

Chapter 1

Lecture # 2-3

- **Process Flow Diagram (PFD)**

A PFD contains the bulk of the Chemical Engineering data necessary for the design of a chemical process.

Information given in a PFD

- All major pieces of equipments in the process will be represented along with a descriptive name and number.
- All process flow streams will be shown and identified with a number. A description of the process conditions and chemical composition of each stream will be included
- All utility streams supplied to major equipment that provides a process function will be shown.
- Basic control loops will be shown.

Basic Information Provided by a PFD

Process Topology

Stream Information

Equipment Information

Process Topology

The location of and interaction between equipment and process streams is referred to as the process topology.

V-101	P-101A/B	E-101	H-101	R-101	C-101 A/B	E-102	V-102	V-104	E-103	E-106	T-101	E-104	V-103	P-102A/B	E-105
Toluene Storage Drum	Toluene Feed Pumps	Feed Preheater	Feed Heater	Reactor	Recycle Gas Compressor	Reactor Effluent Cooler	HighPres Phase Sep.	Low Pres. Phase Sep.	Tower Feed Heater	Benzene Reboiler	Benzene Column	Benzene Condenser	Reflux Drum	Reflux Pumps	Product Cooler

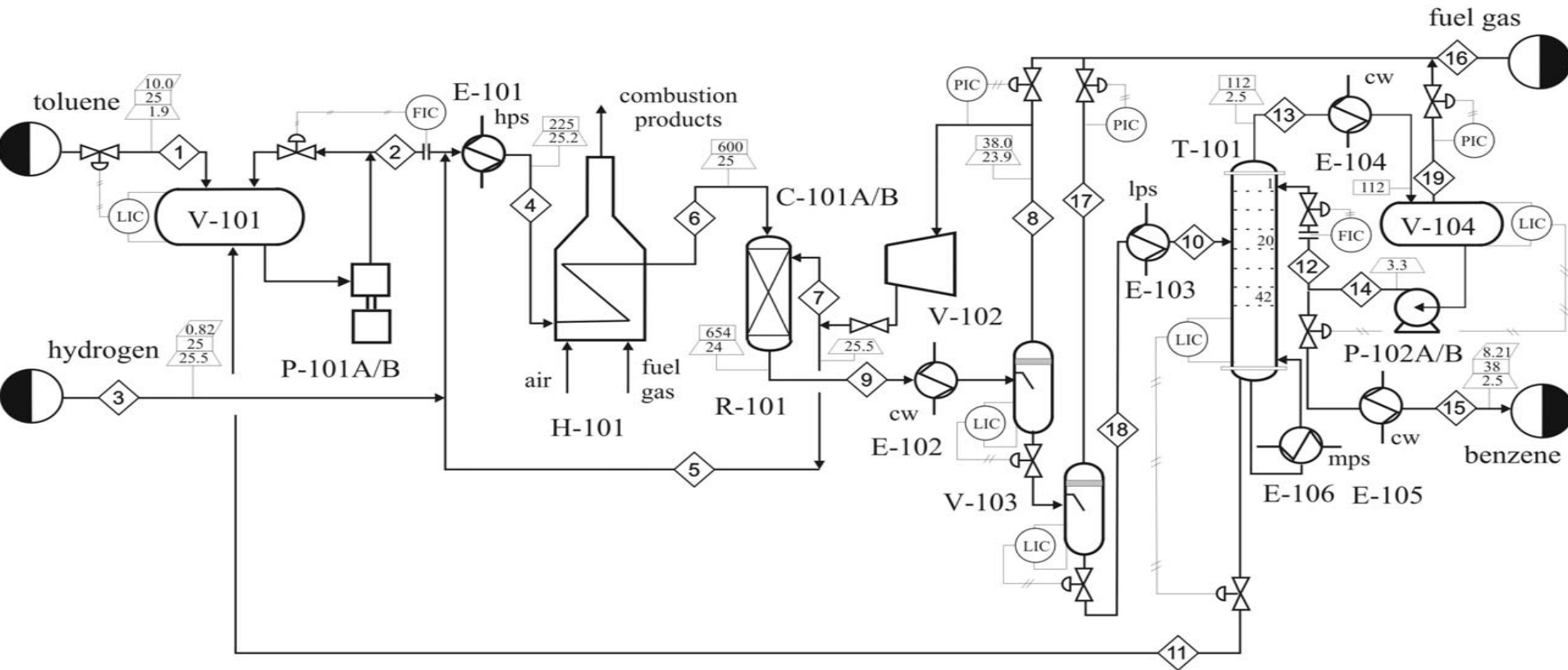


Figure 1.5: Process flow diagram (PFD) for the production of benzene via the hydrodealkylation of toluene

