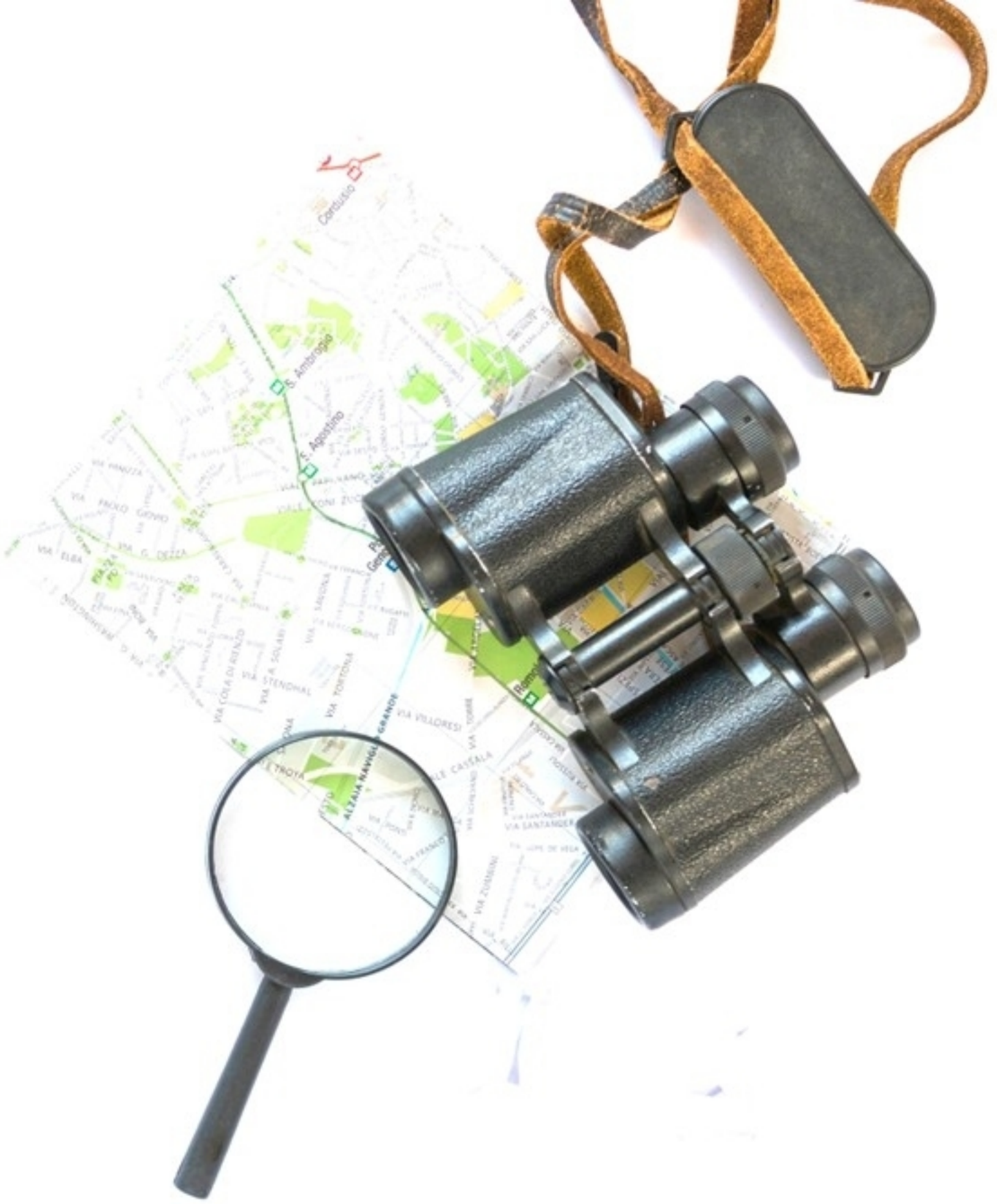
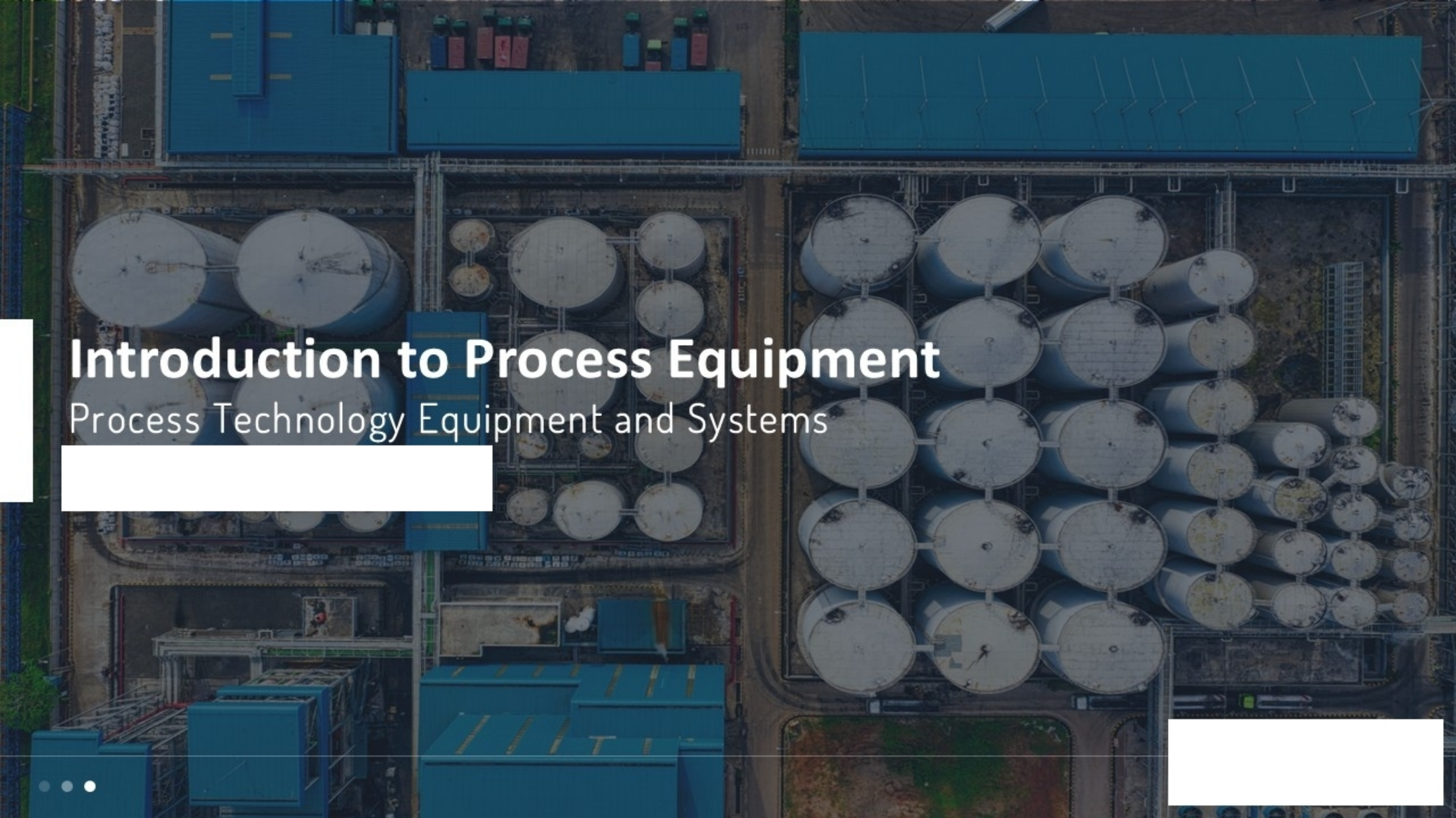
PROCESS TECHNOLOGY

Equipment and Systems

Course Topics



- Introduction to Process Equipment 01
- Stationary Equipment Overview 02
- Rotary Equipment Overview 03



Introduction to Process Equipment

Process Technology Equipment and Systems

Upstream E&P

Drilling and Exploration

Transporting

Production Workover

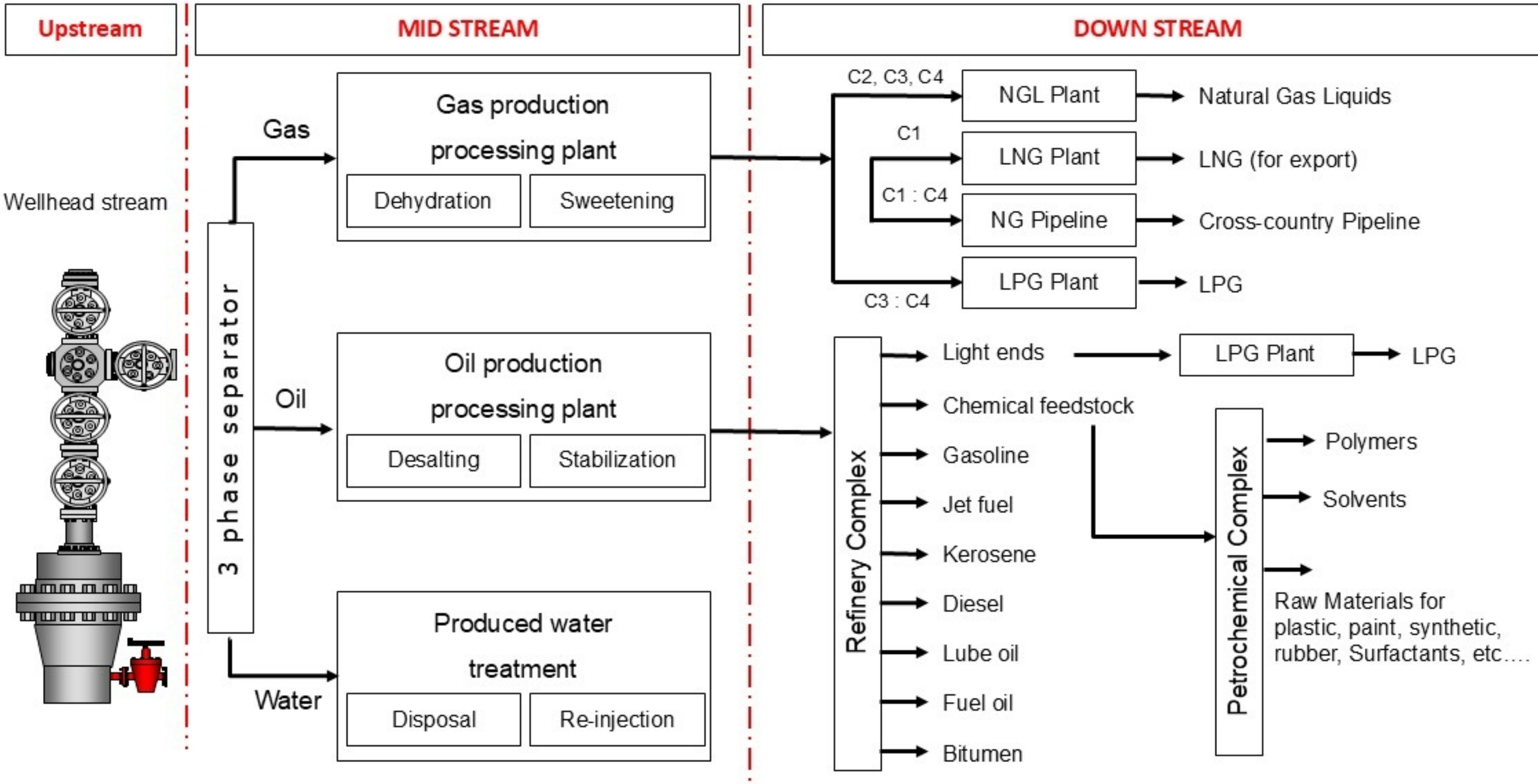
Midstream

Storage

Processing and treatment

Downstream

CLASSIFICATION OF OIL & GAS INDUSTRY



Overview of Downstream O&G Industry

Process Technology Equipment and Systems

- The downstream sector is the final stage in the oil and gas value chain.
- It involves the ***processing, refining, distribution, and marketing*** of petroleum products and derivatives.

Key activities include:

A. Refining crude oil into usable products (e.g., gasoline, diesel, jet fuel).
B. Treating natural gas to remove impurities.
C. Distributing and selling finished products to consumers.

Key Players in the Downstream Industry

A. Refineries:
   B. Large-scale facilities that process crude oil into refined products.

C. Gas Processing Plants:
   D. Facilities that treat and purify natural gas.

E. Petrochemical Plants:
   F. Convert hydrocarbons into chemicals and plastics.

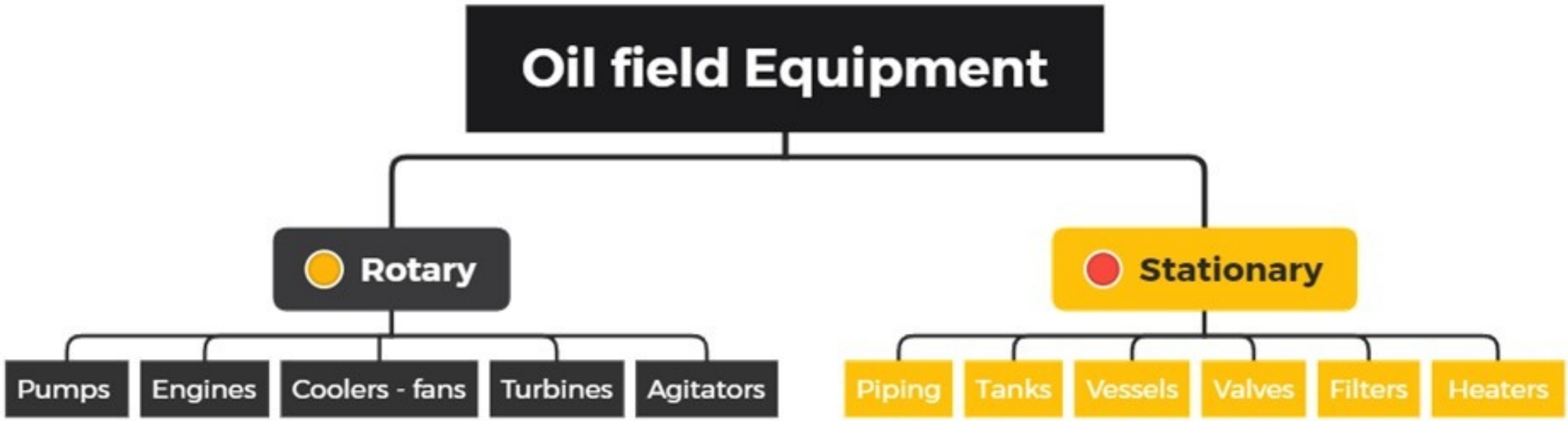
G. Distribution Networks:
   H. Pipelines, storage terminals, and transportation systems.

Classification of Downstream Equipment

Process Technology Equipment and Systems

- Process operations rely on a wide range of equipment to process, store, and transport oil and gas products.

Equipment can be classified into two main categories:



Further classification can be based on their function in the process (e.g., process equipment vs. utility equipment).

Classification of Downstream Equipment

Process Technology Equipment and Systems

- Process operations rely on a wide range of equipment to process, store, and transport oil and gas products.

Stationary Equipment

1. **Definition:**
   - Equipment that remains fixed in place during operation.
2. **Key Characteristics:**
   - No moving parts (or minimal moving parts).
   - Designed for storage, separation, heat transfer, or chemical reactions.
3. **Examples:**
   - Storage Tanks
   - Heat Exchangers
   - Reactors
   - Distillation Columns
   - Separators
   - Pressure Vessels
   - Furnaces and Boilers
   - Piping and Valves

Rotary Equipment

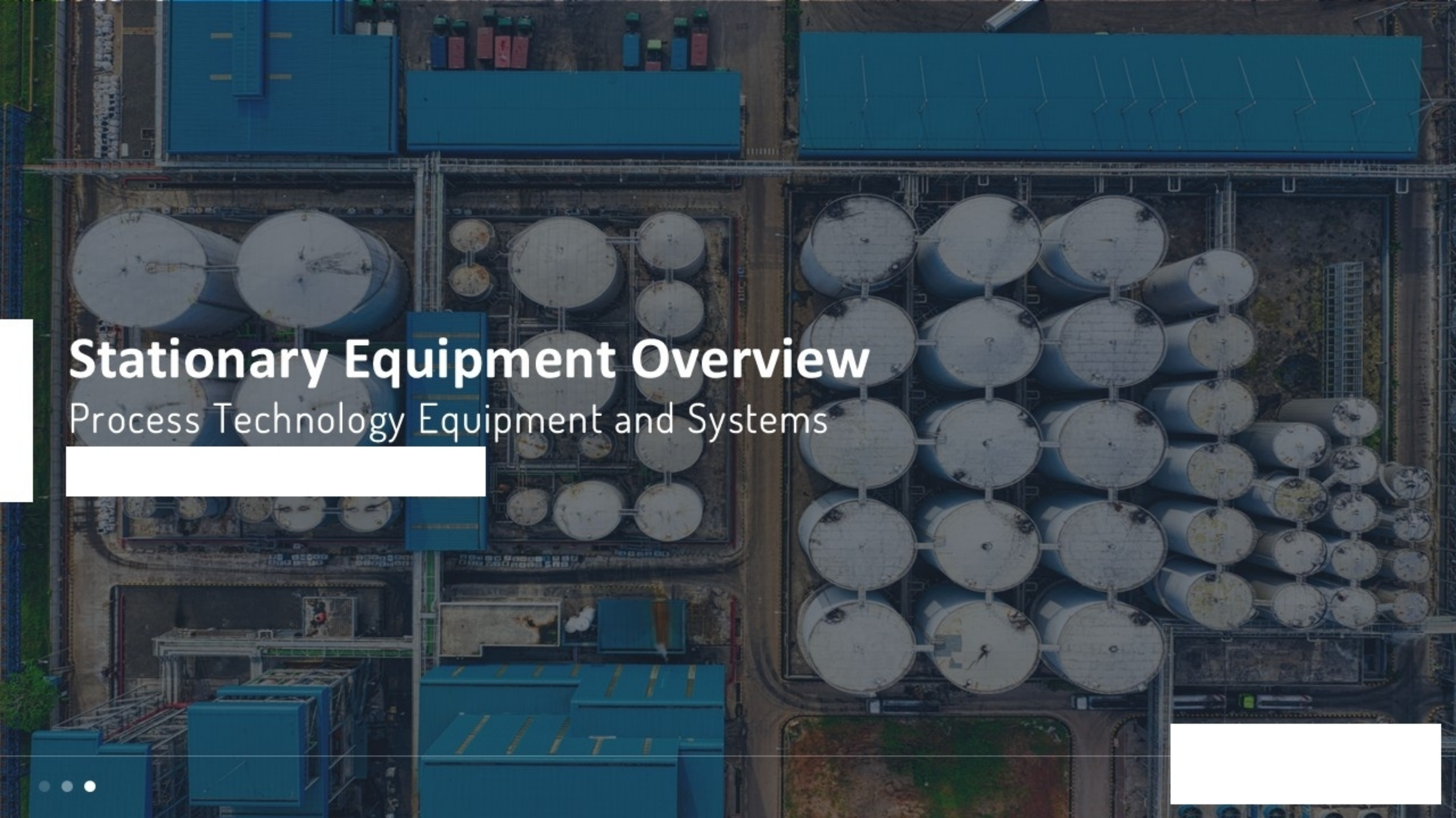
1. **Definition:**
   - Equipment that involves rotating components to perform their function.
2. **Key Characteristics:**
   - Contains moving parts (e.g., impellers, blades, rotors).
   - Used for fluid transfer, compression, or mechanical energy conversion.
3. **Examples:**
   - Pumps
   - Compressors
   - Turbines
   - Fans and Blowers
   - Mixers and Agitators
   - Centrifuges

Process Equipment vs. Utility Equipment

Process Technology Equipment and Systems

- **Process Equipment:** Directly involved in the transformation of raw materials into finished products.
- ***Examples***:
  - Reactors,
  - Distillation columns,
  - Separators,
  - Compressors,
  - Pumps
  - Tanks

- **Utility Equipment:** Supports the main process by providing essential services (e.g., power, cooling, heating).
- ***Examples***:
  - Plant and Instrument Air
  - Fuel natural Gas
  - Fire Protection
  - City and Process Water
  - Wastewater
  - Hot Water Heating
  - Steam and Condensate
  - Fuel Handling: Gasoline, Diesel
  - Cooling Water
  - Motor/Hydraulic/Cutting Oil
  - Process Gases: N_2, H_2 and CO_2.



