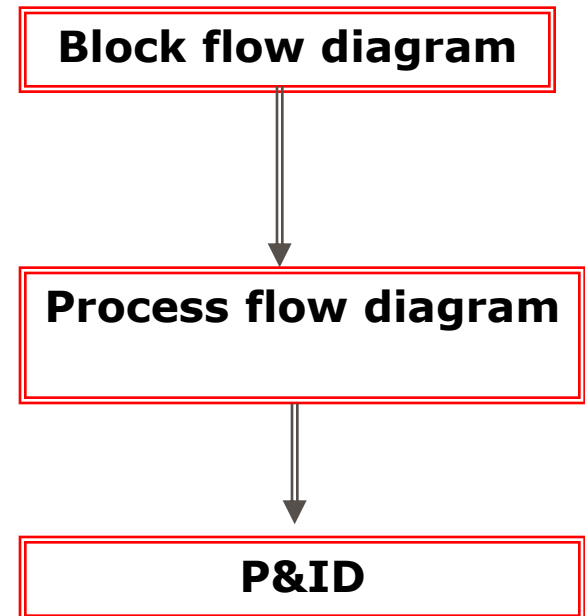
What are P& ID?

P&ID ----- Process and Instrumentation Diagram

(Also known as Piping and Instrumentation Drawing)

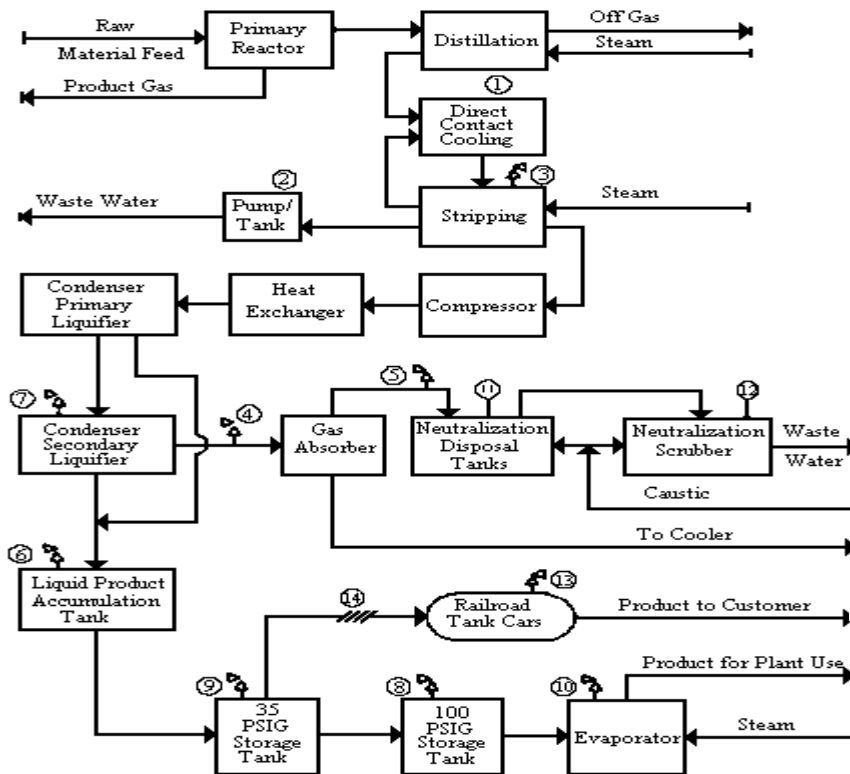
is the bird's eye view of the plant that compiles the results of its basic design

- ✓ **Communication tool**
- ✓ **A record to assist memory**
- ✓ **Extension of the flow diagram**



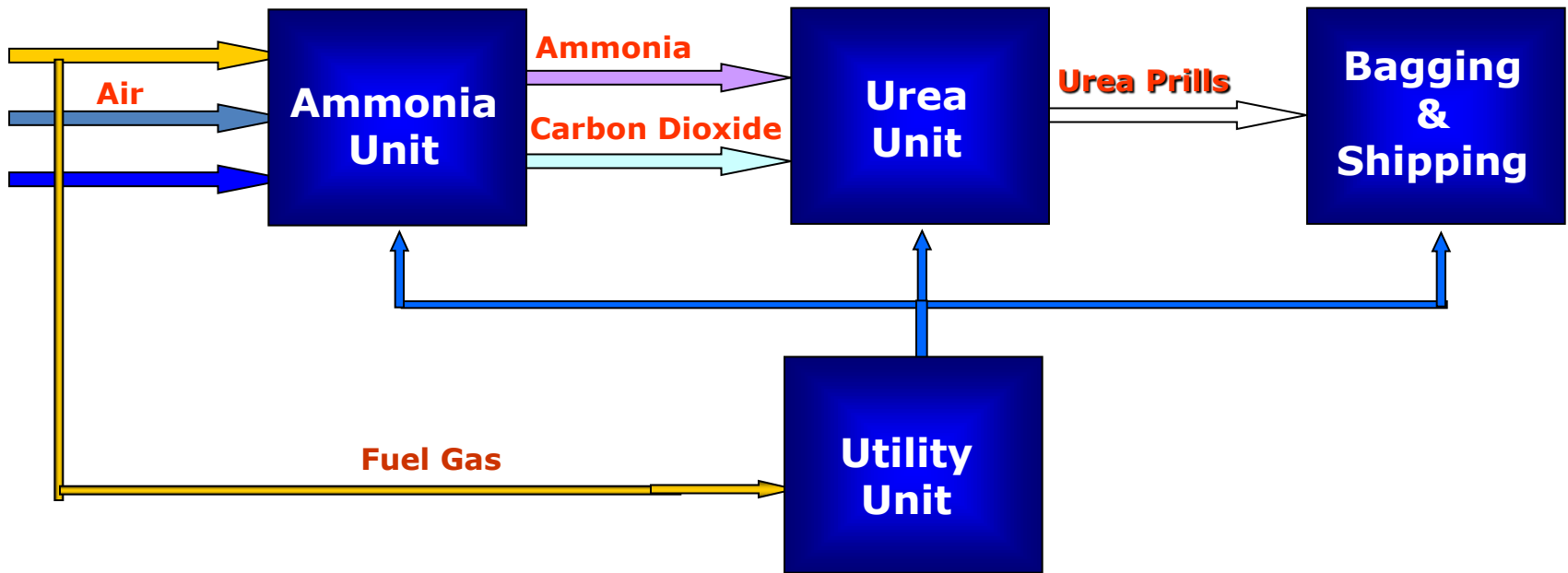
Block Flow Diagram

The block or rectangles represents unit operations and the blocks are connected by lines representing the process flow streams



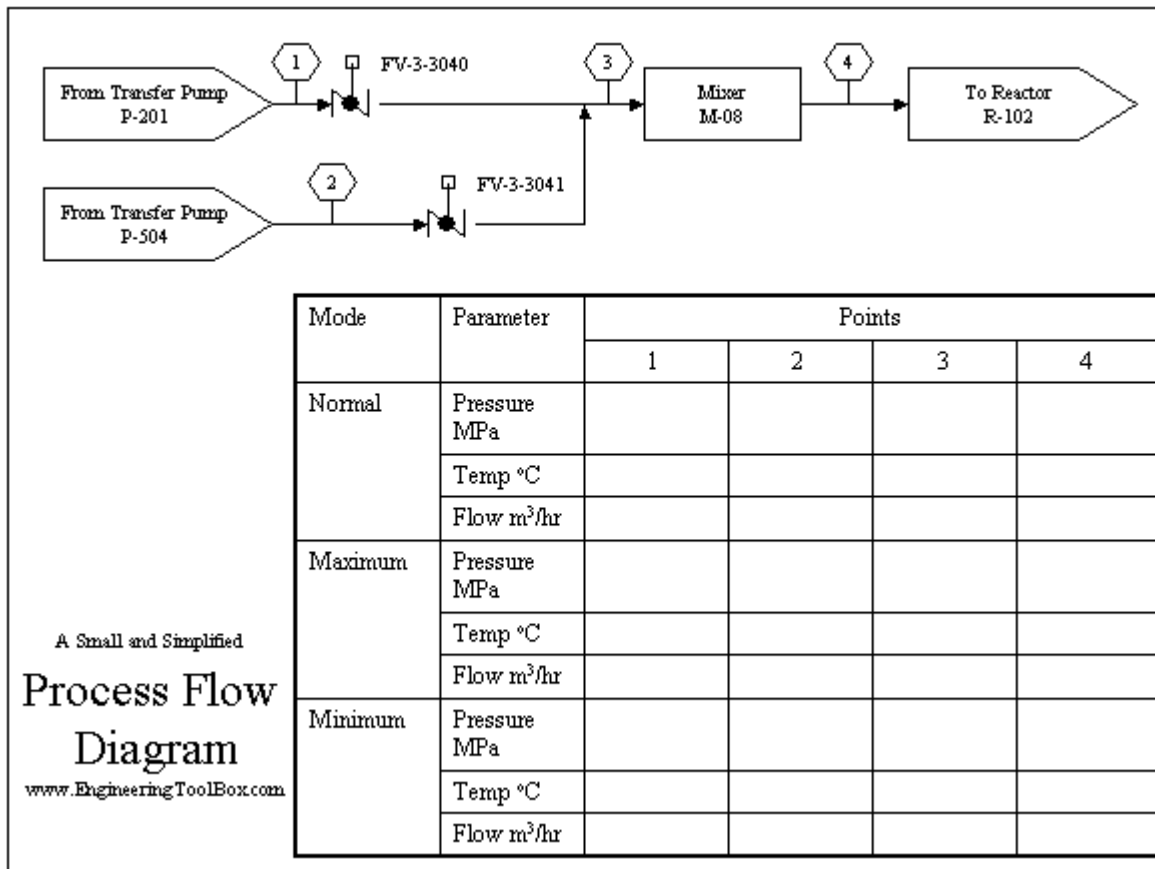
- ✓ Focus on process sequence
- ✓ Mass balance requirements

Block flow diagram Example



Process Flow Diagram (PFD) or Flow Sheet

- ✓ Relationships between the major components in the system
- ✓ Tabulate process design values for the components



Process flow diagram

It is a diagram of fluid flow system showing the equipment items connected by major process pipes and containing data on essential process control circuits or major process requirements. It would include following details.

- ① Process piping
- ① Major equipment names
- ① Major equipment numbers
- ① Major equipment identification numbers
- ① Control valves
- ① Interconnection with other system
- ① Major bypass and circulation lines

Continued.....

- ⊙ Process parameters i.e. temperature and pressure

- ⊙ Composition of fluids

A process flow diagram does not following details,

- ⊙ Pipe class

- ⊙ Pipe line number

- ⊙ Maintenance vents and drains

- ⊙ Relief and safety valves

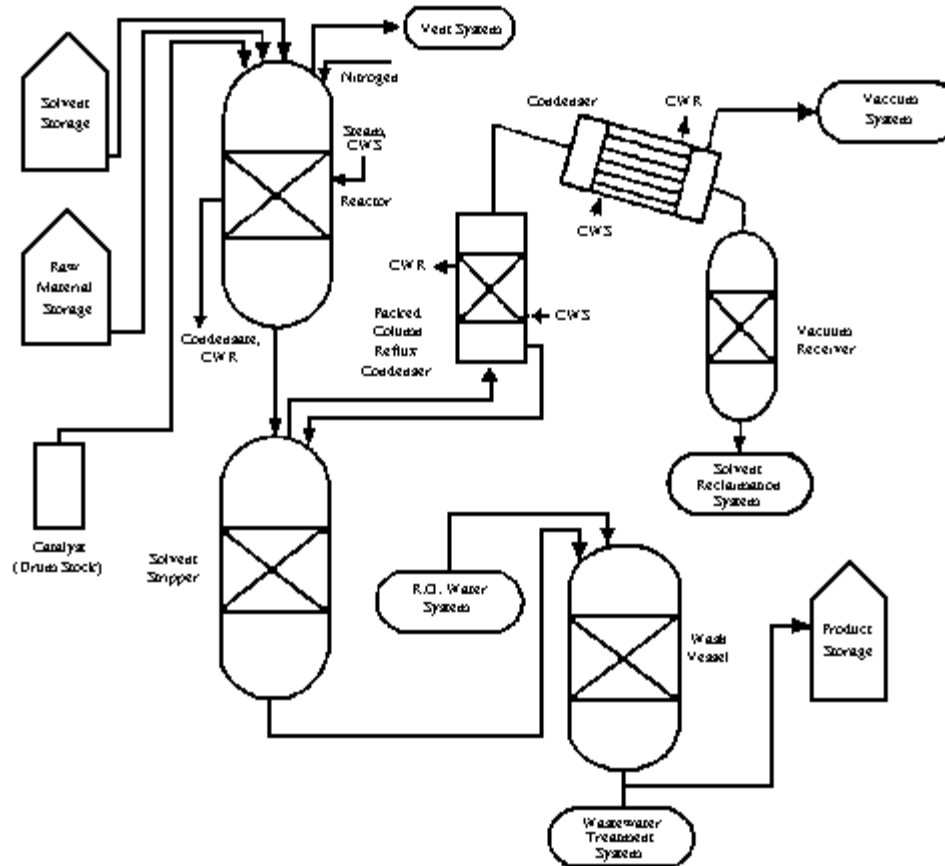
- ⊙ Code class information

- ⊙ Seismic class information

- ⊙ Instruments

Process Flow Diagram (PFD) Continued....

