Chapter 1 - Chemical Process Diagrams

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CHE 4101-Plant Design

The most effective way of communicating information about a process is through the use of flow diagrams.

Cyber Classroom

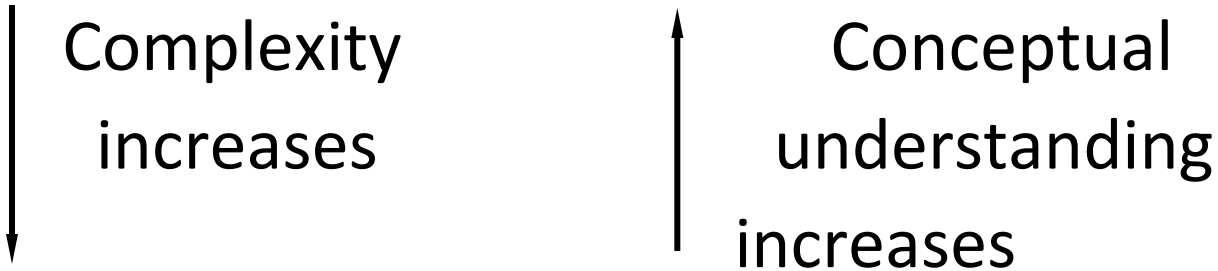
http://cyber.hankyong.ac.kr/index.jsp?epTicket=LOG-2-dTc74yB0jKYnrd1eGfSHYJUJohr07jNCGLk-50&_ep_sid_=D0EA50B6B626A81C44CA33BCE11D1011

Outline

- Flow Diagrams
  - Block Flow Diagrams (BFD)
  - Process Flow Diagrams (PFD)
  - Piping and Instrument Diagrams (P&ID)
- Other common diagrams
- 3-D plant layout diagrams

3 Levels of Diagram

- Block Flow Diagram (BFD)
- Process Flow Diagram (PFD)
- Piping and Instrumentation Diagram (P&ID) – often referred to as Mechanical Flow Diagram



As chemical engineers, we are most familiar with BFD and PFD.

The Block Flow Diagram (BFD)

- BFD shows overall processing picture of a chemical complex
  - Flow of raw materials and products may be included on a BFD
  - BFD is a superficial view of facility – Ch E information is missing

Block Flow Diagrams (BFD)

- Emphasis not on details regarding blocks; focus on flow of streams through process.

- Conventions:
  - Operations shown by blocks
  - Major flow lines shown with arrows giving flow direction
  - Flow goes from left to right whenever possible
  - Light streams toward top, heavy streams toward bottom
  - Critical information unique to the process supplied (i.e., reaction stoichiometry, conversion)
  - Avoid crossing lines; horizontal continuous, vertical broken.
  - Simplified material balance (overall)

