CH0204 Organic Chemical Technology

Lecture 1

Introduction to Chemical Production Processes

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Assistant Professor (OG)
Department of Chemical Engineering

- Anatomy of Chemical Process
- Terminologies
- Overview of topics covered in OCT

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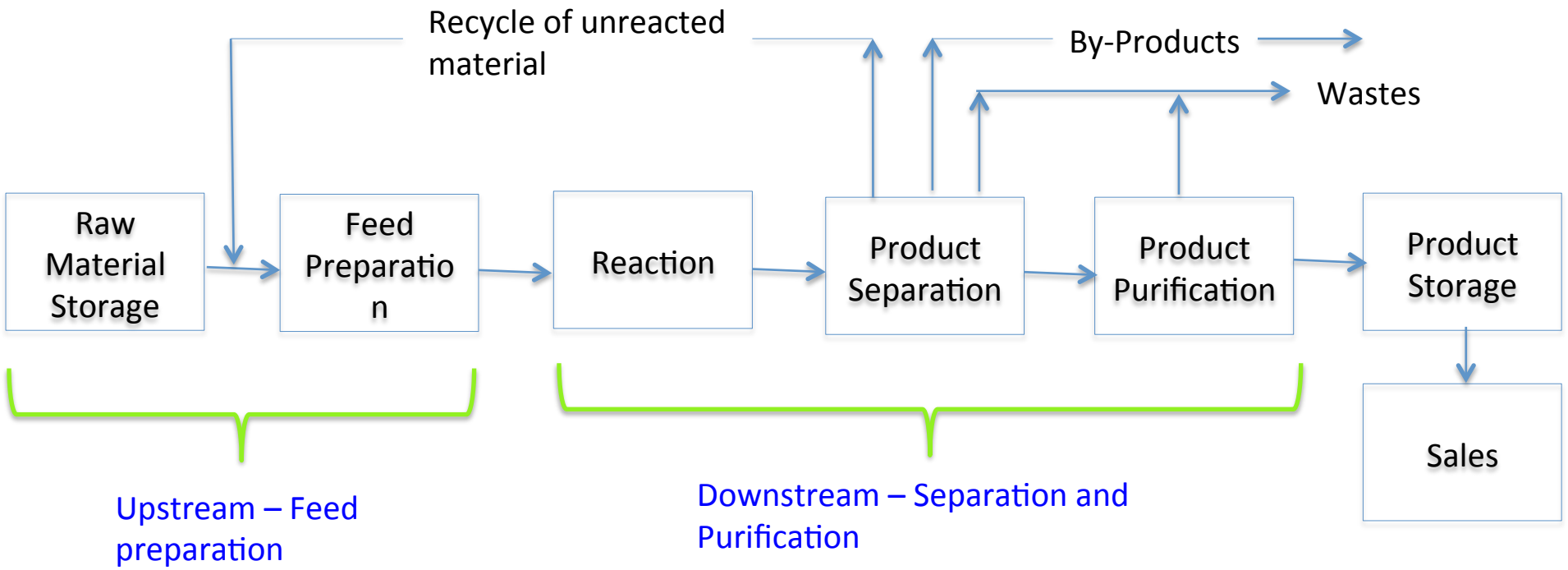
Anatomy of Chemical Process



Source: Sinnott R. K, (1999) Coulson and Richardson's, Chemical Engineering Design, Vol 6, 3rd Edition, Elseveir, Pp 5.

- Anatomy of Chemical Process
- Terminologies
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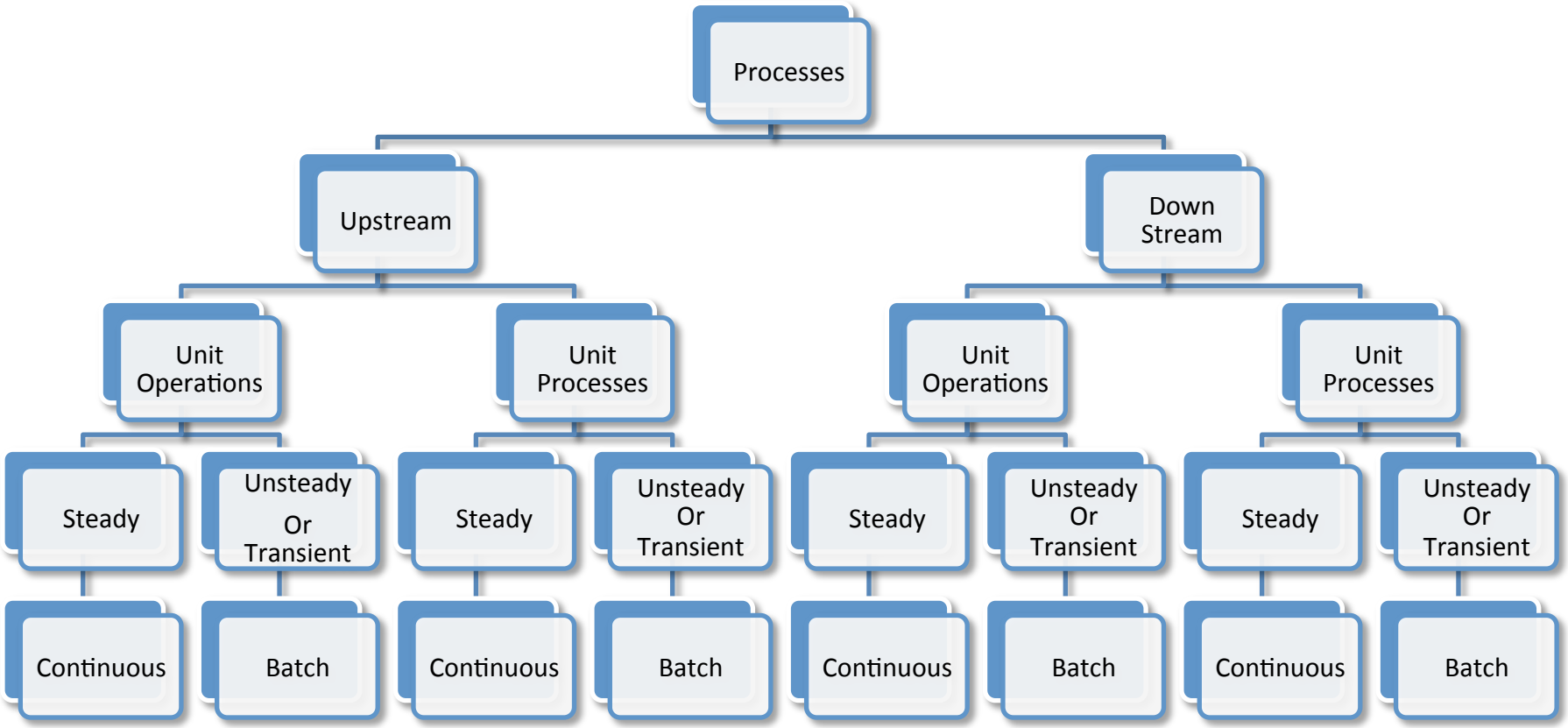
Anatomy of Chemical Process

Terminologies

Overview of topics covered in OCT

Terminologies



Terminologies

Process

Dictionary meaning

A process is one or series of actions or operations or treatments that results in an end [Product].