Stationary Equipment Overview

Process Technology Equipment and Systems

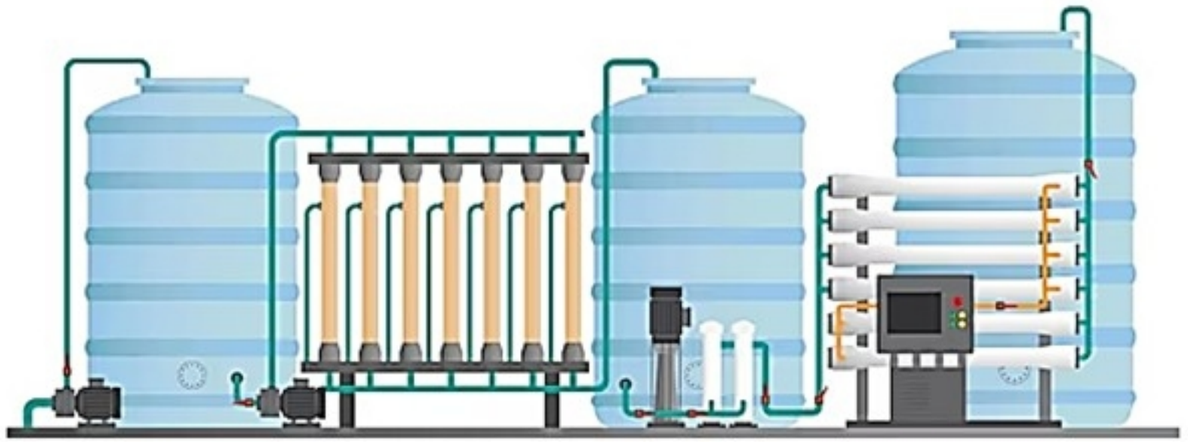
Stationary Equipment

Process Technology Equipment and Systems

- **Stationary Equipment:** refers to fixed equipment that does not have moving parts (or has minimal moving parts) during operation.
- It is designed to perform *specific functions* such as **storage, separation, heat transfer, or chemical reactions**.

Core Functions:

- Storage of raw materials, intermediates, and finished products.
- Separation of oil, gas, and water.
- Heat exchange for temperature control.
- Facilitating chemical reactions in reactors.



Stationary Equipment

Process Technology Equipment and Systems

Equipment	Function
Storage Tanks	Store crude oil, products, and chemicals
Heat Exchangers	Transfer heat between fluids
Reactors	Facilitate chemical reactions
Distillation Columns	Separate crude oil into fractions
Separators	Separate oil, gas, and water
Pressure Vessels	Store or process fluids under pressure
Furnaces and Boilers	Provide heat or generate steam
Piping and Valves	Transport and control fluid flow

Storage Tanks

Process Technology Equipment and Systems

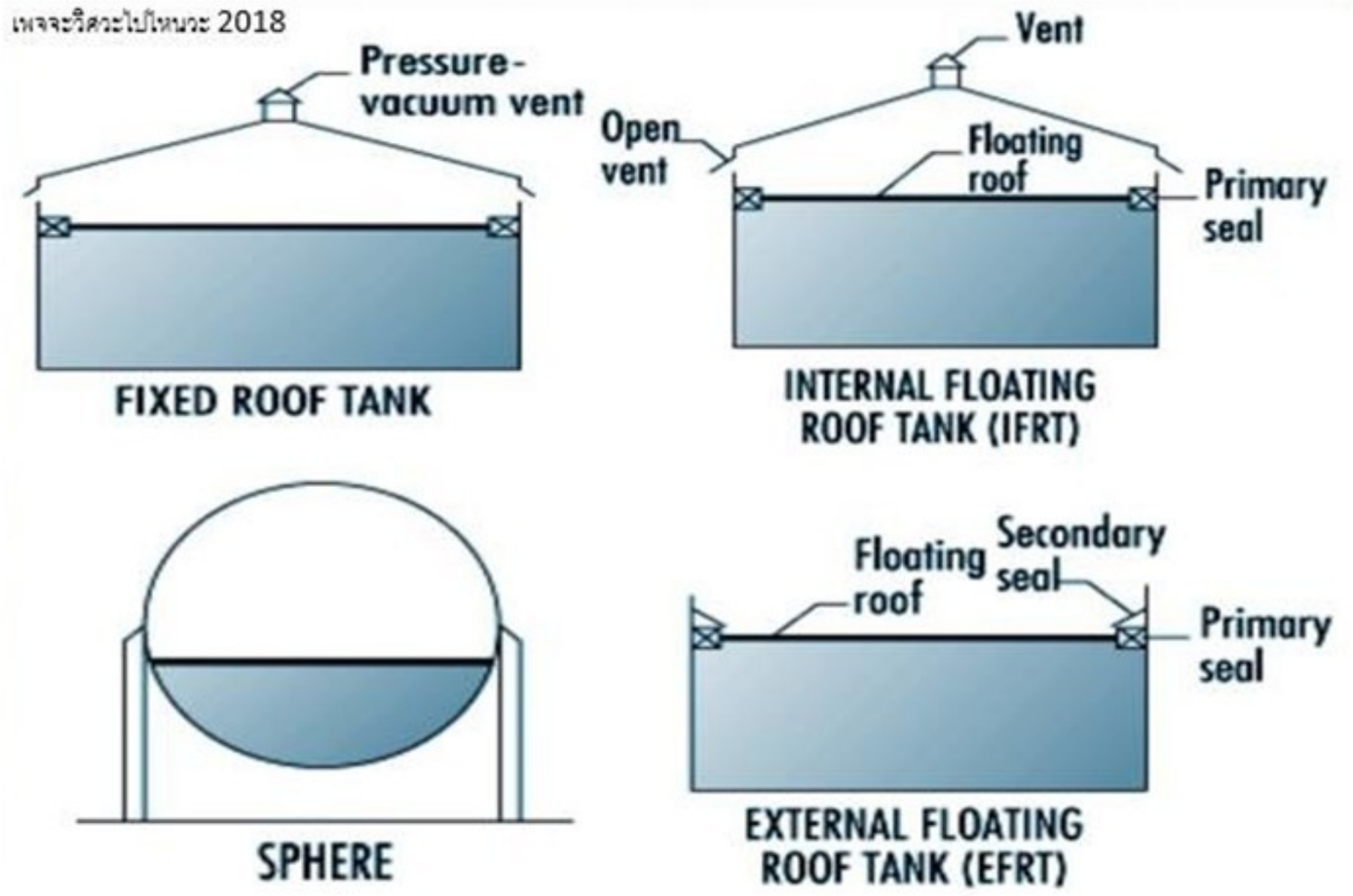
- Large containers designed to store liquids or gases.
- Used for crude oil, refined products, chemicals, and water.

- **Primary Functions:**
  - Store raw materials (e.g., crude oil) before processing.
  - Store intermediate and finished products (e.g., gasoline, diesel).
  - Ensure a steady supply of materials for downstream processes.
- **Importance:**
  - Critical for **inventory management** and **supply chain efficiency**.
  - Provides **buffer storage** to handle fluctuations in production and demand.

Storage Tanks

Process Technology Equipment and Systems

- **Tank Classification**
  - Atmospheric Tank,
  - Low Pressure Tank (< 15 psig),
  - High pressure Tanks
- **Types of Storage Tanks**
  - Fixed Roof Tanks
  - Floating Roof Tanks
  - Spherical Tanks
  - Underground Storage Tanks

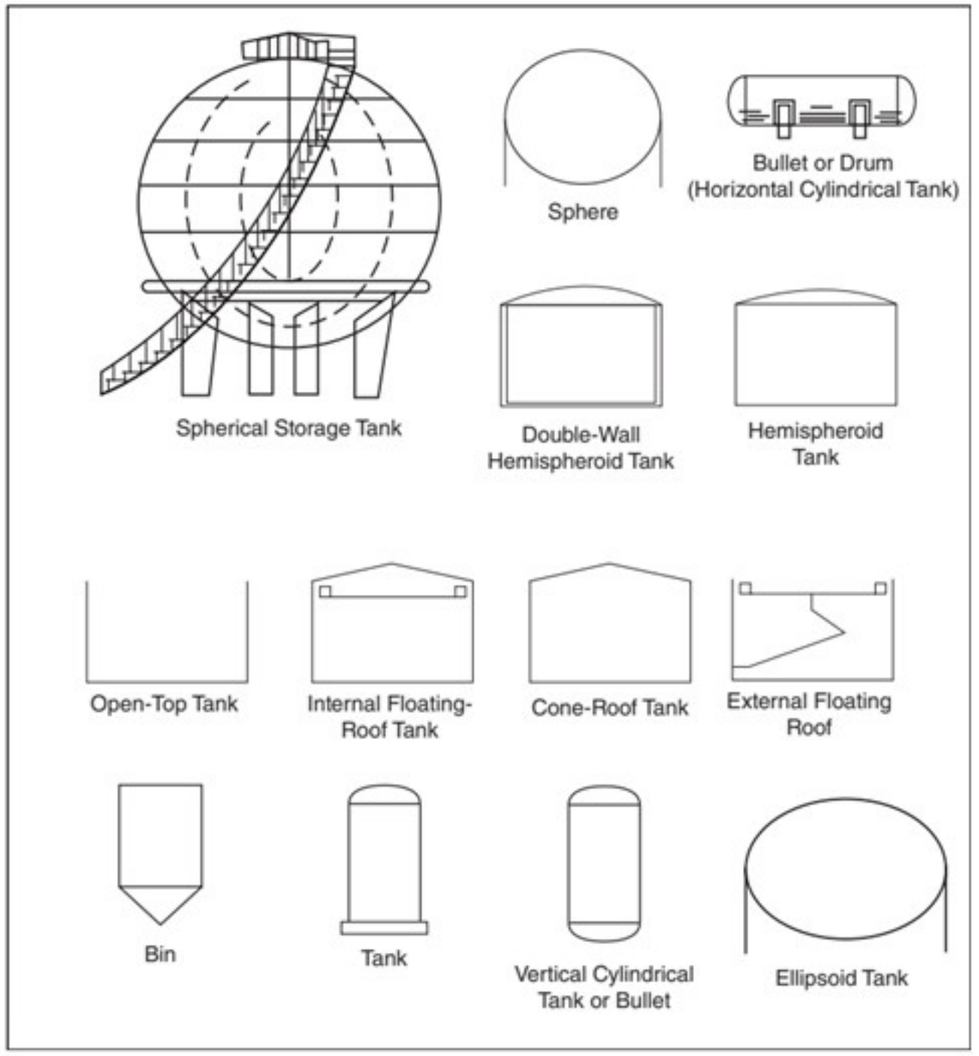


Storage Tanks

Process Technology Equipment and Systems

- **Storage Tanks Types**

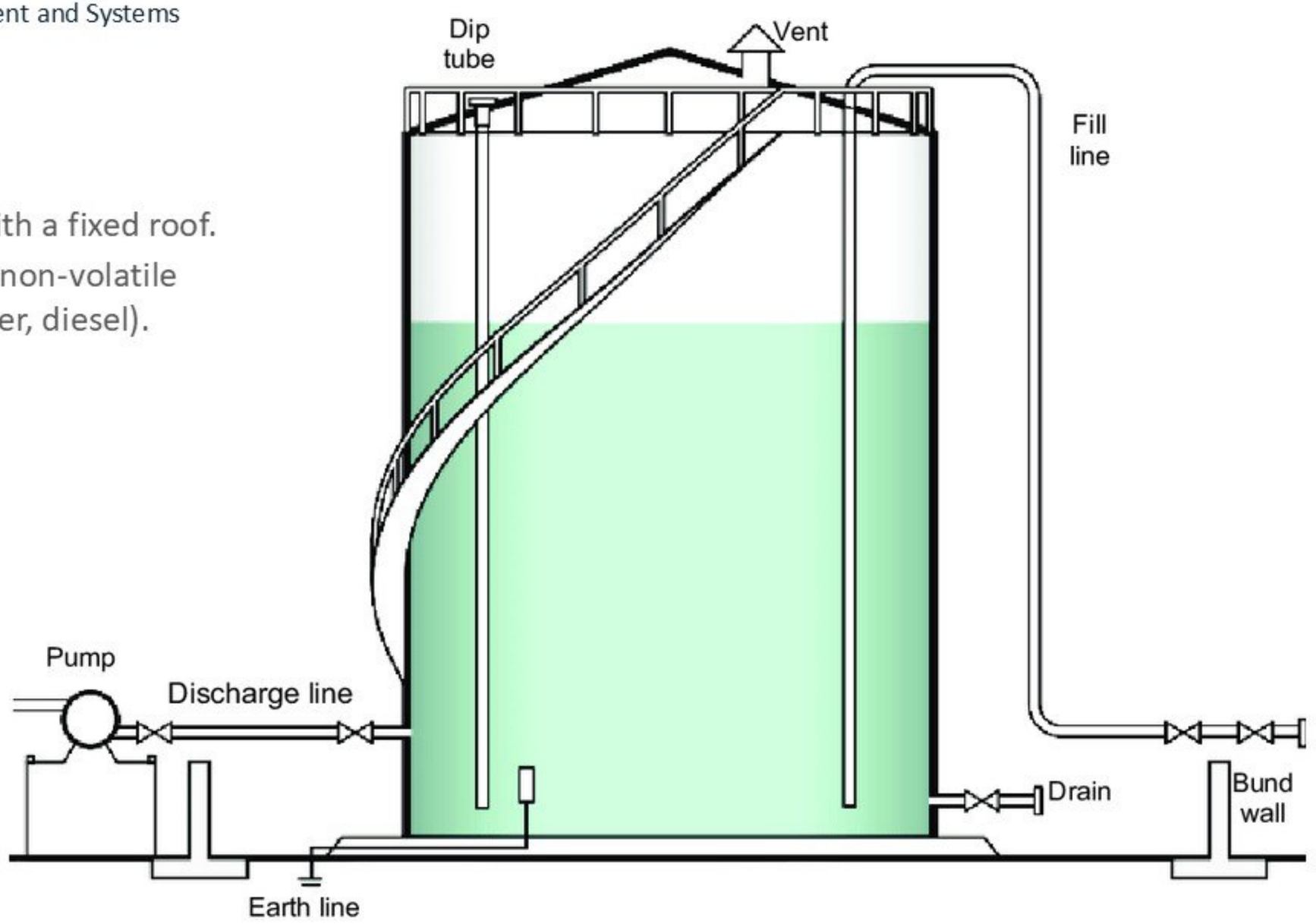
Type of Tank	Design	Applications
Fixed Roof Tank	Fixed roof, vertical	Non-volatile liquids (e.g., diesel)
Floating Roof Tank	Floating roof, vertical	Volatile liquids (e.g., crude oil)
Spherical Tank	Spherical shape	High-pressure gases (e.g., LPG)
Underground Tank	Cylindrical, underground	Fuel storage (e.g., gas stations)



Storage Tanks

Process Technology Equipment and Systems

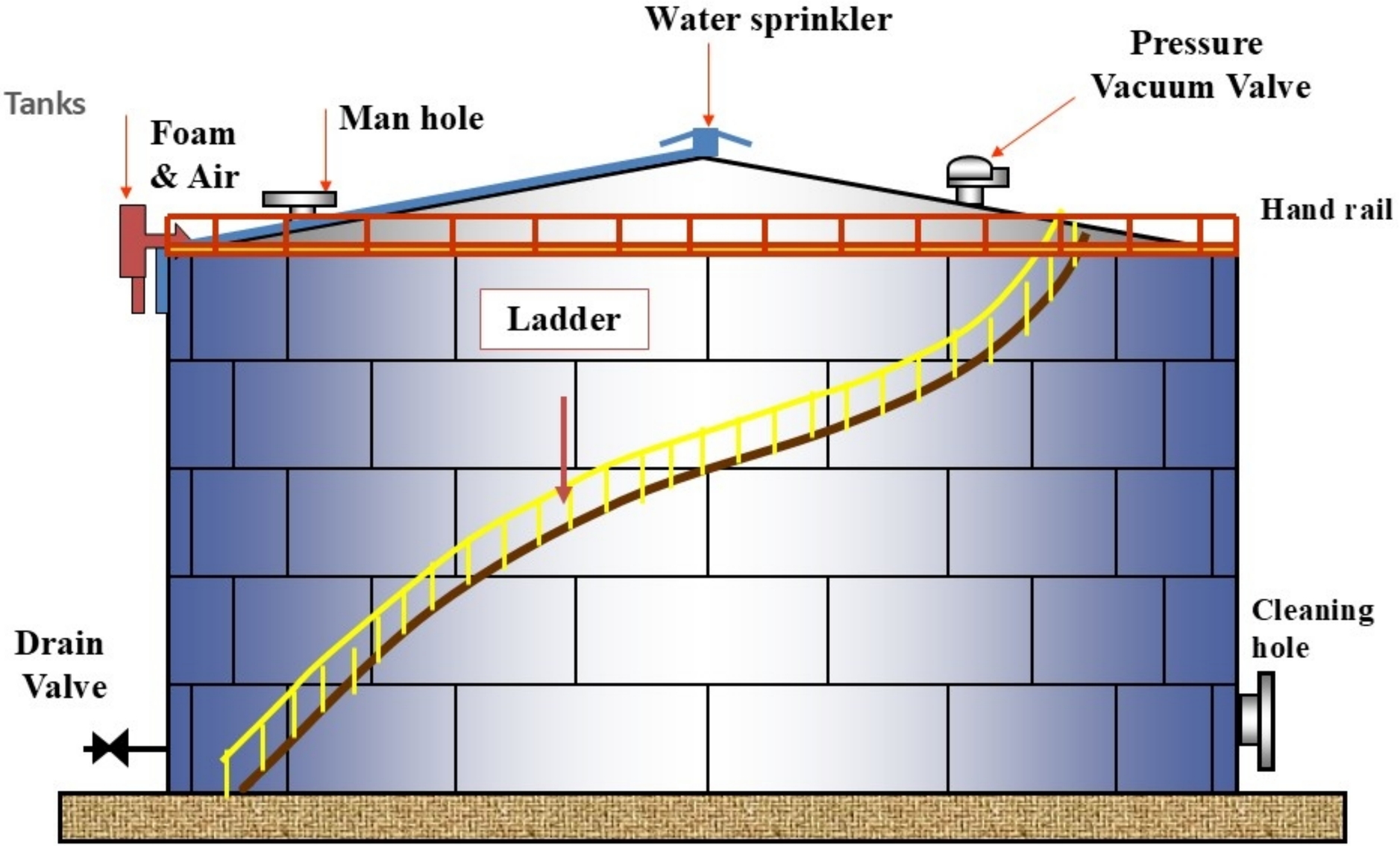
- **Fixed Roof Tanks**
  - Simple design with a fixed roof.
  - Used for storing non-volatile liquids (e.g., water, diesel).



