Lecture 3

WRI Technology Lectures

Process Design

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The lecture is three parts:

Part 1: Unit operations and flowsheeting
Part 2: Process design components
Part 3: Applications from the WRI

Part 1

Unit Operations and Flowsheeting

Unit Operations

- Unit Operations is a method of analysis and design of chemical engineering processes in terms of individual tasks/operations

- It is a way of organizing chemical engineering knowledge into groups of individual tasks/operations

- A unit operation: basic step in a chemical engineering process

Unit Operations: Classification

Fluid flow processes

- fluid transport
- solids fluidization
- mixing

Heat transfer processes

- heating/cooling
- evaporation/condensation

Mass transfer processes

- absorption
- distillation
- extraction
- adsorption
- drying

Thermodynamic processes

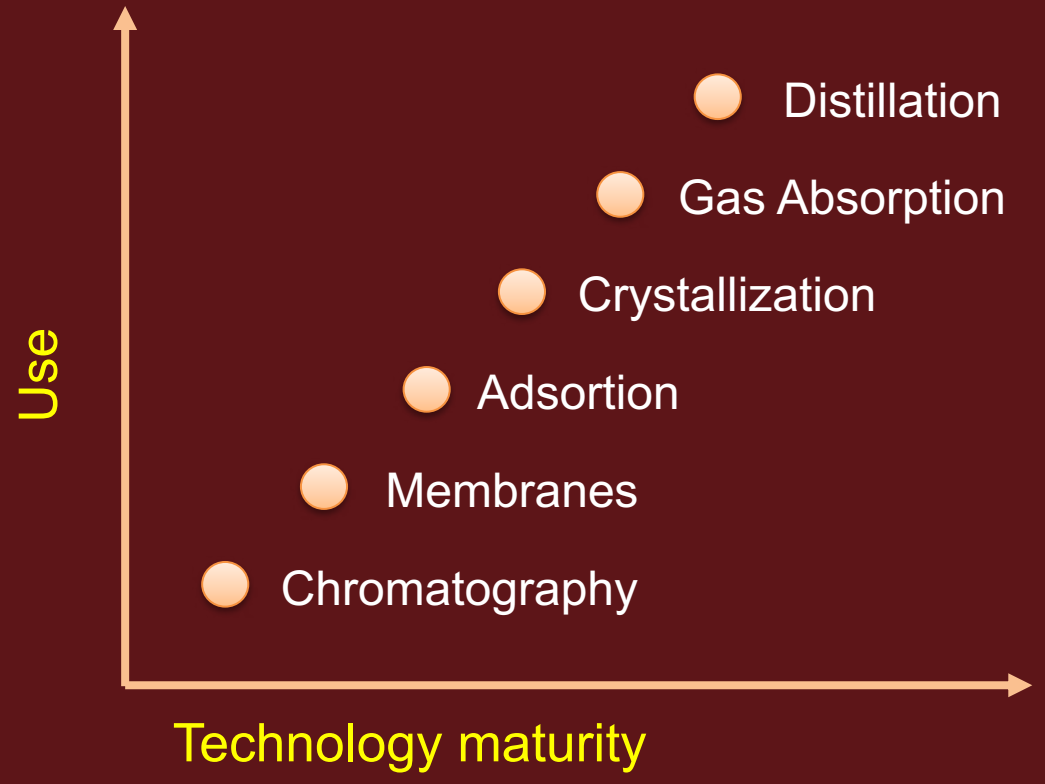
- liquifaction
- refrigeration

Mechanical processes

- crushing