Working definition

In Chemical Engineering , the term process focus on operations such as chemical reactions, fluid transport, size reduction and enlargement, heat generation and transport, distillation, gas absorption, bioreactors and so on that cause physical and chemical change in materials.

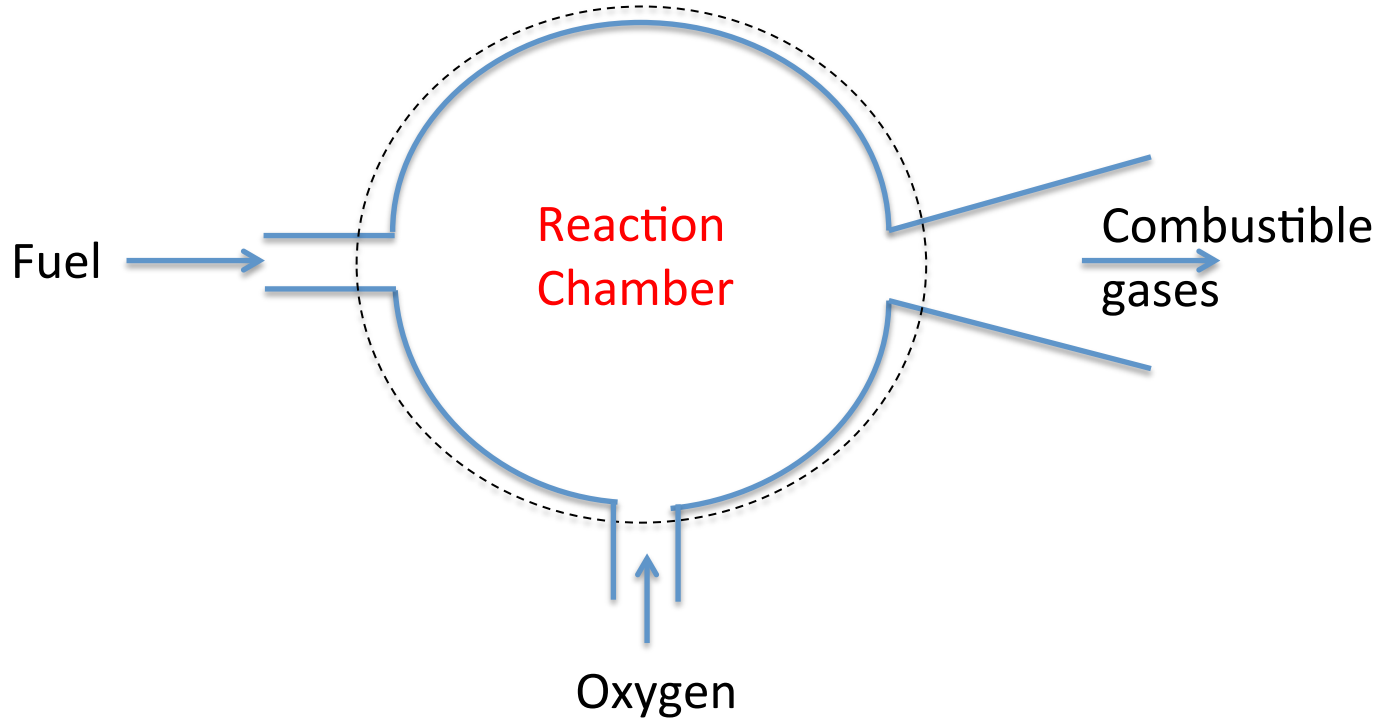
Source: David M. Himmelblau (1997) Basic Principles and Calculations in Chemical Engineering, 6th edition, Prentice Hall India, Pp 142 - 143.

Terminologies

System

Any arbitrary portion or whole of process set out specifically for analysis.

In other words, the system is the one where we focus our attention.



Source: David M. Himmelblau (1997) Basic Principles and Calculations in Chemical Engineering, 6th edition, Prentice Hall India, Pp 142 - 143.

Terminologies

Upstream Process

The process that are employed in petrochemical, chemical and biochemical industries where the raw materials are processed.

The various process that are covered till the separation and purification of raw materials are called upstream process or feed preparation process in the above mention process industries.

Downstream Process

The process by which separation and purification of products from raw materials takes place.

Terminologies

Unit Operations

Unit operations is the one or series of operations in which only physical changes are studied with the combination of science and engineering principles. e.g Distillation, Evaporation, Drying and so on.

Unit Processes

Unit process is the one or series of operations in which chemical changes are studied with the combination of science and engineering principles. e.g. Alkylation, Hydrogenation, Esterification and so on.

Terminologies

Continuous Process

Continuous process are designed to operate 24 hours a day, 7 days a week, throughout the year. Some downtime (Shut down and Start up) will be allowed for maintenance and for some processes, catalyst regeneration.

The plant attainment, that is, the percentage of available hours in a year that the plant operates, will be usually 90 t0 95%.

Attainment, % = (hours operated)/(8720 days) x 100

Continuous processes will be more economical for large scale production.

Source: Sinnott R. K, (1999) Coulson and Richardson's, Chemical Engineering Design, Vol 6, 3rd Edition, Elseveir, Pp 7.

Terminologies

Batch Process

Batch processes are designed to operate intermittently (or periodically). Some or all, the process units being frequently shut down and start up.

Batch processes are used where some flexibility is wanted in production rate or product specification.

Source: Sinnott R. K, (1999) Coulson and Richardson's, Chemical Engineering Design, Vol 6, 3rd Edition, Elseveir, Pp 7-8.

Terminologies

Steady-state process

Steady-state process is one, where the parameters such as temperature, pressure, and concentration remains unchanged with time.

Unsteady-state (or transient) process

Unsteady-state process is one, where the parameters such as temperature, pressure, and concentration changes with time.