Example of a Process Flow Diagram

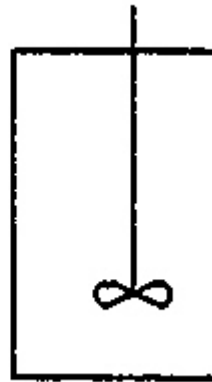


Process Flow Diagram (PFD) Continued....

Classic Symbols:

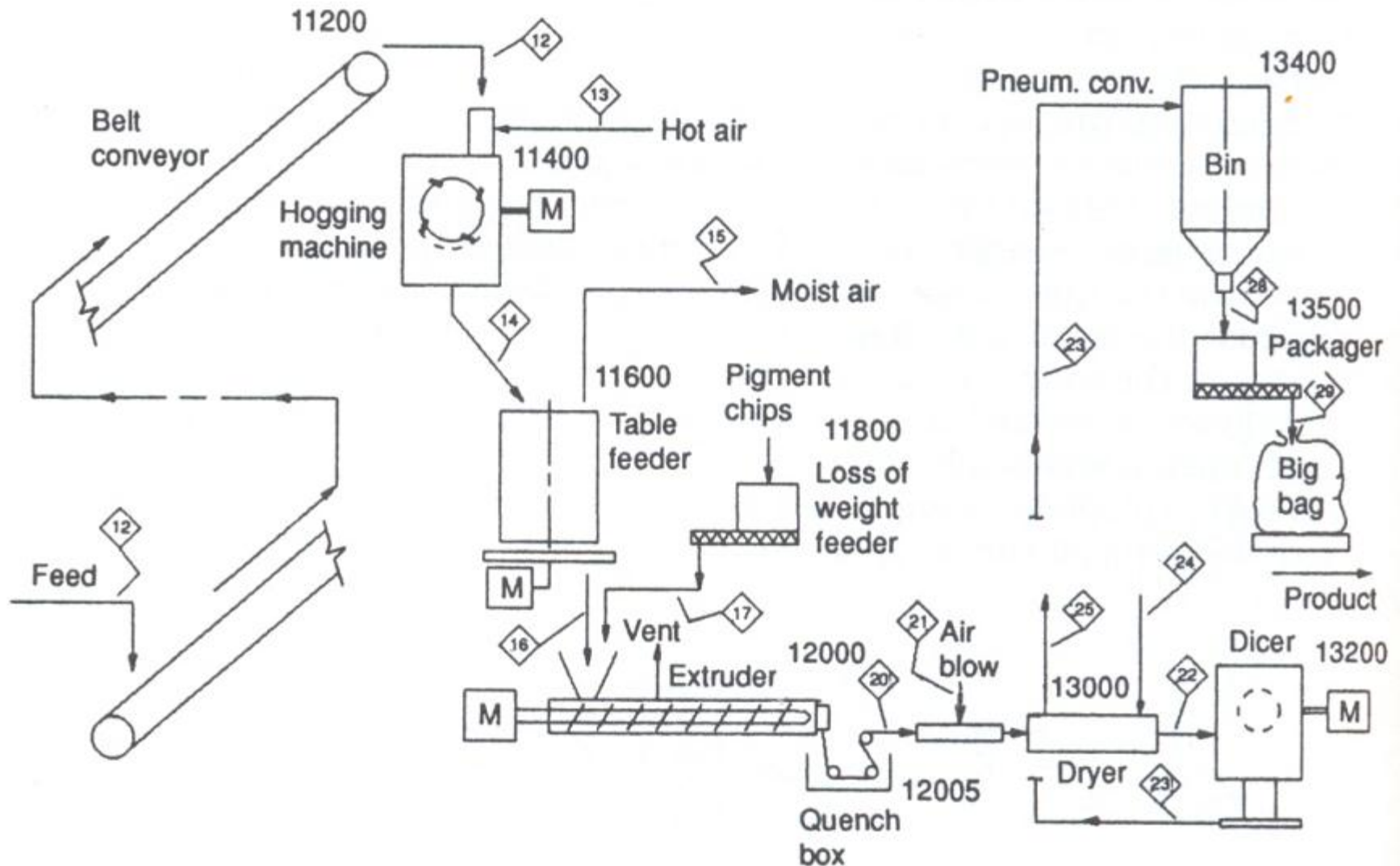


Pump



Stirred
tank

Another Example of PFD



Another Example of PFD (Cont...)

	12 hogger feed		13 drying air		14 hogger discharge		15 moist air		16 extruder feed		17 pigment chips	
	average rate	design rate	average rate	design rate	average rate	design rate	average rate	design rate	average rate	design rate	average rate	design rate
polymer	1050	1260			1050	1260			1050	1260	26	34
plgmet											4.1	6.3
dir1	2.6	5.2			2.6	5.2			2.6	5.2		
other #1	2.1	2.5			nil	.1			nil	.1		
name #1	water	water			water	water			water	water		
other #2												
name #2												
water			5	18	7.1	20.5	7.1	20.5				
air			450	900	450	900	450	900				
temperature			130	150	130	150	130	150				
pressure			~atm.	~atm.								

Another Example of PFD (Cont...)

	18 [unused]		19 [unused]		20 extrudate		21 blow air		22 dicer feed		23 dicer output	
	average rate	design rate	average rate	design rate	average rate	design rate	average rate	design rate	average rate	design rate	average rate	design rate
polymer					1076	1294			1076	1294	1076	1294
pigment					4.1	6.3			4.1	6.3	4.1	6.3
dirt					2.6	5.2			2.6	5.2	2.6	5.2
other #					11	13	n/a	n/a	nil	.5	nil	.5
name #1					water	water						
other #2												
name #2												
water												
air							22.4	25.8				
temperature												
pressure												

What is a P&ID(Process &Instrumentation Drawing)

- A Process and Instrument Drawing (P&ID) includes more details than a PFD(Process Flow Diagram).
- It includes major and minor flows, control loops and instrumentation.
- P&ID is sometimes referred to as a Piping and Instrumentation Drawing.

Process and instrumentation diagram

It is a schematic representation of functional relationship of piping, instrumentation and system equipment components. It is termed as final step of process design. It includes following information's,

- ⦿ Instrumentation and their designation along with indicators, recorders and controllers
- ⦿ All equipments with their names and particular numbers
- ⦿ All valves and their corresponding numbers
- ⦿ Piping related to its size, schedule, material of construction and insulation

Continued.....

- ⦿ Miscellaneous - vents, drains, special fittings, sampling lines, reducers
- ⦿ Permanent start-up and flush lines
- ⦿ Directions of flow
- ⦿ Interlinked references
- ⦿ Control inputs and outputs, interlocks
- ⦿ Quality standard
- ⦿ Computer control system input
- ⦿ Identification of components and subsystems delivered by others
- ⦿ Intended physical sequence of the equipment

Distinction Between PFD & PID

	PFD	P&ID
1. Used During Construction	No	Yes*
2. Shows all process and service piping	No	Yes
3. Indicates presence of all controls	No	Yes
4. Shows all motors	No	Yes
5. Shows thermal insulations	No	Yes
6. Shows major equipment	Yes	Yes
7. Shows flow quantities	Yes	No
8. Shows stream compositions	Yes	NO

P&ID Symbols

A symbol expresses or suggests an idea by standing for it

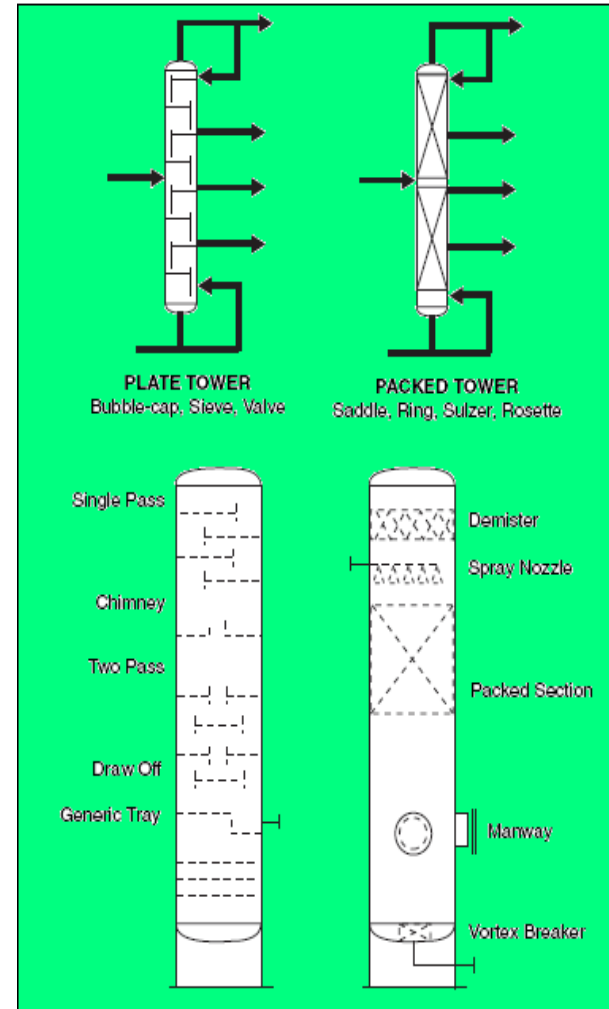
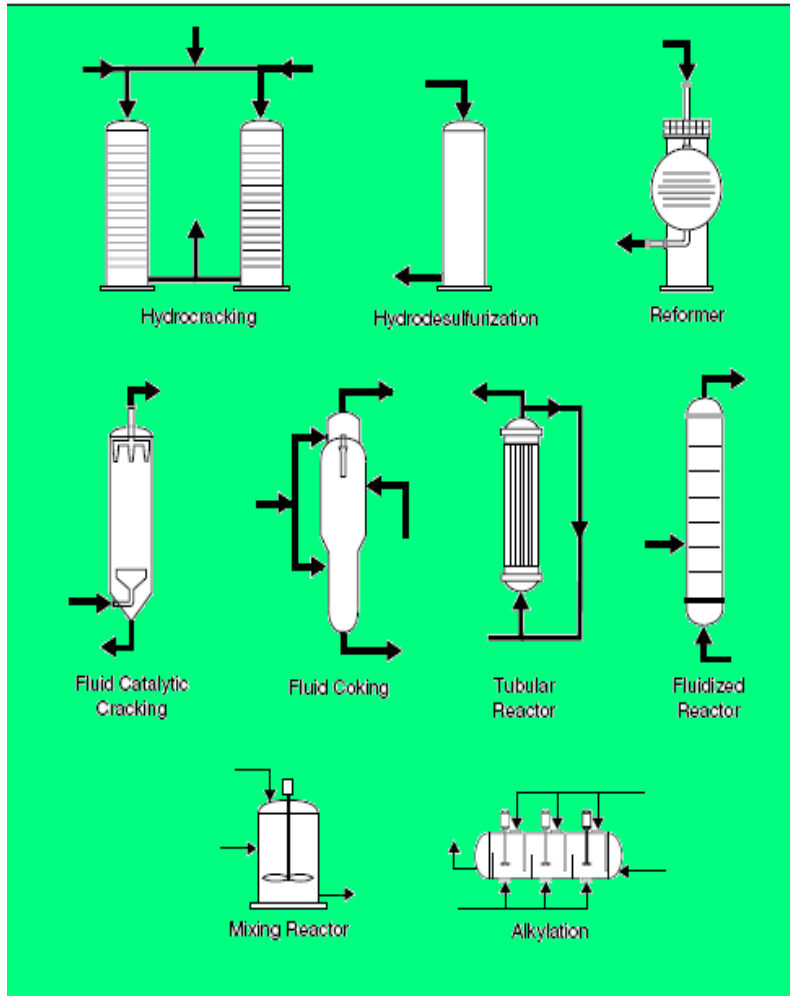
		Piping reducers (eccentric on the left, concentric on the right).		Check valve.
		This symbol flags items included with other components.		Air set, instrument air—type 8.
		Steam trap assembly—type 4.		Line delimiter. Equipment at destination is given. The continuing P&ID and pertinent coordinates are given.
		Specialty item—sketch 23 shows the details.		Electric motor and electric motor with integral speed reducer (gear motor).
		Instrument function performed via software in a programmable logic controller or a micro/mini computer (also referred to as MBE; see p. 191). Control room mounted.		Gearbox.
		Same function in a stand-alone unit.		Common field-mounted instrument.† This instance shows a manually operated switch.
		Air-operated control valve. Internals are the globe valve type—even though symbol is for a gate valve—by convention.		Rotameter.†
		Solenoid valve.		Interlock—interlock 9.
		Three-way solenoid valve.		Purge connection—type 6.
				Connection at battery limit.
				Shutdown.