- sieving
- solid transportation

Chemical separation processes

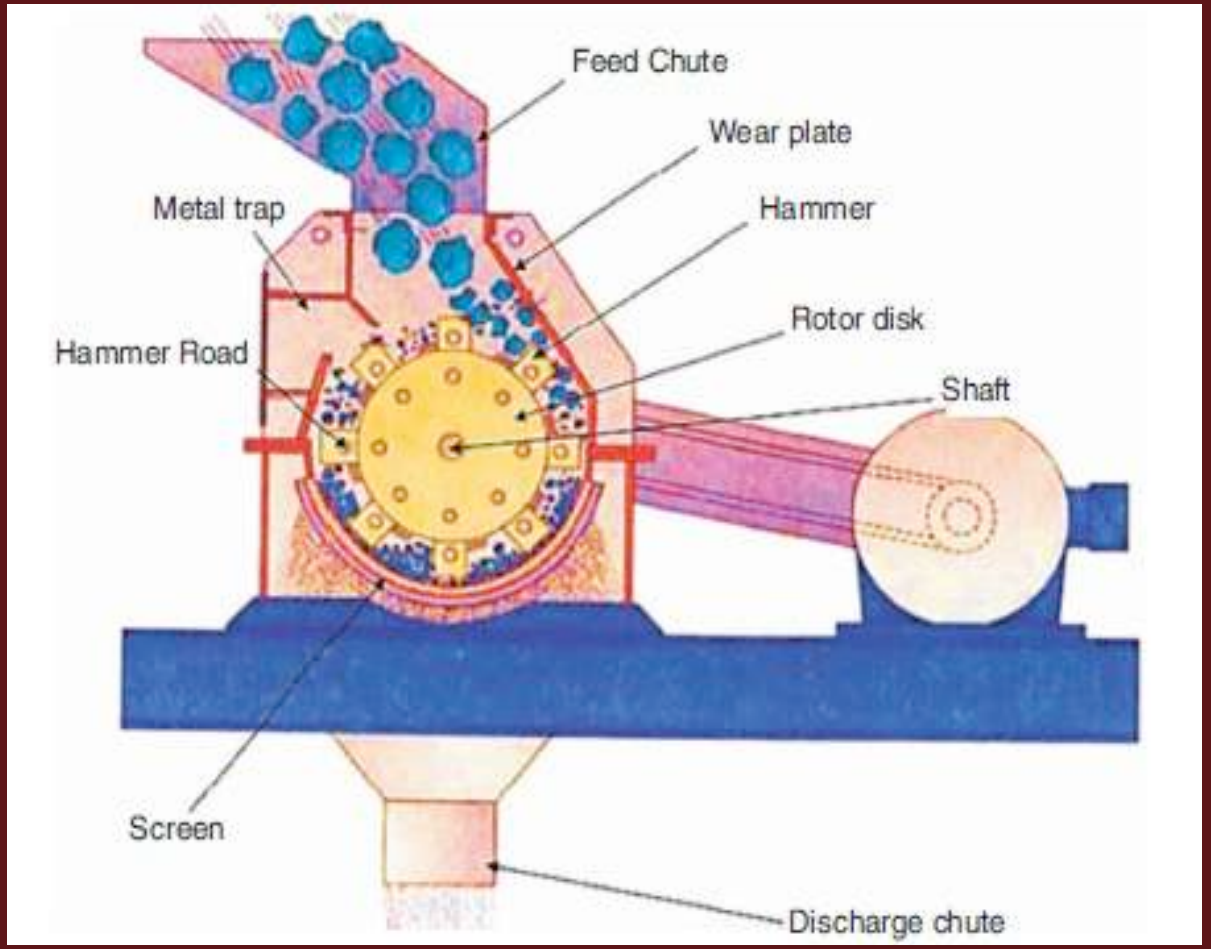
- play a central role in chemical engineering



Size Reduction Unit Operations As applied in the SW sector

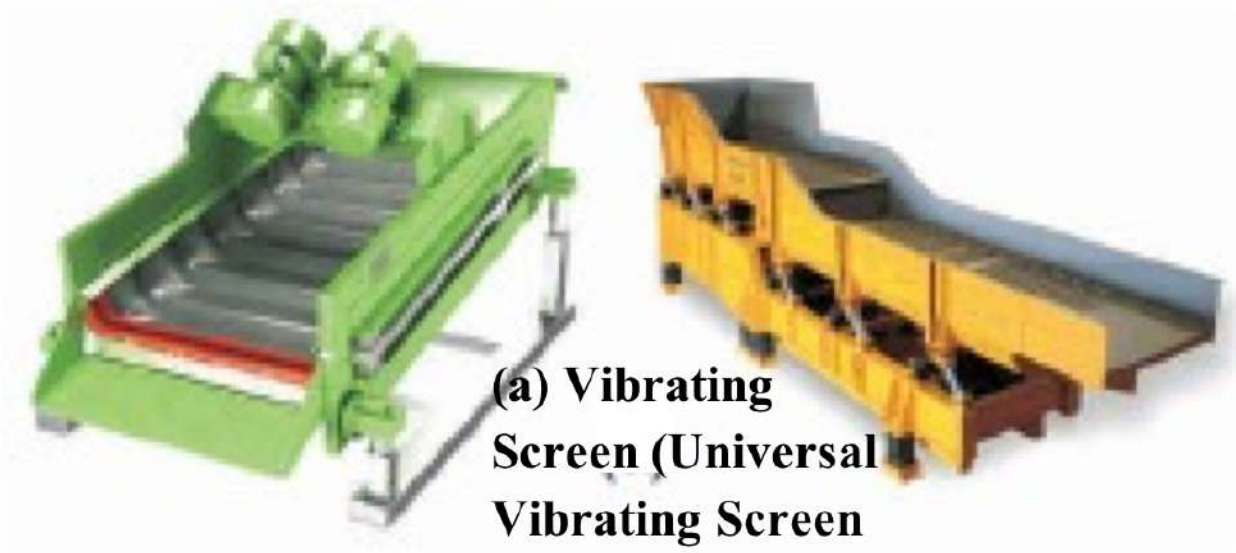
No.	Type of equipment	Functions	Applications
1.	Small grinders	Grinding, mashing	Organic residential solid wastes.
2.	Chippers	Cutting, slicing	Paper, cardboard, tree trimmings, yard wastes, wood, plastics.
3.	Large grinders	Grinding, mashing	Brittle and friable materials. Used mostly in industrial operations.
4.	Jaw crushers	Crushing, breaking	Large solids
5.	Rasp mills	Shredding, tearing	Moistened solid wastes. Most commonly used in Europe.
6.	Shredders	Shearing, tearing	All types of municipal wastes.
7.	Cutters, clippers	Shearing, tearing	All types of municipal wastes.
8.	Hammer mills	Breaking, tearing, cutting, crushing	All types of municipal wastes. Most commonly used equipment for reducing size and homogenizing composition of wastes