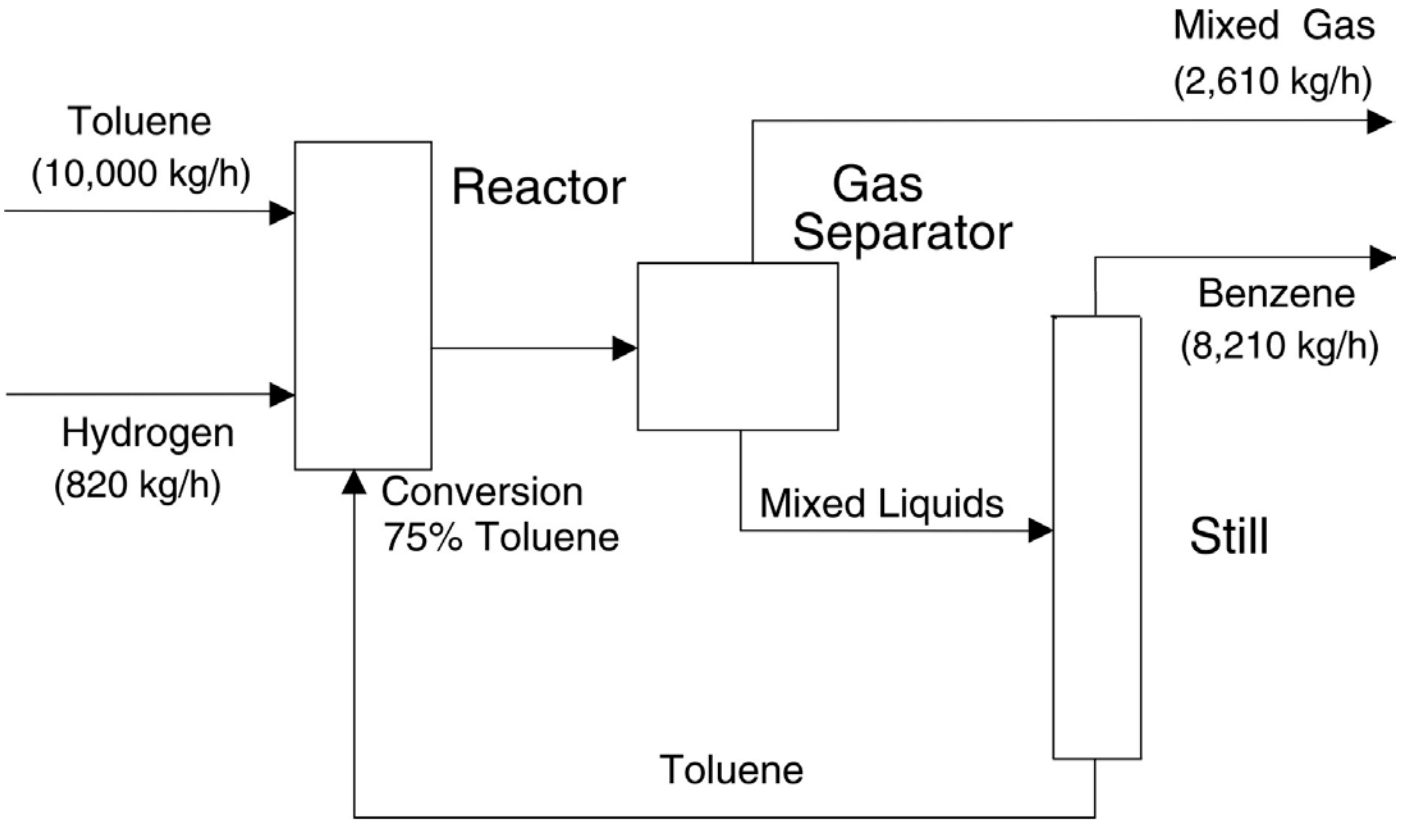
Definitions of BFD

- Block Flow Process Diagram
  - Figure 1.1
  - Similar to sketches in material and energy balances

Definitions of BFD

- Block Flow Plant Diagram
  - Figure 1.2
  - Gives a general view of a large complex plant

The Block Flow Process Diagram



Reaction : $C_7H_8 + H_2 = C_6H_6 + CH_4$

The Block Flow Plant Diagram

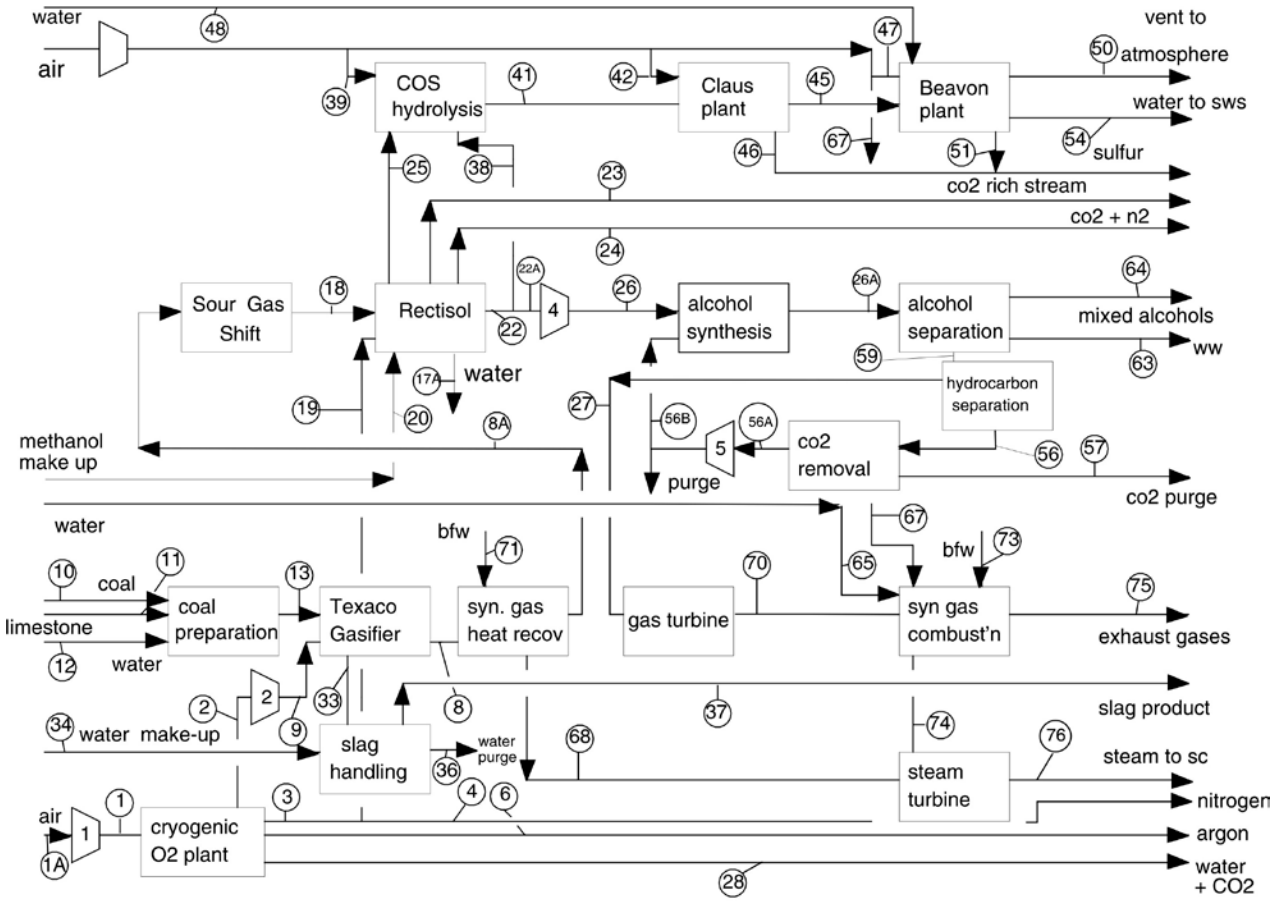


Figure 1.2: Block Flow Plant Diagram of a Coal to Higher Alcohol Fuels Process

The Process Flow Diagram (PFD)