Storage Tanks

Process Technology Equipment and Systems

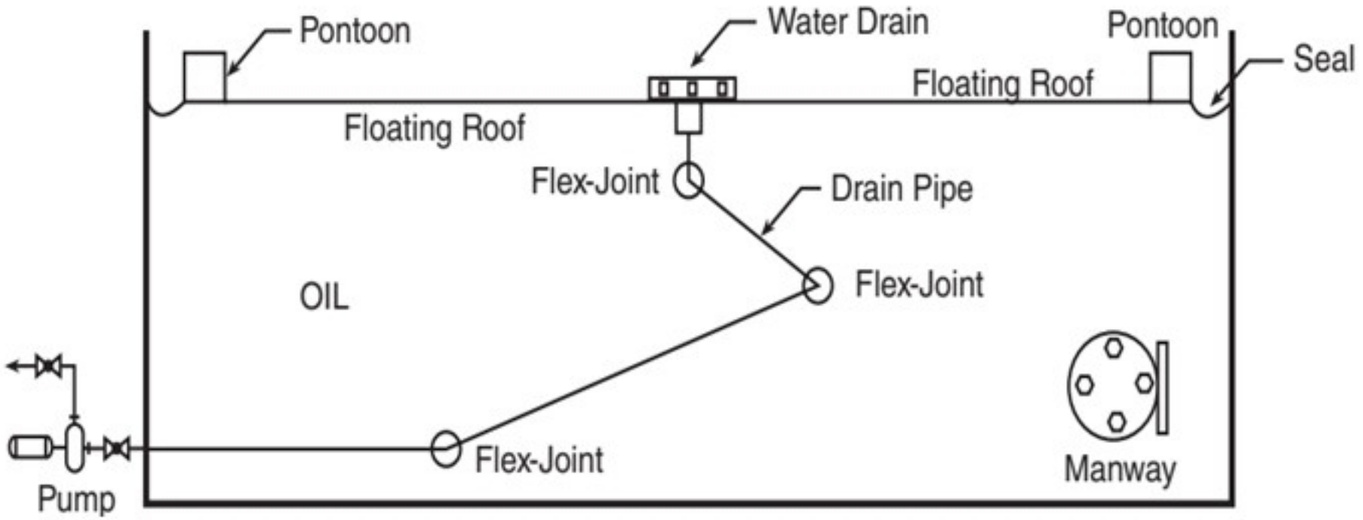
- Fixed Roof Tanks

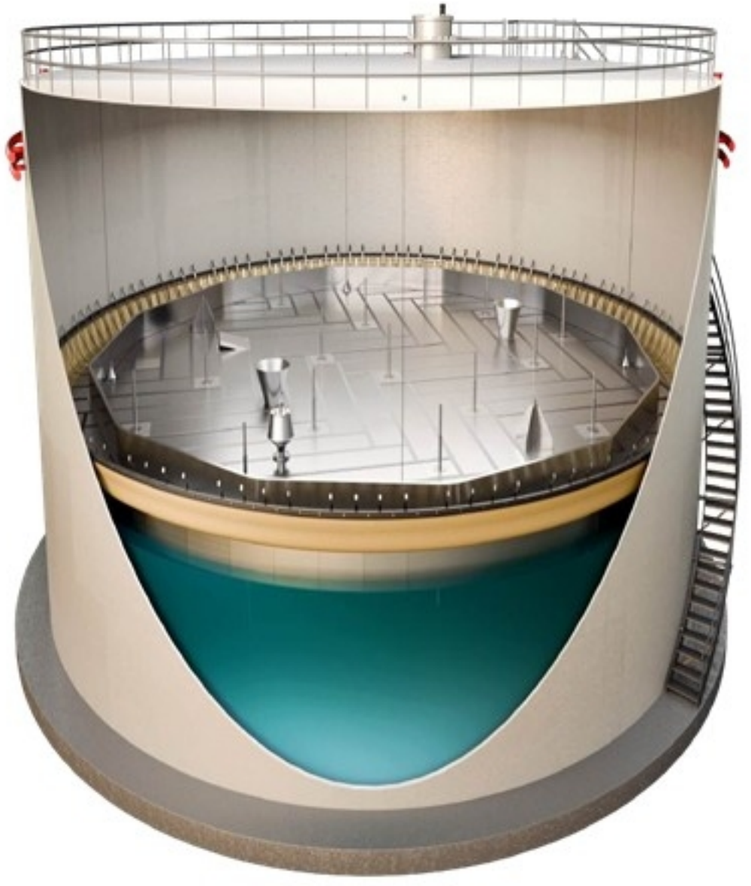


Storage Tanks

Process Technology Equipment and Systems

- **Floating Roof Tanks:**
  - Roof floats on the liquid surface to minimize vapor space.
  - Used for storing volatile liquids (e.g., crude oil, gasoline).