Terminologies

Recycle stream

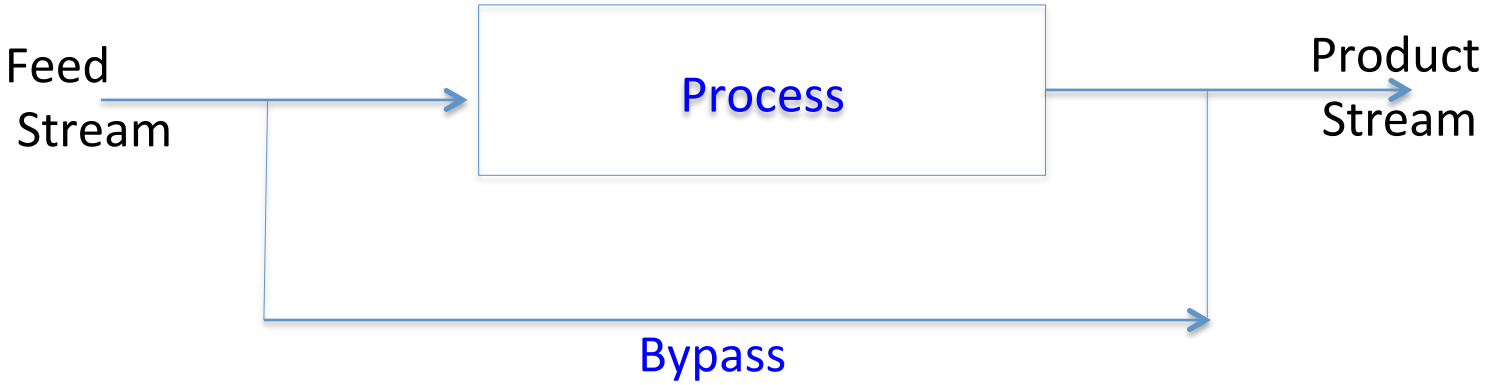
A common recycle stream structure is the reactor/separator, which is used to recover unreacted material.

Terminologies

By pass stream

By pass operation is the one in which one or more steps in the production process is skipped off.

Most often this kind of streams are used for maintenance and or service of equipment in continuous production process.



Terminologies

Purge

When a process uses a recycled loop, there often can be build up of some undesired material inside the system. By using a purge a fraction of the recycle loop material or accumulated undesired materials can be removed.

Terminologies

Process Diagram

Representation of flow of various streams in the production processes and they are grouped as follows,

1. Block Diagram
2. Process Flow Diagram (PFD)
3. Process and Instrumentation Diagram (P and I D's)

Terminologies

1. Block Diagram

A block diagram is the simplest form of presentation.

Each block can represent a single piece of equipment or complete stage in process.

Block diagrams are useful for representing a process in a simplified form in reports and text books, but only have limited use in as engineering documents.

Source: Sinnott R. K, (1999) Coulson and Richardson's, Chemical Engineering Design, Vol 6, 3rd Edition, Elseveir, Pp 130.

Terminologies

2. Process Flow Diagram (PFD)

A process flow diagram is one in which all incoming and out going materials and utilities are shown .

Process flow diagrams includes ,

a. Arrangement of major pieces of equipment's and their interconnections.

b. Operating conditions of each streams, such as temperature pressure and composition.

c. Heat added or removed in a particular equipment .

d. Any specific information which is useful in understanding the process.

Source: Bhatt. B. I and Vora, (1999) Stoichimetry, Vol 6, 4th Edition, Tata Mc Graw Hill, Pp 130.

Terminologies

3. Piping and Instrumentation Diagram (P & I D's)

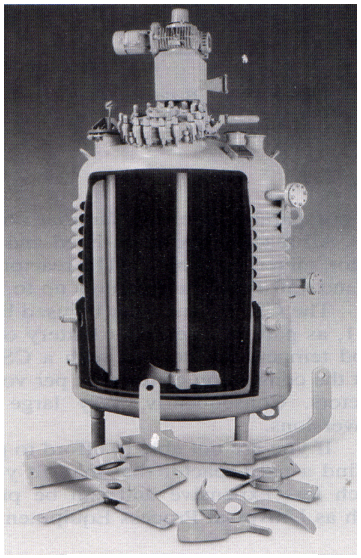
Piping and instrumentation diagram shows the engineering details of the equipment, instruments, piping, valves and fittings; and their arrangement.

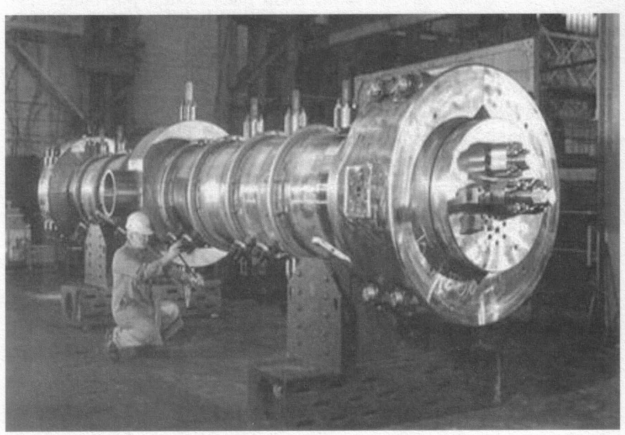
P & I diagram also shows the arrangement of the process equipment, piping, pumps, instruments, valves, control loop and other fittings.

For simple process, the utility (service) lines can be shown on the P & I diagram. For Complete process, separate diagrams should be used to show the service line.

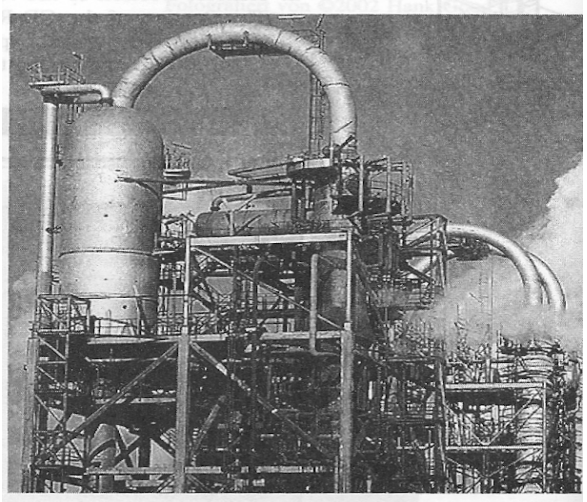
Terminologies

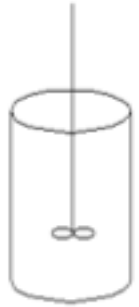
Schematic representation of equipment that are used in flow diagrams

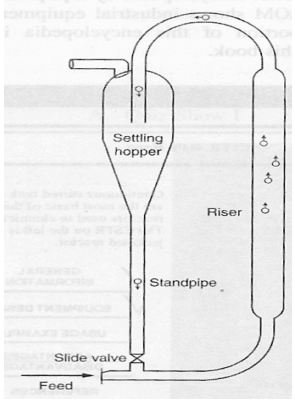




Polyethylene reactor; this 16-in inner-diameter reactor is designed to operate at 35,000 psi and 600°F; in operation, this reactor is in a vertical configuration. Courtesy of Autoclave Engineers, Division of Snap-tite, Inc.







Source: Scott Fogler. H, (2006) Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall India, Pp 19-29.