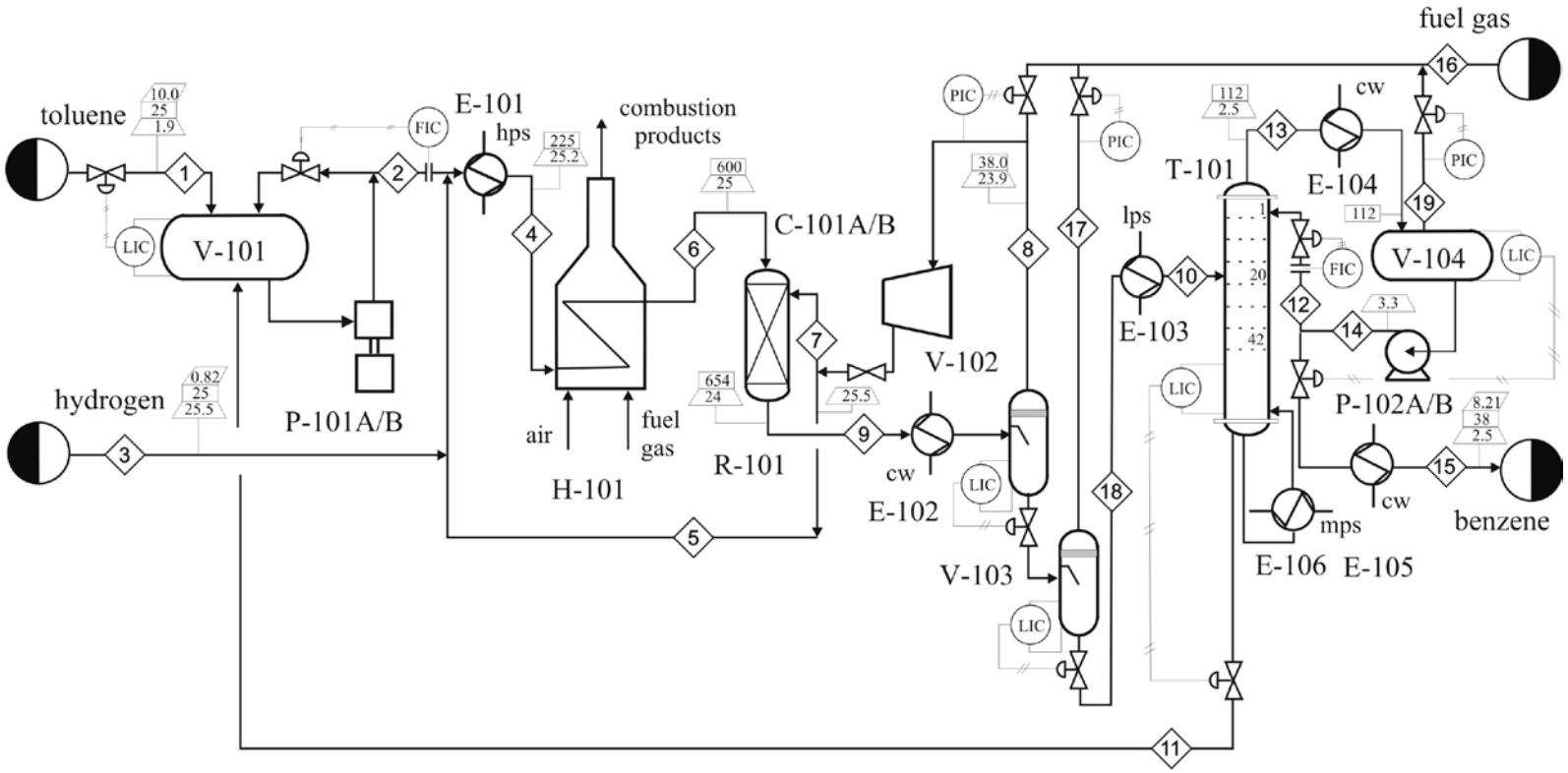
- PFD shows all process engineering information
- Typical conventions (vary by company):
  - All major equipment represented, uniquely numbered
  - All process flow streams shown and uniquely numbered, with description of thermodynamic conditions and composition (often in an accompanying table)
  - All utility streams supplied to major process equipment shown
  - Basic control loops, illustrating control strategy during normal operation

The Process Flow Diagram (cont'd)

- The topology of the process – showing the connectivity of all the streams and the equipment
  - Example for toluene HDA – Figures 1.3 and 1.5
  - Tables 1.2 and 1.4 – list information that should be on the PFD but cannot fit
  - Use appropriate conventions – consistency is important in communication of process information
  - ex. Table 1.2

Process Flow Diagram (cont'd)