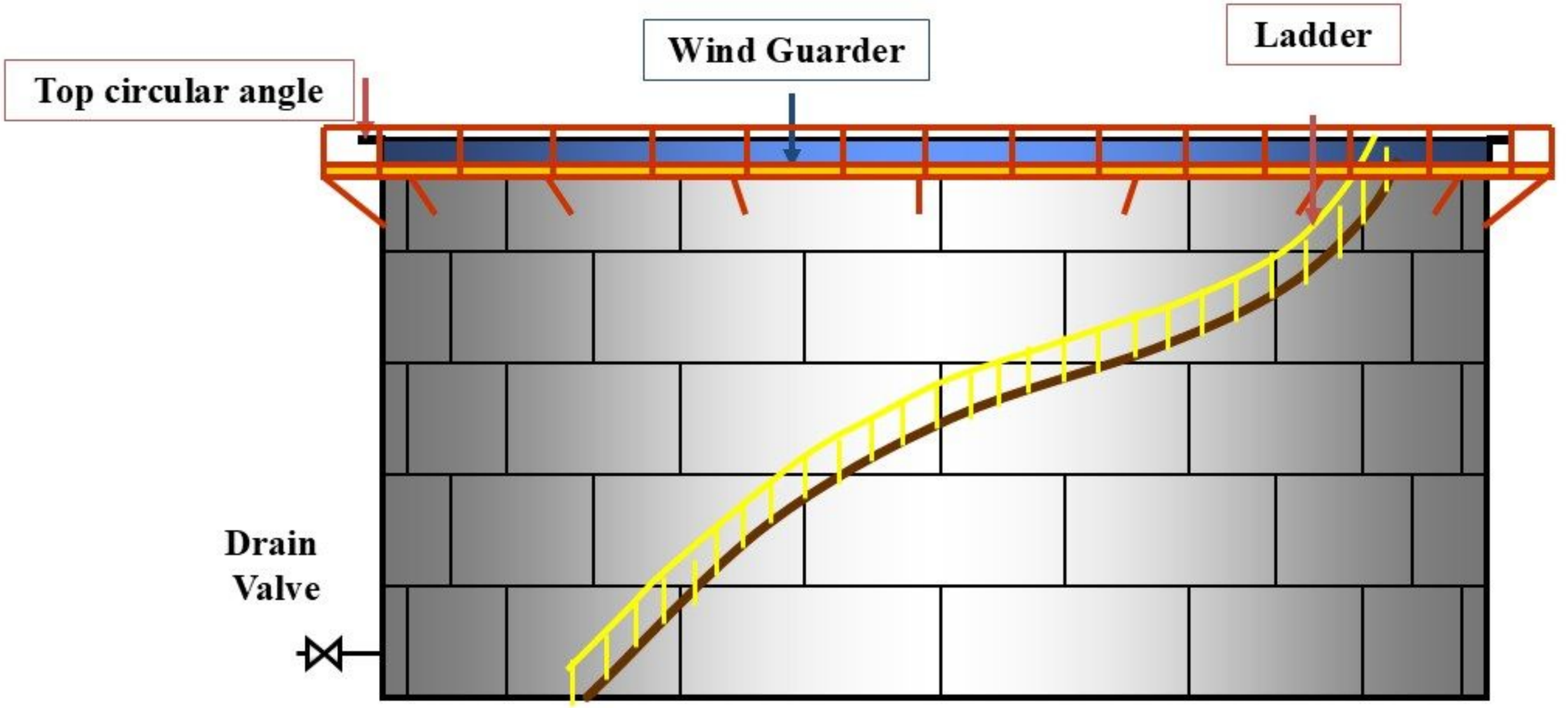




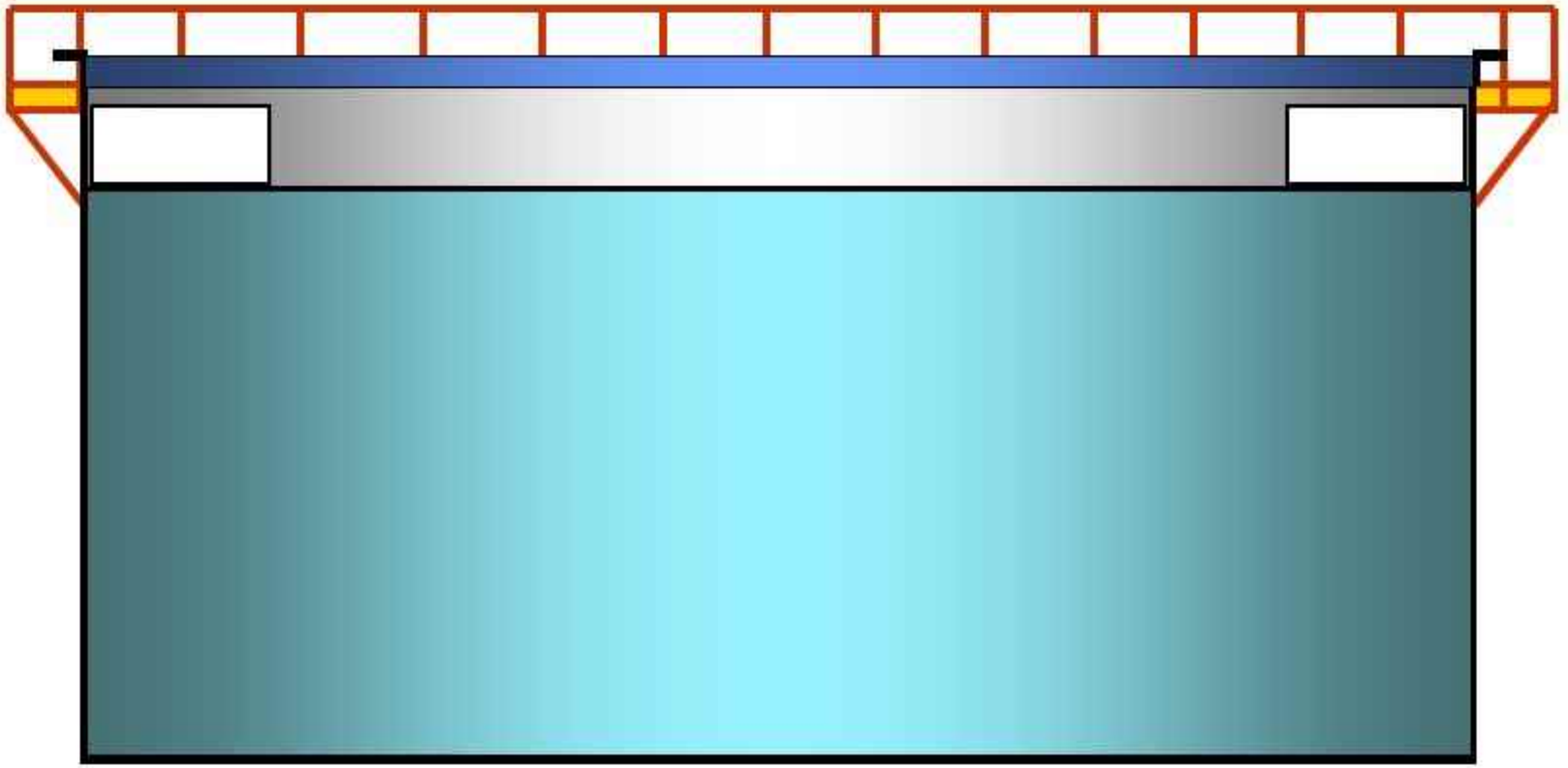
Storage Tanks

Process Technology Equipment and Systems

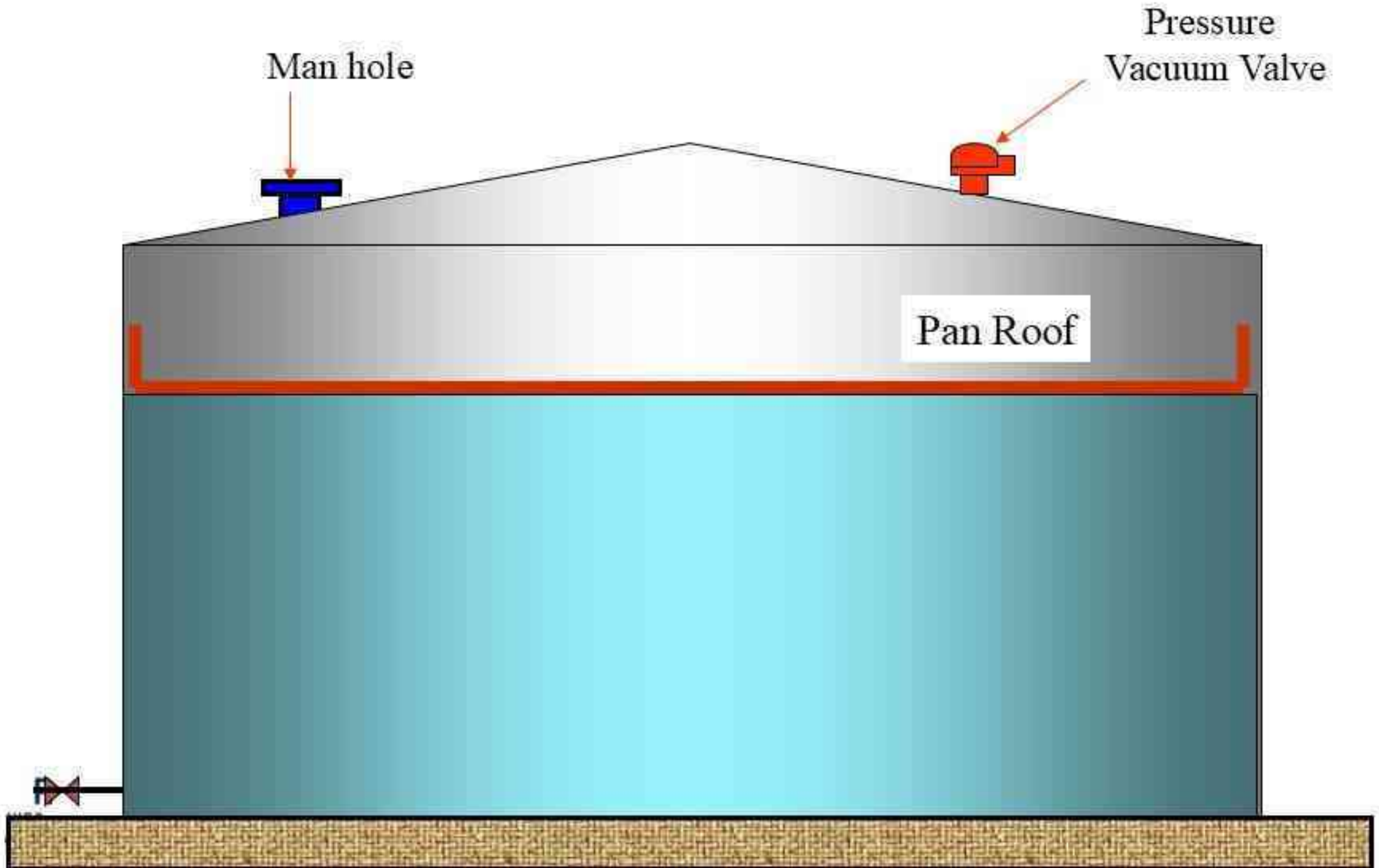
- EXTERNAL FLOATING ROOF

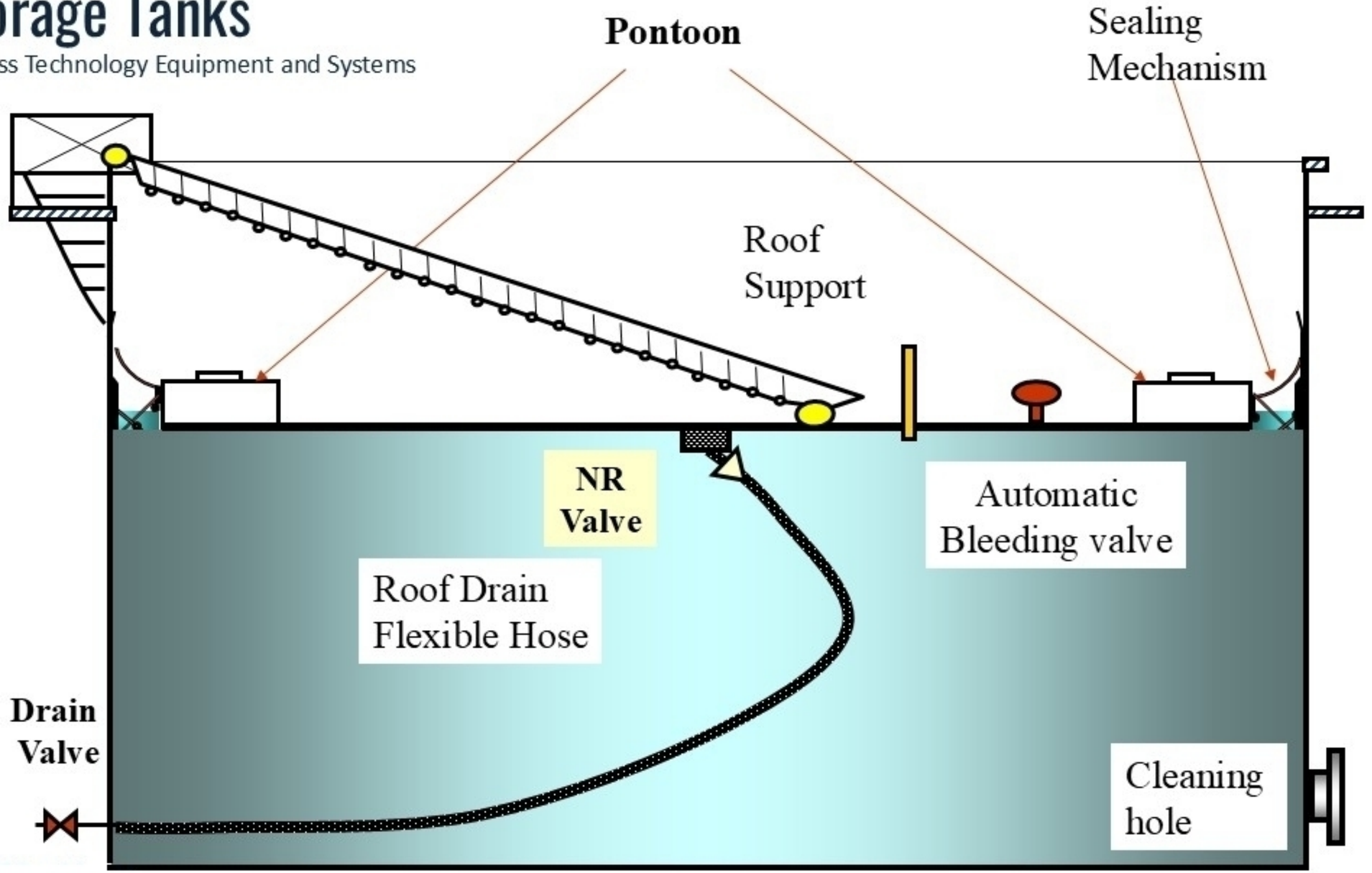


PONTOON

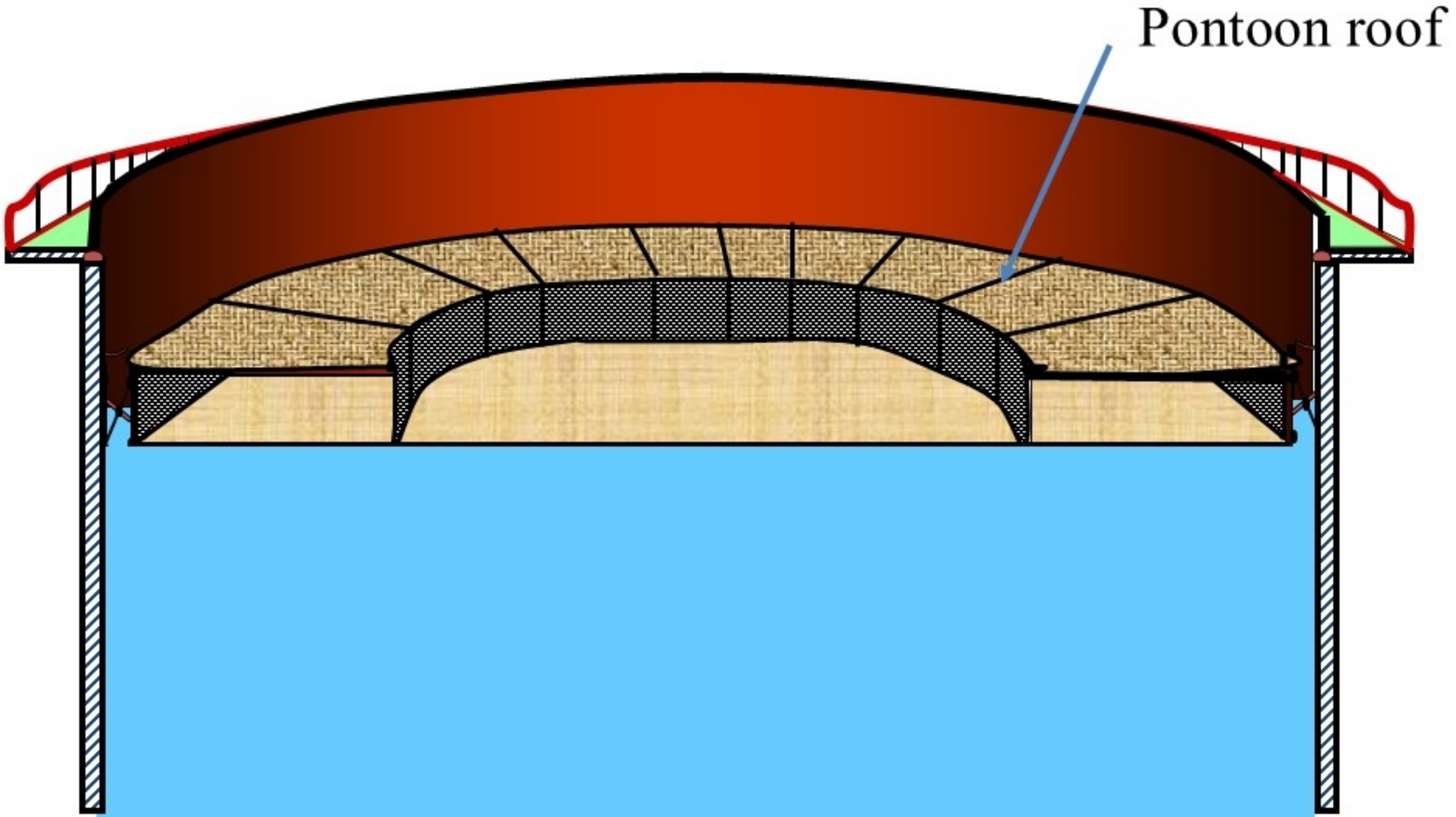


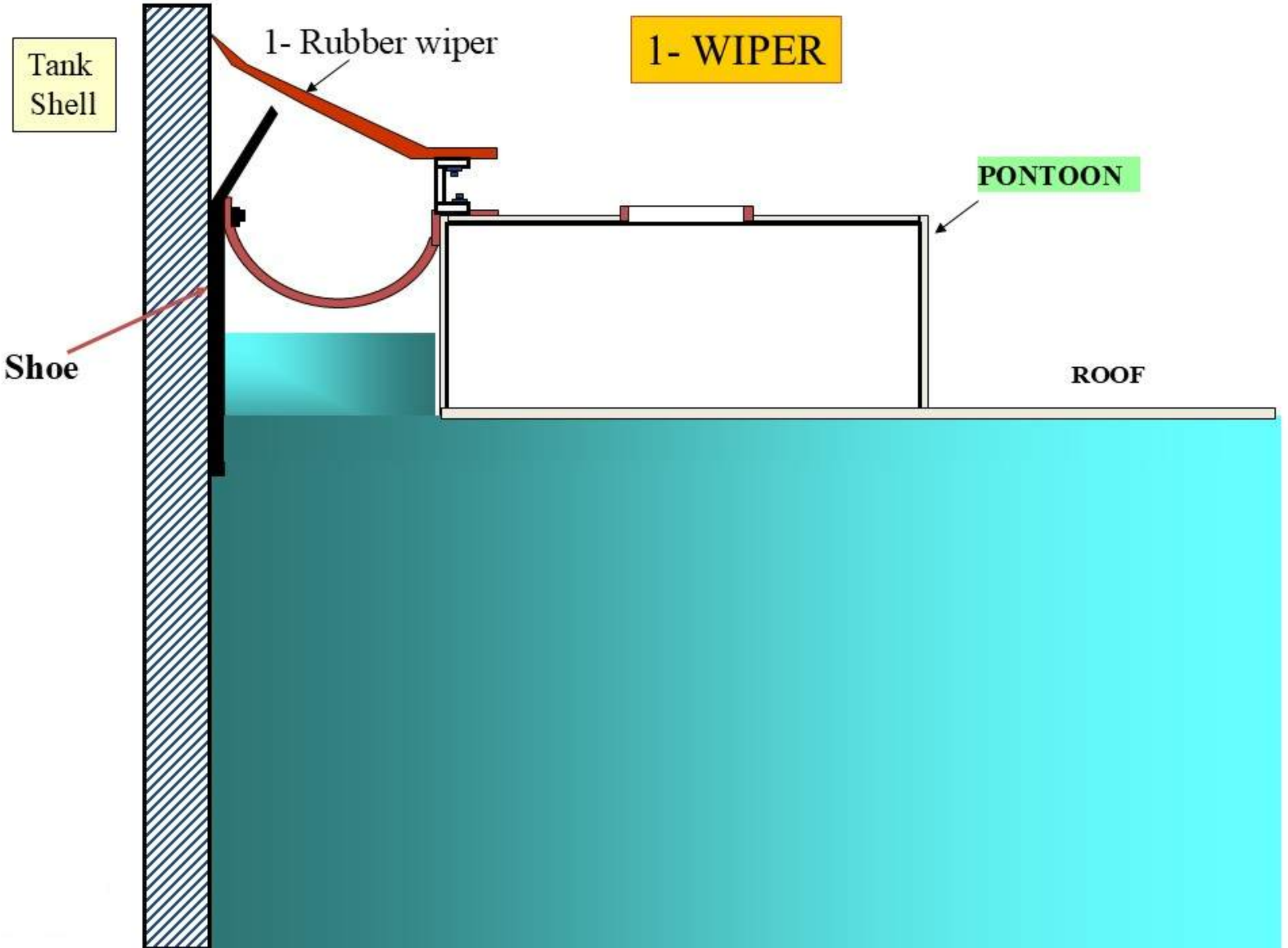
INTERNAL FLOATING COVER



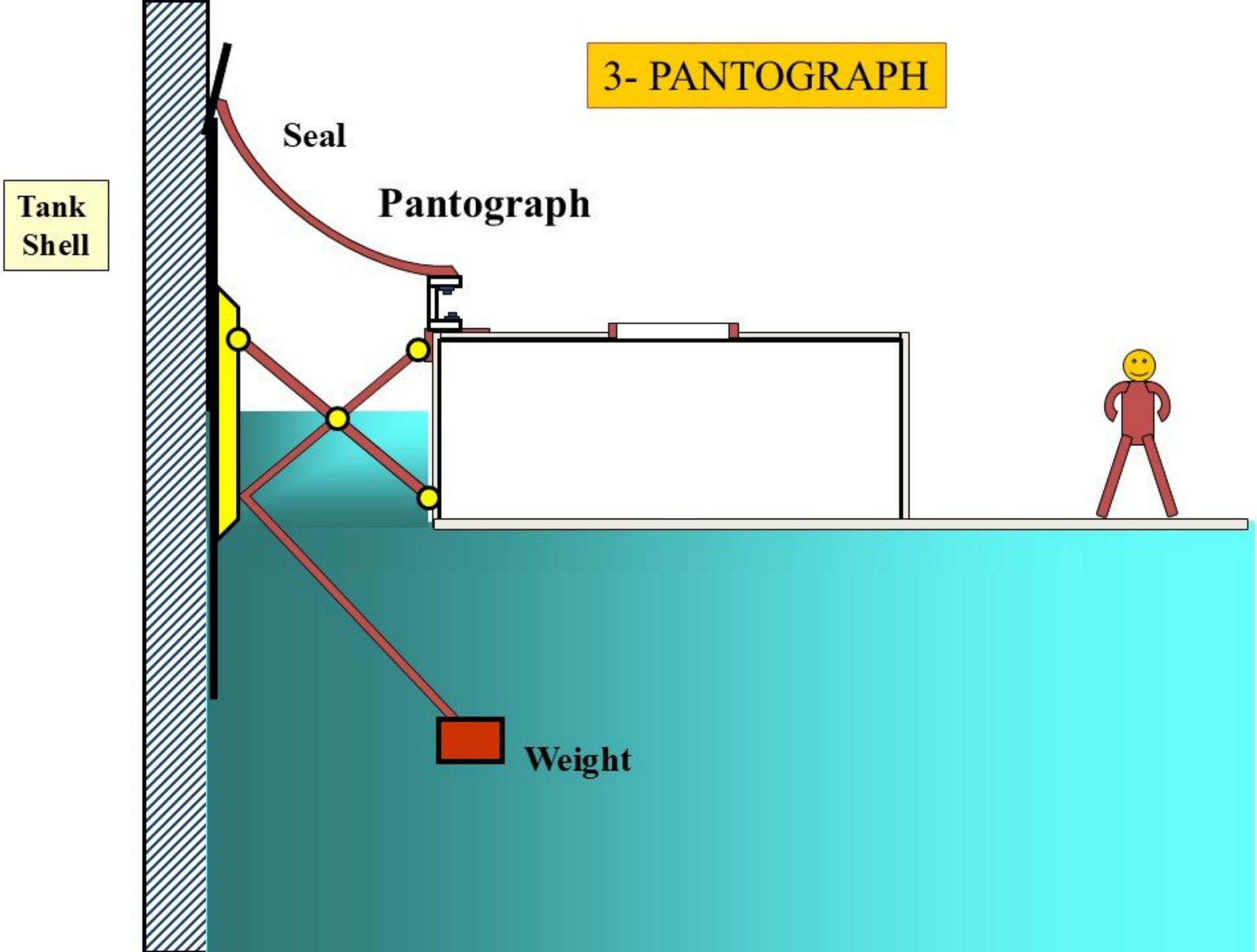

Pontoon
Sealing Mechanism
Roof Support
NR Valve
Automatic Bleeding valve
Roof Drain Flexible Hose
Drain Valve
Cleaning hole

a. Pontoon Roofs




Tank
Shell
1- Rubber wiper
1- WIPER
PONTOON
Shoe
ROOF

3- PANTOGRAPH



Storage Tanks

Process Technology Equipment and Systems

- **Spherical Tanks:**
  - Spherical shape for high-pressure storage.
  - Used for storing liquefied gases (e.g., LPG, LNG)

Storage Tanks

Process Technology Equipment and Systems

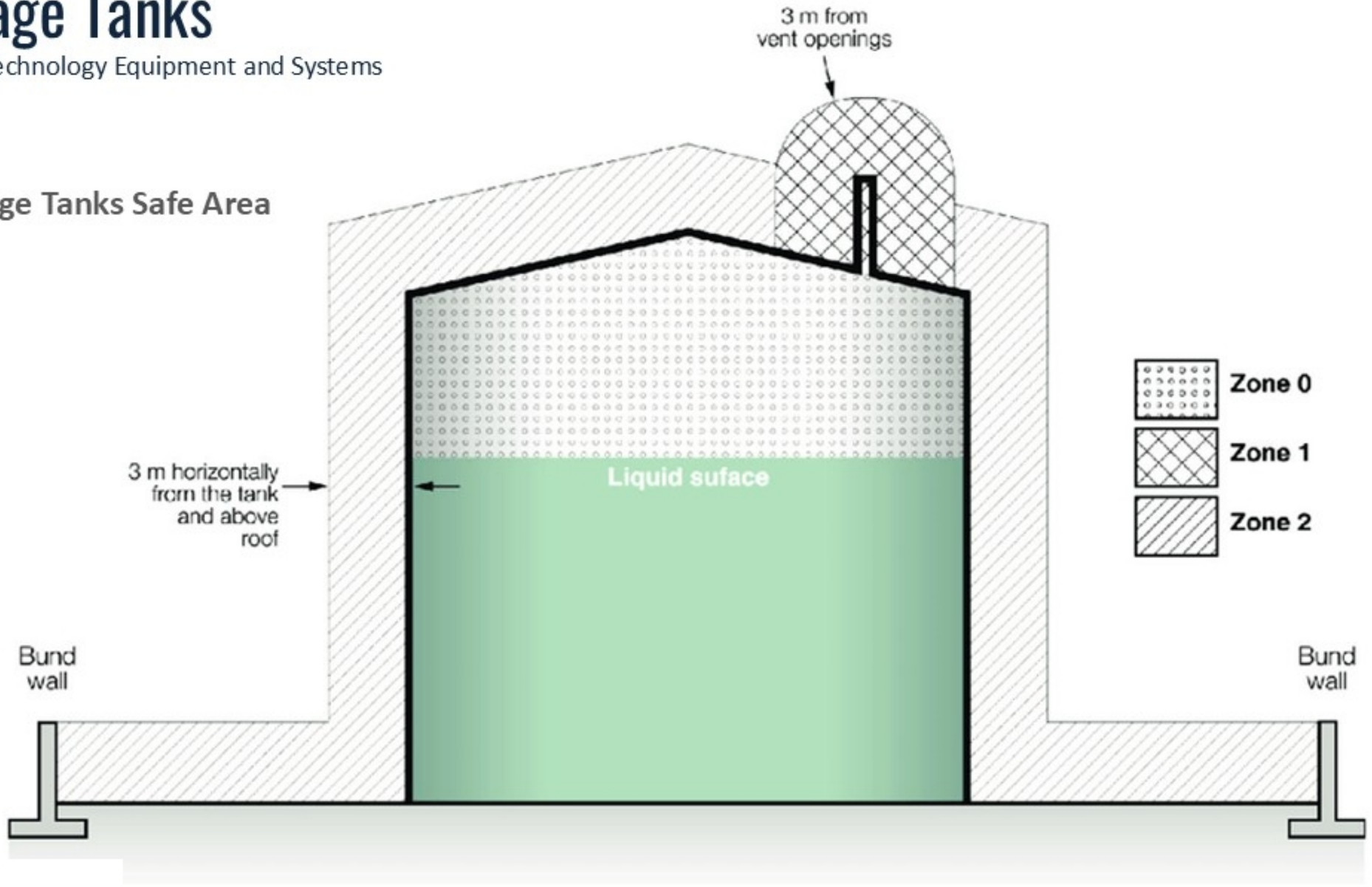
- **Underground Storage Tanks:**
  - Installed below ground for space efficiency and safety.
  - Used for fuel storage at gas stations.