Symbols for Drawing PFD

20

Section 1 Conceptualization and Analysis of Chemical Processes

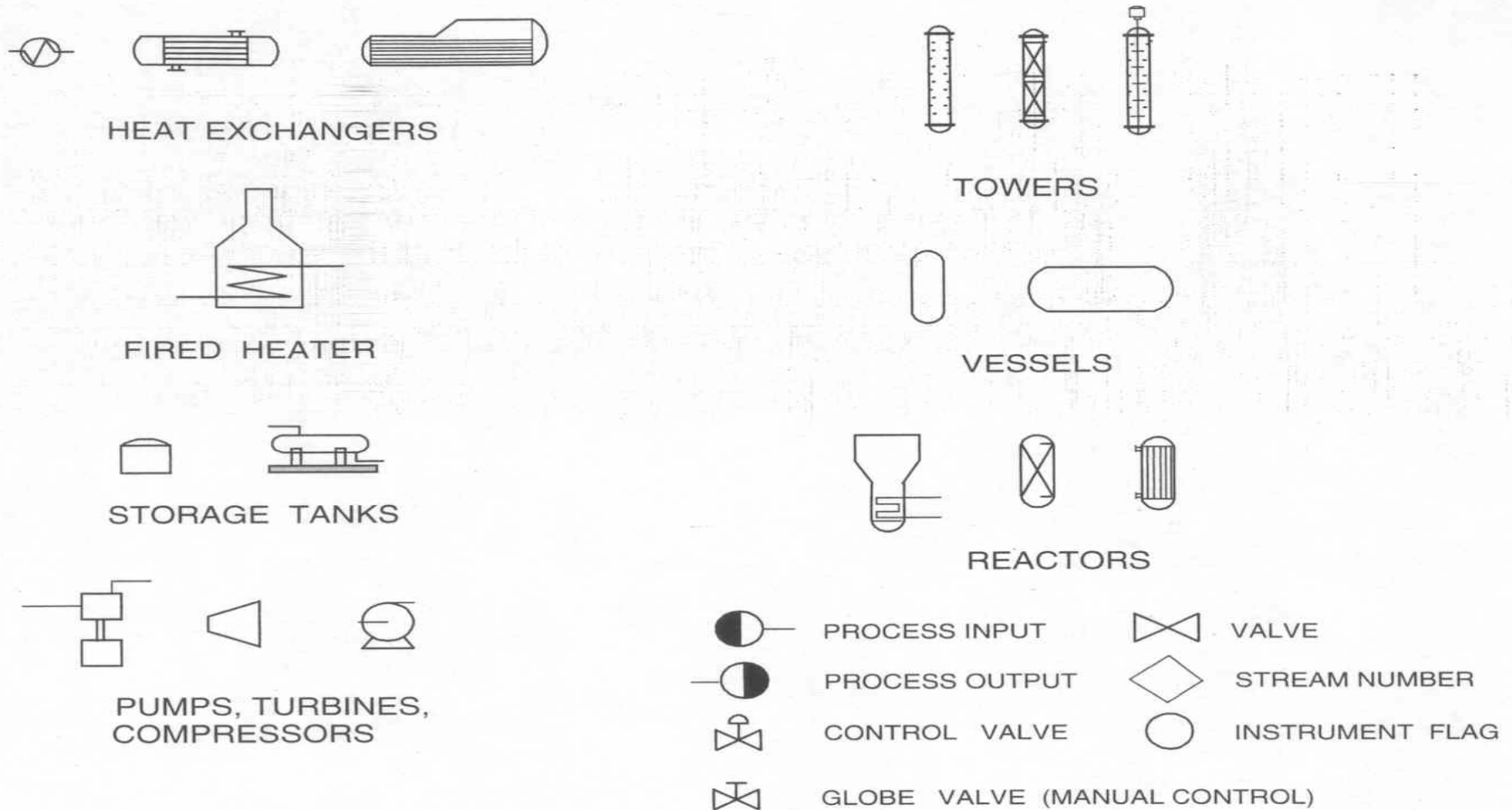


Figure 1.4 Symbols for Drawing Process Flow Diagrams

Conventions Used for Identifying Process Equipment

Process Equipment

General Format **XX-YZZ A/B**

XX are the identification letters for the equipment classification

C - Compressor or Turbine

E - Heat Exchanger

H - Fired Heater

P - Pump

R - Reactor

T - Tower

TK - Storage Tank

V - Vessel

Y designates an area within the plant

ZZ are the number designation for each item in an equipment class

A/B identifies parallel units or backup units not shown on a PFD

Supplemental Information

Additional description of equipment given on top of PFD

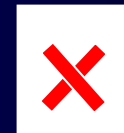
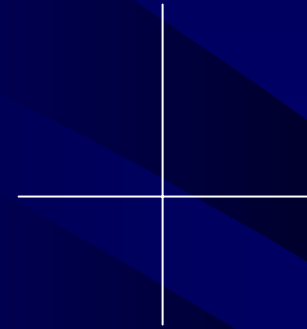
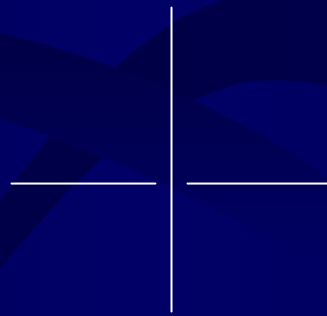
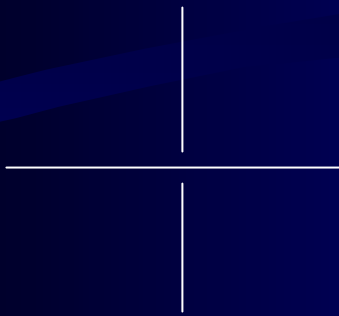
Numbering of Equipment

- *XX-YZZ A/B/...*
 - *XX* represents a 1- or 2-letter designation for the equipment (P = pump)
 - *Y* is the 1 or 2 digit unit number (1-99)
 - *ZZ* designates the equipment number for the unit (1-99)
 -
 - *A/B/...* represents the presence of spare equipment

Example

- Equipment T-905 is the 5th tower in unit nine hundred. Equipment P-301 A/B is the 1st Pump in unit three hundred plus a spare *XX-YYY A/B/...*
- Use unambiguous letters for new equipment
 - Example: Turbine use Tb or J not T (for tower)