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



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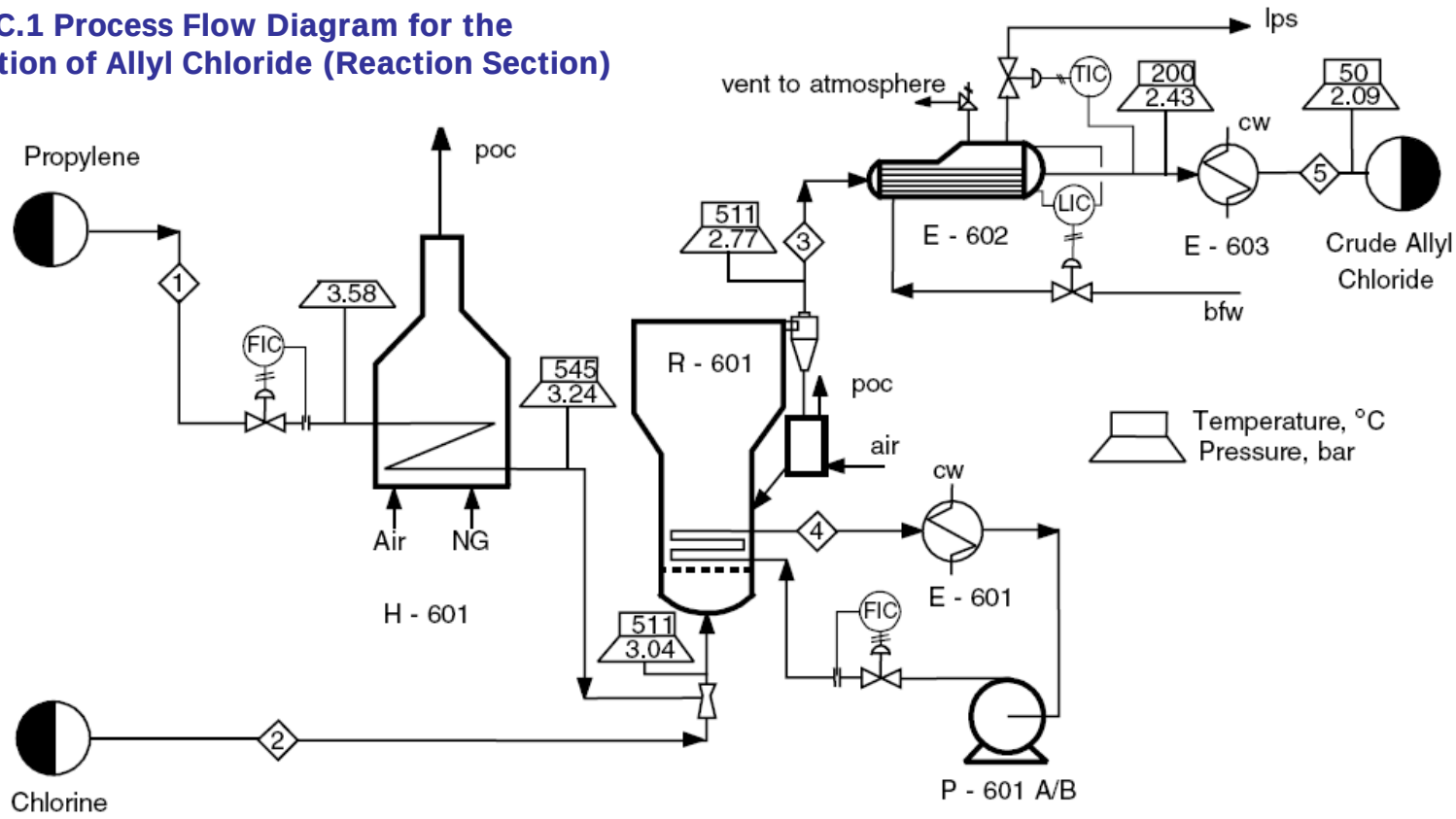
Process Flow Diagram (cont'd)

H-601	R-601	J-601	E-601	P-601 A/B	E-602	E-603
Reactor Feed Heater	Fluidized Bed Reactor	Jet Mixer	Dowtherm Cooler	Dowtherm Pumps	Waste Heat Boiler	CrudeAllyl Chloride Cooler

Figure C.1 Process Flow Diagram for the Production of Allyl Chloride (Reaction Section)