- **A bullet tank**
  - A bullet tank is a storage container that houses natural gas liquids (NGLs).

Storage Tanks

Process Technology Equipment and Systems

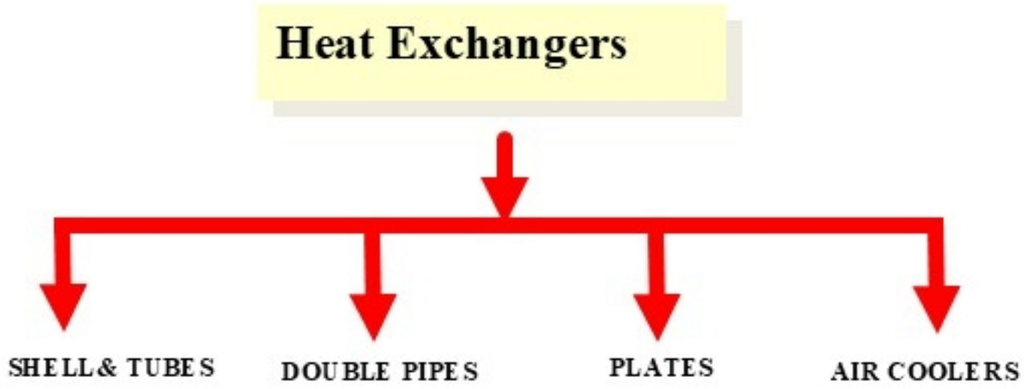
- **Storage Tanks Safe Area**



Heat Exchangers

Process Technology Equipment and Systems

- Devices that ***transfer heat*** between fluids without mixing them.
- Essential for heating, cooling, and heat recovery.



Role in Process Operations

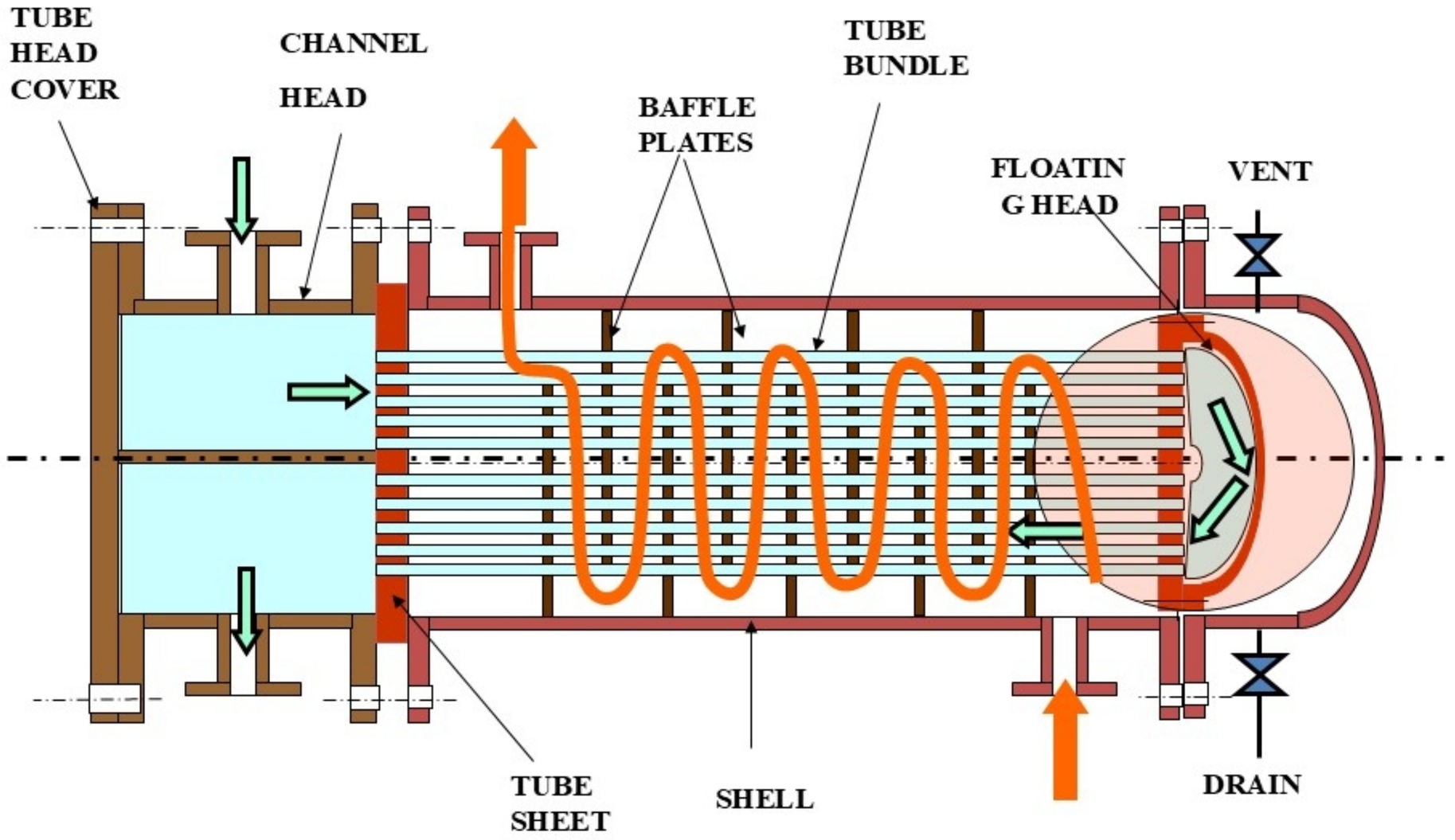
- Preheat crude oil.
- Cool refined products.
- Recover waste heat for energy efficiency.

Types of Heat Exchangers

- **Shell and Tube:** High-pressure and high-temperature applications.
- **Plate and Frame:** Compact and efficient for low to medium pressure.
- **Air-Cooled:** Uses air for cooling, ideal for water-scarce areas.
- **Double-Pipe:** Simple design for small-scale applications.

Heat Exchangers

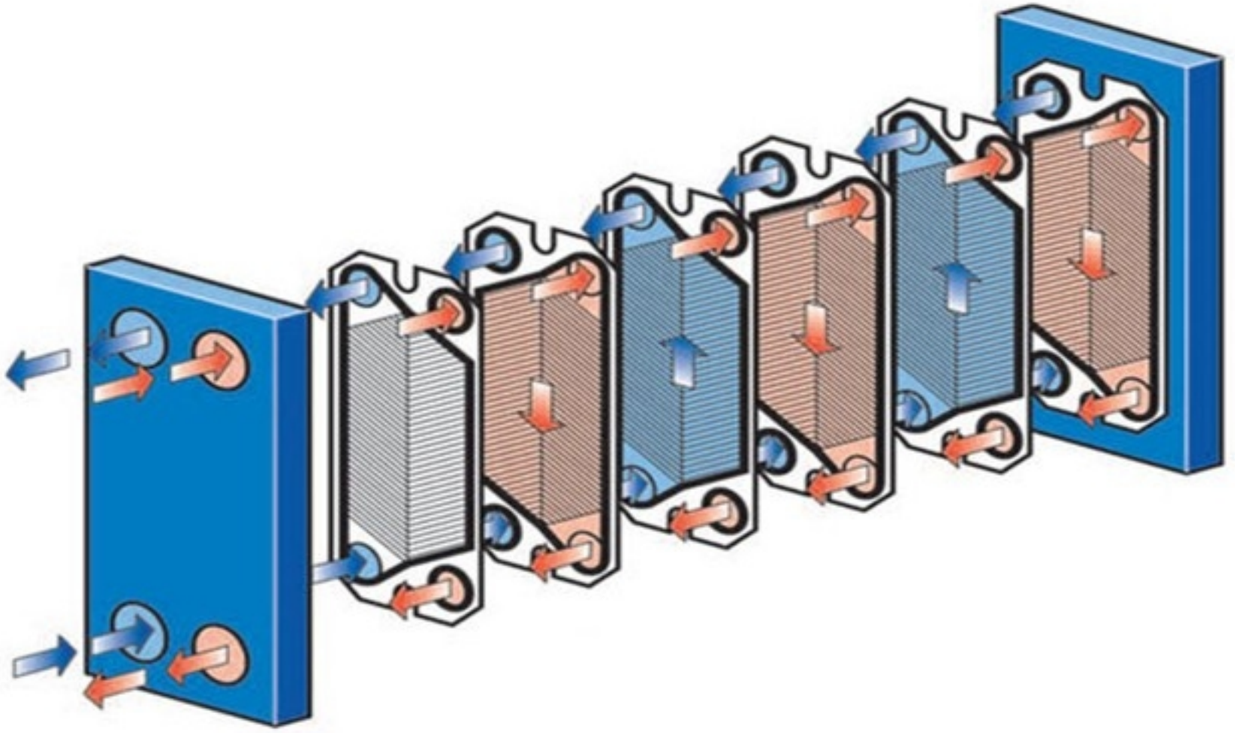
Process Technology Equipment and Systems



Heat Exchangers

Process Technology Equipment and Systems

The plate heat exchanger

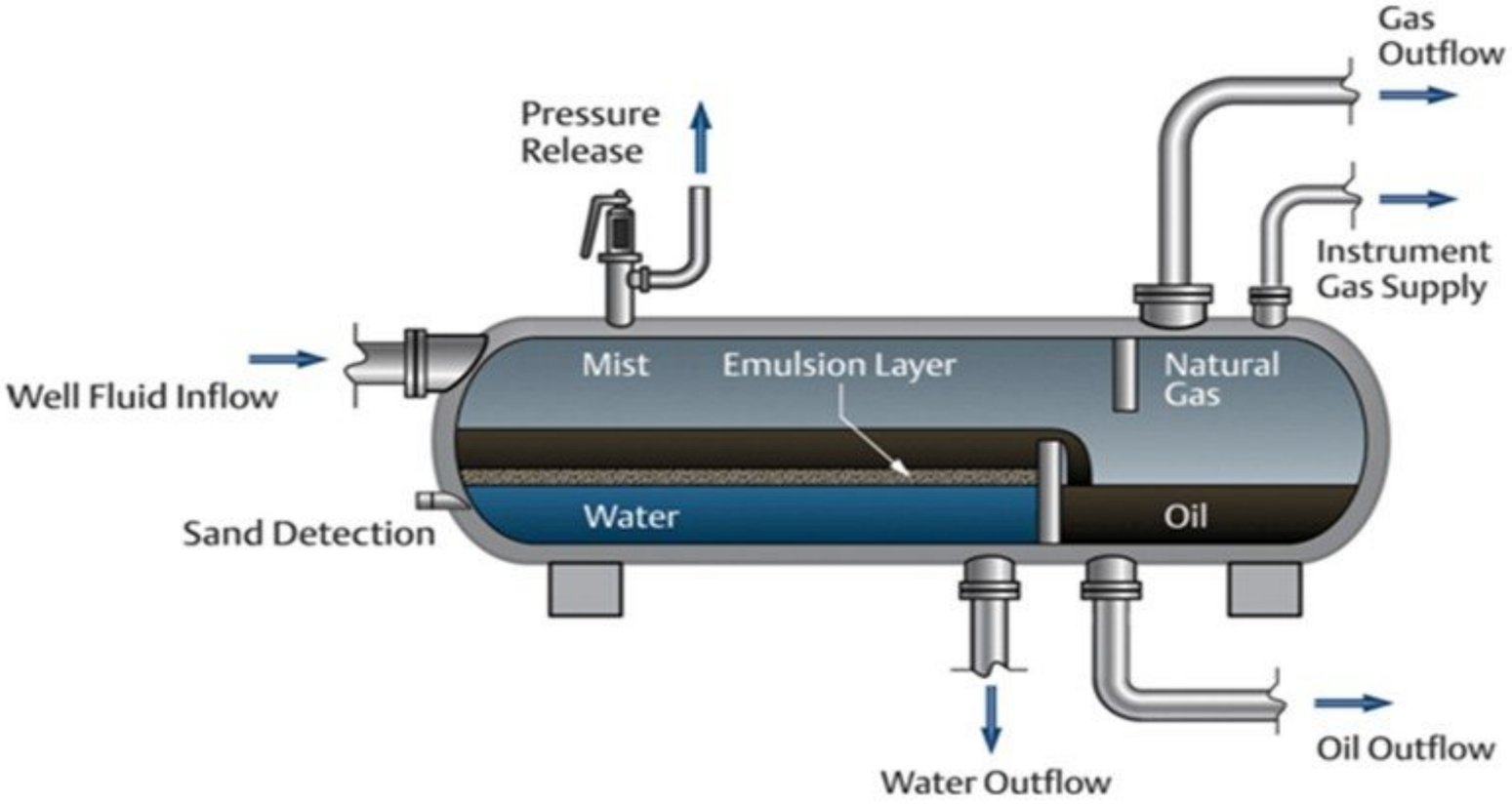


Separators

Process Technology Equipment and Systems

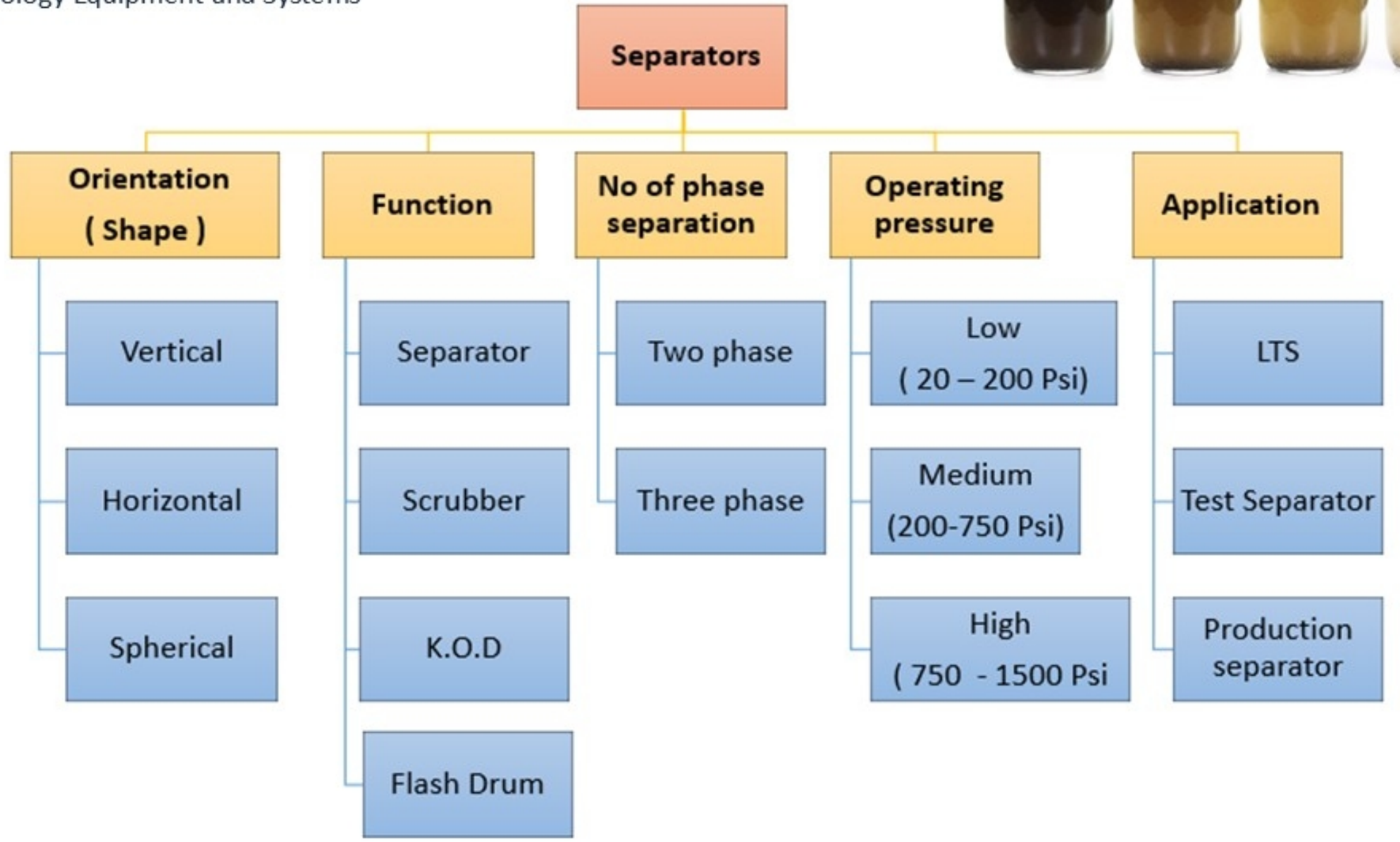
- Equipment used to separate oil, gas, and water from a mixed fluid stream.
- Critical for purifying hydrocarbons and ensuring product quality.