 - Replace old vessel V-302 with a new one of different design - use V-319 (say) not V-302 – since it may be confused with original V-302 the presence of spare equipment.

- Number streams from left to right as much as possible
- Horizontal lines are dominant



- Add arrows for
 - Change in direction
 - Inlet of equipment
- Utility streams should use convention given in Table 1.3 (lps, cw, fg, etc)

Utility

Table 1.3 Conventions for Identifying Process and Utility Streams

Process Streams	
<p>All conventions shown in Table 1.1 apply. Diamond symbol located in flow lines. Numerical identification (unique for that stream) inserted in diamond. Flow direction shown by arrows on flow lines.</p>	
Utility Streams	
lps	Low-pressure Steam: 3–5 barg (sat) ‡
mps	Medium-pressure Steam: 10–15 barg (sat) ‡
hps	High-pressure Steam: 40–50 barg (sat) ‡
htm	Heat Transfer Media (Organic): to 400°C
cw	Cooling Water: From cooling tower 30°C returned at less than 45°C [†]
wr	River Water: From river 25°C returned at less than 35°C
rw	Refrigerated Water: In at 5°C returned at less than 15°C
rb	Refrigerated Brine: In at –45°C returned at less than 0°C
cs	Chemical Waste Water with high COD
ss	Sanitary Waste Water with high BOD, etc.
el	Electric Heat (specify 220, 440, 660V service)
ng	Natural Gas
fg	Fuel Gas
fo	Fuel Oil
fw	Fire Water
<p>‡These pressures are set during the preliminary design stages and typical values vary within the ranges shown. [†]Above 45°C, significant scaling occurs.</p>	