Terminologies

Schematic representation of equipment that are used in flow diagrams

British Standard, BS1553 “Graphical symbols for general engineering ”

American National Standard Institute, ANSI

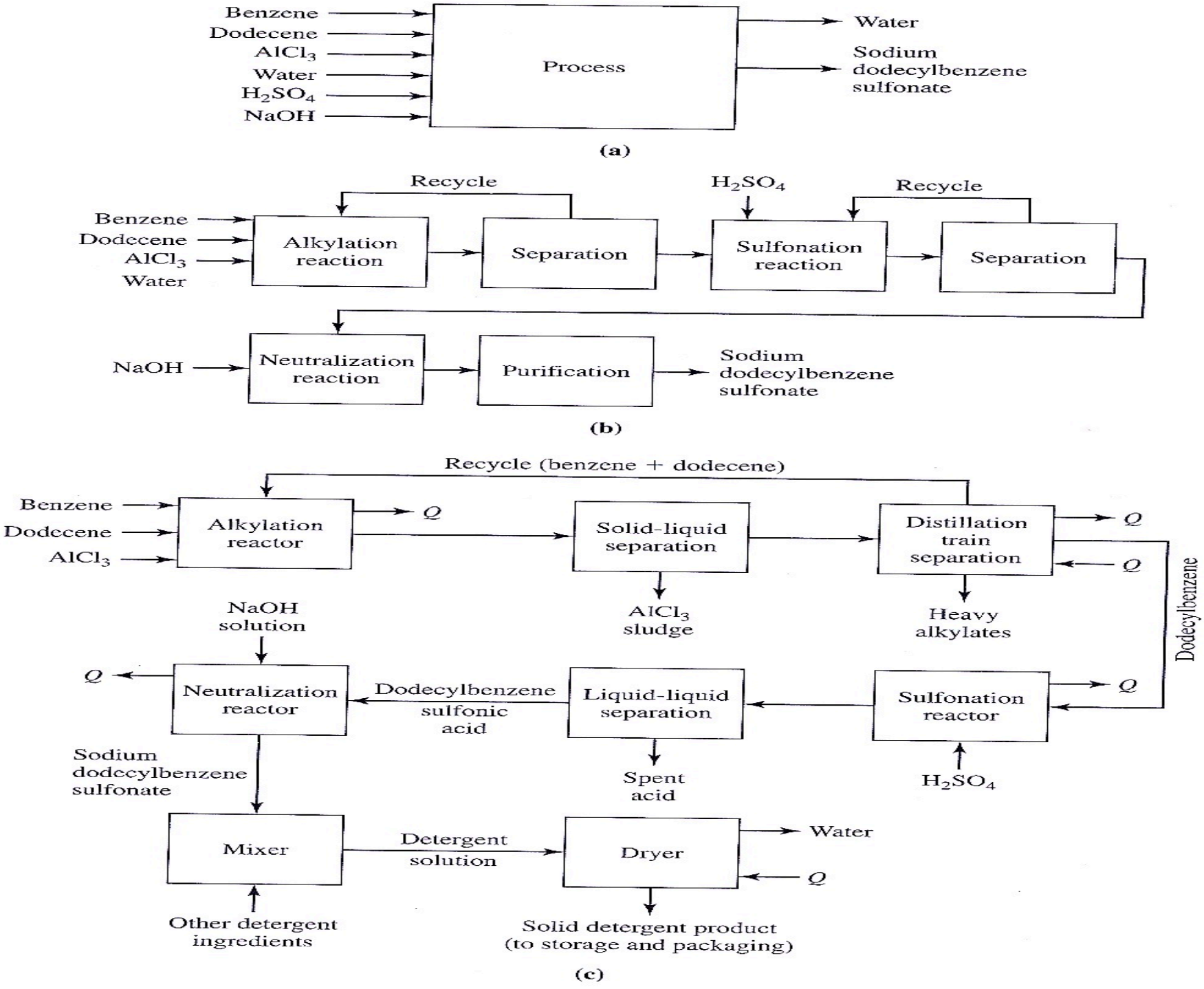
German Standard, DIN 28004

Source: Sinnott R. K, (1999) Coulson and Richardson’s, Chemical Engineering Design, Vol 6, 3rd Edition, Elseveir, Pp 130.

Terminologies

Block diagram - Sodium dodecyl benzene

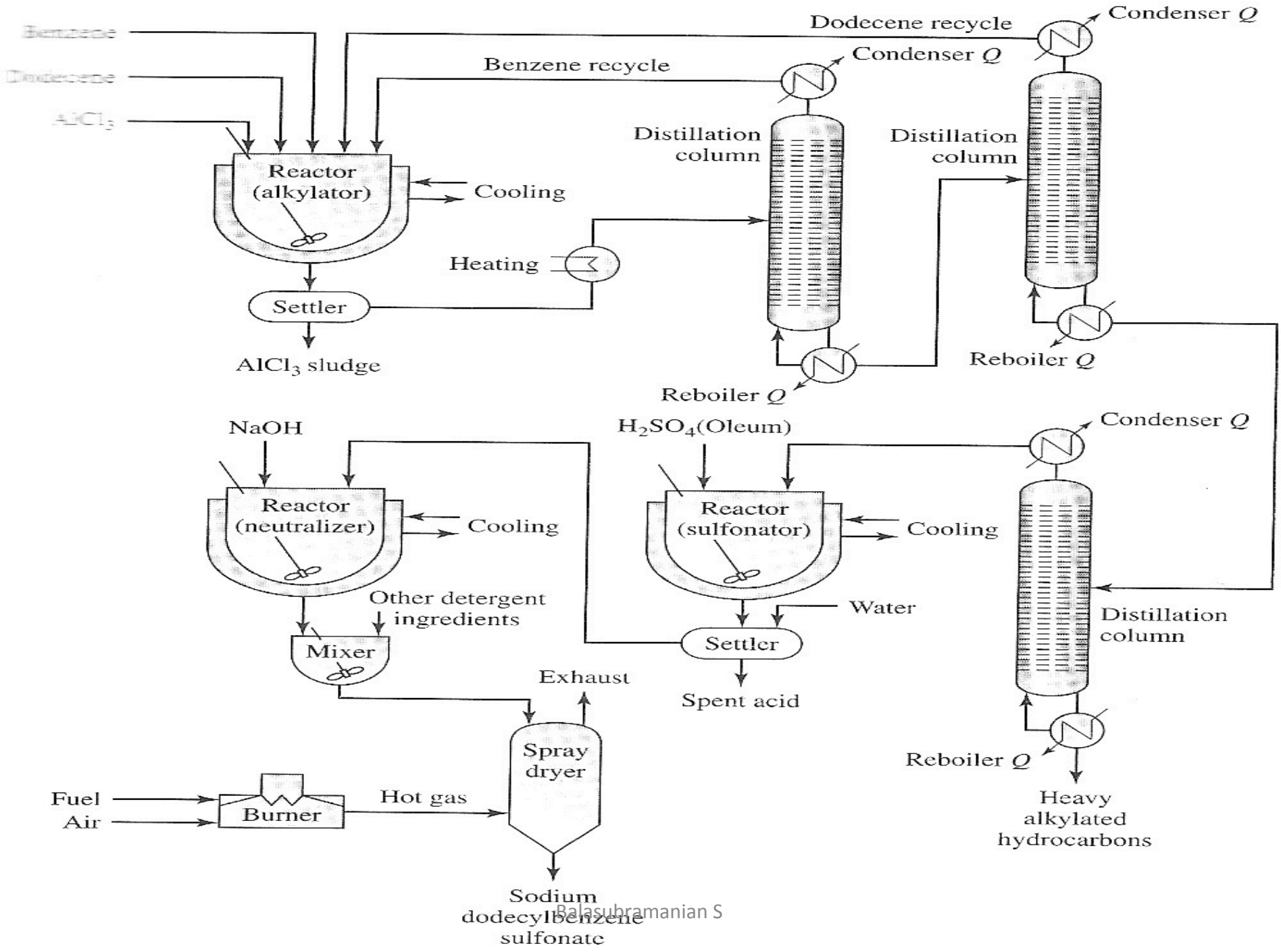
Source: Max S. Peters, Klaus D. Timmerhaus, Ronald E. West, (1997) Plant Design and Economics for Chemical Engineers , 5th Mc. Graw Hill, Pp 128.


