

# PRODUCTION EQUIPMENT STATIONERY & ROTARY

OGS-ZTP-GT-TRM-0007

**OGS**  
OIL & GAS SKILLS



# Hany F. Ismail

**Consultant Engineer**

**Projects Control / Planning**

**Oil / Gas**

**B.Sc.** Of Mechanical Engineering – **Cairo University**, 1975

**Master Degree:** Baroujia University – **Italy**

Member of American Society of Mechanical Engineering – **ASME**

Member of Projects Management Institute – **PMI**

Member of **Federation of Arab Engineers**

Member of **Scientific Committee** of Syndicate of Engineers

**Who's Who** in Science and Engineering

Projects Management Professional (**PMP**)

**Man of the Year** Excellent Certification, **UAE**

## **Relevant Experiences**

Over **30 years** of experience worked as a **Consultant Engineer** after holding various positions for Oil / Gas Industries in the field of **Projects Control & Planning** , Projects Commissioning and Management, Shutdown/Turnaround Integrated Planning & Management, Maintenance Planning and Construction/Commissioning of new Refineries and LNG Plants

# MAIN TOPICS

---

## 1. Common Static Equipment used in Oil & Gas field

- ✓ **Separators**
- ✓ **Storage Tanks**
- ✓ **Slug Catcher**
- ✓ **Gas Scrubber**
- ✓ **Flare Knock out Drum**
- ✓ **Towers and Columns**
- ✓ **Heat Transfer Equipment**
  - ☐ Heat Exchangers
  - ☐ Air Coolers
  - ☐ Plate Heat Exchangers
- ✓ **Pipes, valves & fittings**

# MAIN TOPICS

---

## 2. Rotating Equipment used in Oil & Gas field

- ✓ **Pumps**
- ✓ **Compressors**
- ✓ **Turbine**
- ✓ **Engines**

# Part – 1

## Static Equipment

# Common Static Equipment used in Oil & Gas field

---

## Static Equipment related STD;

|                     |                                                                                           |
|---------------------|-------------------------------------------------------------------------------------------|
| ASME Section VIII-1 | Rules for Construction of Pressure Vessels                                                |
| TEMA Class B        | Pressure vessels for chemical process services                                            |
| TEMA Class C        | Pressure vessels for general commercial applications                                      |
| TEMA Class R        | Pressure vessels for the severe requirements of petroleum processing                      |
| API 650             | Welded Steel Tanks for Oil Storage                                                        |
| API 620             | Design and Construction of Large Welded Low Pressure Storage Tanks`                       |
| API 572             | Inspection of Pressure Vessels (Towers, Drums, Reactors, Heat Exchangers, and Condensers) |
| API 521             | Flare Knock out Drum (KOD) Design & Sizing                                                |

# Common Static Equipment used in Oil & Gas field

---

## Static Equipment related STD;

ISO 16812 or API 660

ISO 13706 or API 661

ISO 15547 or API 662

API 598 & API 6D

API 520 & API 576

ANSI B31.3

ANSI B36.10

ANSI B16.5

ANSI B16.20

ANSI B16.21

Shell & Tube Heat Exchanger

Air Cooled Heat Exchangers

Plate Heat Exchangers for General Refinery Services

Valves

PSV Selection & Inspection

Piping Code

Piping Specs

Flange Code

Metallic Gasket

Non Metallic Gasket

# Common Static Equipment used in Oil & Gas field

---

## Separators

Separator are vessels is in which gas, oil and water are separated from each other. The principle of separation relies on gravity, gas, oil and water havig different densities

If solid particles are entrained in the fluid they will also be separated at the bottom of separator.