Stream Information

- Since diagrams are small not much stream information can be included
- Include important data – around reactors and towers, etc.
 - Flags are used – see toluene HDA diagram
 - Full stream data, as indicated in Table 1.4, are included in a separate flow summary table – see Table 1.5

Stream Information

- **Essential Information**

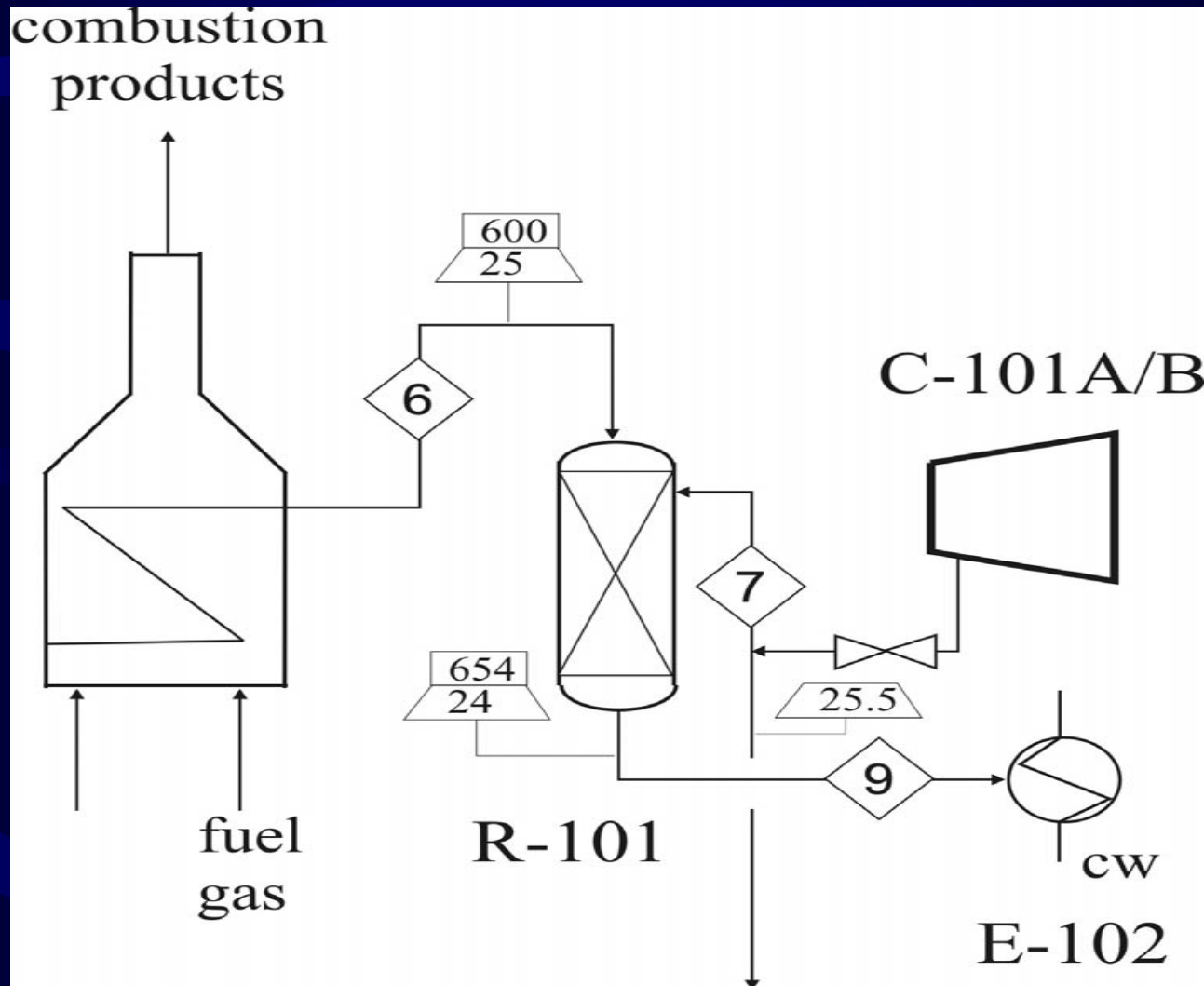
- Stream Number
- Temperature ($^{\circ}\text{C}$)
- Pressure (bar)
- Vapor Fraction
- Total Mass Flow Rate (kg/h)
- Total Mole Flow Rate (kmol/h)
- Individual Component Flow Rates (kmol/h)