Benzene
Dodecene
AlCl3
Water
H2SO4
NaOH
Process
Water
Sodium dodecylbenzene sulfonate
(a)
Recycle
H2SO4
Recycle
Benzene
Dodecene
AlCl3
Water
Alkylation reaction
Separation
Sulfonation reaction
Separation
NaOH
Neutralization reaction
Purification
Sodium dodecylbenzene sulfonate
(b)
Recycle (benzene + dodecene)
Benzene
Dodecene
AlCl3
Alkylation reactor
Q
Solid-liquid separation
Distillation train separation
Q
Q
AlCl3 sludge
Heavy alkylates
Dodecylbenzene
NaOH solution
Q
Neutralization reactor
Dodecylbenzene sulfonic acid
Liquid-liquid separation
Sulfonation reactor
Q
Spent acid
H2SO4
Sodium dodecylbenzene sulfonate
Mixer
Detergent solution
Dryer
Water
Q
Other detergent ingredients
Solid detergent product (to storage and packaging)
(c)

Terminologies

Process flow diagram - Sodium dodecyl benzene

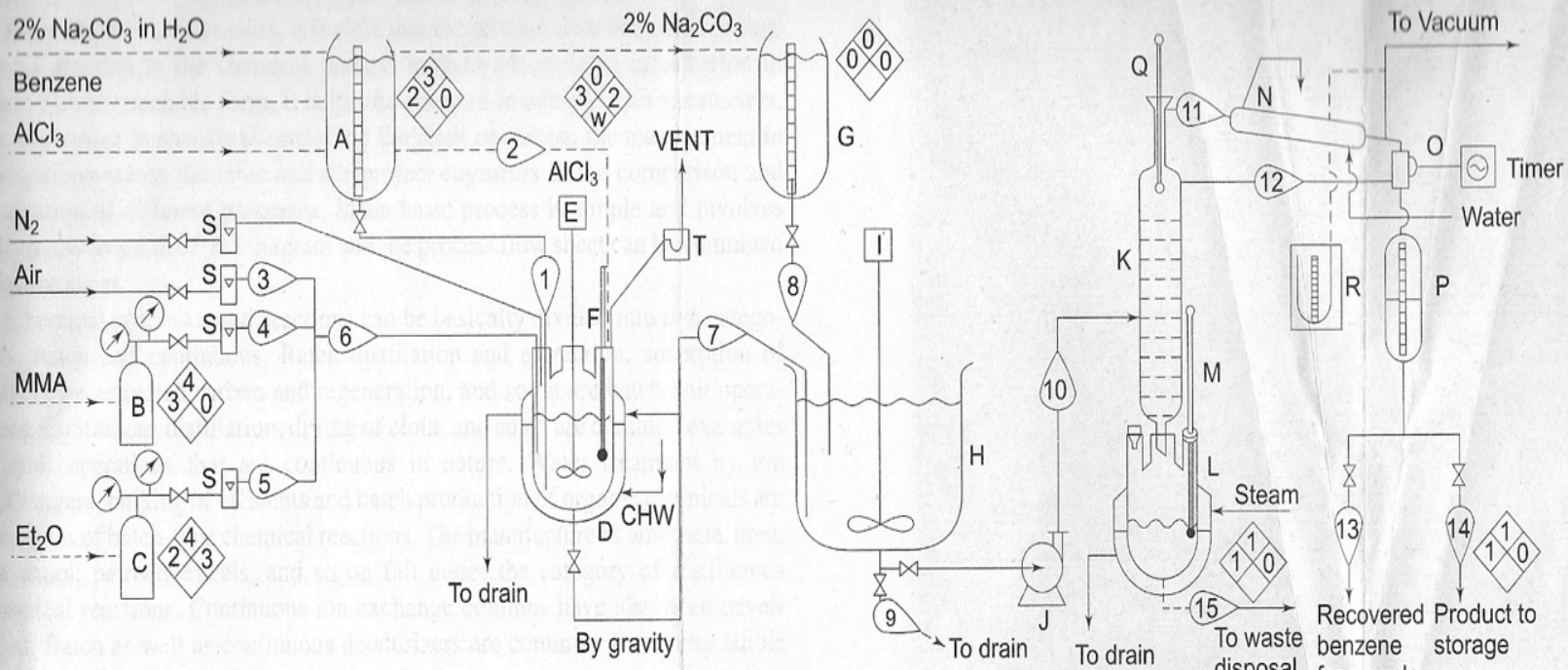
Source: Max S. Peters, Klaus D. Timmerhaus, Ronald E. West, (1997) Plant Design and Economics for Chemical Engineers , 5th Mc. Graw Hill, Pp 128.



Terminologies

Process flow diagram – Phenyl ethyl alcohol production

Source: Max S. Peters, Klaus D. Timmerhaus, Ronald E. West, (1997) Plant Design and Economics for Chemical Engineers , 5th Mc. Graw Hill, Pp 128.



Line no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Process material or description	Benzene	Aluminium chloride	Air	MMA	Ethylene oxide	Feed gas	Crude product	2% Na_2CO_3	Decanted water	Column feed	Over head	Reflux	Recovered benzene	Phenylethyl alcohol	Residue
Physical state	L	S	G	G	G	G	L	L	L	L	G	L	L	L	L
Flow units	mL	g	cc/s	cc/s	cc/s	mL	mL	mL	mL	mL/s	L/s	mL/s	mL	mL	mL
Rate or quantity	810	61	0.125	0.042	0.67	250	850	500	520	0.083	0.42	0.083	740	62	28
Pressure torr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	760/10	760/10	0.0	0.0	0.0
Density kg/L	0.88	2.44	0.0012	0.0013	0.0018	0.0017	0.96	1.02	1.06	0.92	0.00004	0.88/1.02	0.88	1.02	1.1
Temperature K	298	298	298	298	298	298	283	298	298	298	353/373	348	303	303	298
Boiling point K	353.1	–	88	266.5	283.7	–	355	378	381	353	353/373	353/373	353.1	493	283
Freeze point K	278.5	–	20	181	162	–	277	268	267	277	279/246	279/246	278.5	246	272
Flash point K	262	NF	NF	205	216	213	262	NF	NF	262	262/357	262/357	262	357	NF
Molar mass	78.1	133.3	28.9	31.1	44.0	40.5	~ 83	~19	~20	~ 80	78/122	78/122	78.1	122.2	~18
Composition by %	mole	mole	mole	mole	mole	mole	mole	mole	mass	mole	mole	mole	mole	mole	mole
Benzene	100	0	0	0	0	0	86.9	0	0.1	93.8	100→0	100→0	100	0.1	0.0
$AlCl_3$	0	100	0	0	0	0	4.7	0	12.1	0.0	0.0	0.0	0.0	0.0	0.0
Ethylene oxide	0	0	0	0	100	80	0.8	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monomethyl amine	0	0	0	100	0	5	0.1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bibenzyl	0	0	0	0	0	0	0.7	0	0.0	0.4	0.0	0.0	0.0	0.1	0.4
Phenylethylal cohol	0	0	0	0	0	0	6.8	0	1.4	5.8	0→100	0→100	0.0	99.8	99.6
Miscellaneous			100			15		100	86.4						