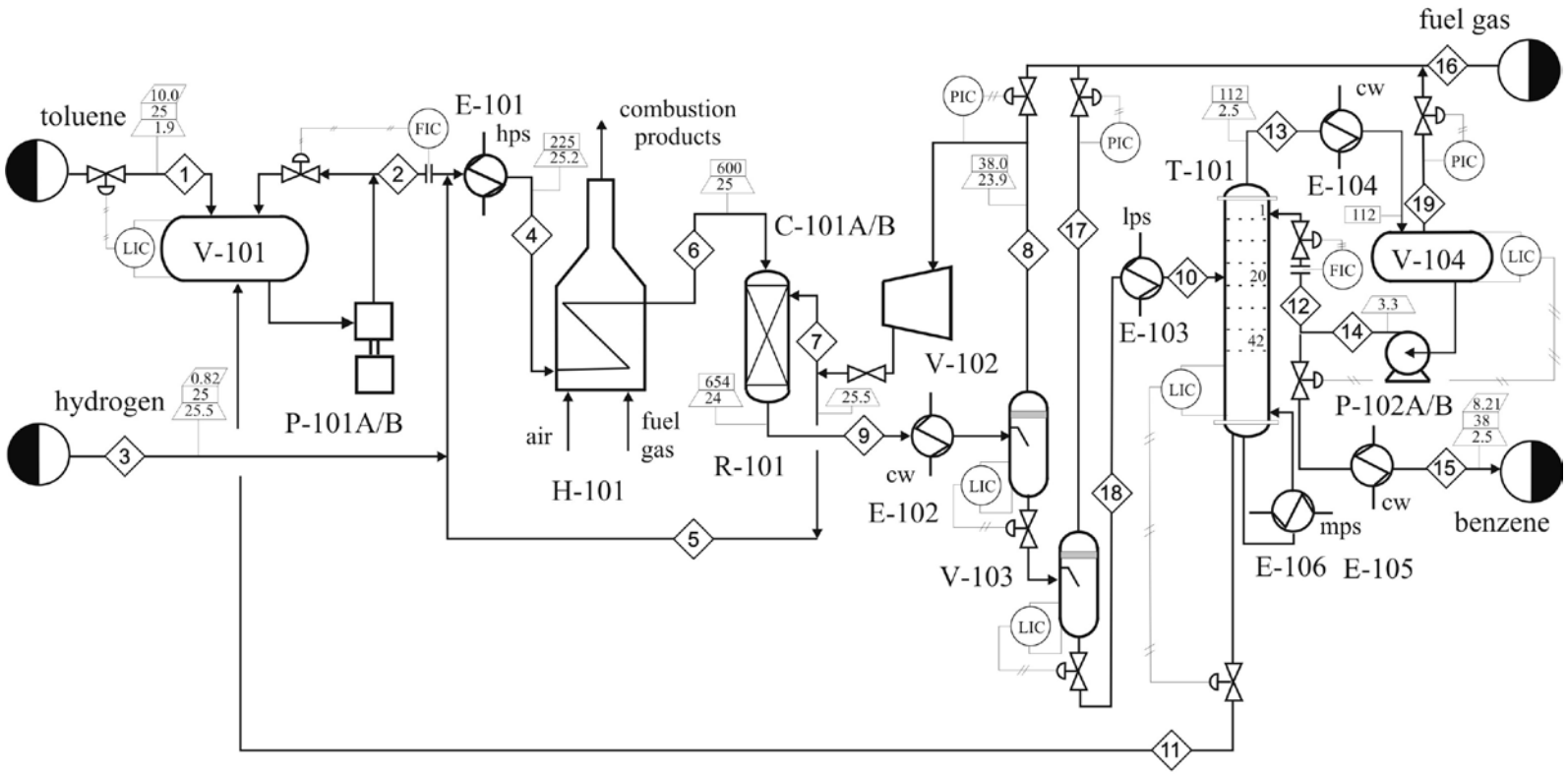


Equipment Numbering

- 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 equipment number of unit (1-99)
  - A/B/… represents presence of spare equipment

Equipment Numbering (cont'd)

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



Equipment Numbering (cont'd)

- T-905 is the 5th tower in unit nine hundred

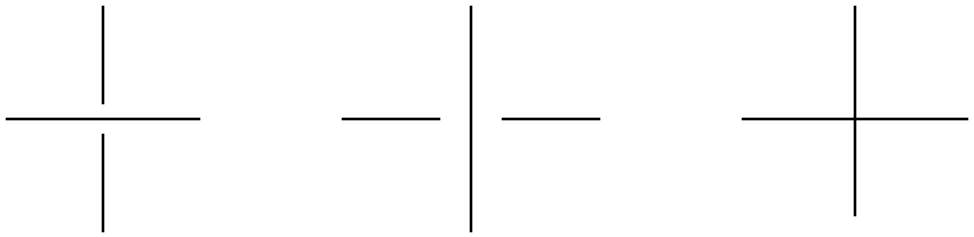
- P-301 A/B is the 1st Pump in unit three hundred plus a spare

Equipment Numbering (cont'd)

- Use unambiguous letters for new equipment
  - Ex. Turbine use Tb or J not T (used for tower)
  - Replace old vessel V-302 with a new one of different design - use V-319 (e.g.) not V-302 – since it may be confused with original V-302

Stream Numbering & Drawing

- Number streams left to right when possible
- Horizontal lines are dominant



yes no no

Stream Numbering & Drawing (cont'd)

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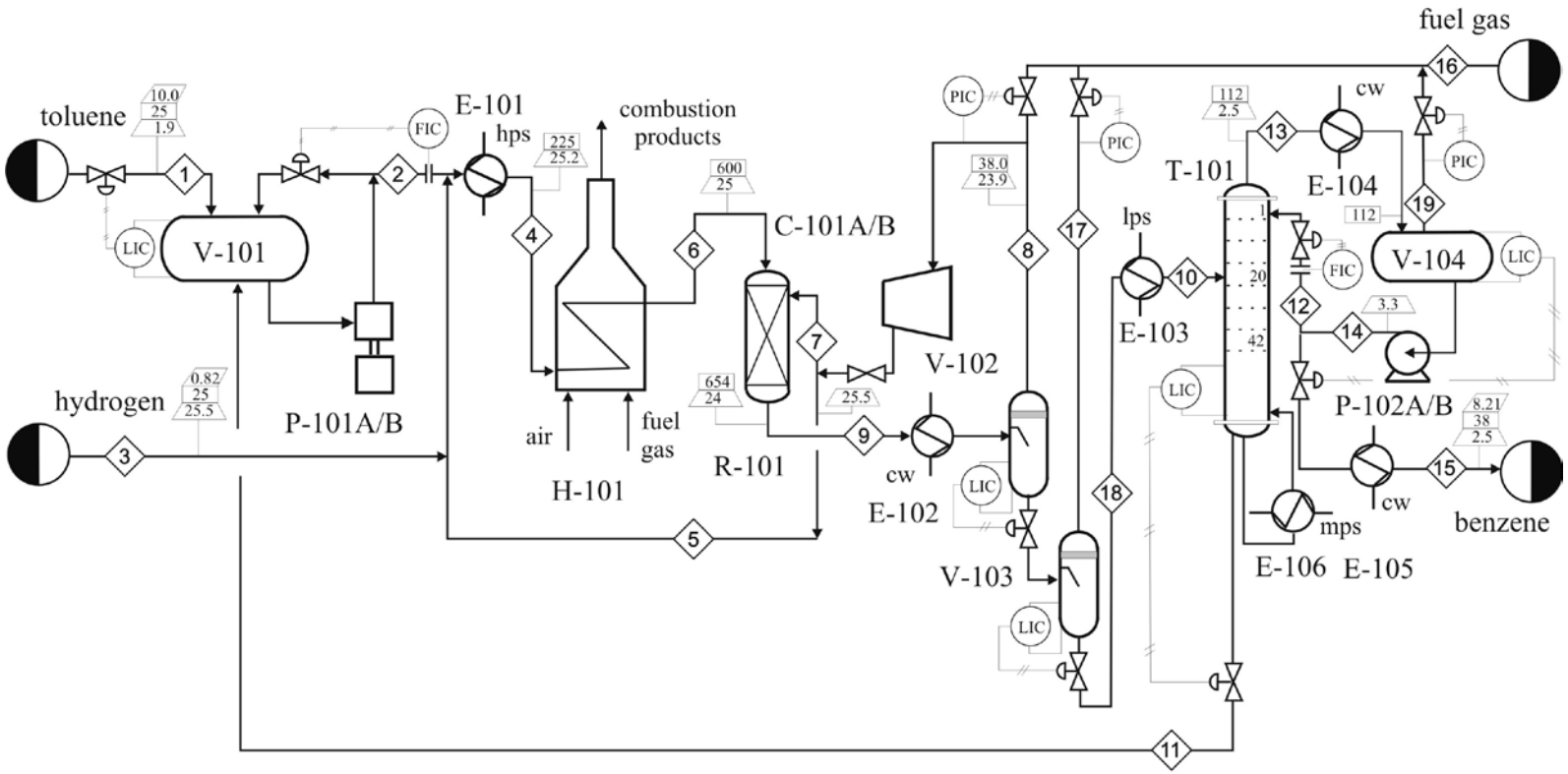