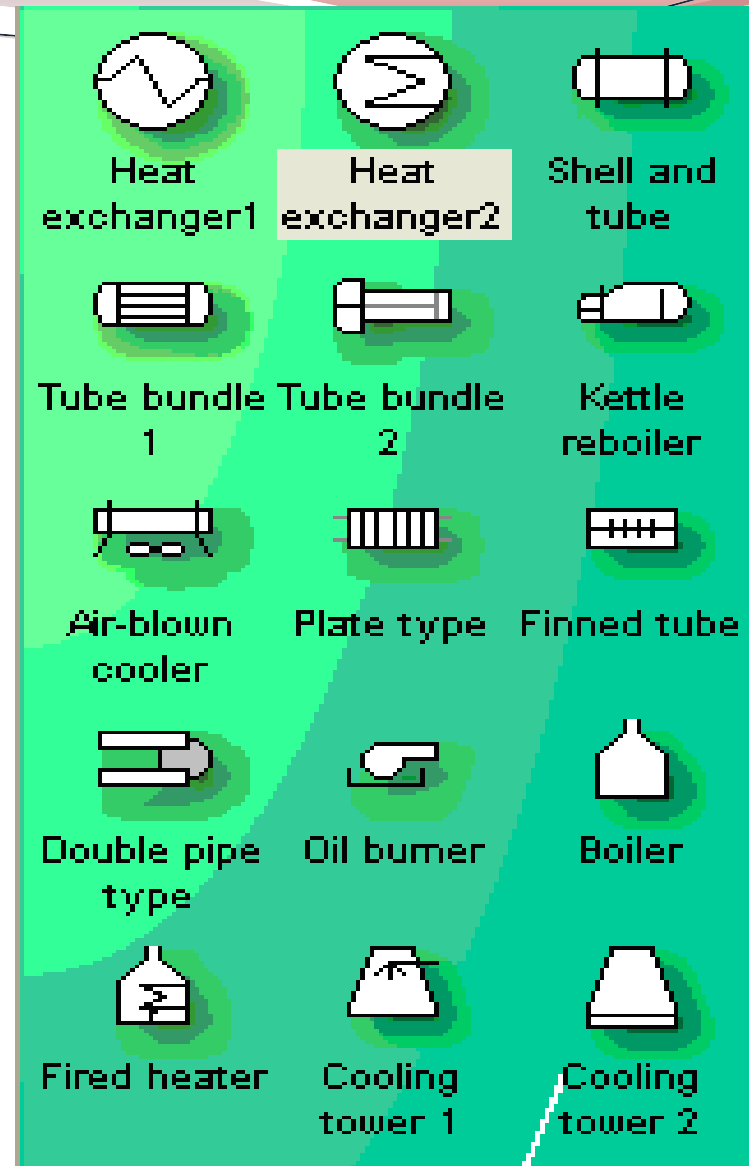
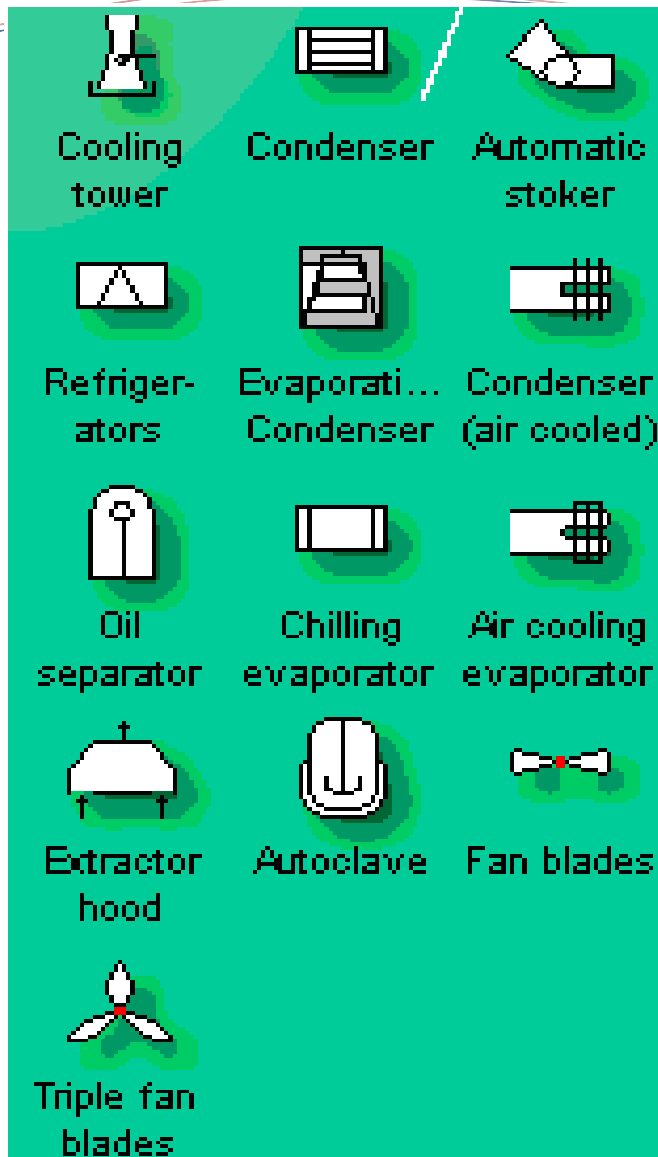
Standard symbols for instruments

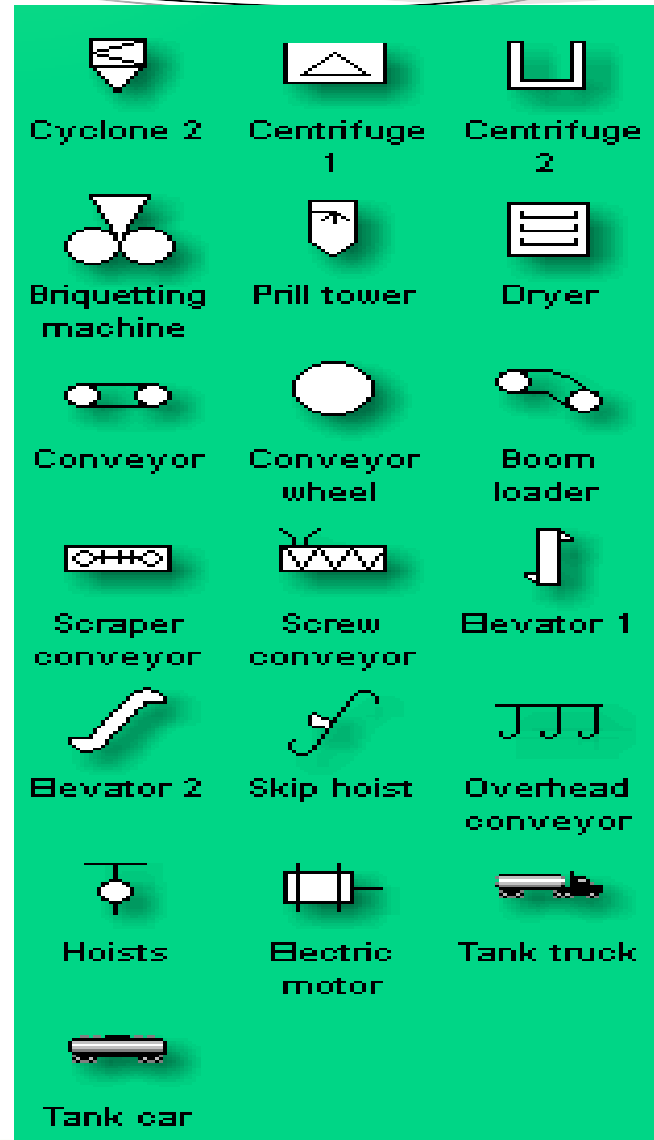
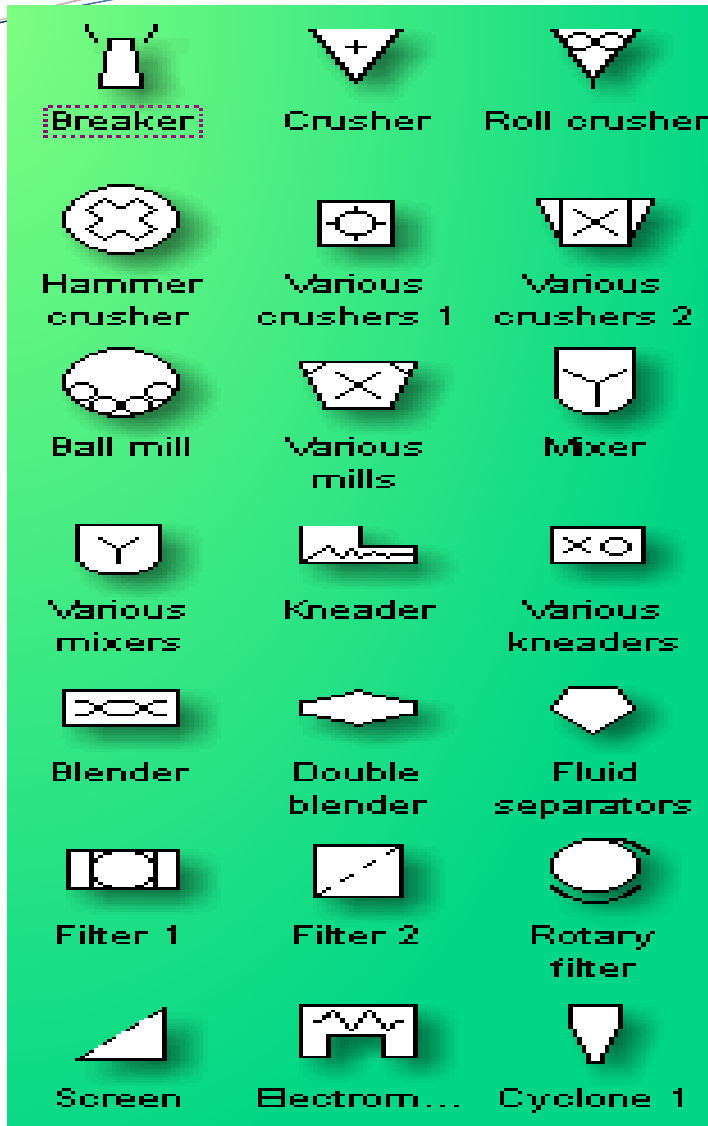
Indicator	CRT	PLC
Computer	Light	Indicator 2
CRT 2	PLC 2	Computer 2
Dashed mid-line	Steam traced	Double
Level Meter	Pressure gauges	Thermom...
Flowmeters	Level meters	Indicator/recorder
Converter	Venturi	Flowmeter
Rotameter	Vortex sensor	Propeller meter
Generic Utility	Operator Box	AND gate

OR gate	NOT gate	Correcting element
Diamond	Signal	Data
Pneumatic	Pneumatic 2	Pneumatic Binary
Electric	Electric 2	Electric 3
Electric Binary	Electric Binary 2	Capillary Tube
Hydraulic	Hydraulic 2	Electro-magnetic
Electro-magnetic 2	Heated / Cooled	Heat Trace
Mechanical	Mechanical 2	

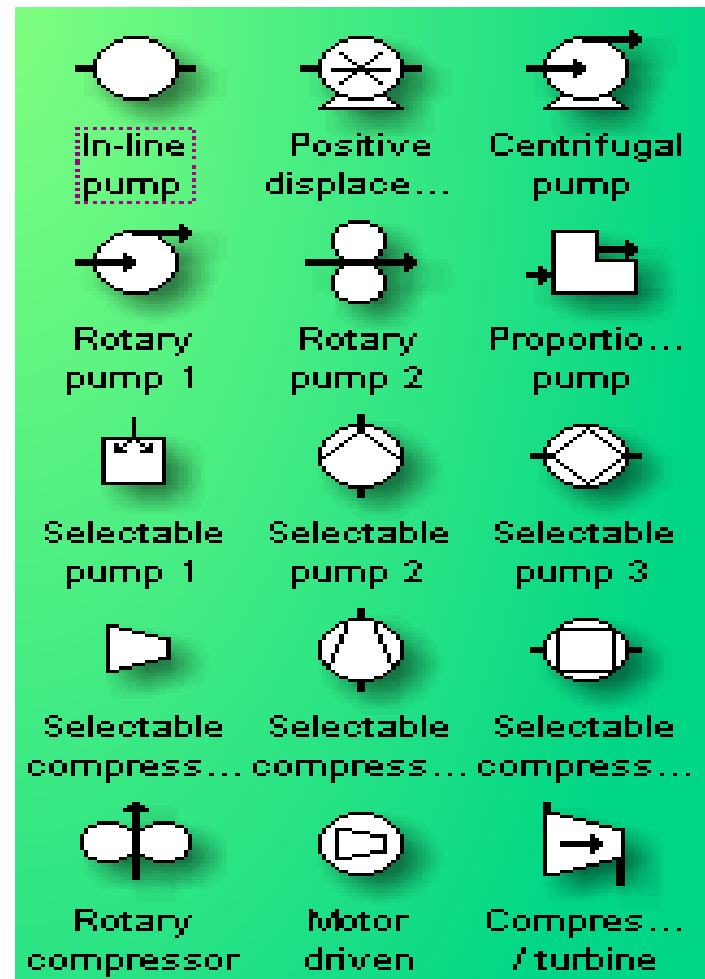
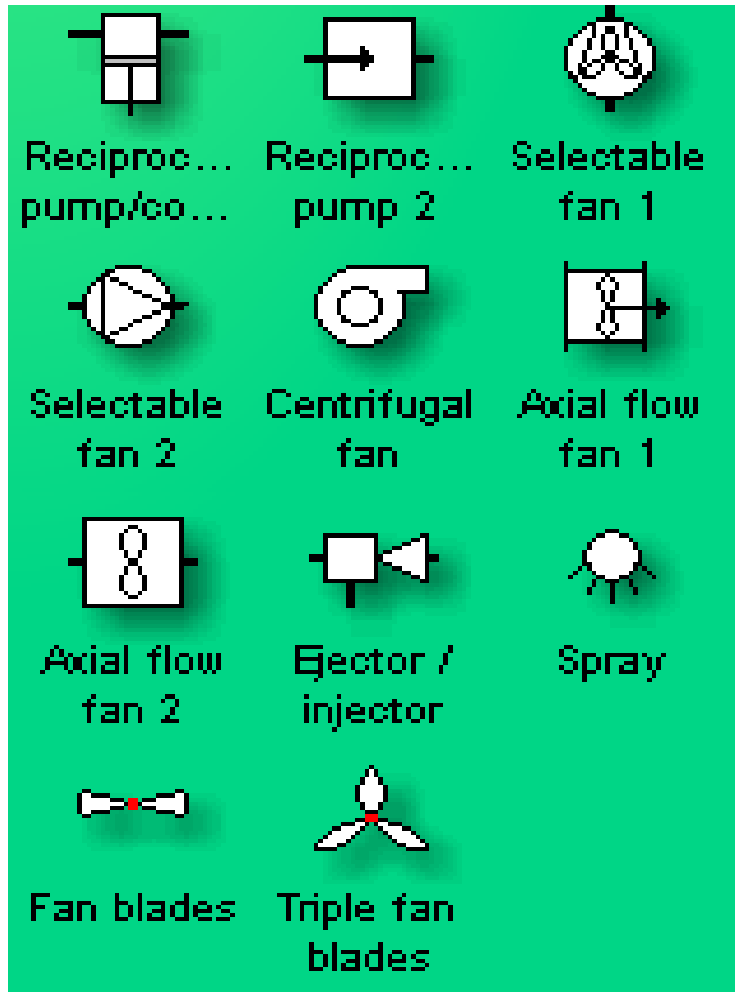
Standard symbols for equipments