Vertical Hammer Mill Used for Size Reduction of Solid Wastes

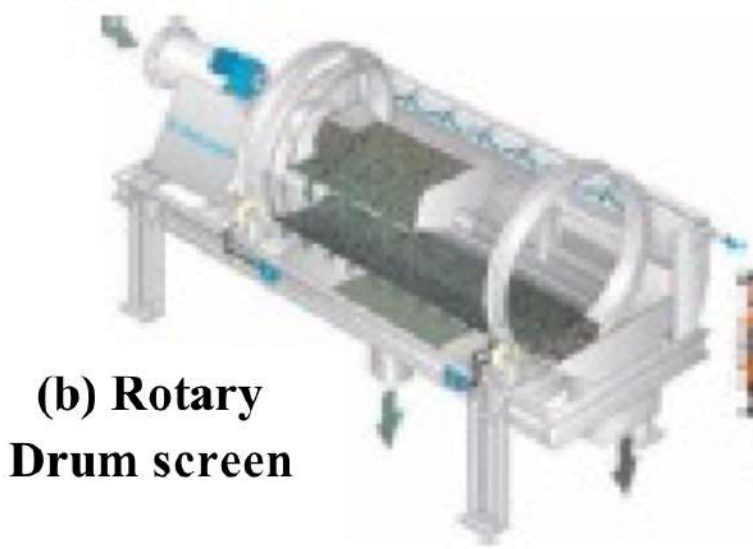


Unit Operation: Solid Separation

Types of screens in use in the solid waste sector



(a) Vibrating Screen (Universal Vibrating Screen

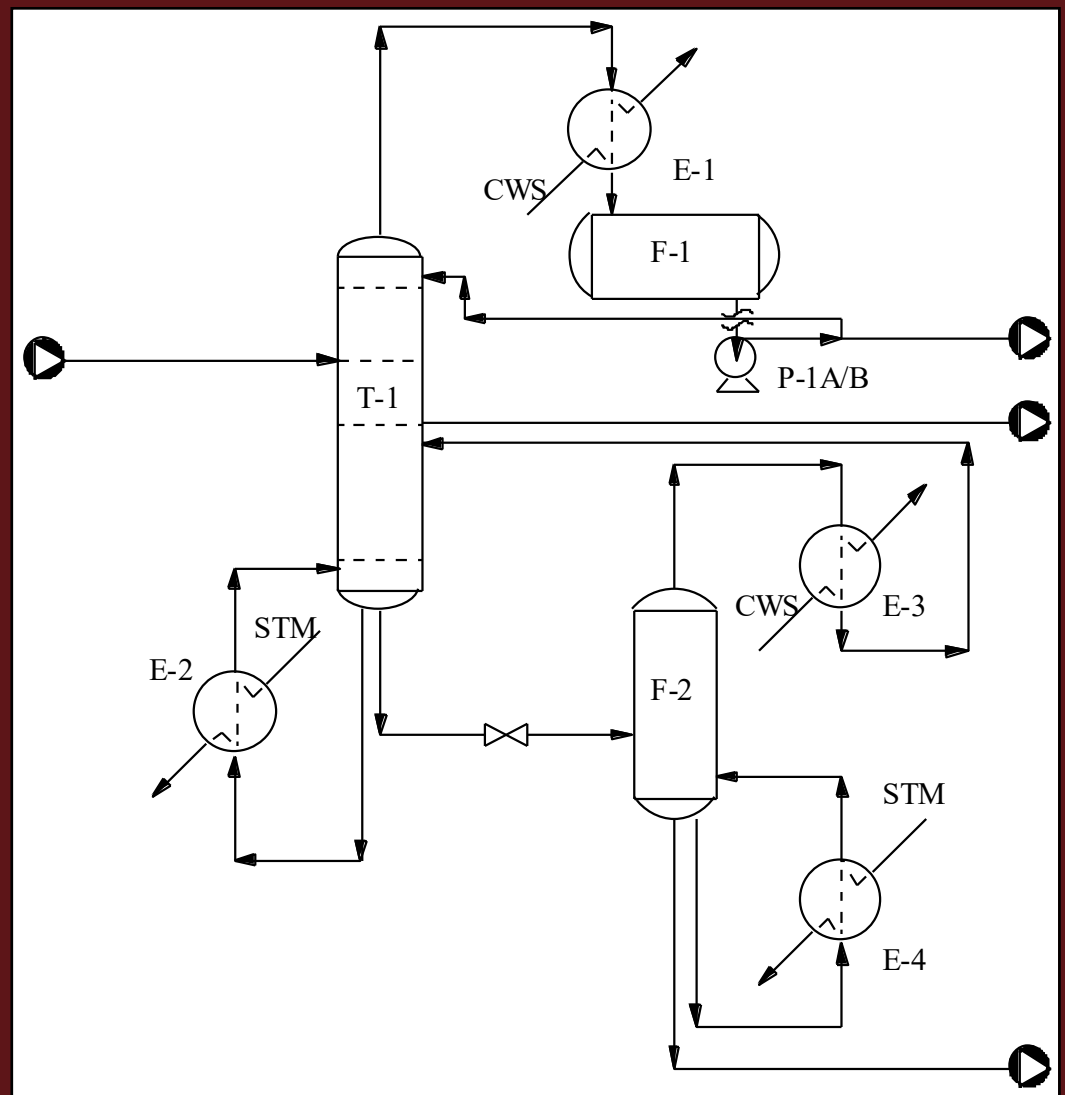


(b) Rotary Drum screen

(c) Trommel Screen

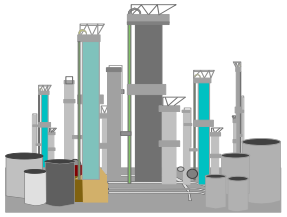