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Stream Numbering & Drawing (cont'd)

- Add arrows for
  - change in direction
  - inlet of equipment

- Utility streams
  - use convention in Table 1.3
  - lps, cw, fg, etc.

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 Numbering & Drawing (cont'd)

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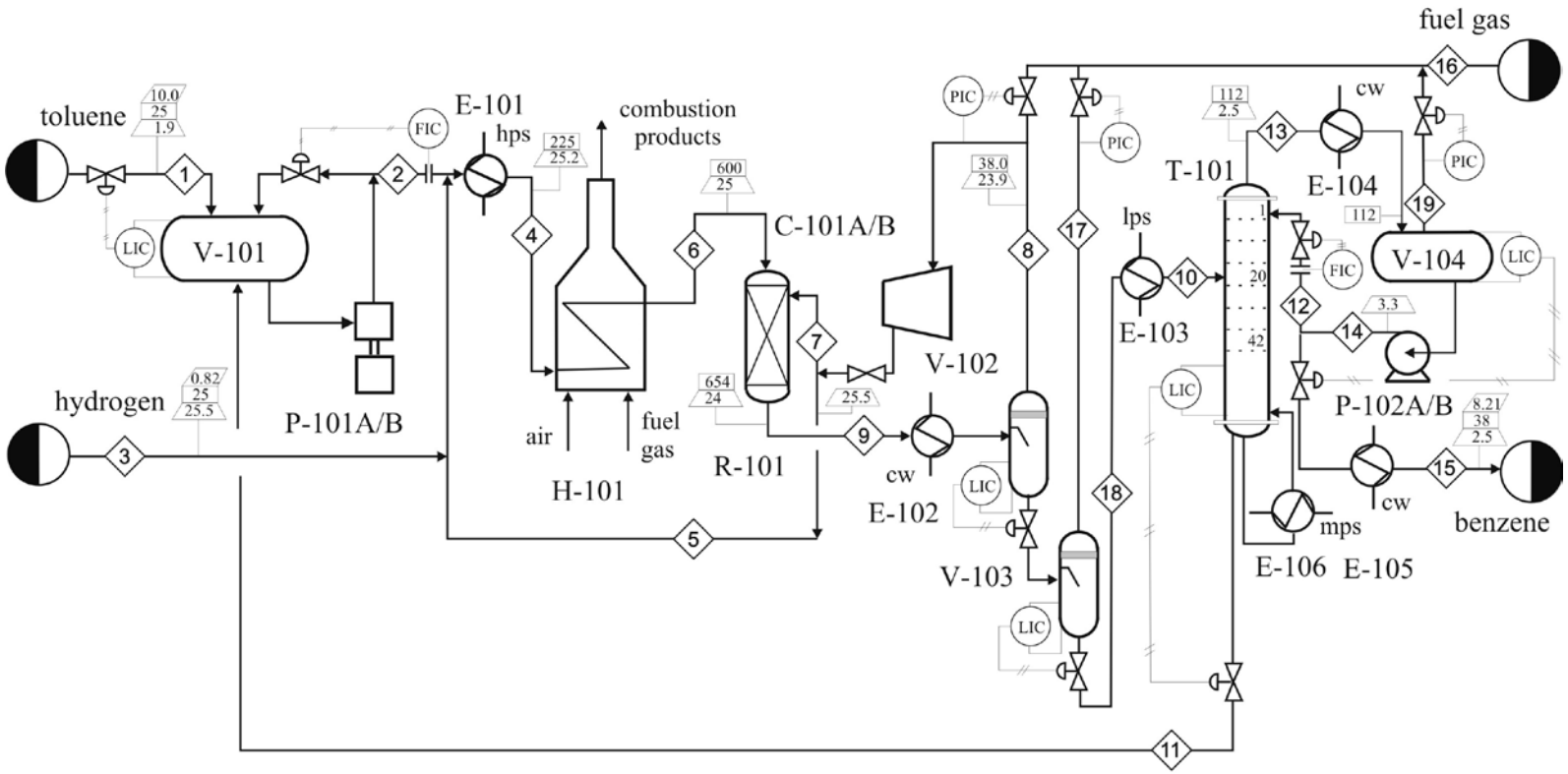