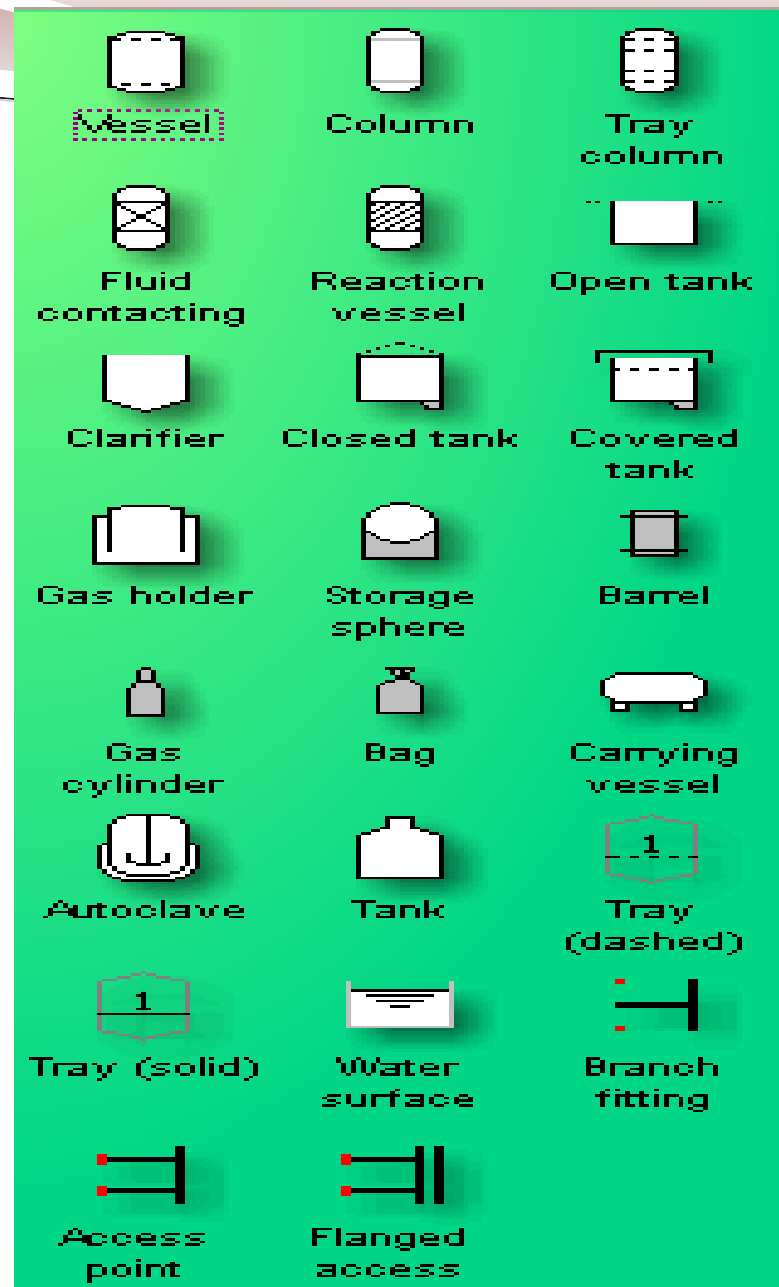




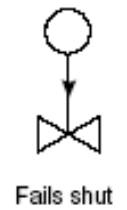
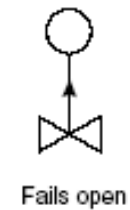
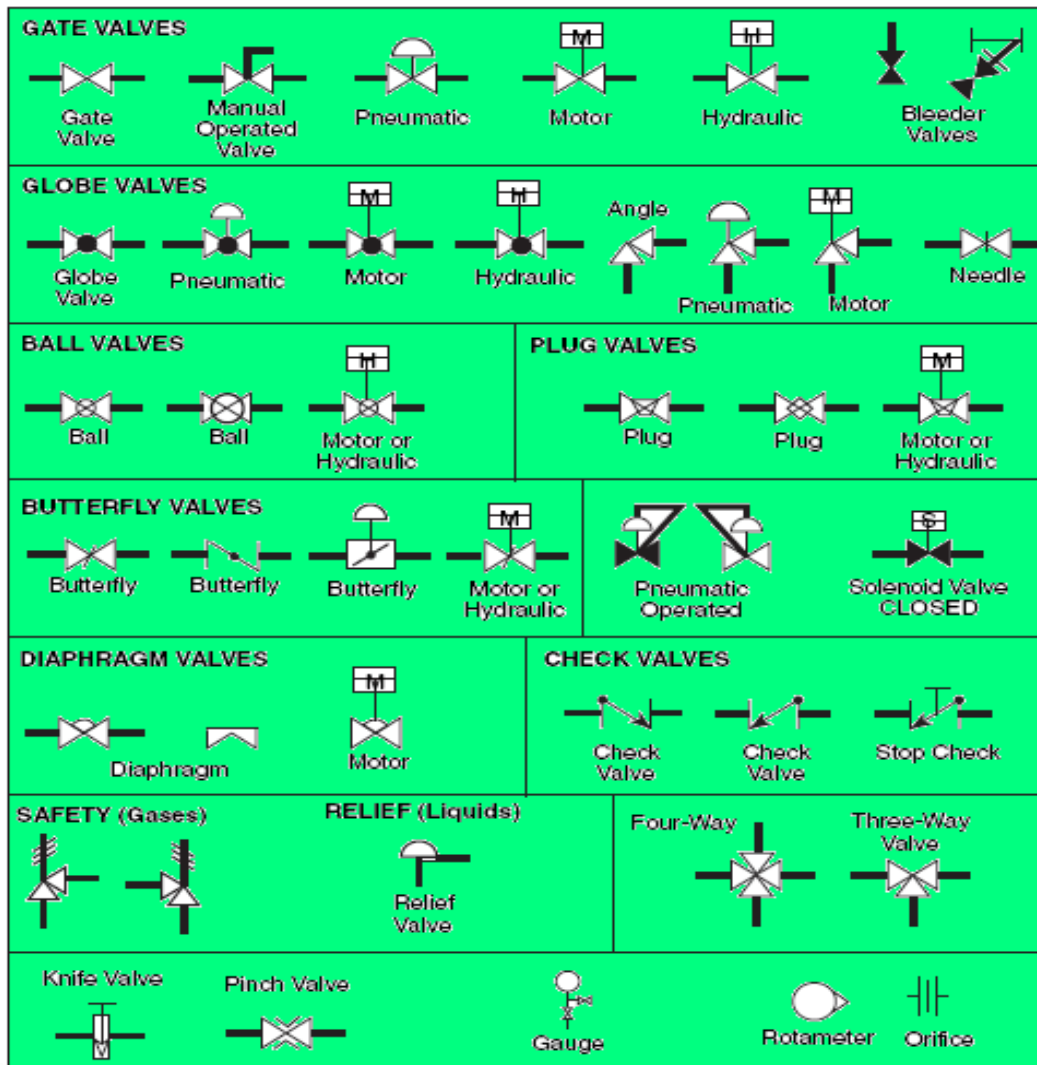
Standard symbols for fluid motive machinery