# Common Static Equipment used in Oil & Gas field

---

## Separators Classification

Separators are **classified** according to the **shape**:

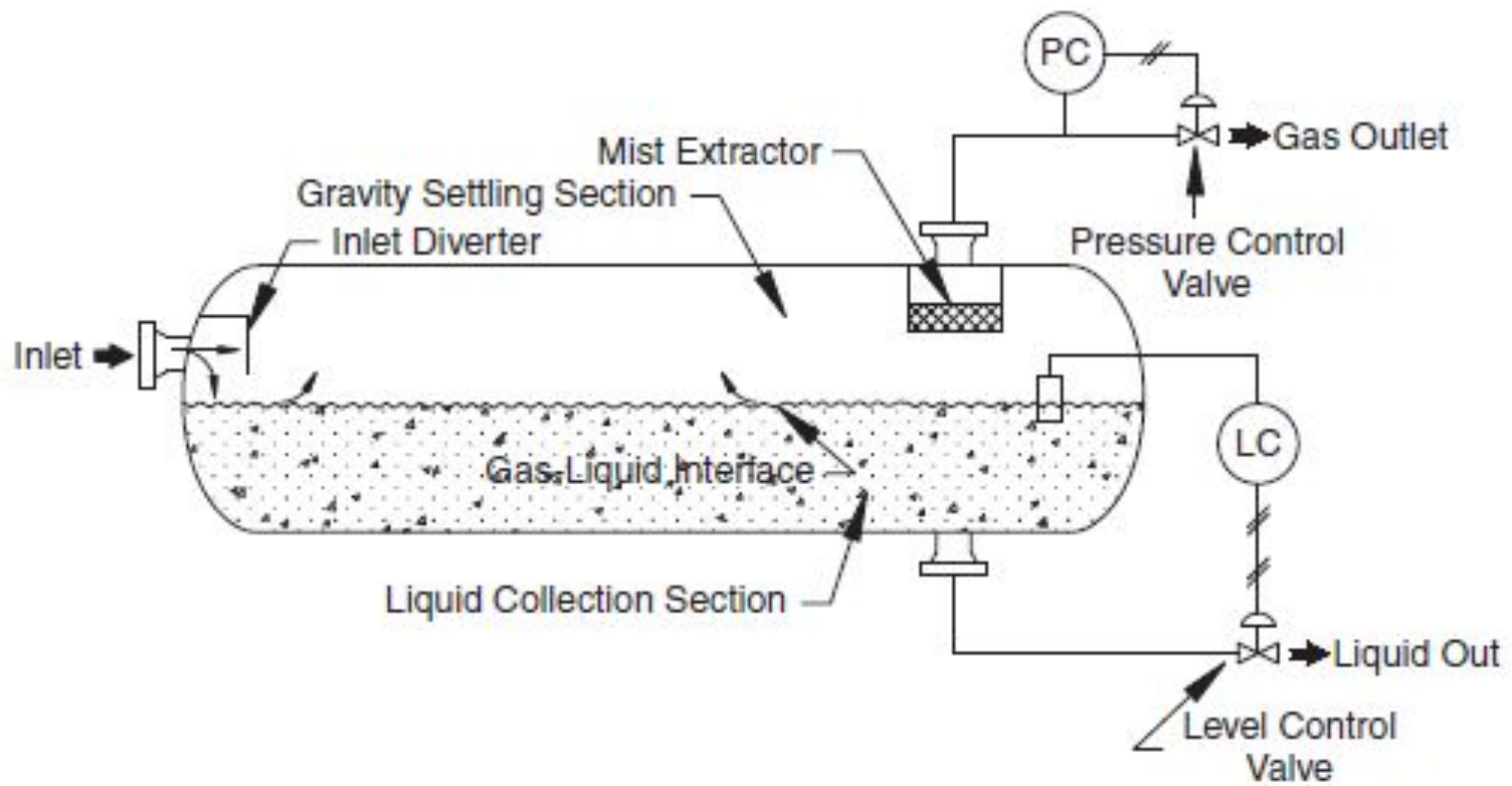
- ✓ horizontal
- ✓ vertical
- ✓ Spherical

Or **Phases** Separated:

- ✓ Two-phases
- ✓ Three-phases

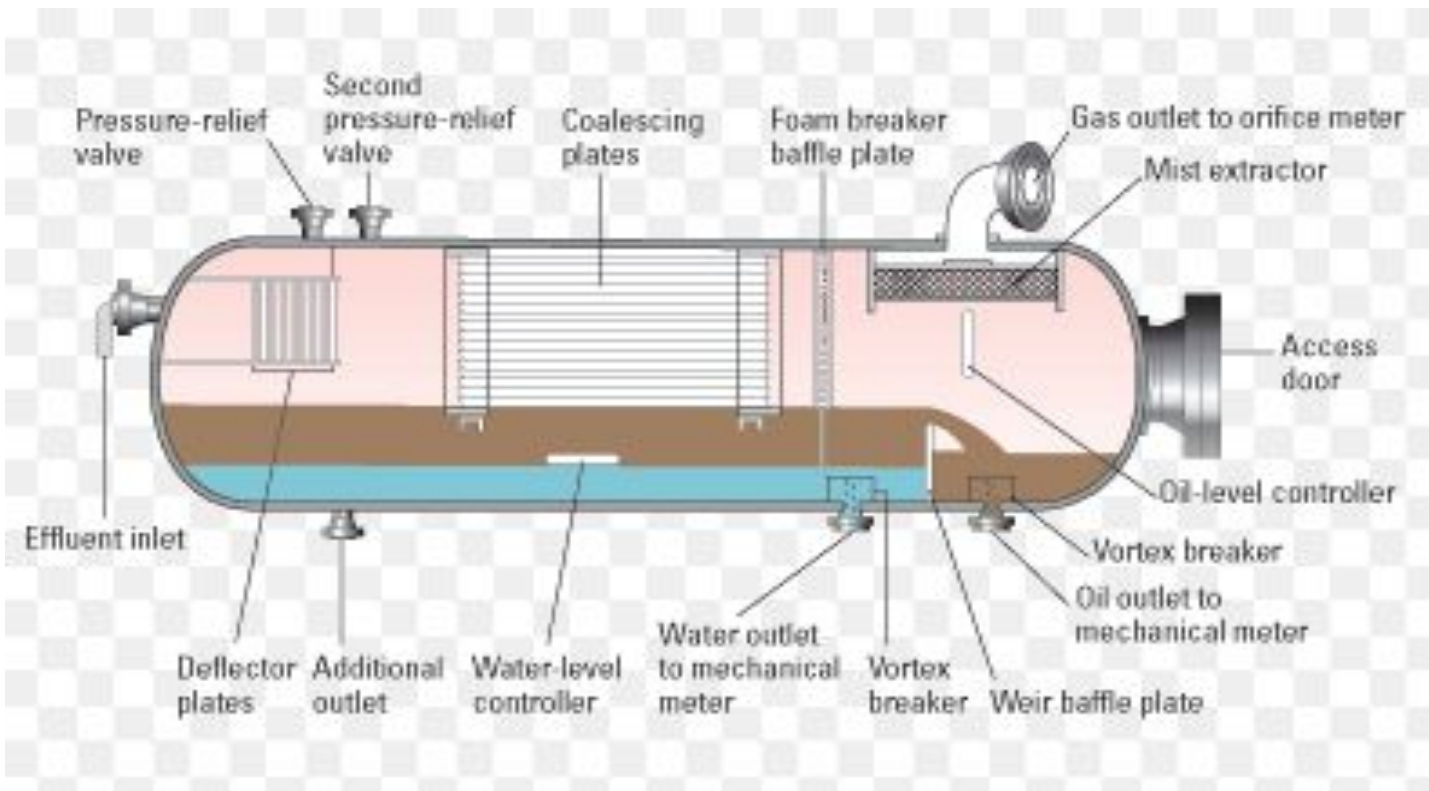
# Common Static Equipment used in Oil & Gas field