- **Optional Information**

- Component Mole Fractions
- Component Mass Fractions
- Individual Component Flow Rates (kg/h)
- Volumetric Flow Rates (m^3/h)
- Significant Physical Properties
 - Density
 - Viscosity
 - Other
- Thermodynamic Data
 - Heat Capacity
 - Stream Enthalpy
 - K-values
- Stream Name

Stream Information/Flag

See Figure 1.5 and 1.6



Stream Information/Flow Summary Table

See Table 1.5

Stream Number	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	25	59	25	225	41	600	41	38	654	90
Pressure (bar)	1.90	25.8	25.5	25.2	25.5	25.0	25.5	23.9	24.0	2.6
Vapor Fraction	0.0	0.0	1.00	1.0	1.0	1.0	1.0	1.0	1.0	0.0
Mass Flow (tonne/h)	10.0	13.3	0.82	20.5	6.41	20.5	0.36	9.2	20.9	11.6
Mole Flow (kmol/h)	108.7	144.2	301.0	1204.4	758.8	1204.4	42.6	1100.8	1247.0	142.2
Component Mole Flow (kmol/h)										
Hydrogen	0.0	0.0	286.0	735.4	449.4	735.4	25.2	651.9	652.6	0.02
Methane	0.0	0.0	15.0	317.3	302.2	317.3	16.95	438.3	442.3	0.88
Benzene	0.0	1.0	0.0	7.6	6.6	7.6	0.37	9.55	116.0	106.3
Toluene	108.7	143.2	0.0	144.0	0.7	144.0	0.04	1.05	36.0	35.0

Equipment Information

- Equipment are identified by number and a label (name) positioned above the equipment on the PFD
- Basic data such as size and key data are included in a separate table (Equipment Summary Table) Table 1.7 (and Table 1.6) in TBWS

See Table 1.6

Table 1.6 Equipment Descriptions for PFD and PIDs

Equipment Type
Description of Equipment
Towers
Size (height and diameter), Pressure, Temperature Number and Type of Trays Height and Type of Packing Materials of Construction
Heat Exchangers
Type: Gas-Gas, Gas-Liquid, Liquid-Liquid, Condenser, Vaporizer Process: Duty, Area, Temperature, and Pressure for both streams No. of Shell and Tube Passes Materials of Construction: Tubes and Shell
Tanks
See vessels
Vessels
Height, Diameter, Orientation, Pressure, Temperature, Materials of Construction
Pumps
Flow, Discharge Pressure, Temperature, ΔP , Driver Type, Shaft Power, Materials of Construction
Compressors
Actual Inlet Flow Rate, Temperature, Pressure, Driver Type, Shaft Power, Materials of Construction
Heaters (Fired)
Type, Tube Pressure, Tube Temperature, Duty, Fuel, Material of Construction
Others
Provide Critical Information

Equipment Information / Equipment Summary Table

See Table 1.7

Vessel	V-101	V-102
Temperature (°C)	55	38
Pressure (bar)	2.0	24
Orientation	Horizontal	Vertical
MOC	CS	CS
Size		
Height/Length (m)	5.9	3.5
Diameter (m)	1.9	1.1
Internals		s.p. (splash plate)

PFD Summary

- PFD, Equipment Summary Table, and Flow Summary Table represent a “true” PFD.
- This information is sufficient for a preliminary estimation of capital investment (Chapter 5) and cost of manufacture (Chapter 6) to be made

THANK YOU