Health, flammability and reactivity hazards of NFPA, USA

Utilities:
Air, electricity, refrigerant
Steam, water, nitrogen.

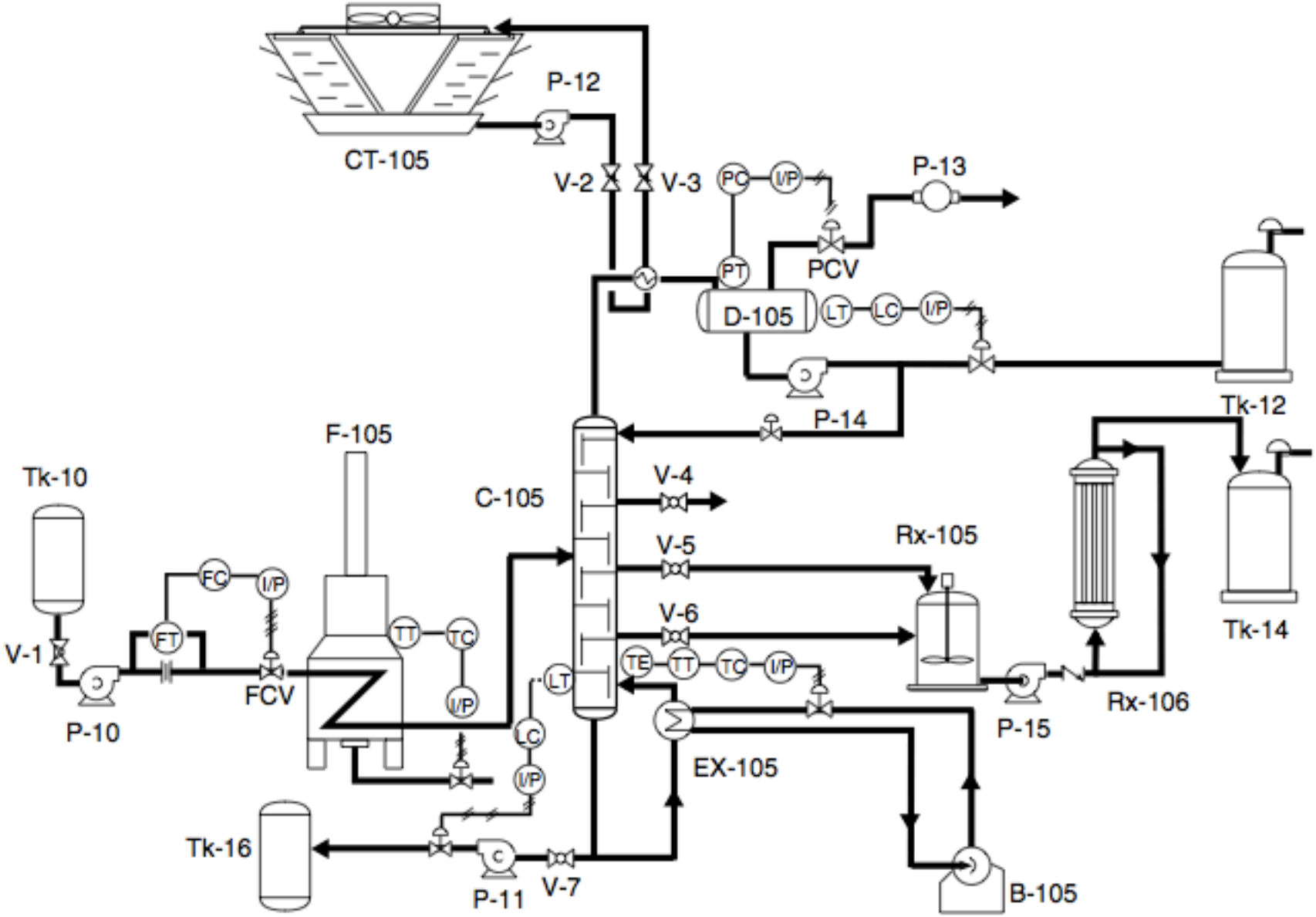
Vessel letter	Code	Requirement and duration
D	A	0.125 mL/s, 4 hours
D	N	51+0.167 mc/s, 4 hours
D	R	283 K H_2O,0.167 mL/s, 4 hou
E	E	40 W, 4 hours
I	E	100 W, 0.3 hours
J	E	15 W, 30 hours
L	S	50 kPa g
N	W	298 K (25°C),0.167 mL/s, 30 h

Ref. U.S. Patent No.
2047 386, 2125 490

Terminologies

Piping and Instrumentation Diagram (P & I D's)