## Horizontal 2-Phases Separators



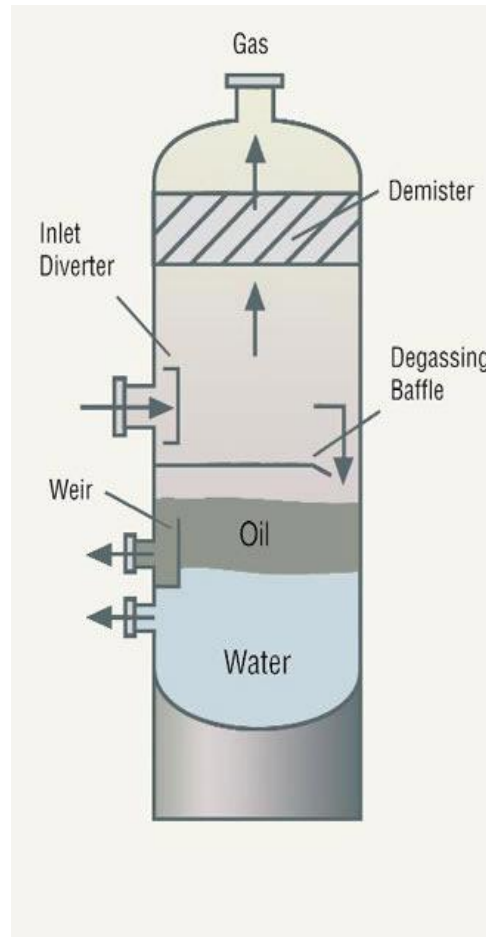
# Common Static Equipment used in Oil & Gas field

## Horizontal 3-Phases Separator



# Common Static Equipment used in Oil & Gas field

## Vertical Separators



# Common Static Equipment used in Oil & Gas field

---

## **Separation Quality;**

Separators are required to provide oil/gas streams that meet saleable pipeline specification.

Oil must have less than 1% (by volume) water.

Water stream must have less than 20 ppm of oil.