Flowsheeting

Flowsheets are the pictorial representation of the process.

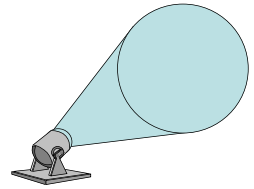


Goal:

Transmit the most amount of information with the least amount of effort on the part of the reader!



Flowsheeting



Chemical Engineering Practice

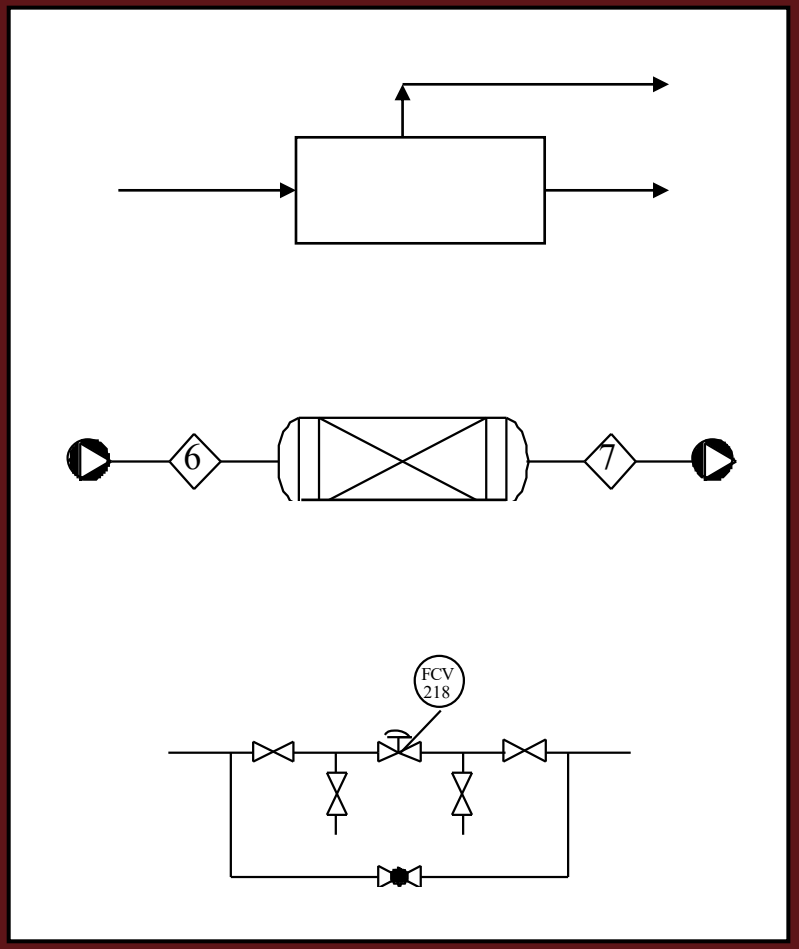
Howat Flowsheet Types:

Increasing Detail

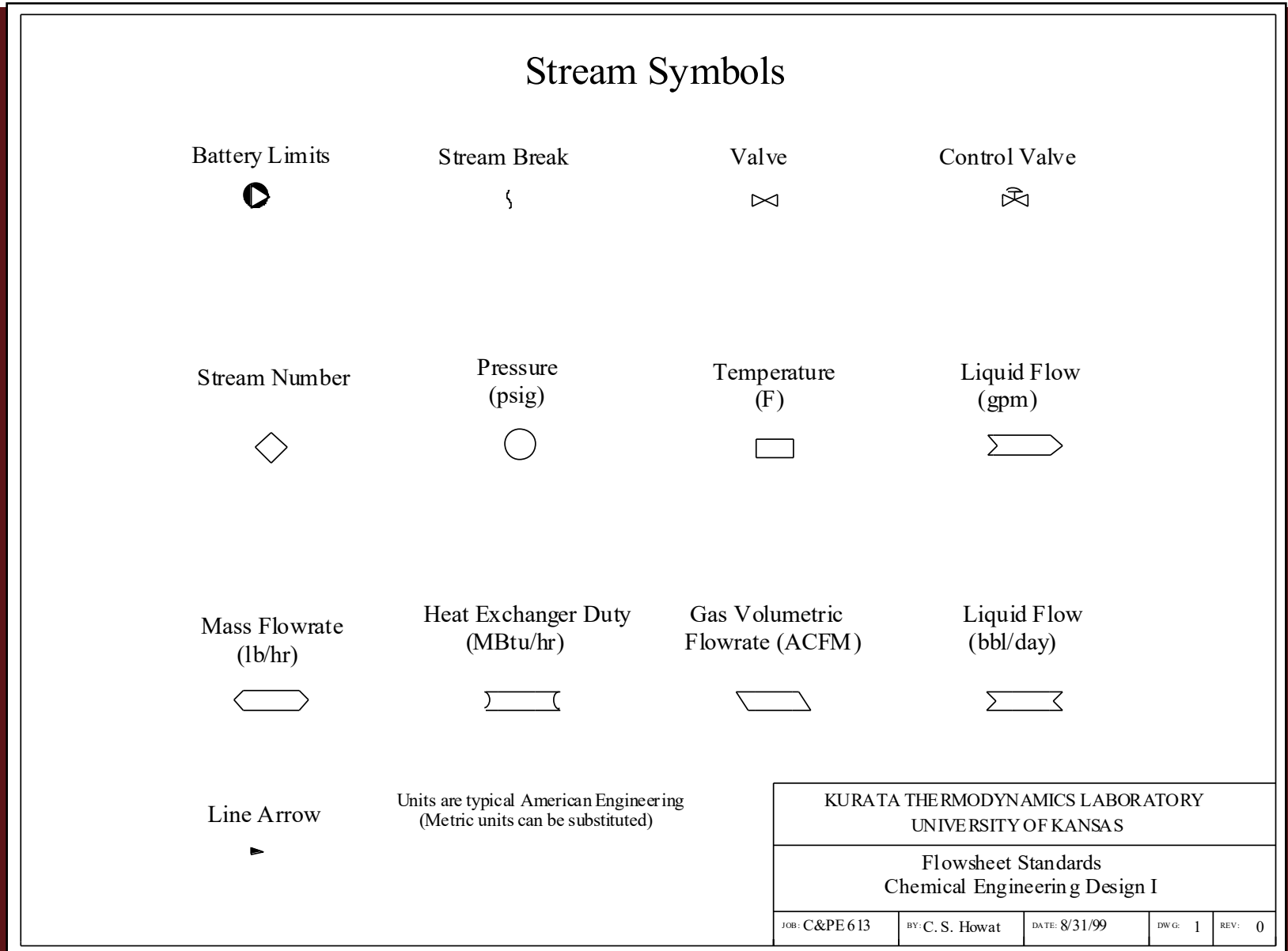
Block

Process

Engineering



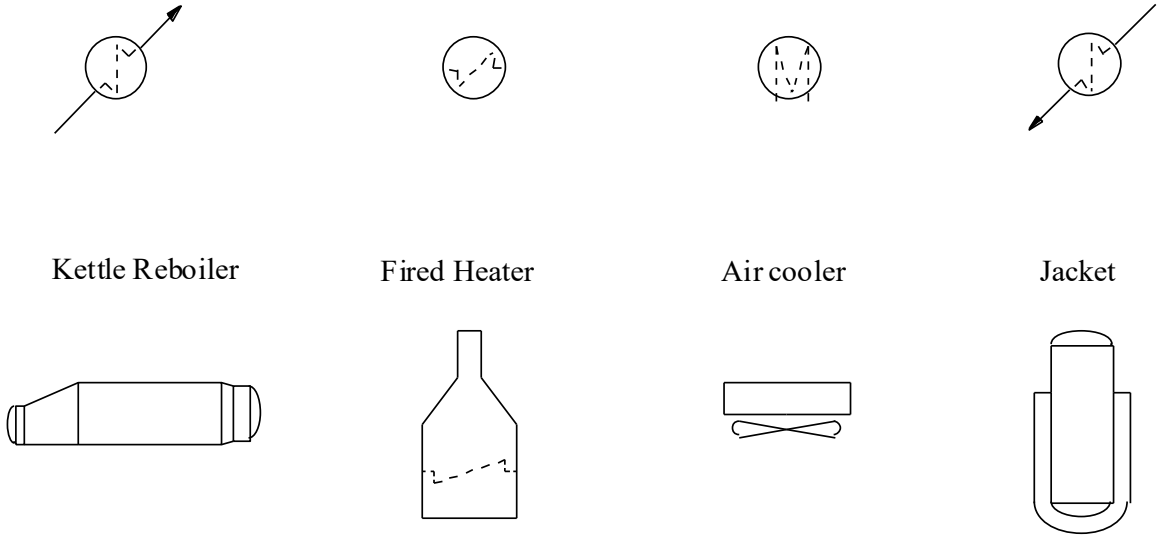
Flowsheeting



Flowsheeting

Heat Exchangers

Examples of Shell and Tube Heat Exchangers



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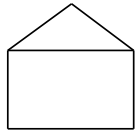
Flowsheet Standards
Chemical Engineering Design I

JOB: C&PE 613	BY: C. S. Howat	DATE: 8/31/99	DWG: 2	REV: 0

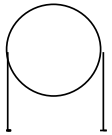
Flowsheeting

Storage Vessels

Atmospheric Tank



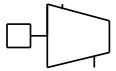
Pressurized Sphere



Pressurized Bullet

Rotating Equipment

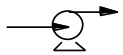
Motor Driven Compressor



Positive Displacement Compressor/Pump

Turbine

Centrifugal Pump



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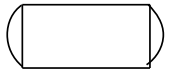
Flowsheet Standards
Chemical Engineering Design I