Source: Max S. Peters, Klaus D. Timmerhaus, Ronald E. West, (1997) Plant Design and Economics for Chemical Engineers , 5th Mc. Graw Hill, Pp 128.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P-12
V-2
V-3
PC
I/P
P-13
PCV
PT
D-105
LT
LC
I/P
P-14
Tk-12
Tk-14
F-105
Tk-10
C-105
V-4
V-5
V-6
Rx-105
FC
I/P
FT
V-1
TT
TC
I/P
FCV
P-10
LT
TE
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TC
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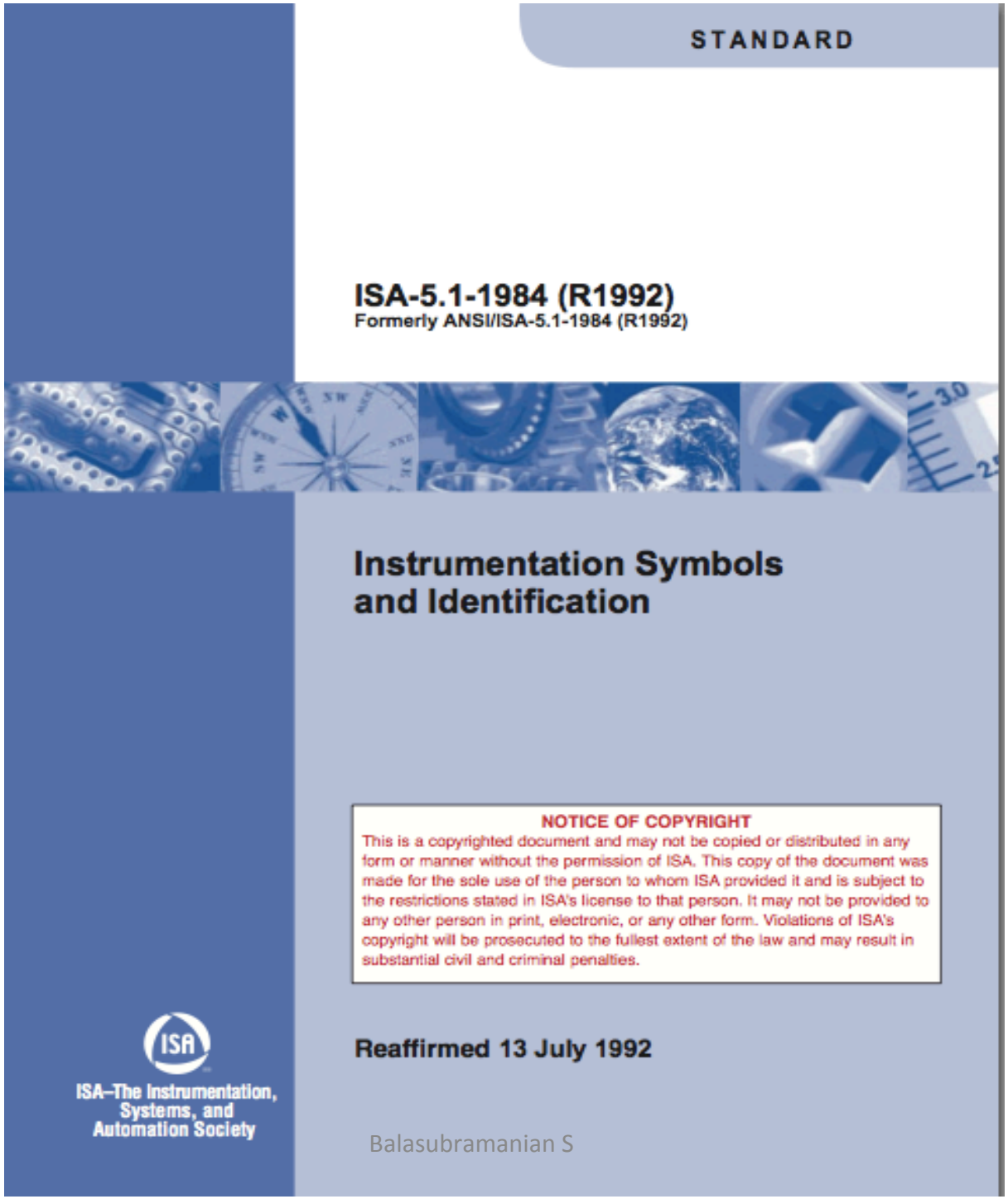
LC
I/P
EX-105
P-15
Rx-106
Tk-16
P-11
V-7
B-105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Reaffirmed 13 July 1992
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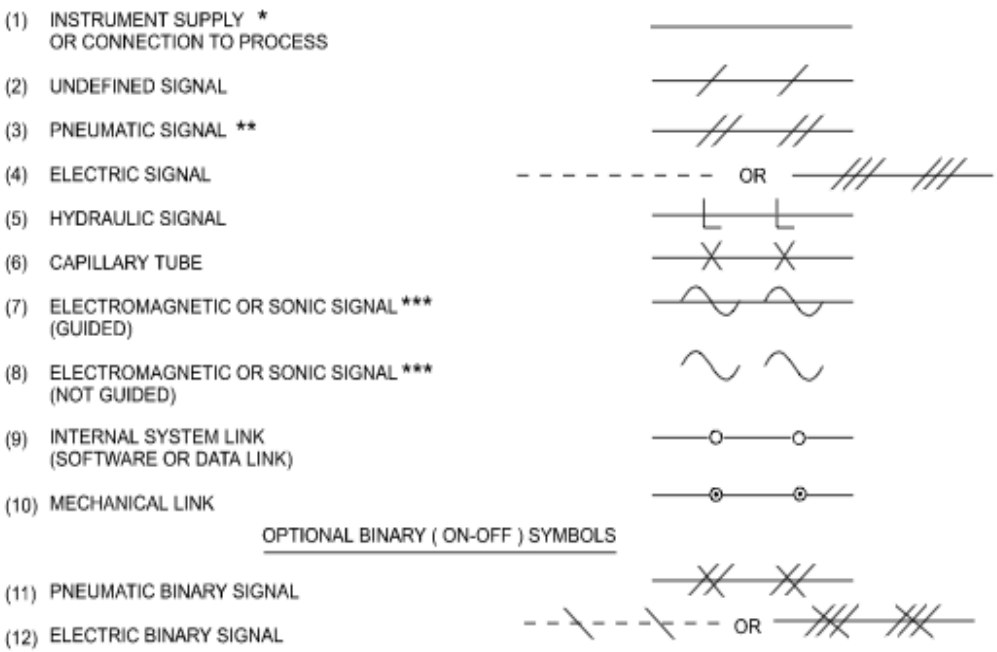
Terminologies



NOTE: 'OR' means user's choice. Consistency is recommended.

* The following abbreviations are suggested to denote the types of power supply. These designations may also be applied to purge fluid supplies.

AS - Air Supply
IA - Instrument Air
PA - Plant Air
} Options
ES - Electric Supply
GS - Gas Supply
HS - Hydraulic Supply
NS - Nitrogen Supply
SS - Steam Supply
WS - Water Supply

The supply level may be added to the instrument supply line, e.g., AS-100, a 100-psig air supply; ES-24DC, a 24-volt direct current power supply.

** The pneumatic signal symbol applies to a signal using any gas as the signal medium. If a gas other than air is used, the gas may be identified by a note on the signal symbol or otherwise.

*** Electromagnetic phenomena include heat, radio waves, nuclear radiation, and light.

Software's used

Acronym	Source
Aspen Plus	www.aspentech.com
ChemCad	www.chemstations.com
DesignII	www.winsim.com
Pro/II	iom.invensys.com

Professional competency

The professional stature of an engineer depends on skill in utilizing all sources of information to reach practical solutions to processing problems.

An engineer becomes competent in his or her profession by mastering the techniques developed by ones predecessors – thereafter the time comes to pioneer new ones.