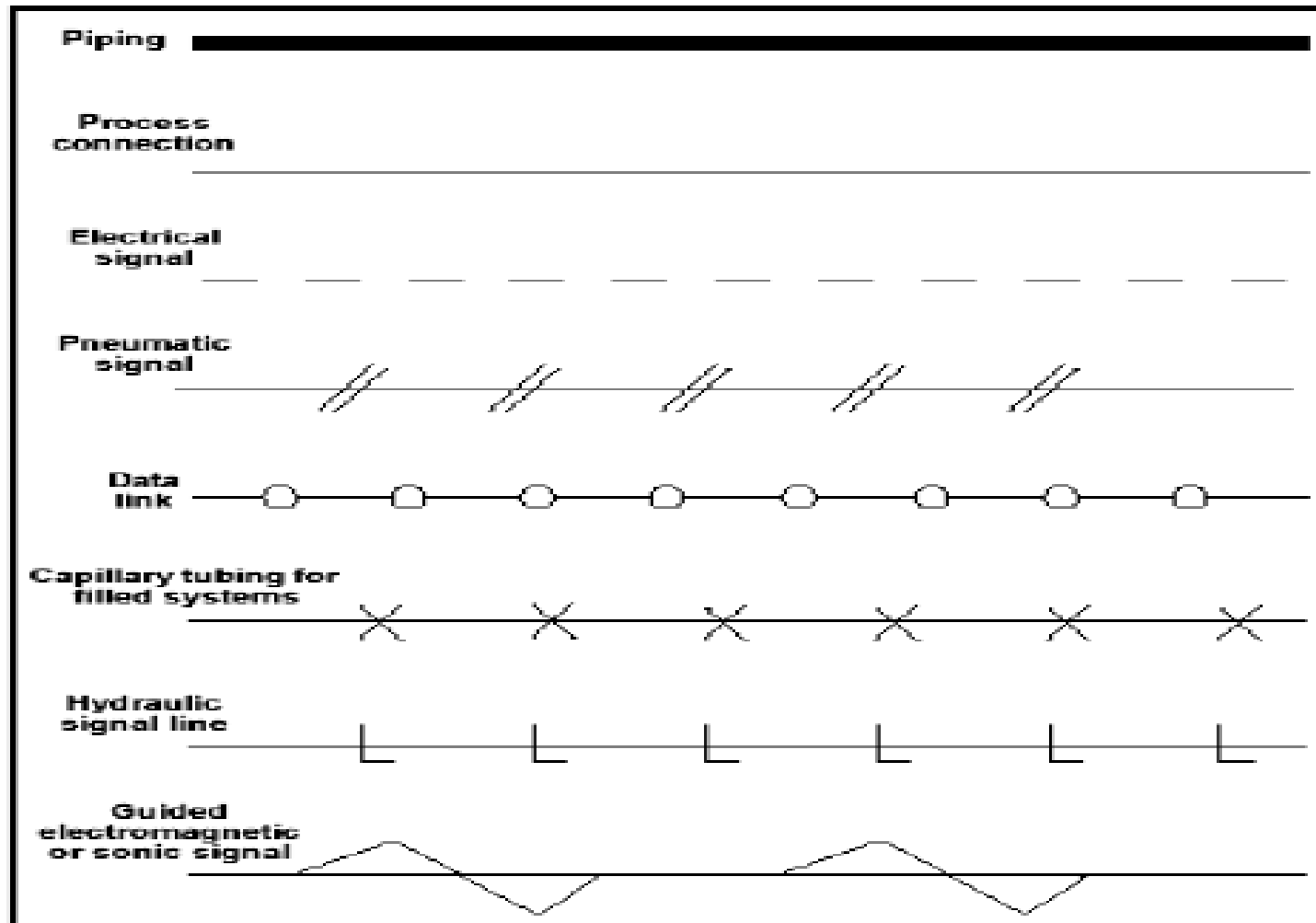
Standard symbols for vessels



Standard symbols for valves



Connection and piping symbols



Piping and Connection Symbols

DIRECTION OF FLOW



AIR CONDITIONING

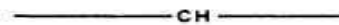
BRINE RETURN



BRINE SUPPLY



CIRCULATING CHILLED OR HOT-WATER FLOW



CIRCULATING CHILLED OR HOT-WATER RETURN



CONDENSER WATER FLOW



CONDENSER WATER RETURN



DRAIN



HUMIDIFICATION LINE



MAKE-UP WATER



REFRIGERANT DISCHARGE



REFRIGERANT LIQUID



REFRIGERANT SUCTION



HEATING

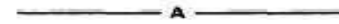
AIR-RELIEF LINE



BOILER BLOW OFF



COMPRESSED AIR



CONDENSATE OR VACUUM PUMP DISCHARGE



FEEDWATER PUMP DISCHARGE



FUEL-OIL FLOW



FUEL-OIL RETURN



FUEL-OIL TANK VENT



HIGH-PRESSURE RETURN



HIGH-PRESSURE STEAM



HOT-WATER HEATING RETURN

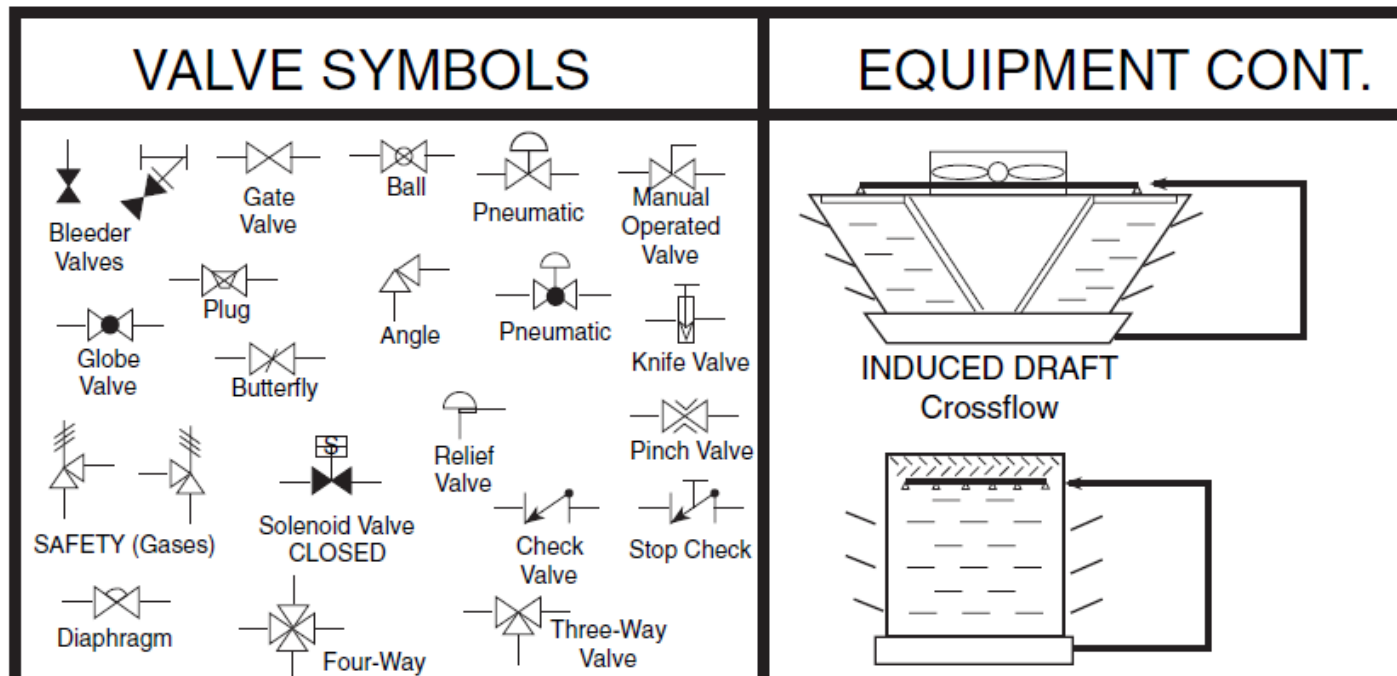


HOT-WATER HEATING SUPPLY



Process Legends

- The process legend provides the information needed to interpret and read the P&ID. Process legends are found at the front of the P&ID. The legend includes information about piping, instrument and equipment.



Process Legends (Cont...)

VALVE SYMBOLS	EQUIPMENT CONT.	LINE SYMBOLS																								
		<p>Future Equipment -----</p> <p>Major Process _____</p> <p>Minor Process _____</p> <p>Pneumatic </p> <p>Hydraulic </p> <p>Capillary Tubing </p> <p>Mechanical Link </p> <p>Electromagnetic, Sonic Optical, Nuclear Electric </p> <p>Connecting Line </p> <p>Non-Connecting Line </p> <p>Non-Connecting Line </p> <p>Jacketed or Double Containment </p> <p>Software or Data Link </p>																								
EQUIPMENT SYMBOLS		INSTRUMENT SYMBOLS																								
		<table border="0"> <tr> <td>TI Temp. Indicator</td> <td>FI Flow Indicator</td> </tr> <tr> <td>TT Temp. Transmitter</td> <td>FT Flow Transmitter</td> </tr> <tr> <td>TR Temp. Recorder</td> <td>FR Flow Recorder</td> </tr> <tr> <td>TC Temp. Controller</td> <td>FC Flow Controller</td> </tr> <tr> <td>LI Level Indicator</td> <td>PI Pressure Indicator</td> </tr> <tr> <td>LT₆₅ Level Transmitter</td> <td>PT₅₅ Pressure Transmitter</td> </tr> <tr> <td>LR₆₅ Level Recorder</td> <td>PR₅₅ Pressure Recorder</td> </tr> <tr> <td>LC₆₅ Level Controller</td> <td>PC₅₅ Pressure Controller</td> </tr> <tr> <td>FE Flow Element</td> <td>I/P Transducer</td> </tr> <tr> <td>TE Temperature Element</td> <td>PIC₁₀₅ Pressure Indicating Controller</td> </tr> <tr> <td>LG Level Gauge</td> <td>PRC₄₀ Pressure Recording Controller</td> </tr> <tr> <td>AT Analyzer Transmitter</td> <td>LA₂₅ Level Alarm</td> </tr> </table>	TI Temp. Indicator	FI Flow Indicator	TT Temp. Transmitter	FT Flow Transmitter	TR Temp. Recorder	FR Flow Recorder	TC Temp. Controller	FC Flow Controller	LI Level Indicator	PI Pressure Indicator	LT ₆₅ Level Transmitter	PT ₅₅ Pressure Transmitter	LR ₆₅ Level Recorder	PR ₅₅ Pressure Recorder	LC ₆₅ Level Controller	PC ₅₅ Pressure Controller	FE Flow Element	I/P Transducer	TE Temperature Element	PIC ₁₀₅ Pressure Indicating Controller	LG Level Gauge	PRC ₄₀ Pressure Recording Controller	AT Analyzer Transmitter	LA ₂₅ Level Alarm
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AT Analyzer Transmitter	LA ₂₅ Level Alarm																									

Process Legends (Cont...)

<p>Progressive Cavity</p> <p>Double-Pipe Heat Exchanger</p> <p>Spiral Heat Exchanger</p> <p>Plate and Frame Heat Exchanger</p> <p>Air Cooled Exchanger (Louvers Optional)</p> <p>Condenser</p> <p>Heater</p>	<p>Two Pass</p> <p>Draw Off</p> <p>Generic Tray</p> <p>Drum</p> <p>Dome Roof Tank</p> <p>Cone Roof Tank</p>	<p>Packed Section</p> <p>Manway</p> <p>Vortex Breaker</p> <p>Sphere</p> <p>Internal Floating Roof Tank</p>	<table border="0"> <tr> <td></td> <td>Level Controller</td> <td></td> <td>Pressure Controller</td> </tr> <tr> <td></td> <td>Flow Element</td> <td></td> <td>Transducer</td> </tr> <tr> <td></td> <td>Temperature Element</td> <td></td> <td>Pressure Indicating Controller</td> </tr> <tr> <td></td> <td>Level Gauge</td> <td></td> <td>Pressure Recording Controller</td> </tr> <tr> <td></td> <td>Analyzer Transmitter</td> <td></td> <td>Level Alarm</td> </tr> </table>		Level Controller		Pressure Controller		Flow Element		Transducer		Temperature Element		Pressure Indicating Controller		Level Gauge		Pressure Recording Controller		Analyzer Transmitter		Level Alarm
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	Temperature Element		Pressure Indicating Controller																				
	Level Gauge		Pressure Recording Controller																				
	Analyzer Transmitter		Level Alarm																				
<p>PREFIXES</p> <table border="0"> <tr> <td>CW- cooling water</td> <td>RX- reactor</td> </tr> <tr> <td>MU- makeup</td> <td>UT- utilities</td> </tr> <tr> <td>FW- feed water</td> <td>CA- chemical addition</td> </tr> <tr> <td>SE- sewer</td> <td>IA- instrument air</td> </tr> </table>		CW- cooling water	RX- reactor	MU- makeup	UT- utilities	FW- feed water	CA- chemical addition	SE- sewer	IA- instrument air	<p>ABBREVIATIONS</p> <table border="0"> <tr> <td>D- drum</td> <td>TK-tank</td> <td>P- pump</td> </tr> <tr> <td>C- column</td> <td>F- furnace</td> <td>V- valve</td> </tr> <tr> <td>CT- cooling tower</td> <td>EX- exchanger</td> <td></td> </tr> </table>		D- drum	TK-tank	P- pump	C- column	F- furnace	V- valve	CT- cooling tower	EX- exchanger				
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<p>APPROVED <i>C. Thomas</i></p> <p>DATE 10-6-99</p>																							
<p>GENERAL LEGEND</p> <p>DISTILLATION UNIT</p>																							
<p>DRAWING NUMBER</p> <p>OO6543</p>																							
<p>REVISION 1</p>		<p>PAGE 1 OF 30</p>																					

P&ID Symbols

The ISA standards and symbols are important for the P&IDs

Process Variable	Symbol	Type of Instrument	Symbol
Analyses	A	Alarm	A
Burner	B	Users Choice	B
Combustion	B	Controller	C
Users Choice	C	Control valve	CV
Users Choice	D	Trap	CV
Voltage	V	Sensor (primary element)	E
Flow Rate	F	Rupture disc	E
Users Choice	G	Sight or gage glass	G
Current (electric)	I	Monitor	G
Power	J	Indicator	I
Time	K	Control Station	K
Level	L	Light (pilot/operation)	L
Users Choice	M	Users Choice	N
Users Choice	N	Flow Resistance Orifice	O
Users Choice	O	Test point (sample point)	P
Pressure / Vacuum	P	Recorder	R
Radiation	R	Switch	S
Speed (or Frequency)	S	Transmitter	T
Temperature	T	Multifunction	U
Multivariable	U	Valve/Damper	V
Vibration	V	Well	W
Weight (force)	W	Unclassified	X
Unclassified	X	Relay	Y
Event	Y	Driver	Z
Position, dimension	Z	Actuator	Z

Example: ISA Symbols for a Level Indicator

LI

"L" for the process variable "Level", and
"I" for the "Indicator" type of instrument.

LI 08

the code for level indicator no. eight

Flowmeter - Indicating

FI 001

Temperature - Transmitter

TT 001

Control Valve

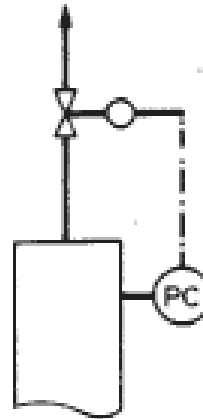
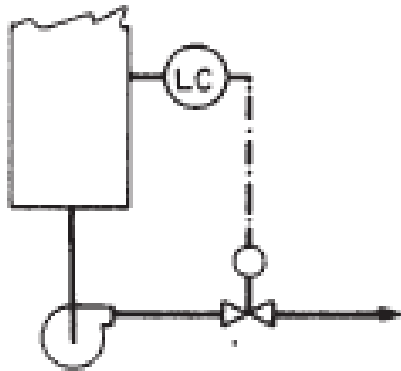
FV 001

Position Switch - High Level

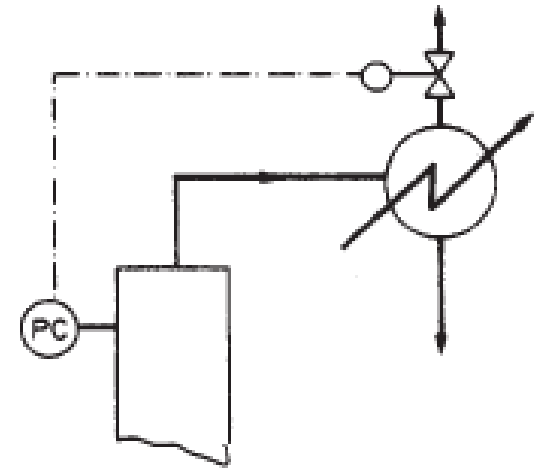
ZSH 001

How to draw the P&ID

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

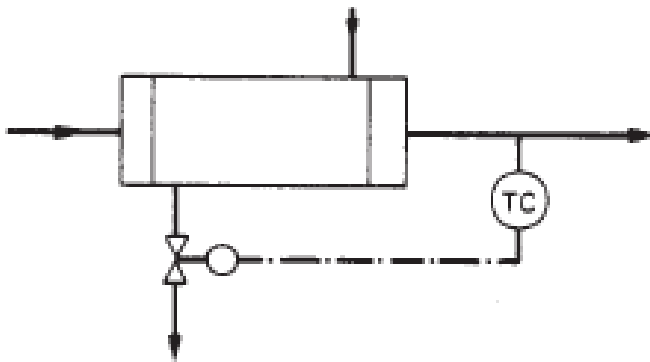


(a)