# Common Static Equipment used in Oil & Gas field

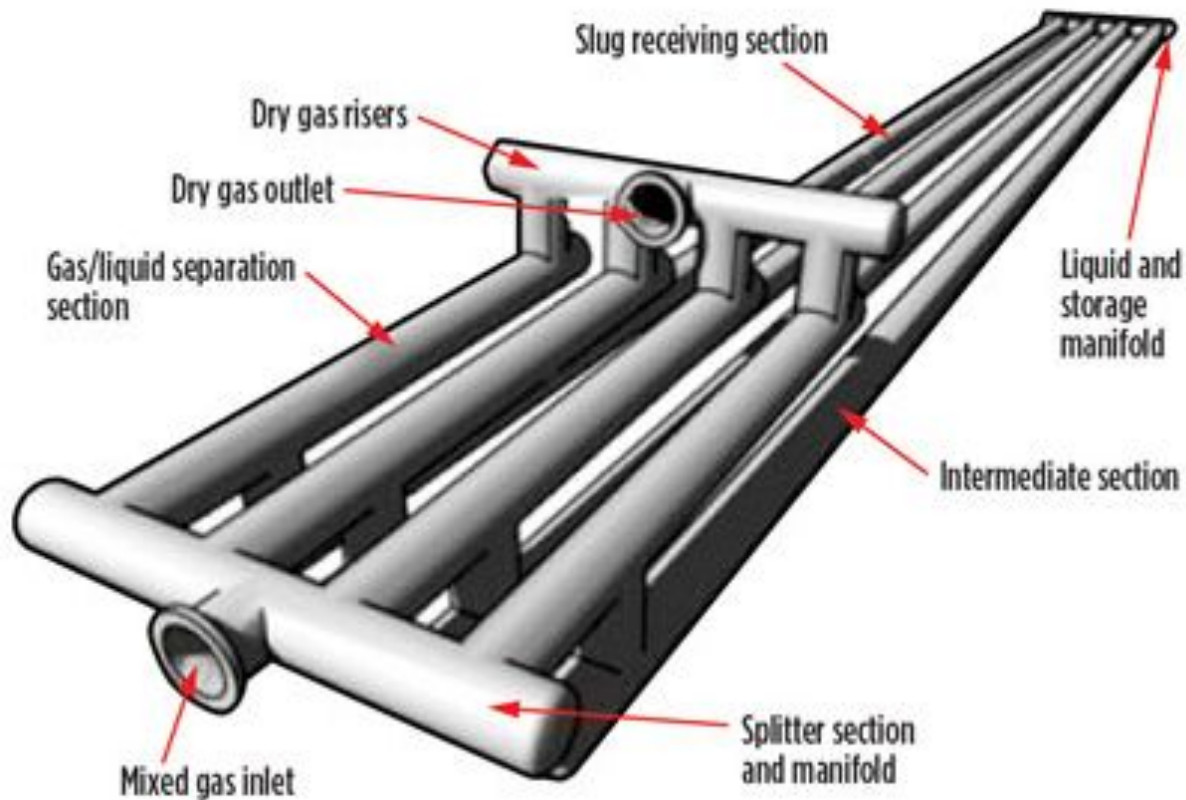
---

## Slug Catcher Vessel



# Common Static Equipment used in Oil & Gas field

## Slug Catcher Finger-Type

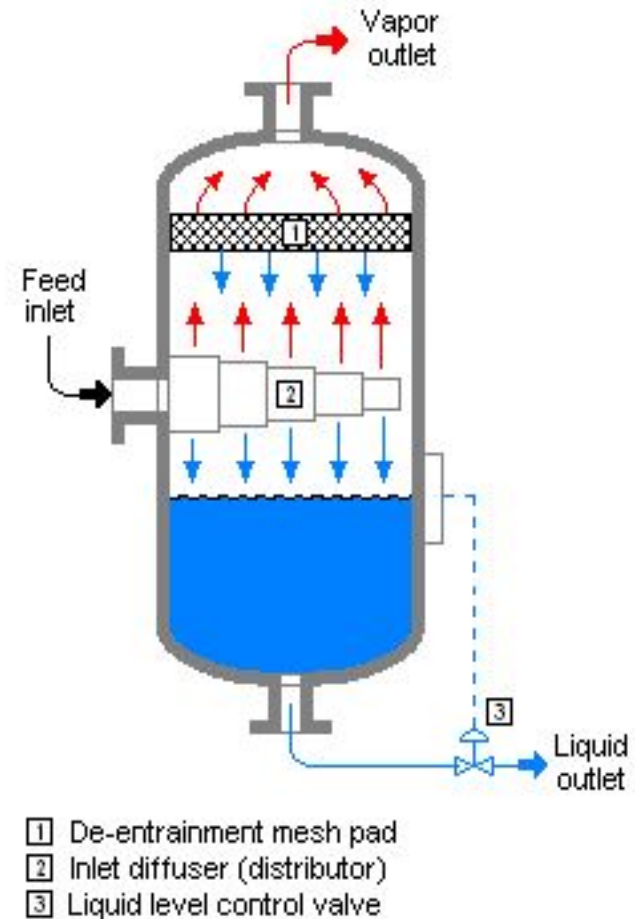


# Common Static Equipment used in Oil & Gas field

## Gas Scrubber

A device to remove dirt, water, foreign matter, or undesired liquids that are part of the gas flow stream.

A scrubber is used to protect downstream rotating equipment or to recover valuable liquids from gas.



# Common Static Equipment used in Oil & Gas field

---

## Flare Knockout Drum

The purpose of KOD to remove any liquid from the relieved gases & to ensure Flare gas is free from any liquid.

Knockout drum design and sizing basis as per API-521.

KOD MOH or SD is required plant total SD and to be considered as the critical path for the plant SD.



# Common Static Equipment used in Oil & Gas field

---

## Pressure Vessels

**What is the difference between 3-phases & 2-phases Separators?**

# Common Static Equipment used in Oil & Gas field

---

## Storage Tanks

In industry, there are many different types of equipment used for the storage of liquids and gases