Source: David M. Himmelblau (1997) Basic Principles and Calculations in Chemical Engineering, 6th edition, Prentice Hall India, Pp 2

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Anatomy of Chemical Process

Terminologies

Overview of topics covered in OCT

Overview of topics covered in OCT

Chapter 1 NATURAL PRODUCTS

Chapter 2 SYNTHETIC ORGANIC CHEMICALS

Chapter 3 PLASTICS

Chapter 4 SYNTHETIC FIBERS

Chapter 5 NUCLEAR INDUSTRIES

Overview of topics covered in OCT

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Chapter 3 PLASTICS

Chapter 4 SYNTHETIC FIBERS

Chapter 5 NUCLEAR INDUSTRIES

Overview of topics covered in OCT

Chapter 1 NATURAL PRODUCTS

1. Edible and Essential oils
2. Soaps and Detergents; Glycerin
3. Pulp and Paper
4. Starch and Starch derivatives
5. Sugar

Overview of topics covered in OCT

Chapter 2 SYNTHETIC ORGANIC CHEMICALS

1. Methane and Synthesis gas
2. Propylene Acetylene and Ethylene
3. Chemicals from Aromatics Benzene, Toluene
4. Xylene, and Naphthalene

Overview of topics covered in OCT

Chapter 3 PLASTICS

1. Polyethylene and Polypropylene
2. Phenolic resins, and Epoxy resins
3. Polymers and their engineering applications

Overview of topics covered in OCT

Chapter 4 SYNTHETIC FIBERS

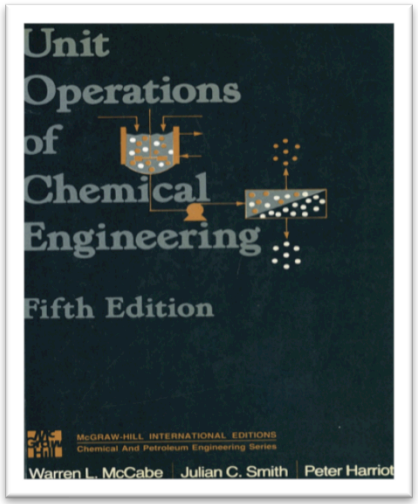
1. Polyamides, Polyesters and Acrylics
2. Natural and Synthetic rubbers
3. Leathers, dyes and intermediates

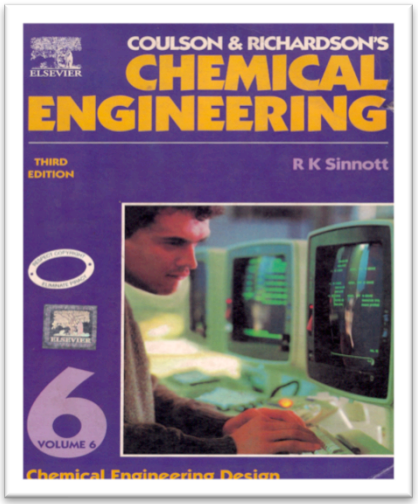
Overview of topics covered in OCT

Chapter 5 NUCLEAR INDUSTRIES

1. Nuclear reaction, uranium and thorium fission
2. Nuclear fuels and Nuclear reactors
3. Fission and Fusion reactions
4. Nuclear fuels and waste disposal

Reference


Unit Operations of Chemical Engineering
Fifth Edition
McGRAW-HILL INTERNATIONAL EDITIONS
Chemical And Petroleum Engineering Series
Warren L. McCabe | Julian C. Smith | Peter Harriot


COULSON & RICHARDSON'S
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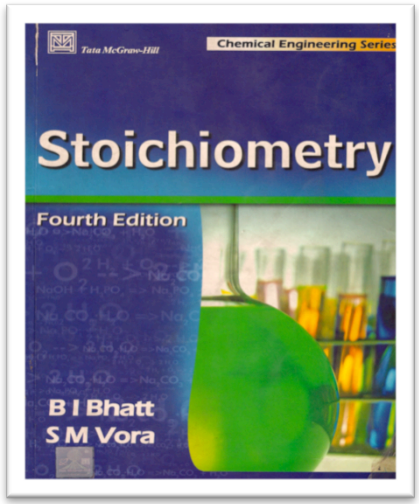
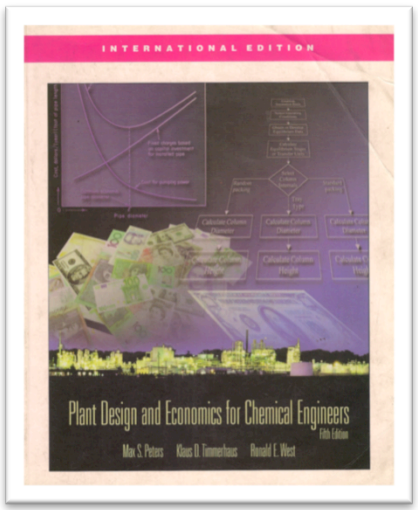
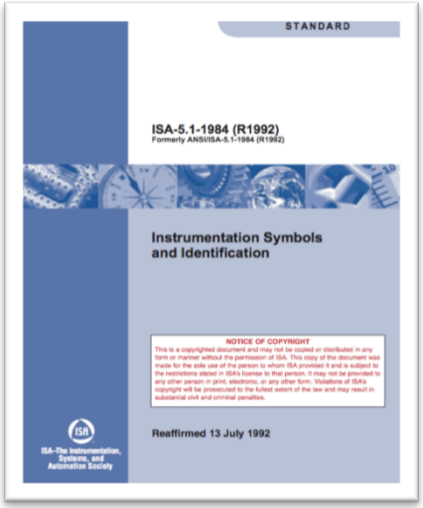
THIRD EDITION
R K Sinnott
6
VOLUME 6
Chemical Engineering Design


Tata McGraw-Hill
Chemical Engineering Series
Stoichiometry
Fourth Edition
B I Bhatt
S M Vora


INTERNATIONAL EDITION
Plant Design and Economics for Chemical Engineers
Fifth Edition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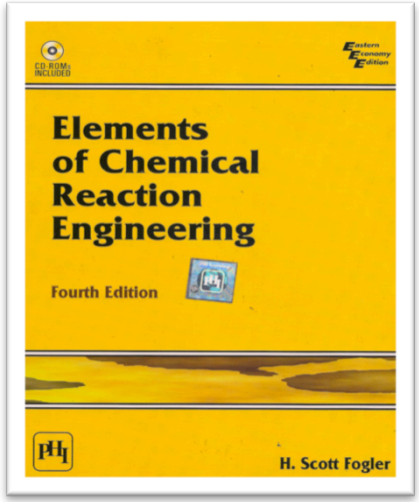
Elements of Chemical Reaction Engineering
Fourth Edition
H. Scott Fogler

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4. Indian Chemical Industry: A Sector Study, Export-Import bank of India, Quest Publications, March 2007
5. www.aiche.org/uploadedFiles/About/Centennial/Books/50/3-Chemist.pdf
6. Warren L. Mc Cabe, Julian C. Smith, Peter Harriot (1997) Unit Operations of Chemical Engineerng , 5th Edition, Mc. Graw Hill, Pp 3-5.

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8. David M. Himmelblau, James B. Riggs. (2009), Basic Principles and Calculations in Chemical Engineering , 7th Prentice Hall India, Pp. XXV
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Thank you

See you with more interesting stuffs in next lecture