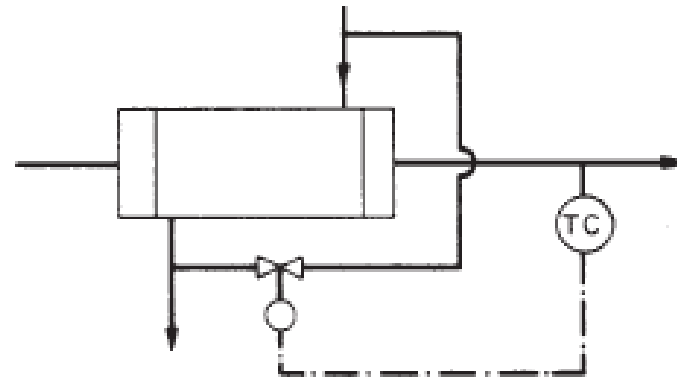


(b)

Heat Exchanger Control

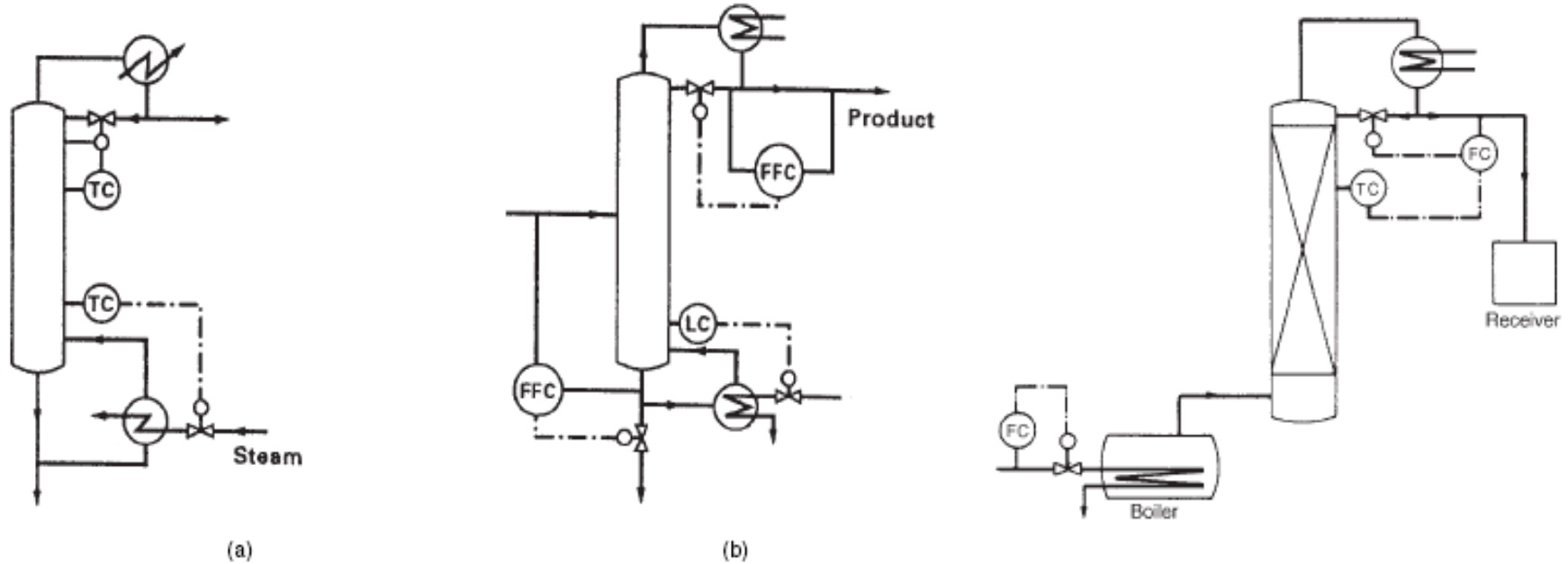


Control of one fluid stream

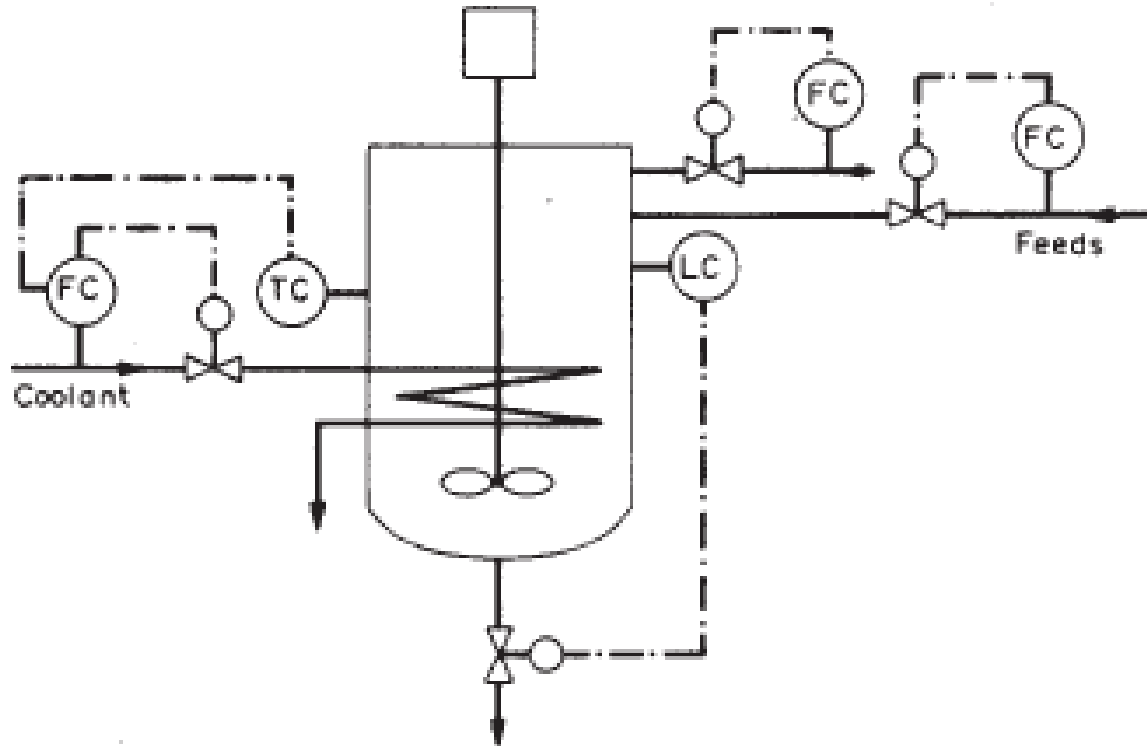


By pass Control

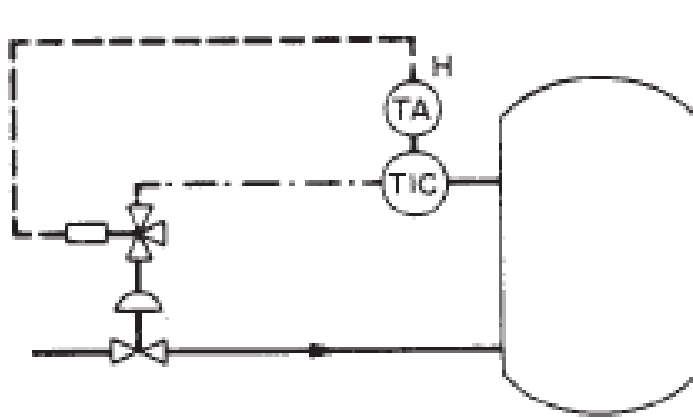
Distillation Control



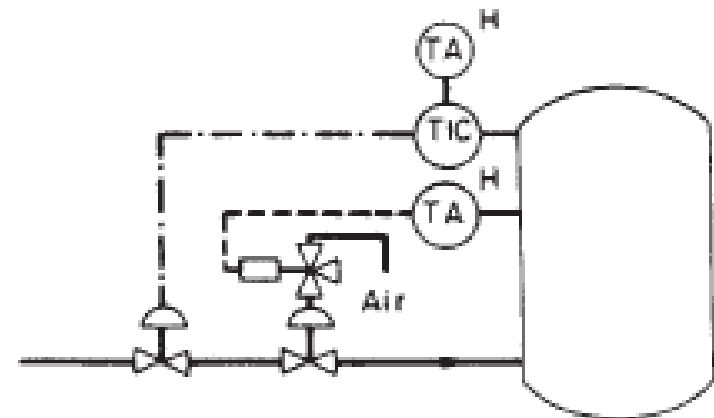
Reactor Control



ALARMS AND SAFETY TRIPS



(a)



(b)

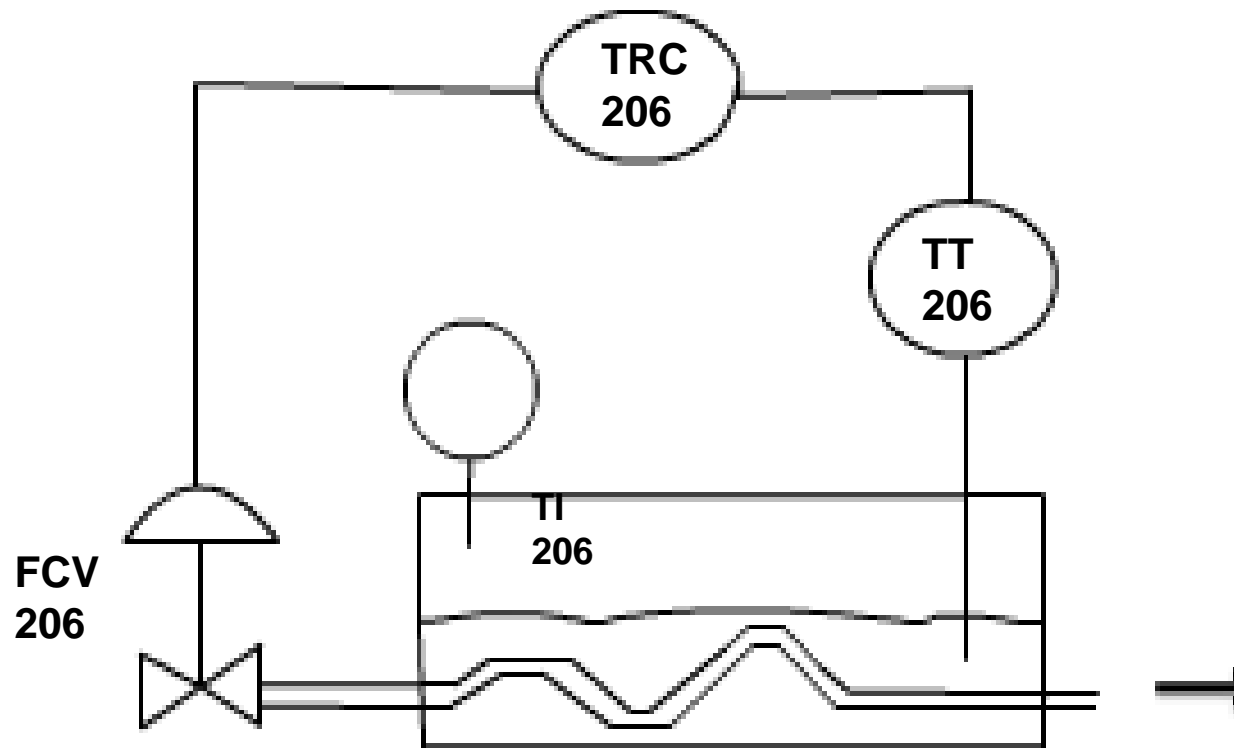
Figure 5.24. (a) Trip as part of control system (b) Separate shut-down trip

Instrument identification by P & ID

- Instruments are identified by a tag number in P & ID. For example,
 - TIC 103 shows instrument identification or tag number
 - T 103 shows loop identification
 - 103 shows loop number
 - TIC shows functional identification
 - T shows first letter
 - IC shows second letter.
- The first letter dictates the control device involved in a process. And second letter dictates the parameter the device is intended to control.