- Can be names as:
  - I. Separator
  - II. Scrubber
  - III. Knock out
  - IV. Vessel
  - V. Gun barrel
  - VI. Drum



Separators

Process Technology Equipment and Systems



Separators

Process Technology Equipment and Systems

Vertical

Horizontal

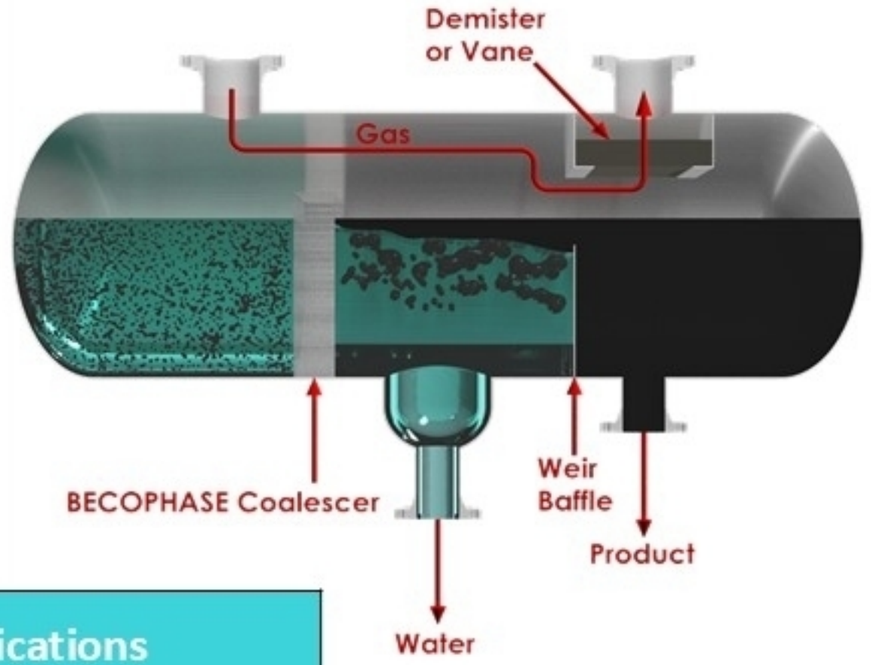
Spherical

Separators

Process Technology Equipment and Systems

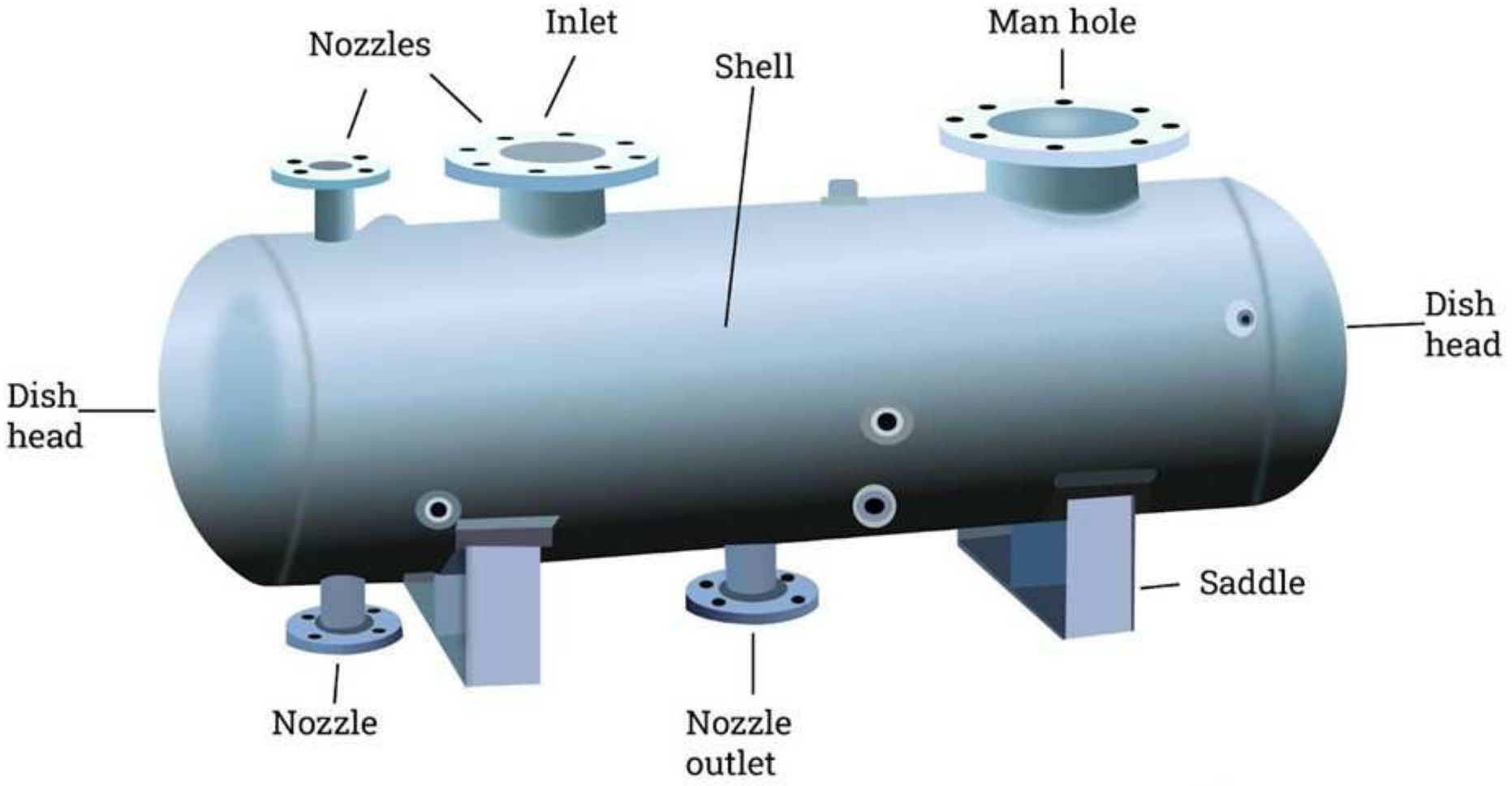
Key Components

- **Inlet**: Entry point for the mixed fluid stream.
- **Gravity Settling Section**: Separates phases based on density.
- **Mist Extractor**: Removes liquid droplets from the gas stream.
- **Liquid Outlet**: Discharges separated oil and water.
- **Gas Outlet**: Discharges purified gas.



Type of Separator	Design	Applications
Two-Phase	Horizontal/Vertical	Separate liquid and gas
Three-Phase	Horizontal/Vertical	Separate oil, gas, and water
Horizontal	Cylindrical	High gas-to-liquid ratios
Vertical	Compact	Low gas-to-liquid ratios

Pressure Vessel



Reactors

Process Technology Equipment and Systems

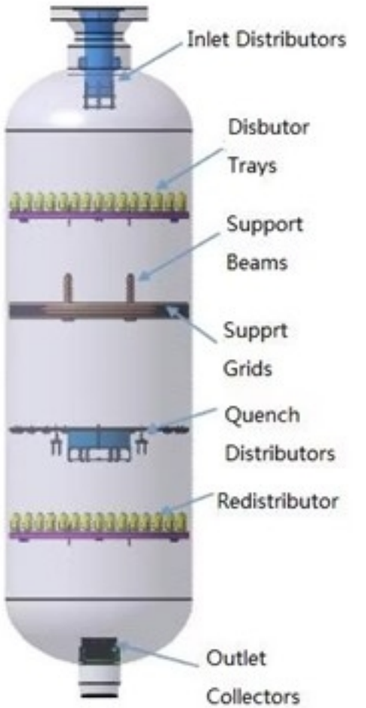
- Equipment designed to facilitate chemical reactions in downstream processes.
- Used to convert raw materials into desired products through catalytic or thermal processes.

Primary Functions:

- Convert hydrocarbons into valuable products (e.g., gasoline, diesel, petrochemicals).
- Remove impurities (e.g., sulfur, nitrogen) through hydrotreating.
- Break down heavy hydrocarbons into lighter fractions (e.g., cracking).

Key Components:

- Reactor Vessel: Contains the reaction mixture.
- Catalyst: Speeds up the reaction without being consumed.
- Heating/Cooling System: Maintains optimal reaction temperature.
- Inlet/Outlet Nozzles: Allow reactant entry and product exit.
- Control Systems: Monitor and adjust reaction conditions.



Distillation Columns

Process Technology Equipment and Systems

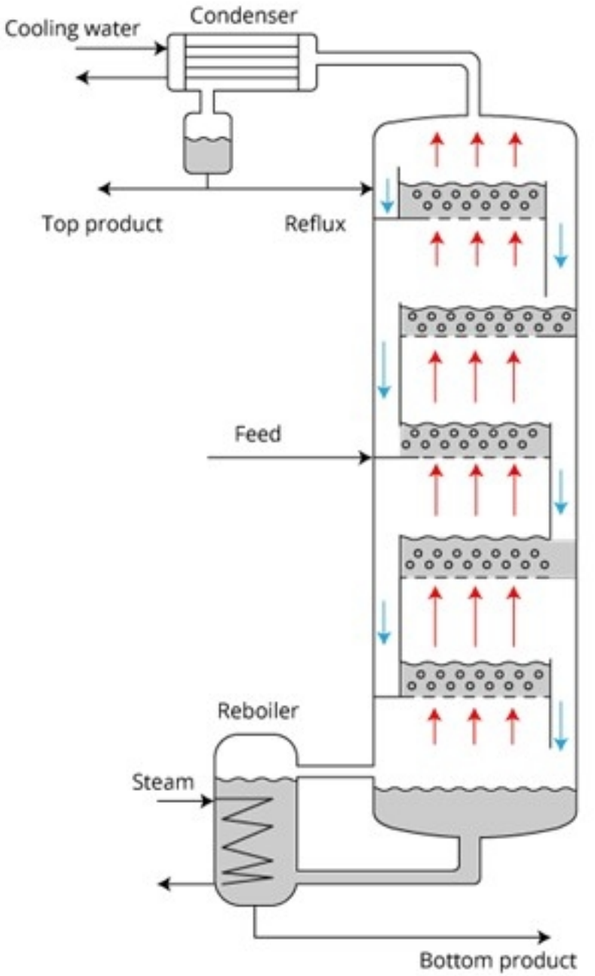
- Equipment used to separate crude oil into fractions based on boiling points.
- A key component of refining processes in the downstream industry.

Primary Functions:

- Separate crude oil into useful fractions (e.g., gasoline, diesel, kerosene).
- Remove impurities and light gases.

Key Components:

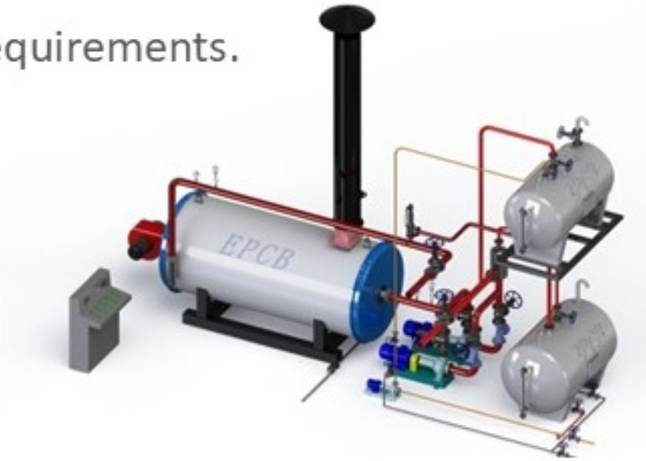
- ***Trays or Packing***: Provide surface area for vapor-liquid contact.
- ***Reboiler***: Supplies heat to vaporize the liquid.
- ***Condenser***: Cools and condenses the vapor into liquid.
- ***Feed Inlet:*** Introduces crude oil into the column.
- ***Product Outlets***: Collect separated fractions at different heights.



Furnaces and Boilers

Process Technology Equipment and Systems

- **Furnaces:** Equipment that provides direct heat for processes (e.g., heating crude oil).
- **Boilers:** Equipment that generates steam for heating, power, or process requirements.



Primary Functions:

- **Furnaces**: Heat crude oil, process fluids, or reactors.
- **Boilers**: Generate steam for power, heating, or chemical processes.

Key Components:

Furnaces:

- Burners: Provide combustion for heat generation.
- Heat Exchanger Tubes: Transfer heat to the process fluid.
- Stack: Releases exhaust gases.

Boilers:

- Burners: Provide combustion for steam generation.
- Steam Drum: Separates steam from water.
- Economizer: Preheats feedwater to improve efficiency.

Piping and Valves

Process Technology Equipment and Systems

- **Piping:** A network of pipes used to transport fluids (e.g., oil, gas, water) between equipment and processes.
- **Valves**: Devices used to control, regulate, or isolate fluid flow within the piping system.

Primary Functions:

- **Piping:** Transport raw materials, intermediates, and finished products.
- **Valves**: Regulate flow, pressure, and direction of fluids.

Types of Piping

Carbon Steel Pipes: Commonly used for high-pressure and high-temperature applications.

Stainless Steel Pipes: Resistant to corrosion, used for corrosive fluids.

Plastic Pipes: Lightweight and corrosion-resistant, used for low-pressure applications.

Composite Pipes: Combine materials for specific properties (e.g., strength, corrosion resistance).

Piping and Valves

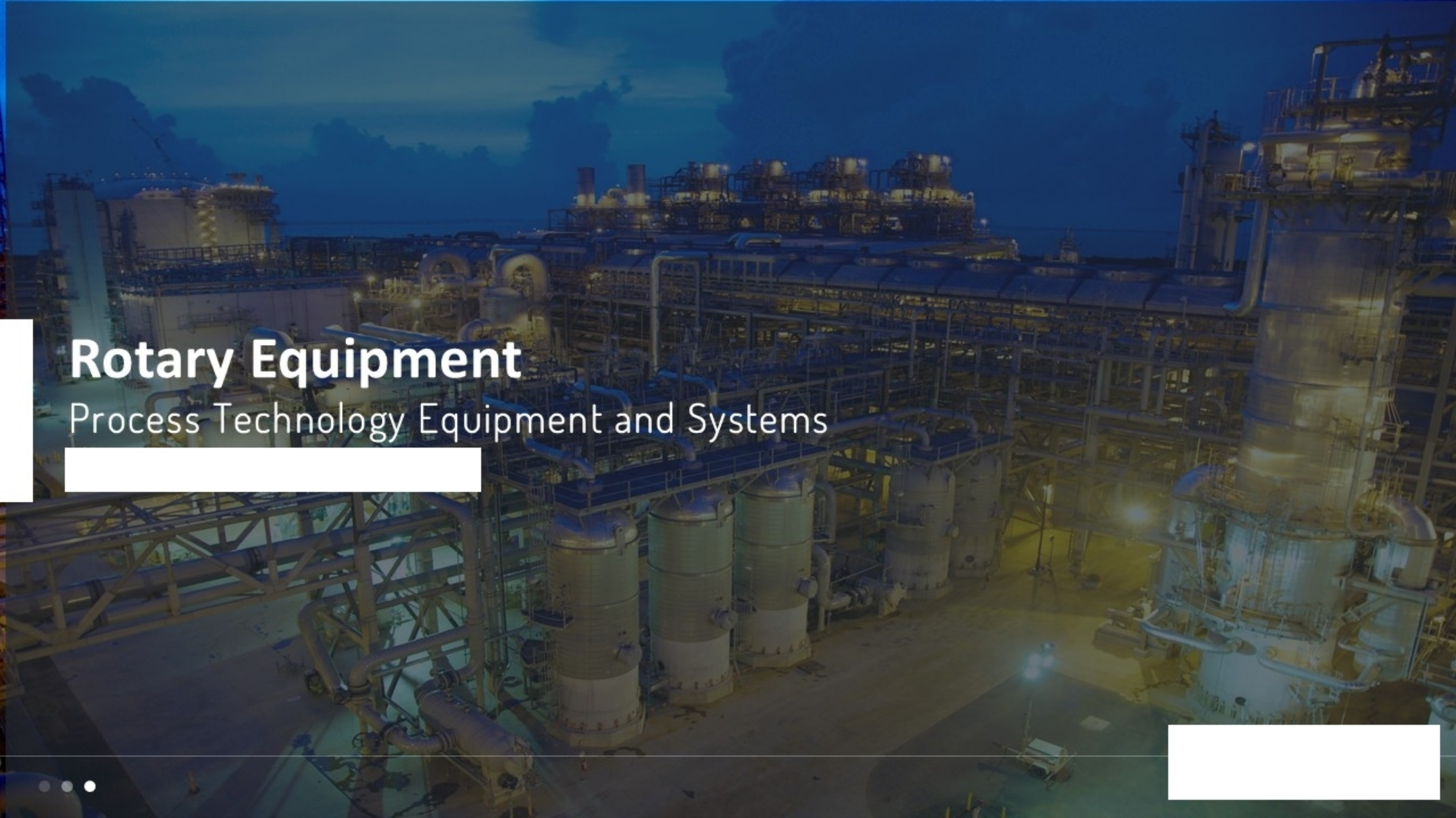
Process Technology Equipment and Systems

- Types of valves

Piping and Valves

Process Technology Equipment and Systems

Valve Type	Function
Gate Valve	- Used for on/off control of fluid flow - Provides minimal pressure drop when fully open.
Globe Valve	- Used for throttling and regulating flow. - Provides precise flow control.
Ball Valve	- Used for quick on/off control. - Low torque operation.
Check Valve	- Allows flow in one direction only and prevents backflow. - used in pump discharge
Butterfly Valve	- Used for on/off and throttling in large pipelines. - - Compact and cost-effective.
Plug Valve	- Used for on/off control and flow diversion. - Suitable for high-pressure and high-temperature.
Diaphragm Valve	- Used for on/off and throttling in corrosive or abrasive fluids. - - Provides leak-proof sealing.
Needle Valve	- Used for precise flow control in small-diameter pipelines. - used in instrumentation and control
Pressure Relief Valve	- Automatically releases excess pressure to protect equipment
Control Valve	- Automatically regulates flow, pressure, or temperature. - Used in process control systems.



Rotary Equipment

Process Technology Equipment and Systems

Rotary Equipment

Process Technology Equipment and Systems

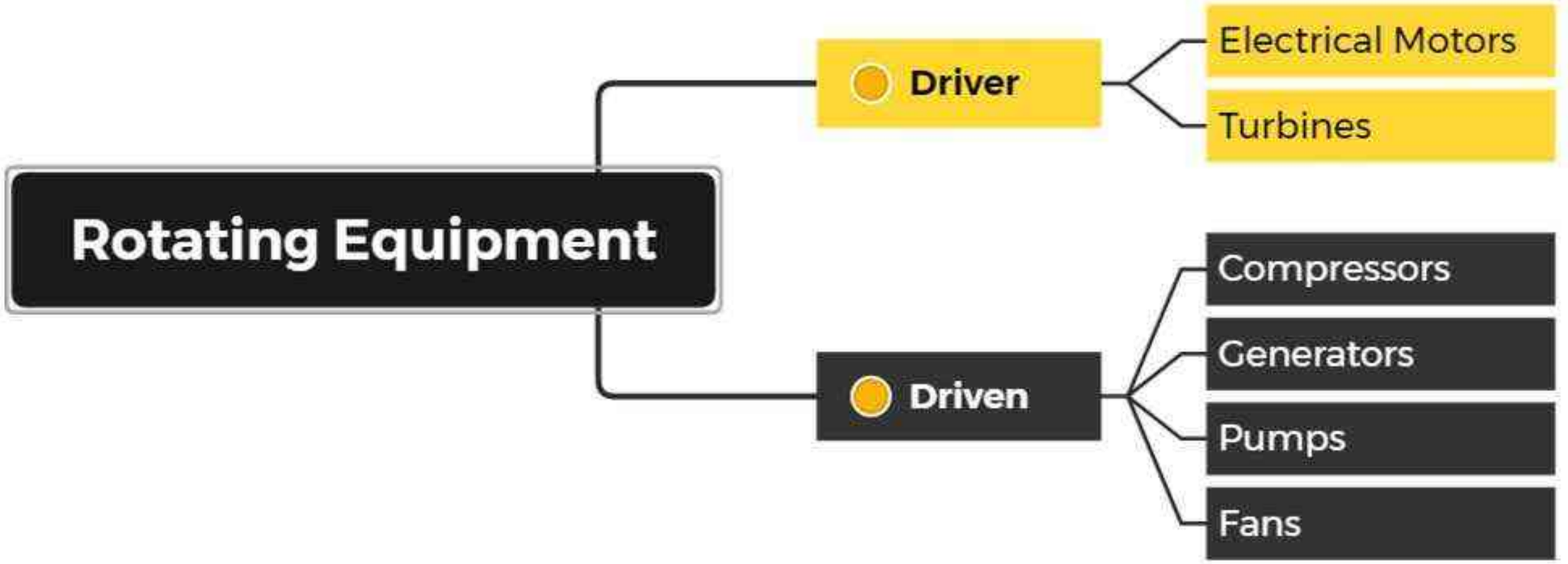
- Equipment with rotating components (e.g., impellers, blades, rotors) to transfer energy, fluids, or mechanical power. Examples: Pumps, compressors, turbines, mixers, fans.