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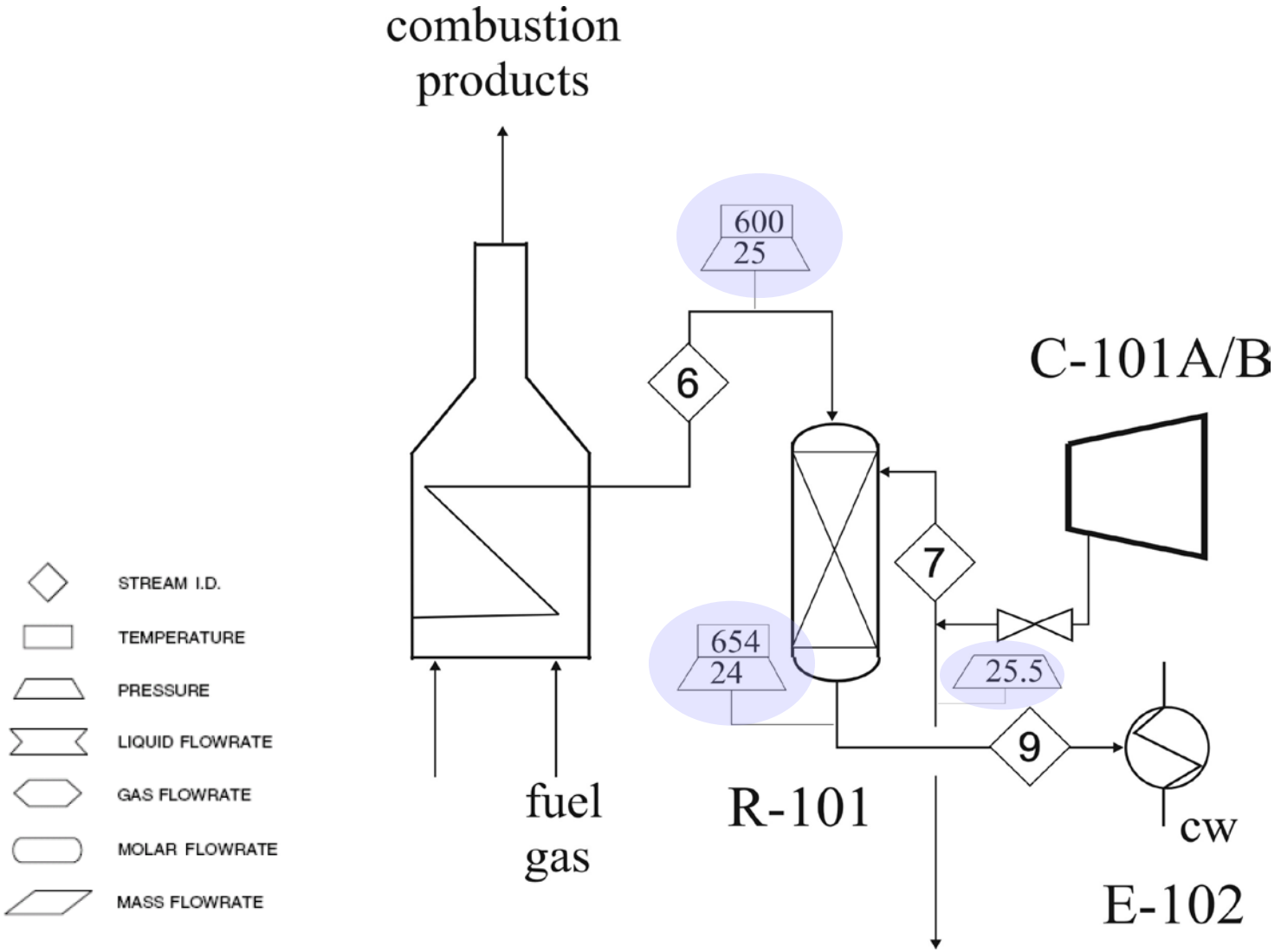
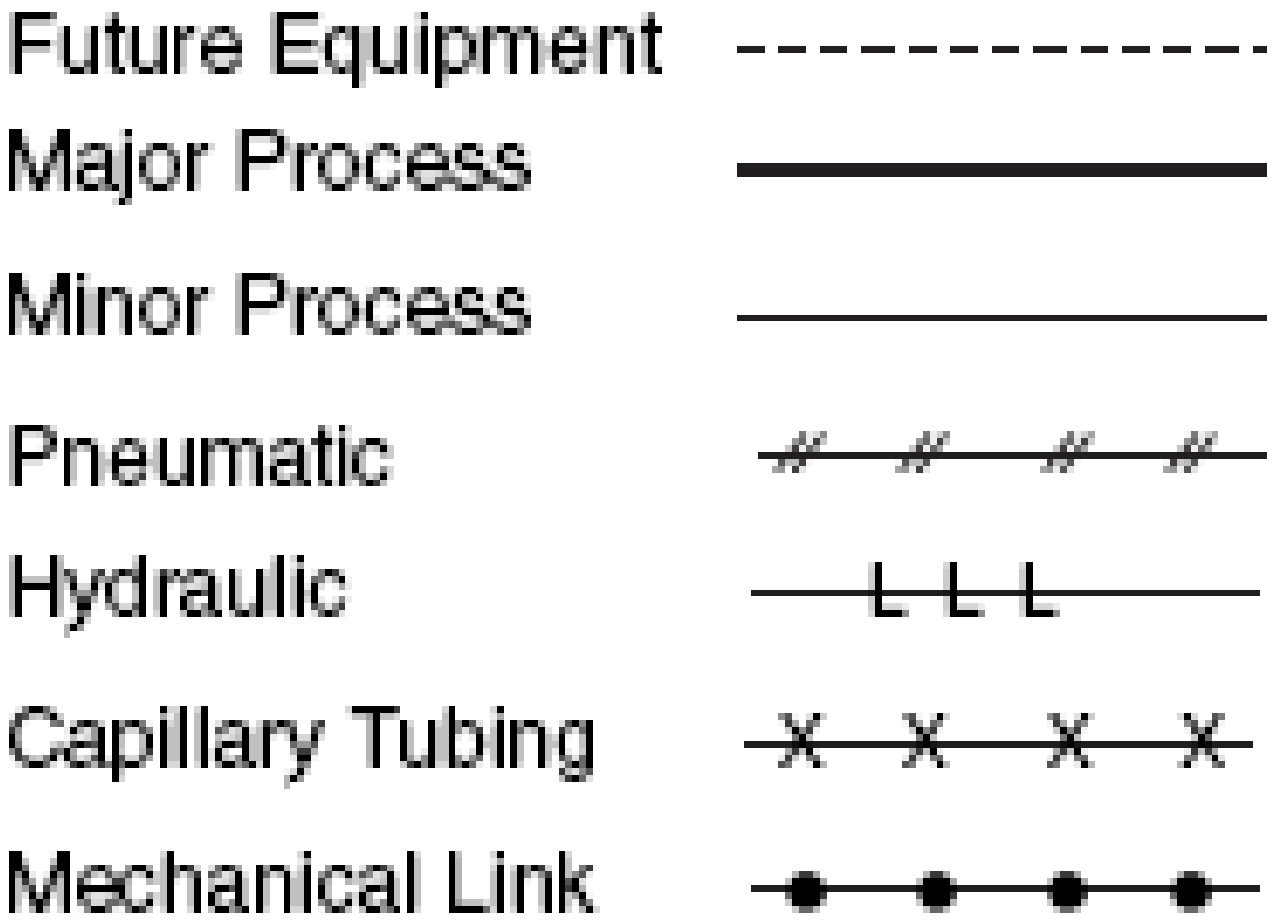
Stream Information - Flags