Tag Numbers

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



Tag descriptors

Pressure

Level

Flow

Temperature

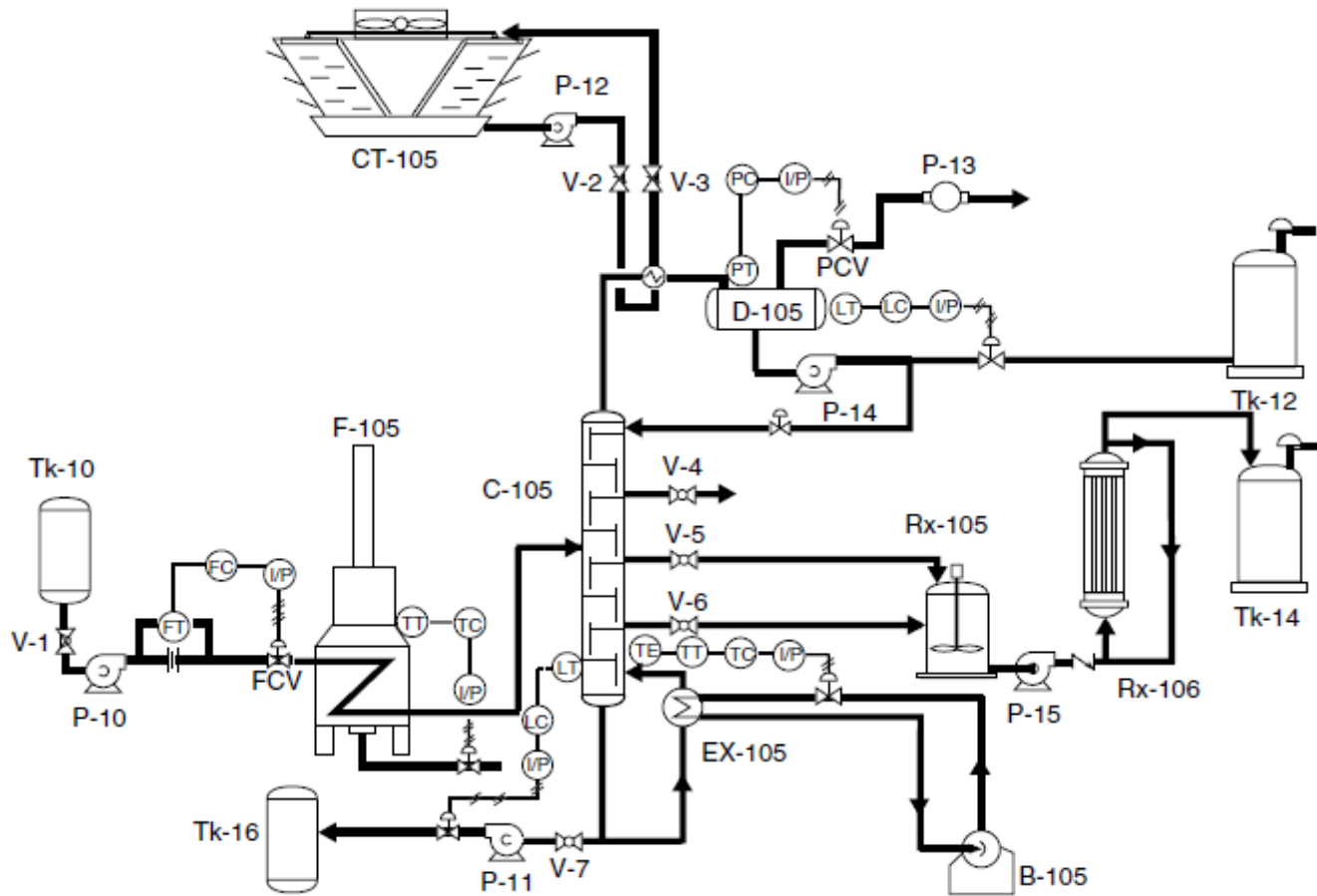
Indicator

Recorder

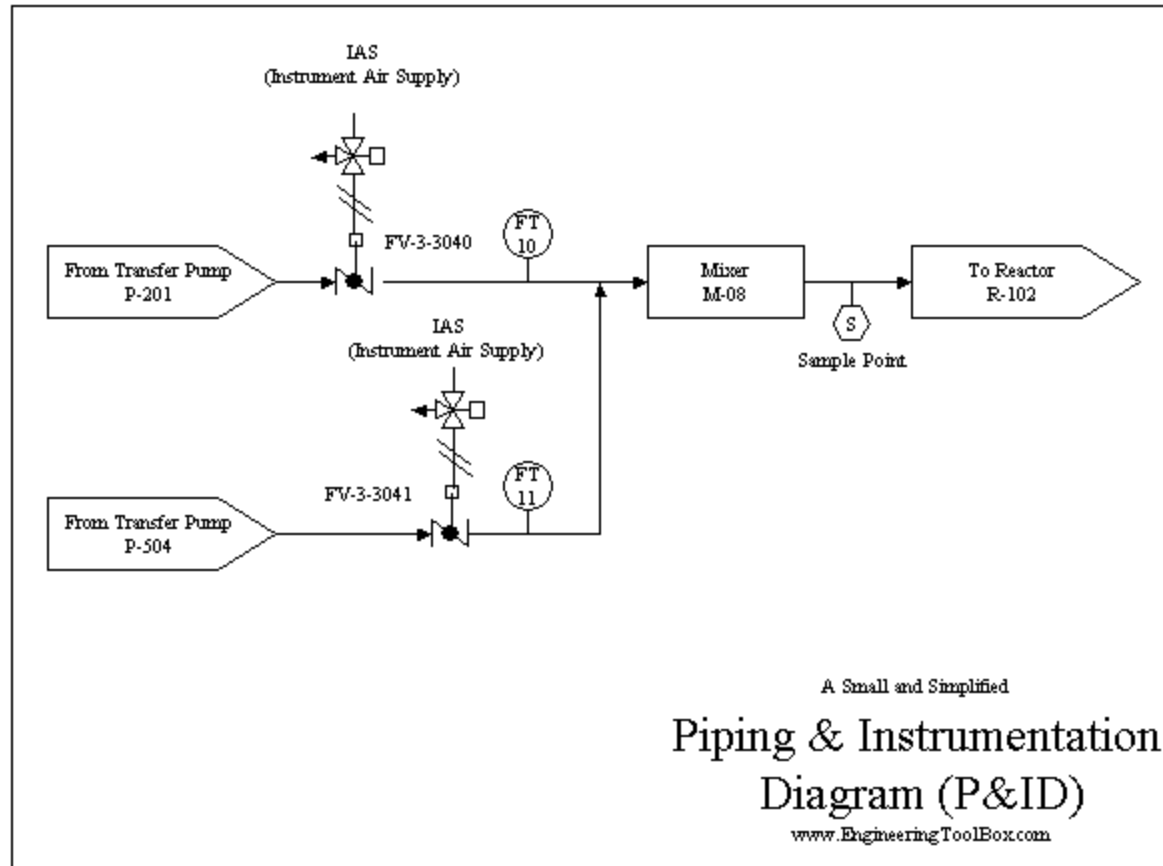
Controller

Transmitter

Example for P&ID



Example for P&ID



Information available from P&ID

- ✓ **Instrumentation and designations**
- ✓ **Mechanical equipment with names and numbers**
- ✓ **All valves and their identifications**
- ✓ **Process piping, sizes and identification**
- ✓ **Miscellaneous - vents, drains, special fittings, sampling lines, reducers, increasers etc.**
- ✓ **Permanent start-up and flush lines**
- ✓ **Flow directions**
- ✓ **Interconnections references**
- ✓ **Control inputs and outputs, interlocks**
- ✓ **Interfaces for class changes**
- ✓ **Seismic category**
- ✓ **Quality level**
- ✓ **Annunciation inputs**
- ✓ **Computer control system input**
- ✓ **Vendor and contractor interfaces**
- ✓ **Identification of components and subsystems delivered by others**
- ✓ **Intended physical sequence of the equipment**

Preliminary P&IS

**1. Format & Sheet Size:
A0 or A1 (ISO)**

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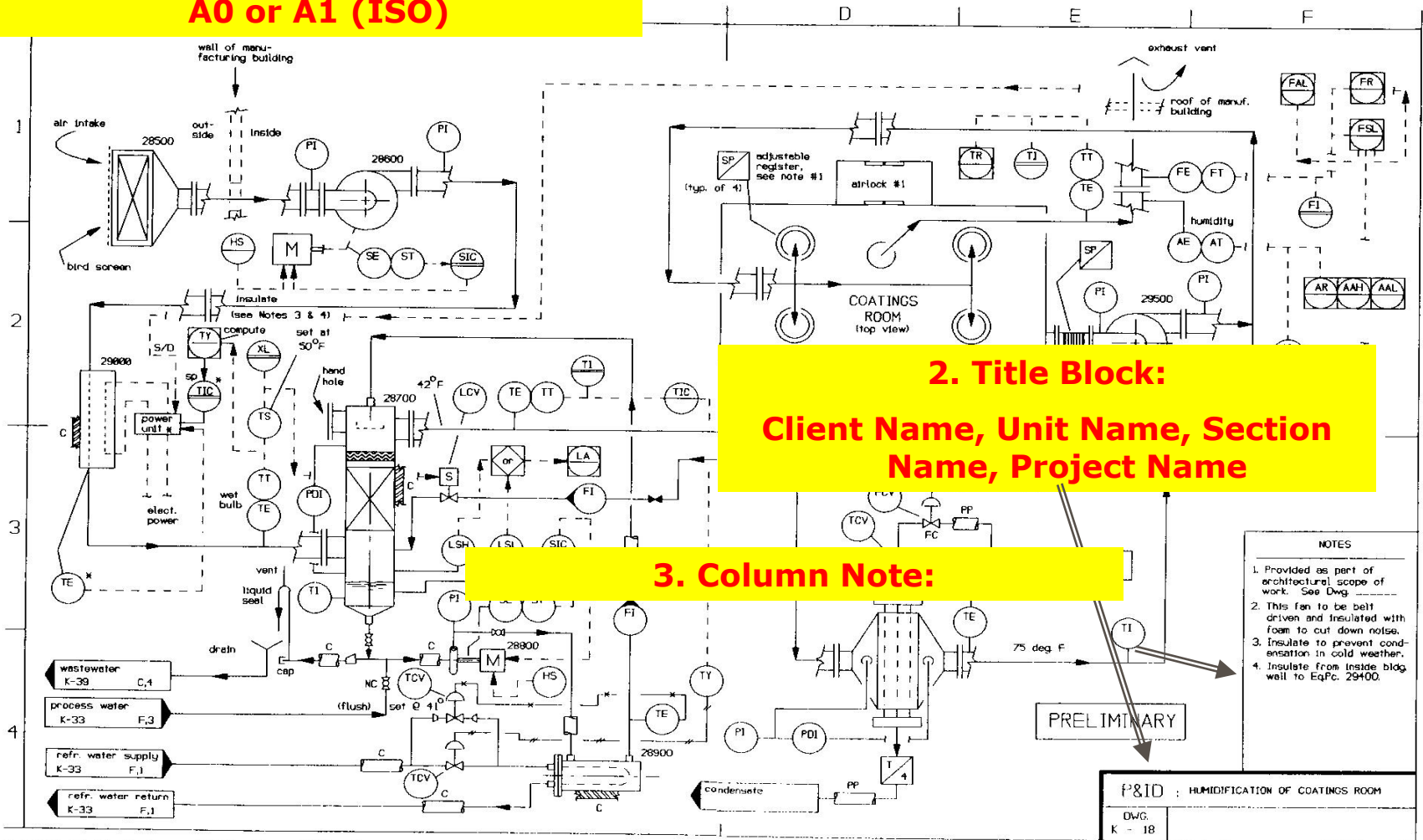


Figure 11-26 Preliminary P&ID of humidification equipment.