Core Functions:

- Fluid Transfer: Move liquids/gases through pipelines.
- Energy Conversion: Convert energy (e.g., steam to mechanical power in turbines).
- Processing: Mix, compress, or separate fluids.

Rotary Equipment

Process Technology Equipment and Systems

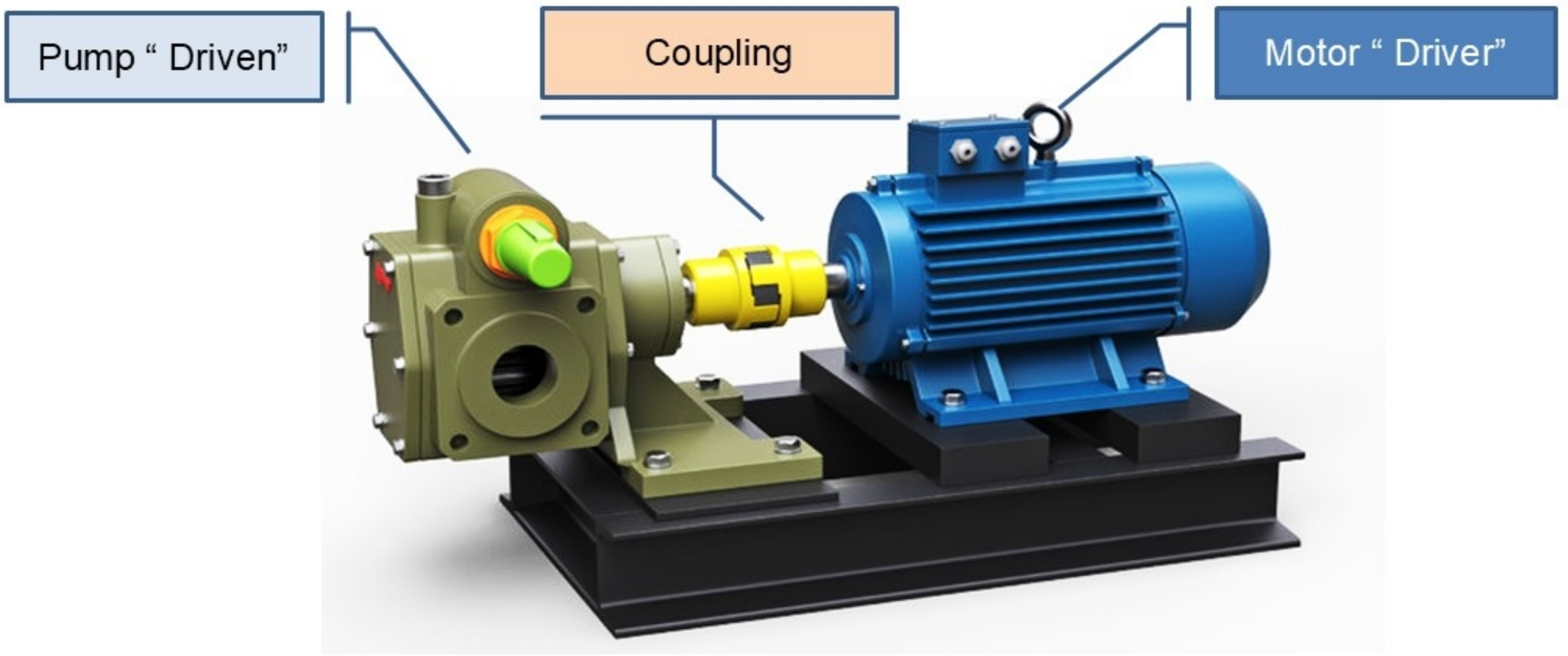


Rotary Equipment

Process Technology Equipment and Systems

A driver

is a device designed to provide rotational energy to another piece of equipment “driven equipment”



Rotary Equipment

Process Technology Equipment and Systems

Drivers: Prime movers

Electrical Motors

Steam Turbines

internal combustion engines

Rotary Equipment

Process Technology Equipment and Systems

Driven Equipment

Pumps

Compressors

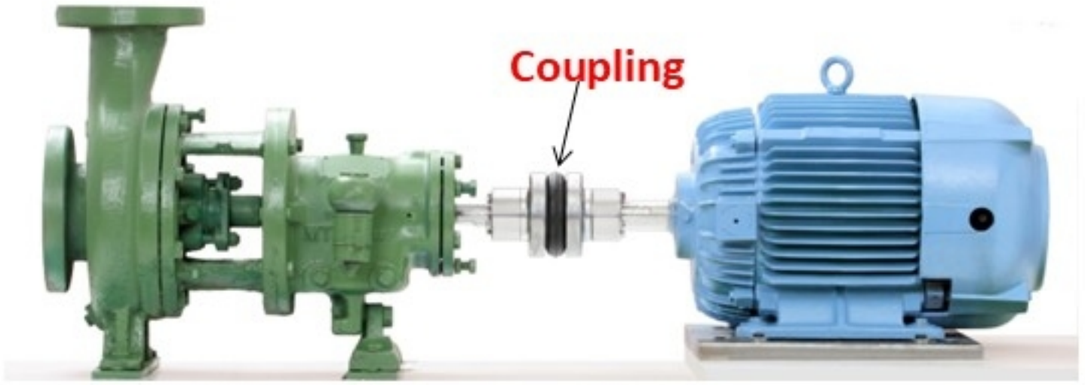
Generators

Fans

Rotary Equipment

Process Technology Equipment and Systems

- Coupling: Connect two shafts of rotating equipment, allowing them to transmit power and motion from one shaft to another.
- The choice of coupling method depends on factors such as the type of equipment, the torque and speed requirements, misalignment allowances, maintenance considerations



Universal Coupling

Sleeve Coupling

Jaw Coupling

Magnetic Coupling

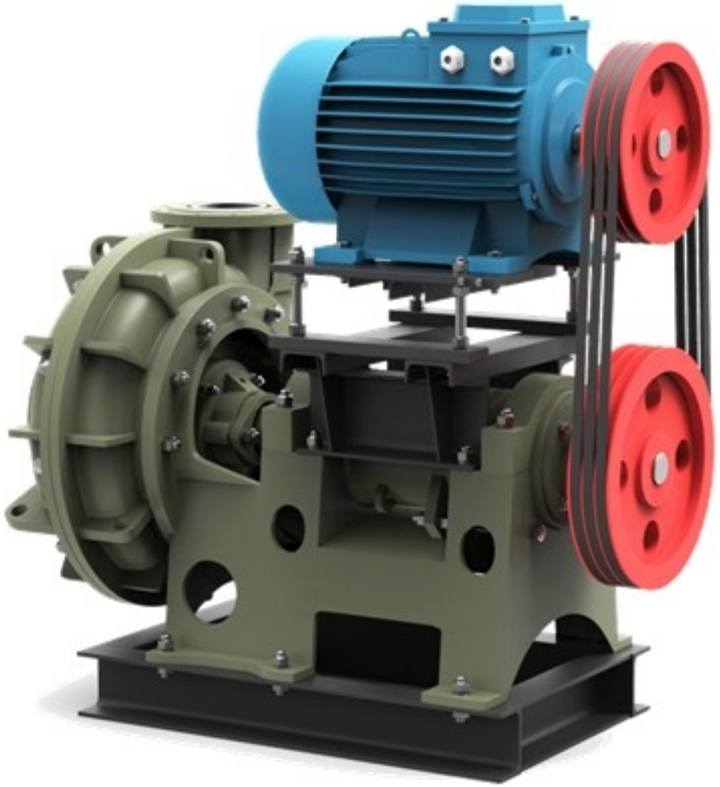
Gear Coupling

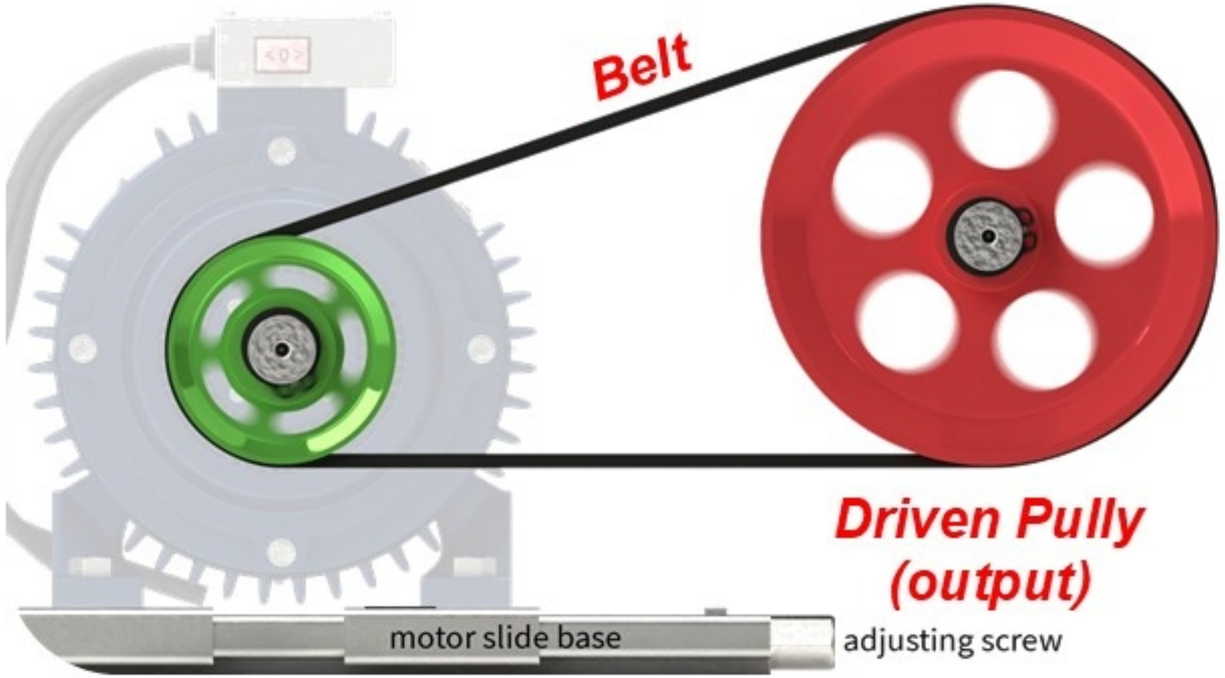
Rotary Equipment

Process Technology Equipment and Systems

Belt drives

- Belts are used to connect two parallel shafts: the drive shaft and the driven shaft. A pulley is mounted on the end of each shaft. Belts fit in the grooves of the pulley.





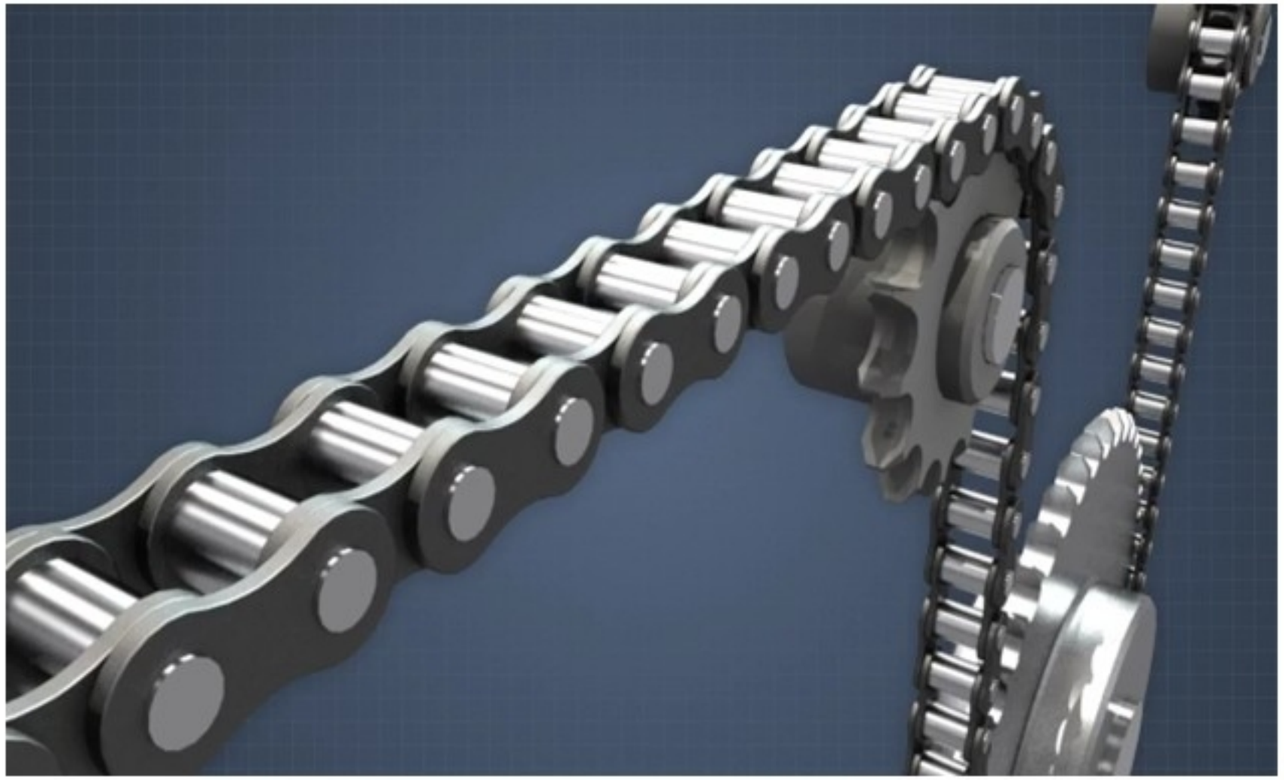
Driver Pully (Input)