JOB: C&PE 613	BY: C. S. Howat	DATE: 8/31/99	DWG: 3	REV: 0

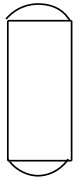
Flowsheeting

Process Vessels

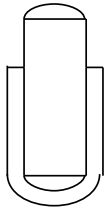
Horizontal Vessel



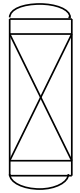
Vertical Vessel



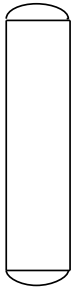
Jacketed Reactor



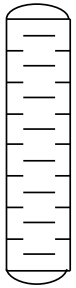
Packed Reactor



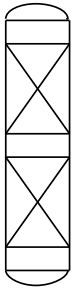
Vertical Tower



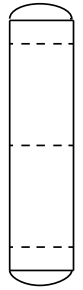
Extraction Tower



Packed Tower



Trayed Tower



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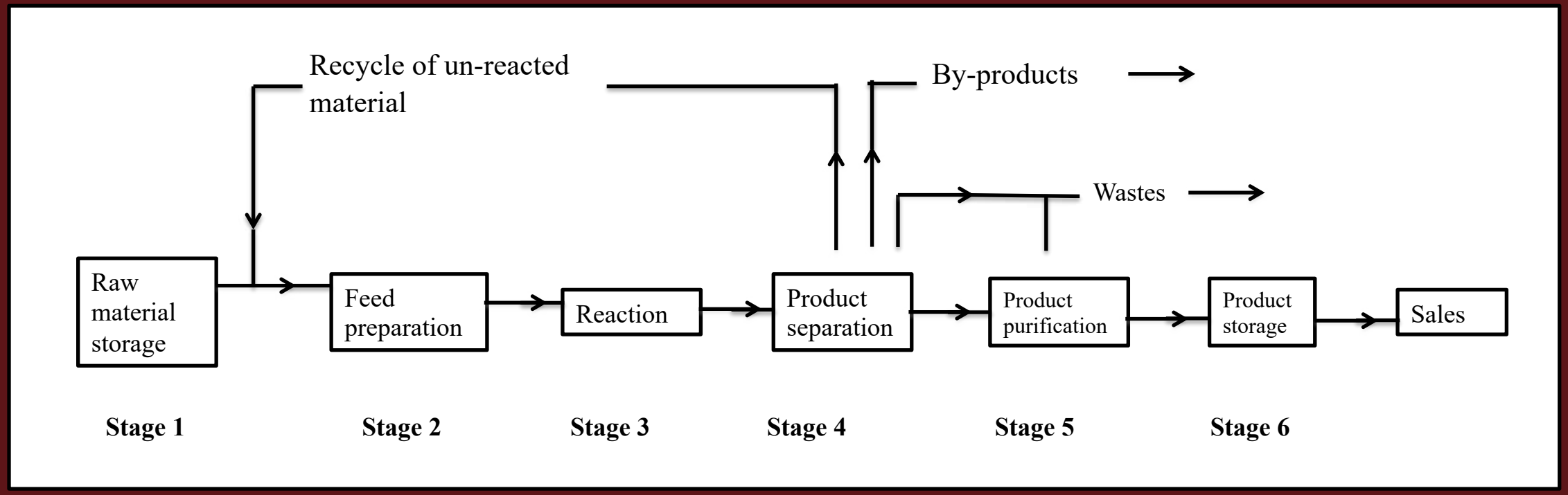
Flowsheet Standards
Chemical Engineering Design I

JOB: C&PE 613	BY: C. S. Howat	DATE: 8/31/99	DWG: 4	REV: 0

Part 2

Process Design Components



Main components in a typical process industry

Stage 1: Raw material storage

Unless the raw materials (also called feed stocks or feeds) are supplied as intermediate products (intermediates) from a neighboring plant, some provision will have to be made to hold several days' or weeks' worth of storage to smooth out fluctuations and interruptions in supply. Even when the materials come from an adjacent plant, some provision is usually made to hold a few hours' or even days' worth of inventory to decouple the processes. The storage required depends on the nature of the raw materials, the method of delivery, and what assurance can be placed on the continuity of supply.

Stage 2: Feed preparation

Some purification and preparation of the raw materials will usually be necessary before they are sufficiently pure, or in the right form, to be fed to the reaction stage. Feed contaminants that can poison process catalysts, enzymes, or micro-organisms must be removed. Liquid feeds need to be vaporized before being fed to gas-phase reactors and solids may need crushing, grinding, and screening.

Stage 3: Reaction

The reaction stage is the heart of a chemical manufacturing process. In the reactor the raw materials are brought together under conditions that promote the production of the desired product; almost invariably, some byproducts will also be formed, either through the main reaction, by side reactions, or from reactions of impurities present in the feed.

Stage 4: Product separation

After the reactor(s) the products and byproducts are separated from any un-reacted material. If in sufficient quantity, the un-reacted material will be recycled to the reaction stage or to the feed purification and preparation stage. The byproducts may also be separated from the products at this stage. In fine chemical processes there are often multiple reaction steps, each followed by one or more separation steps.

Stage 5: Purification

Before sale, the main product will often need purification to meet the product specifications. If produced in economic quantities, the byproducts may also be purified for sale.

Stage 6: Product storage

Some inventory of finished product must be held to match production with sales. Provision for product packaging and transport is also needed, depending on the nature of the product. Liquids are normally dispatched in drums and in bulk tankers; solids in sacks, cartons, or bales.

Ancillary Processes

In addition to the main process, provision must be made for the supply of the services (utilities) needed, such as process water, cooling water, compressed air, and steam. Facilities are also needed for maintenance, firefighting, offices and other accommodation, and laboratories.

After we decide on the product design, the development of a chemical process plant begins with process design

Phase 1: Process design, which covers the steps from the initial selection of the process to be used, through to the issuing of the process flow sheets and includes the selection, specification, and engineering design of equipment. In a typical organization, this phase is the responsibility of the Process Designer. The process designer may also be responsible for the preparation of the piping and instrumentation diagrams.