Stream Drawing



Stream Drawing

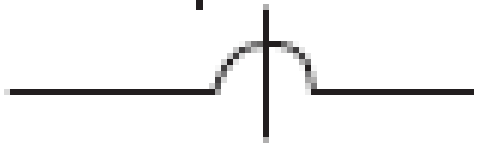
Electromagnetic, Sonic
Optical, Nuclear

Electric

Connecting Line

Non-Connecting Line

Non-Connecting Line



Jacketed or Double Containment

Software or Data Link

The Process Flow Diagram (cont'd)

Essential Information

Stream Number
Temperature (°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

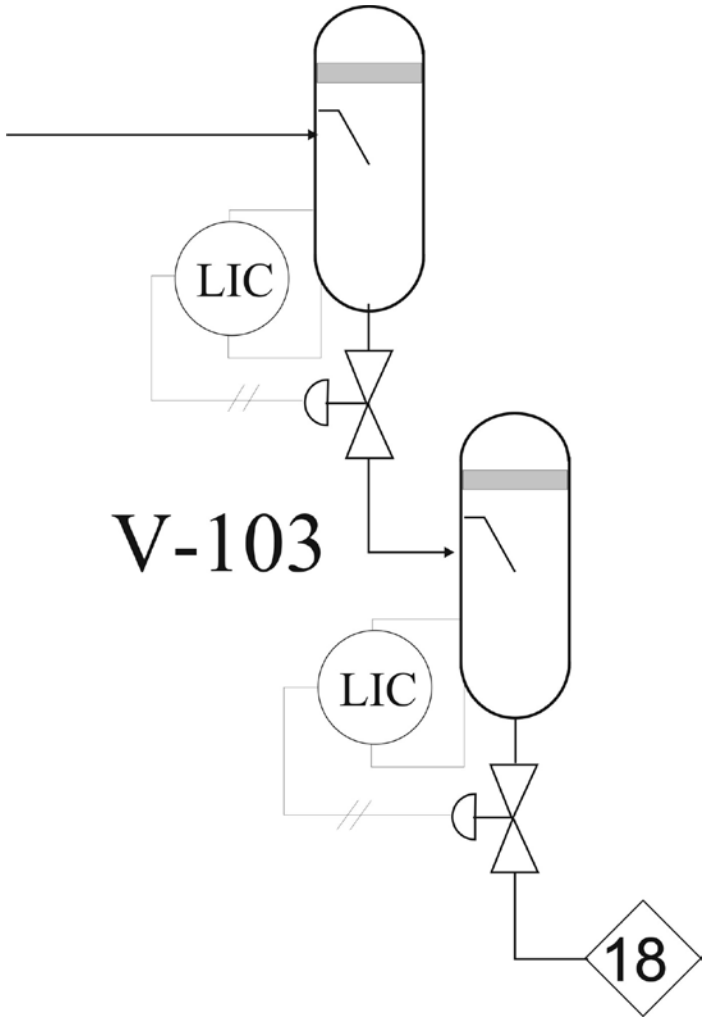
Table 1.4: Information in a Flow Summary

Basic Control Loops

- Often the basic control loops (those involving maintaining material balance and reactor controls) are included on the PFD; instrumentation and other control loops are not shown

- The final control element in nearly all chemical process control loops is a valve.

Basic Control Loops



Basic Instrumentation Symbols