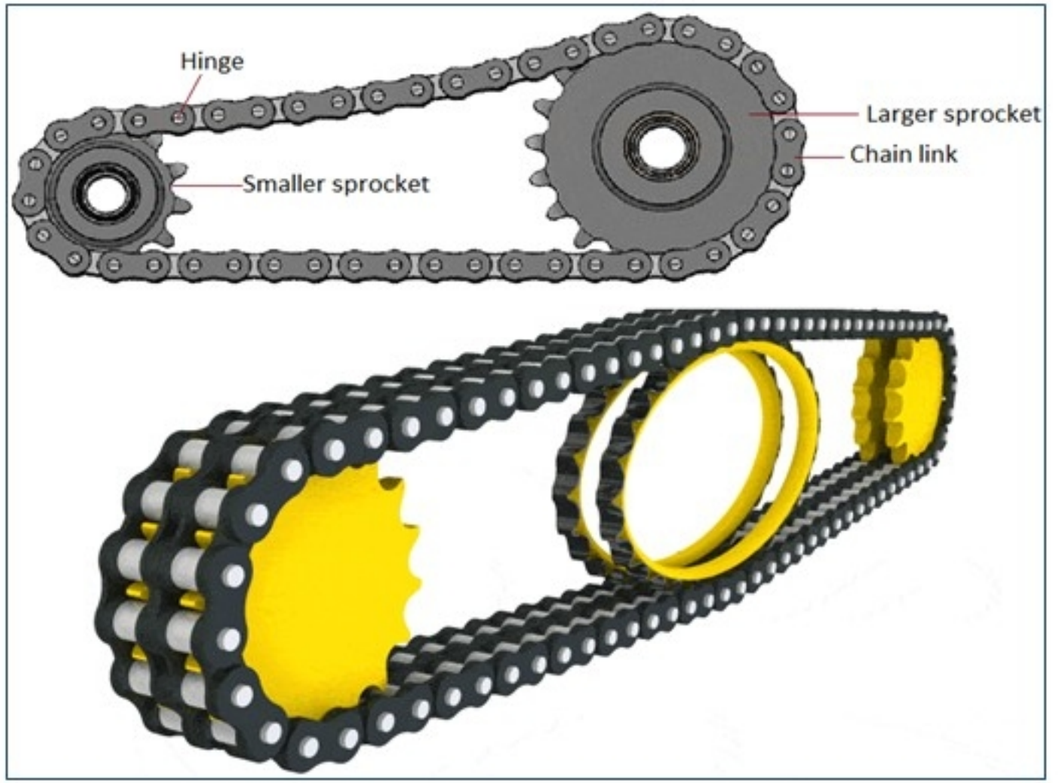
Rotary Equipment

Process Technology Equipment and Systems

Chain drives

- Chain drives are designed for low speeds and high torque conversions



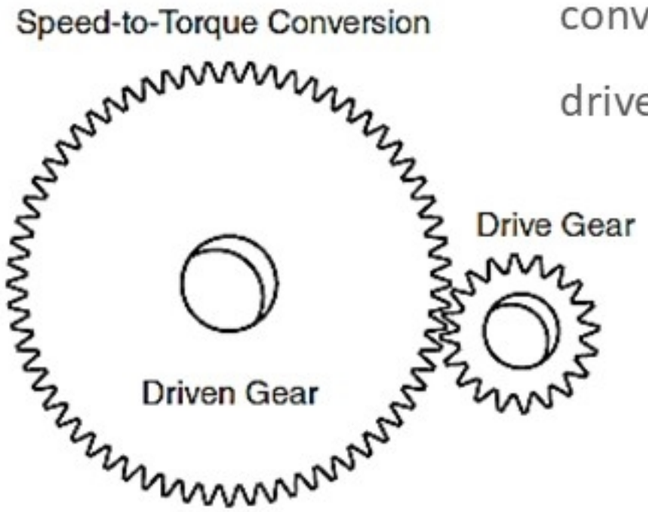


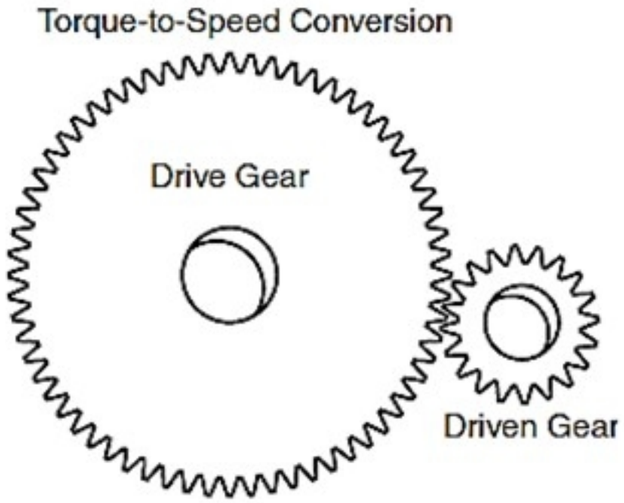
Rotary Equipment

Process Technology Equipment and Systems

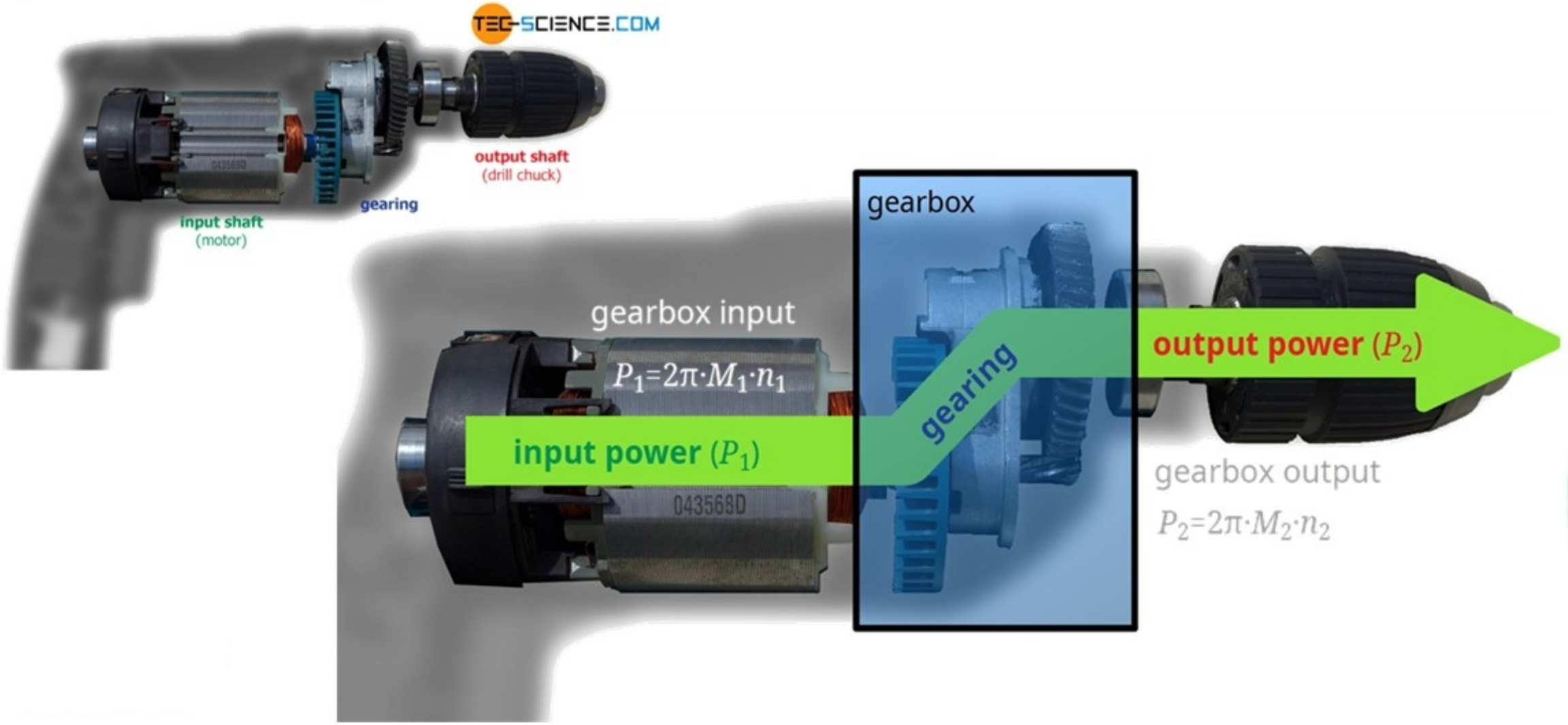
Gearboxes

- In gear drives, gear wheels, are also referred to as cogwheels or toothed wheels or simply gears, engage with each other and thus form-locking convert the revolution speed and torque of the drive shaft to the desired value on the output shaft.





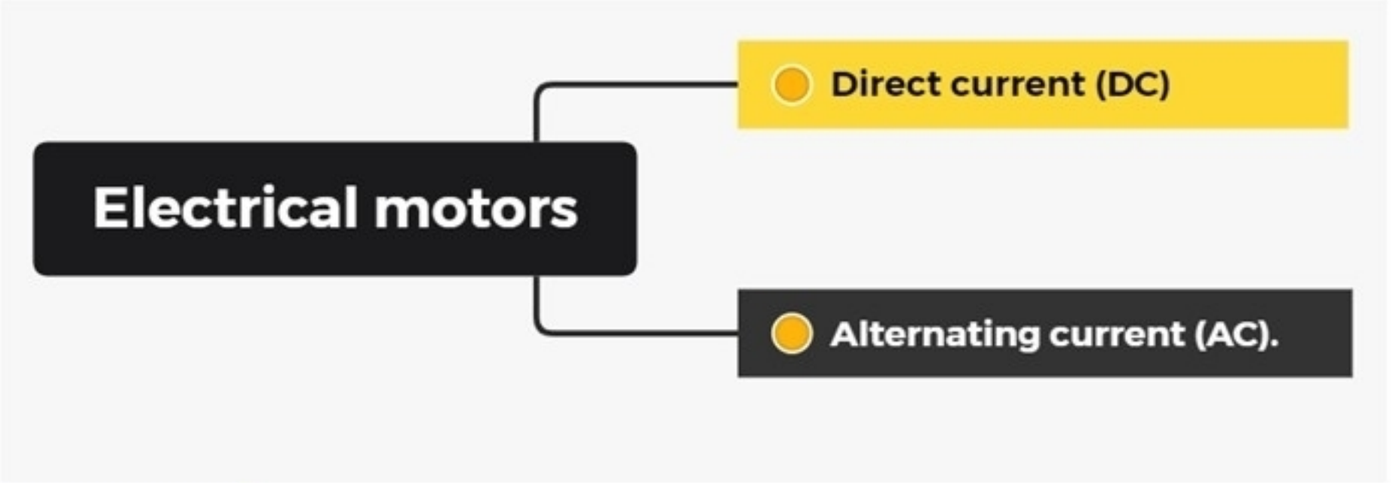
Gearboxes

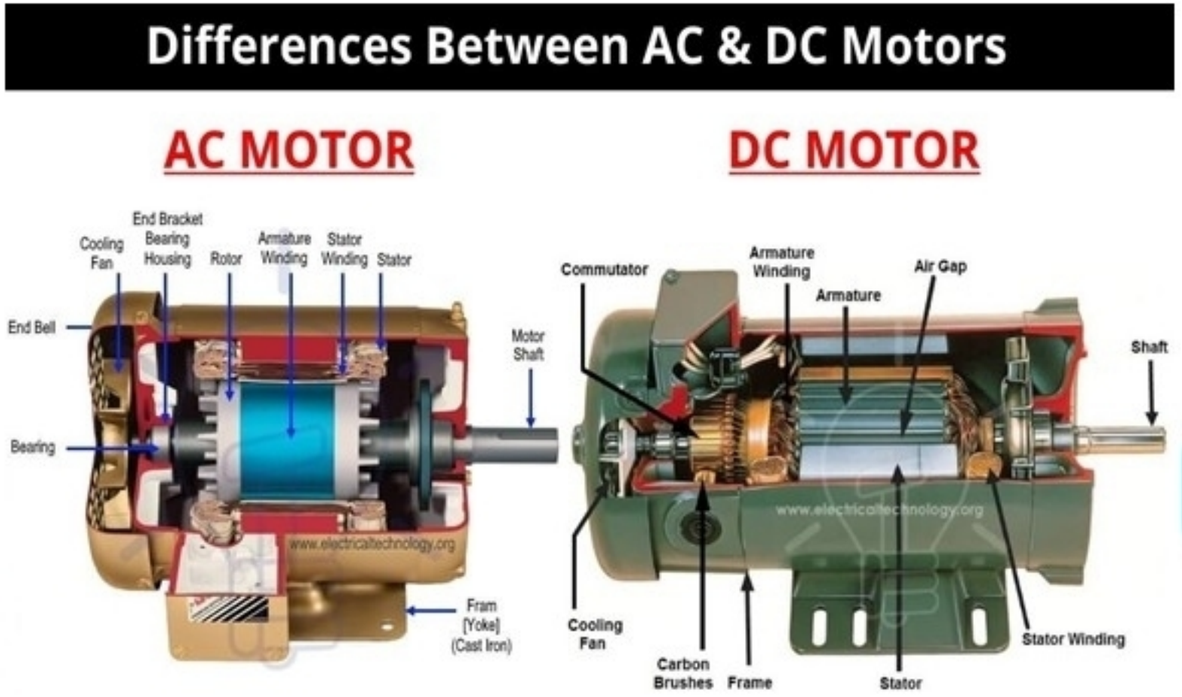

TEC-SCIENCE.COM
output shaft
(drill chuck)
gearing
input shaft
(motor)
gearbox input
$P_1=2\pi\cdot M_1\cdot n_1$
input power (P_1)
gearbox
gearing
output power (P_2)
gearbox output
$P_2=2\pi\cdot M_2\cdot n_2$

Rotary Equipment

Process Technology Equipment and Systems

Electric Motors





Rotary Equipment

Process Technology Equipment and Systems

DC Motors

- Required transformer.
- Provide High output torque.
- Expensive and repeated maintenance required.
- Used for Generator Startup
- Used batteries to obtain power supply

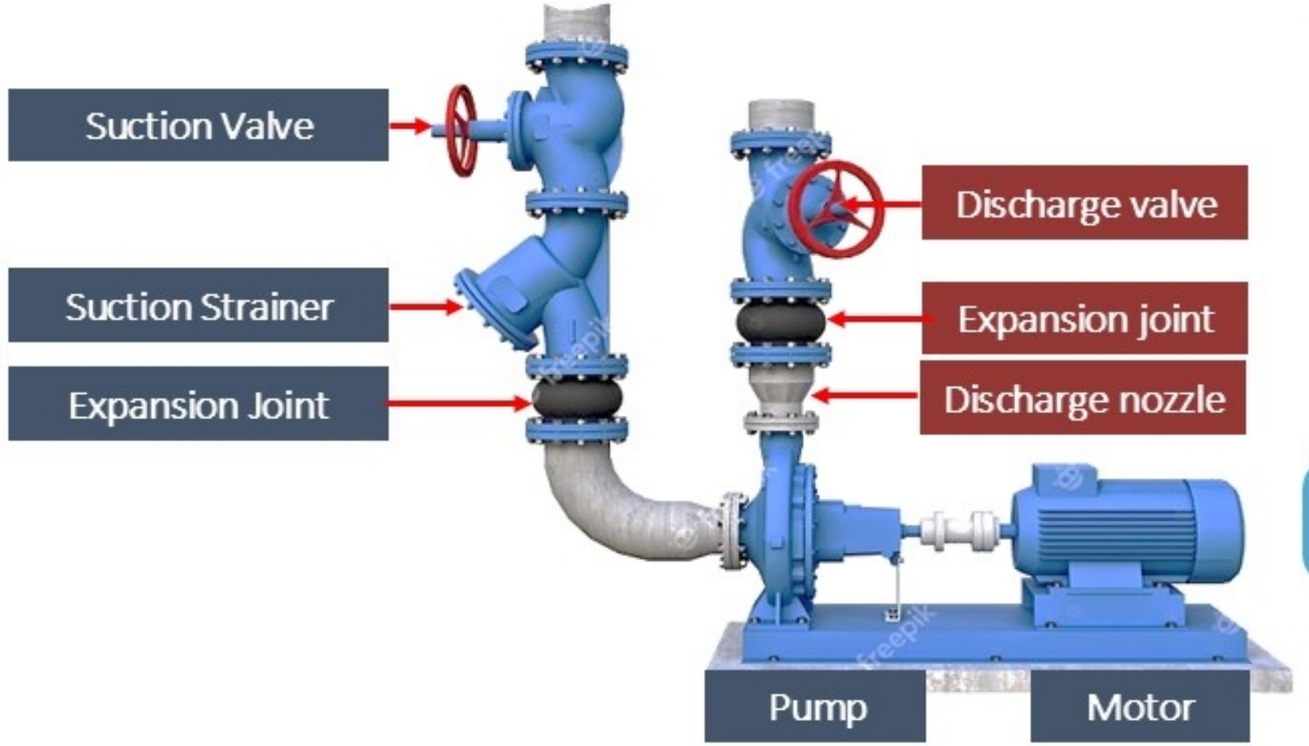
AC Motors

- High availability
- Low maintenance Cost.
- Many types available depend on voltage, usages, usages.

Pumps

Process Technology Equipment and Systems

- Mechanical devices that move fluids (liquids or slurries) by converting mechanical energy into hydraulic energy.
- Essential for transporting fluids through pipelines, reactors, and storage systems.



Pumps

Process Technology Equipment and Systems

Role in Downstream Operations

- Transfer crude oil, refined products, and chemicals.
- Maintain flow rates and pressure in pipelines.
- Support processes like cooling, injection, and mixing.

ANSI Centrifugal

Lobe/Sanitary

Self Priming Centrifugal

Rotary Gear

Horizontal Split Case

Metering/Dosing

Reciprocating Plunger/Piston

Air Operated

High Pressure

Progressing Cavity

Submersible

Vertical Pumps

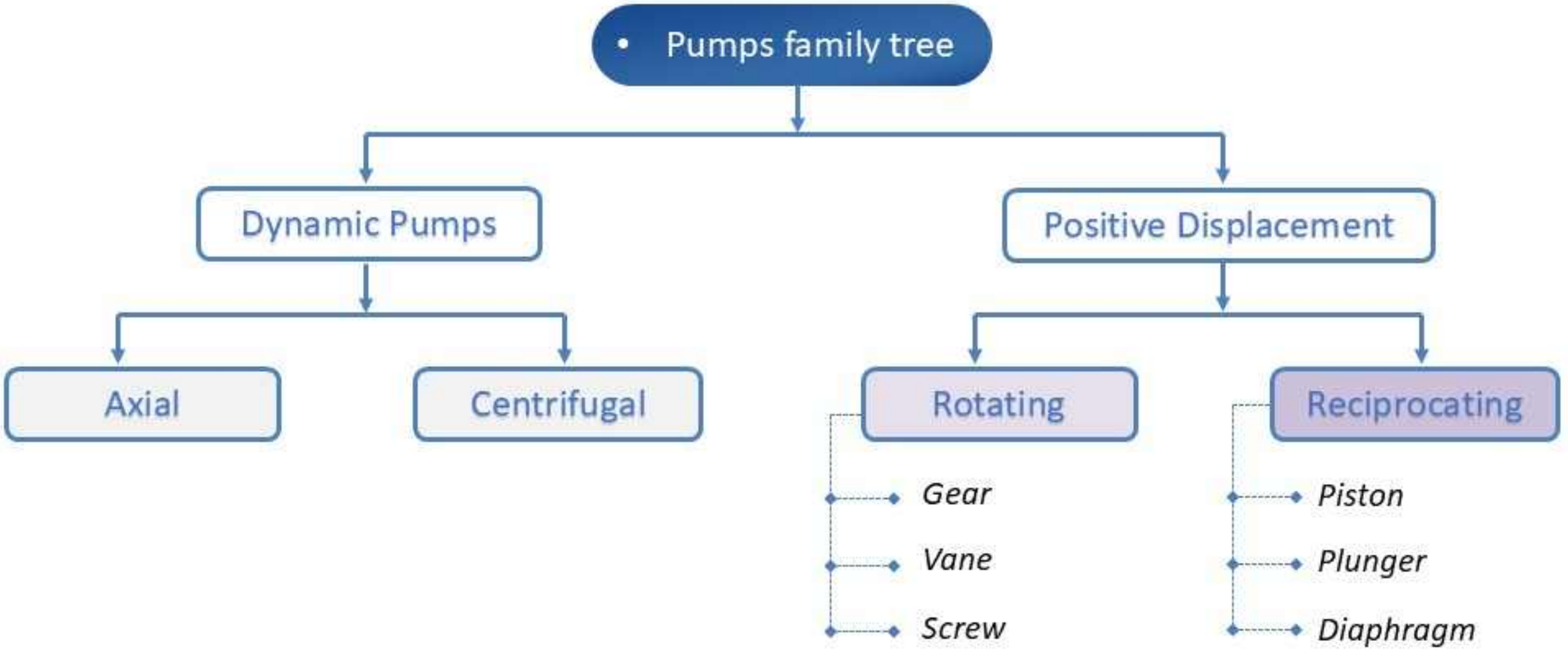
High Pressure Diaphragm

Magnetically Driven

Multistage

Pumps

Process Technology Equipment and Systems



Pumps

Process Technology Equipment and Systems

	Positive D.P.	Centrifugal	Axial Flow
Dis. Pressure P	V. HIGH	HIGH	Low
Flow Rate Q	Low	HIGH	V. HIGH
Efficiency	HIGH	MEDIUM	V. HIGH
cost	V. HIGH	LOW	LOW
Pulsation	YES	NO	NO

Compressors

Process Technology Equipment and Systems

- Mechanical devices that increase gas pressure by reducing its volume.
- Essential for transporting and processing gases in downstream operations.

Role in Downstream Operations

- Compress natural gas for pipelines or storage.
- Boost gas pressure for processing (e.g., refining, petrochemicals).
- Support gas injection in enhanced oil recovery (EOR).

01 *positive displacement (Reciprocating)*

Reciprocating Compressors:

high pressure ↑ | low Flow ↓

02 *Dynamic compressors*

Centrifugal Compressors:

Low pressure ↓ | High Flow ↑

Compressors

Process Technology Equipment and Systems

- Compressor Family
  - Positive Displacement
    - Reciprocating
      - *Single acting piston*
      - *Double acting*
      - *Diaphragm*
    - Rotary
      - *LOBE (straight – helical)*
      - *Liquid Ring*
      - *Screw (wet – dry)*
      - *Sliding Vane*
  - Dynamic
    - Centrifugal
    - Axial