4. Equipment Design Data

Preliminary P&IS

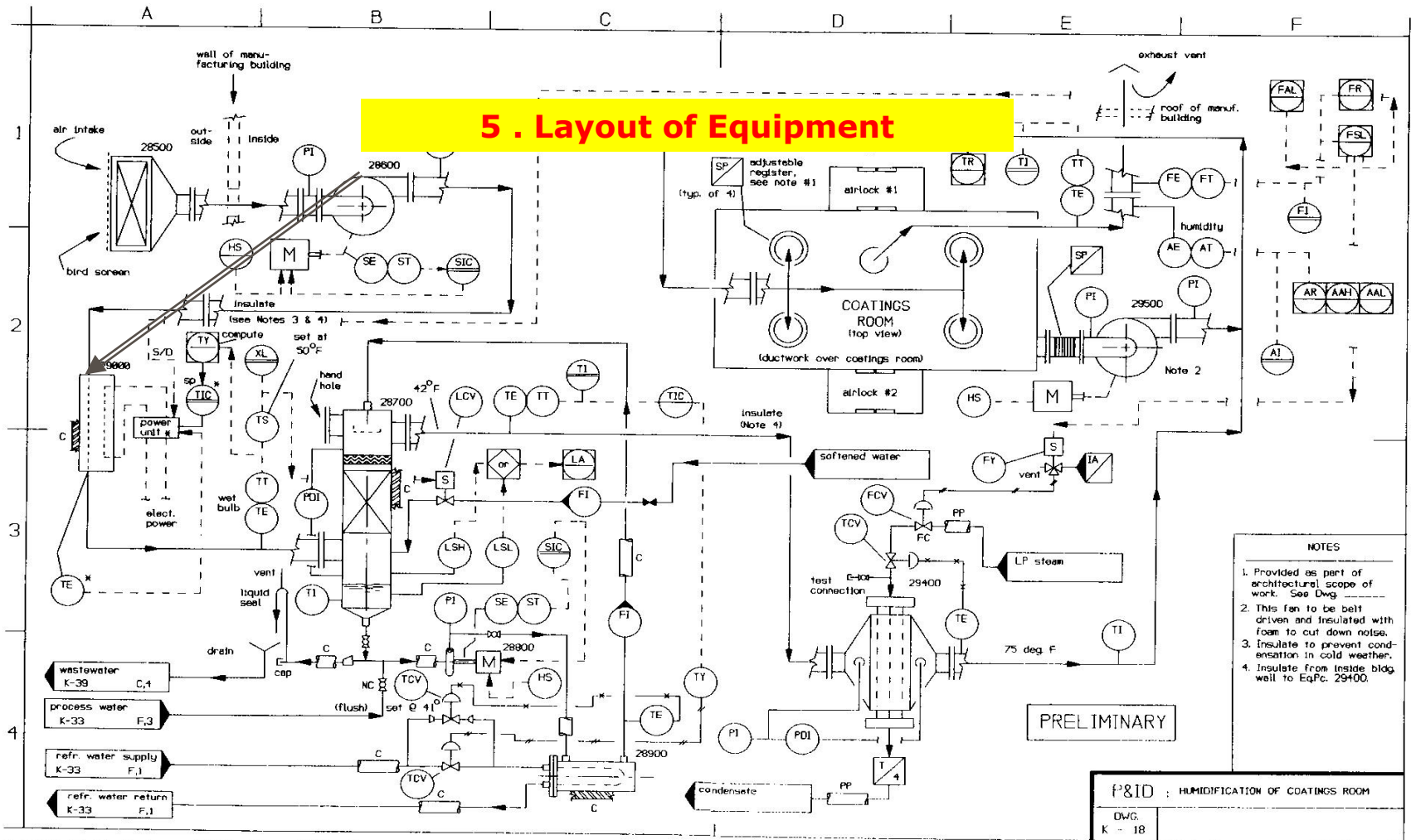
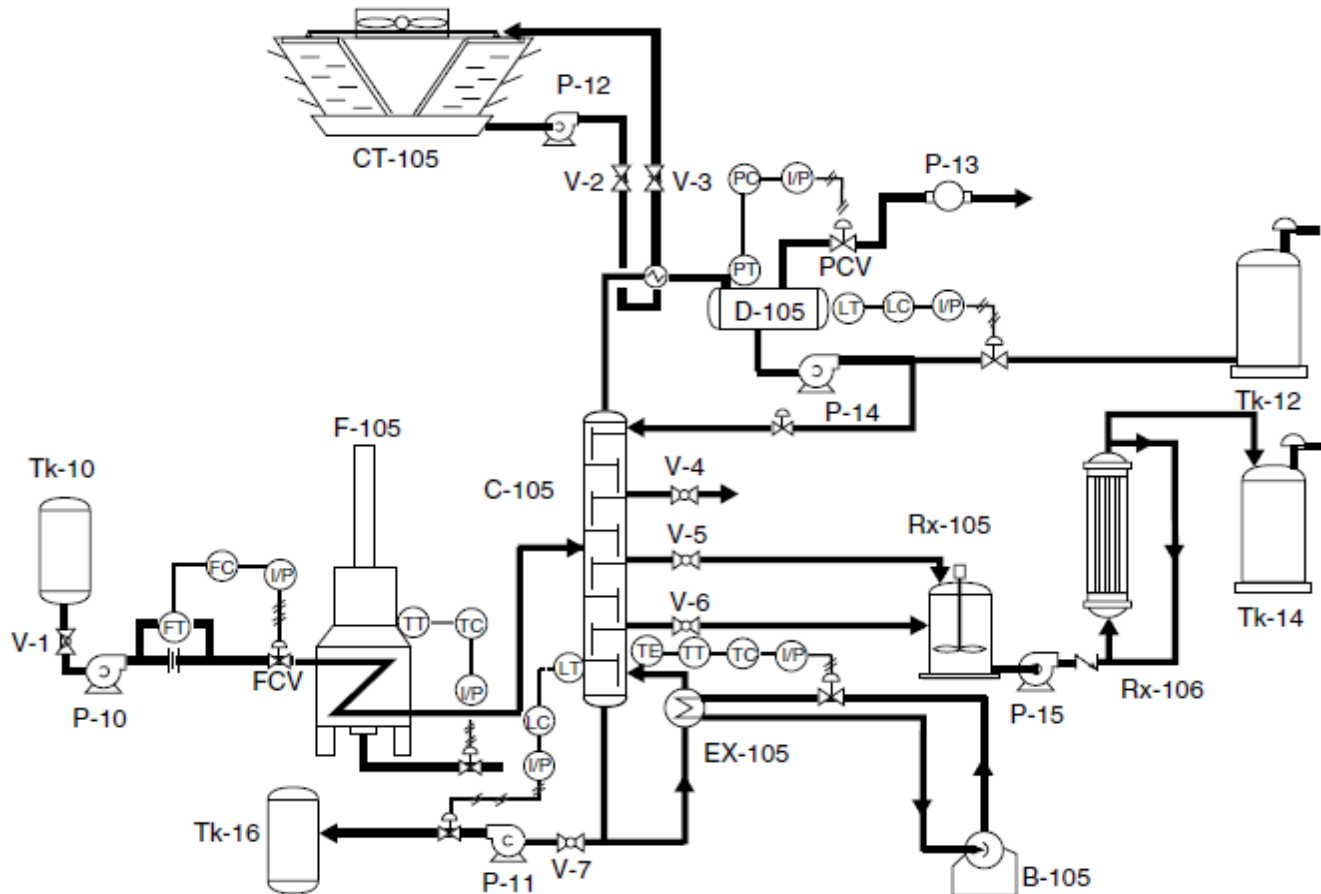
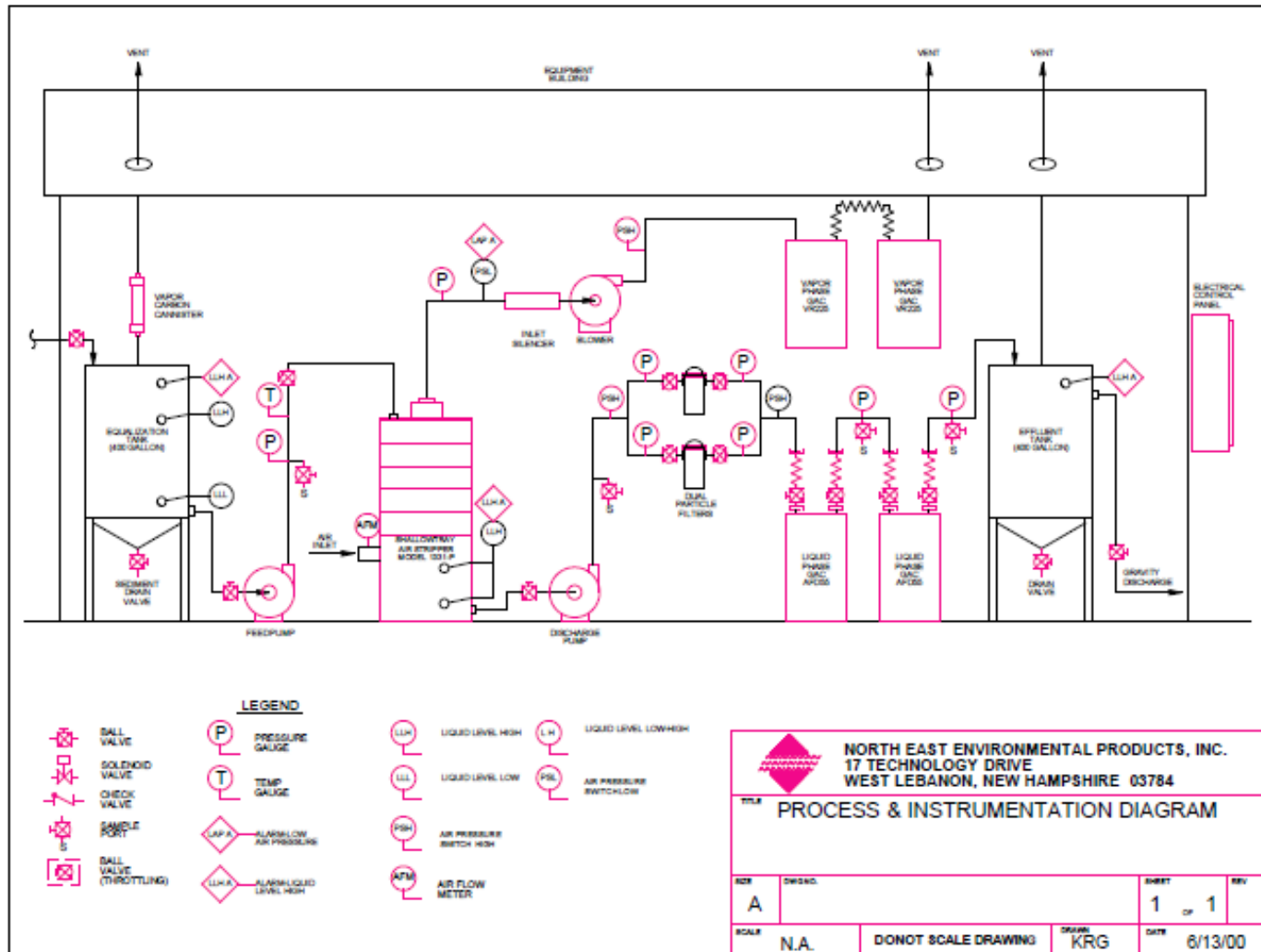


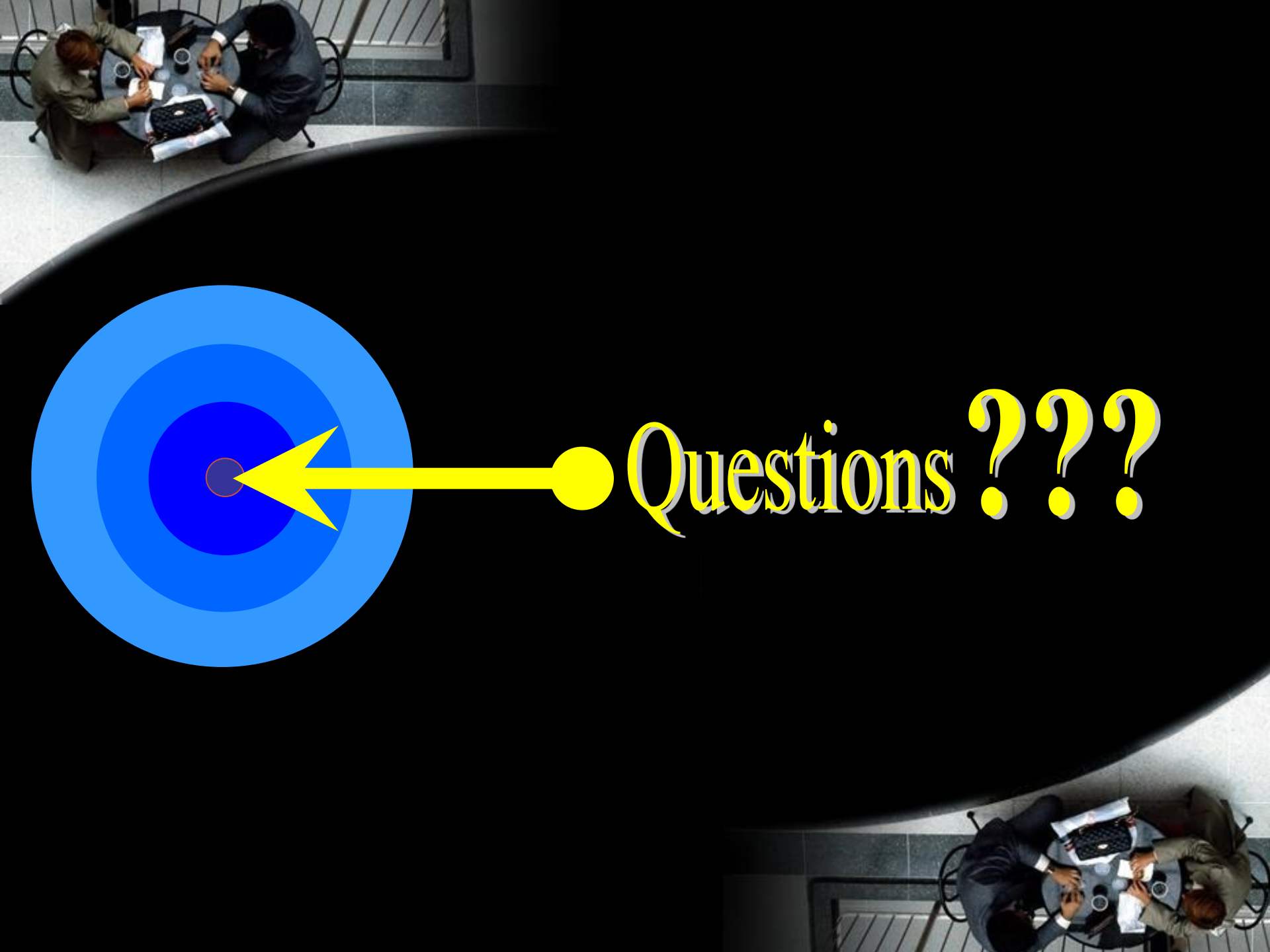
Figure 11-26 Preliminary P&ID of humidification equipment.

Example for P&ID



Example for P&ID





Questions ???



Thank you
Danke
Terima kasih

شكرا

谢谢

merci

நன்றி