Then, we move to plant design

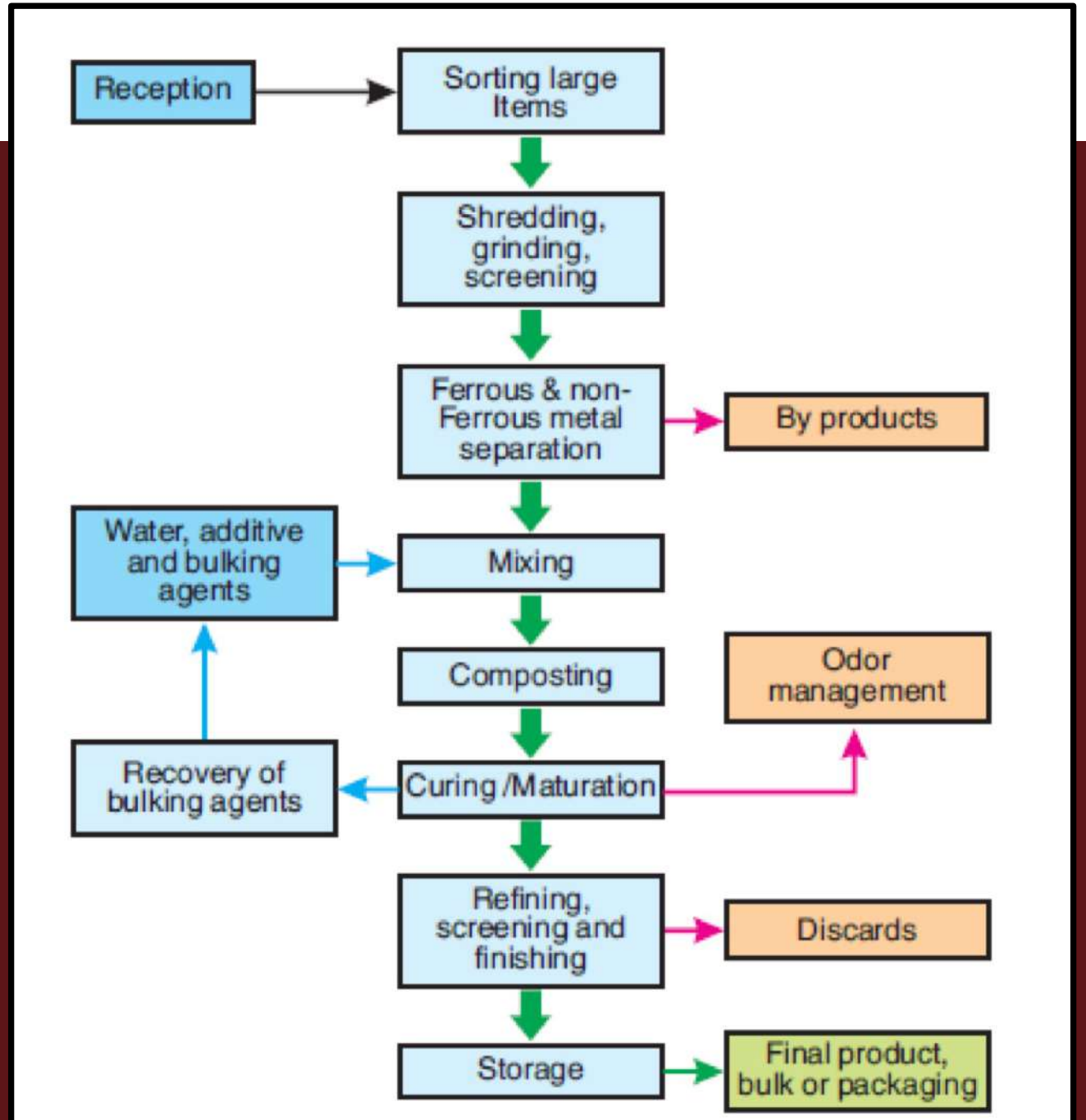
Phase 2: Plant design, including the detailed mechanical design of equipment; the structural, civil, and electrical design; and the specification and design of the ancillary services. These activities will be the responsibility of specialist designer, having expertise in the whole range of engineering disciplines.

Part 3

Applications from the waste recycling industry

Applicaion#1:

Composting Process Flow Diagram



Application #2:

Used oil regeneration process flow sheets
Go TO: Compendium of used oil regeneration technologies, UNIDO 2003

Application #3:

Flowsheets for the recovery of materials from e-waste

GO TO: Compendium of technologies for the recovery of materials from WEEE, UNEP 2017

Application #4

Converting Waste Plastics into a Resource

UNEP Compendium of technologies, 2009

Application #5

Scrap Tires

Handbook on recycling Applications and management in US and Mexico, EPA 2010

Application #6

Wastes from Food Industries

Waste management for the food industries, Elsevier 2008