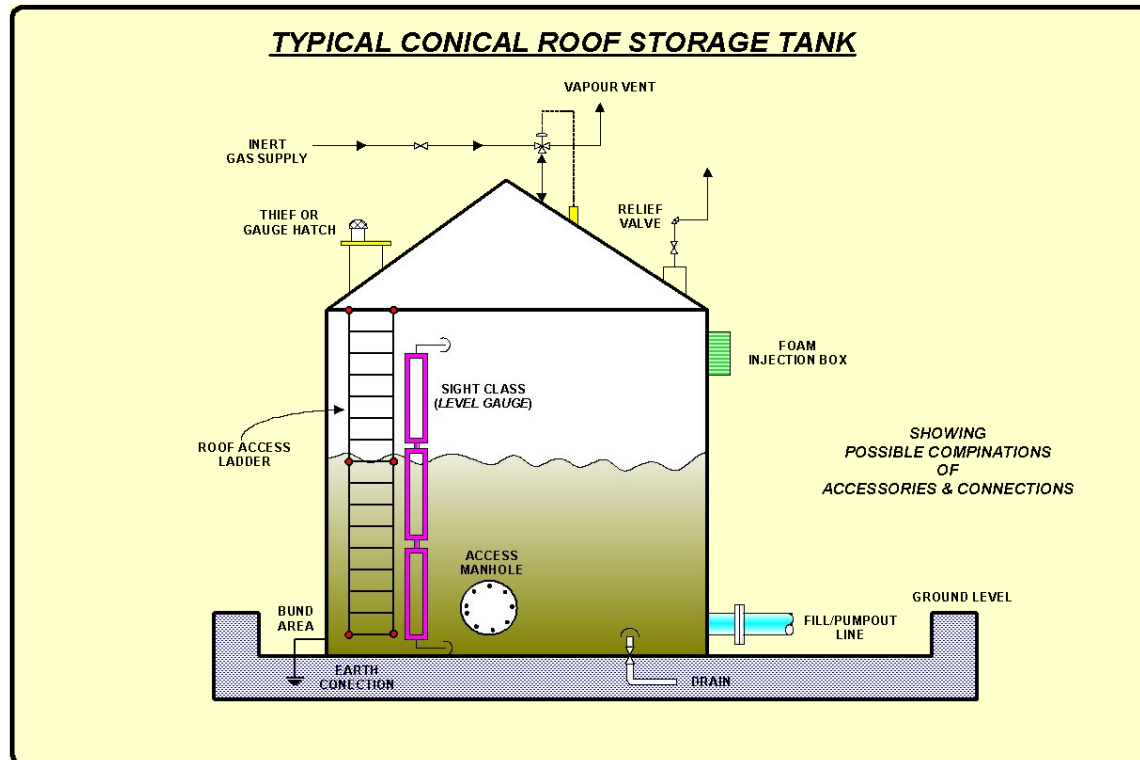
Storage Tanks can be:

- Fixed or Floating Roof
- Vertical and Horizontal Cylindrical
- Spherical

# Common Static Equipment used in Oil & Gas field

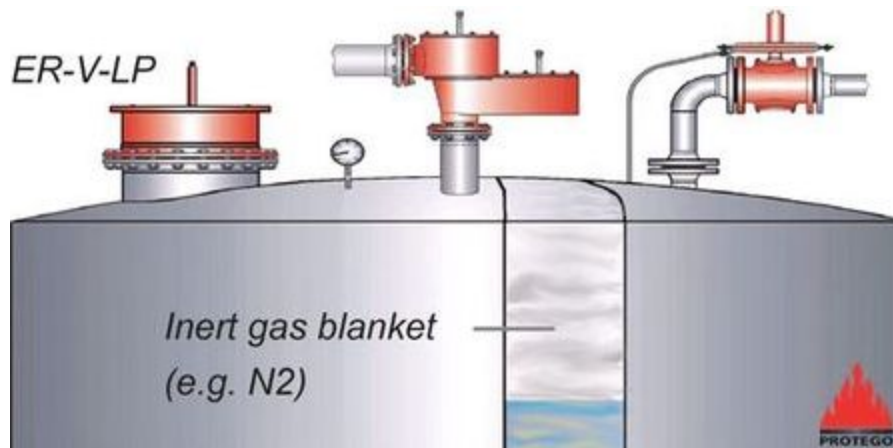
## Storage Tanks

### □ Fixed Roof



# Common Static Equipment used in Oil & Gas field

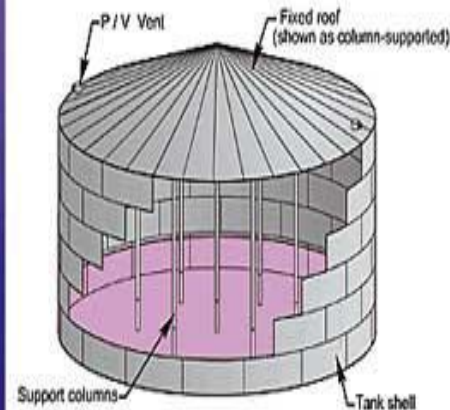
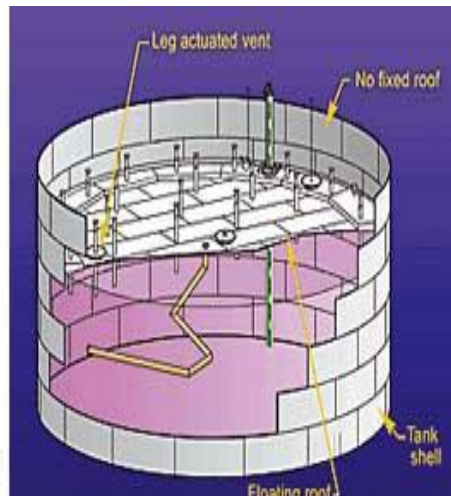
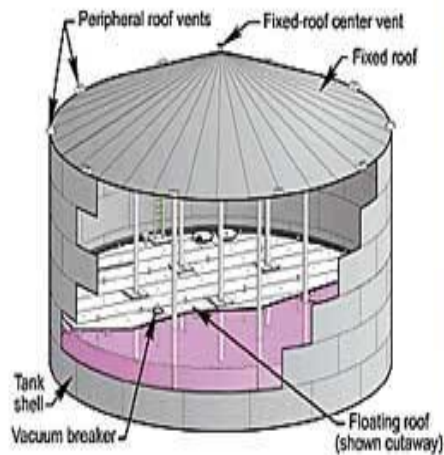
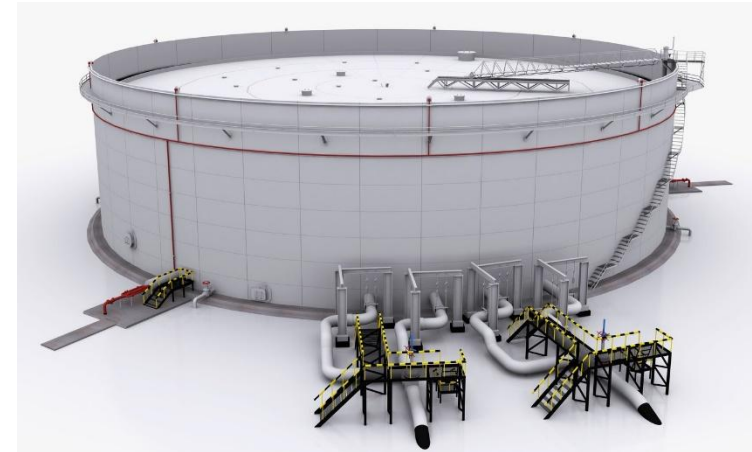
Fixed roof storage tanks pumping out or drain protection



# Common Static Equipment used in Oil & Gas field

## Storage Tanks

### □ Floating Roof



# Common Static Equipment used in Oil & Gas field

---

## Storage Tanks

### □ Spherical Tanks



# Common Static Equipment used in Oil & Gas field

---

## Storage Tanks

**What are the protection devices in the storage Tank?**

# Common Static Equipment used in Oil & Gas field

---

## **Towers and Columns**

Towers are classified according to the type of “internals” in the tower, and according to the function performed by the tower.

Tower Dimensions: Towers typically range in diameter from 3 to 20 FEET and in height from 20 to 150 FEET.

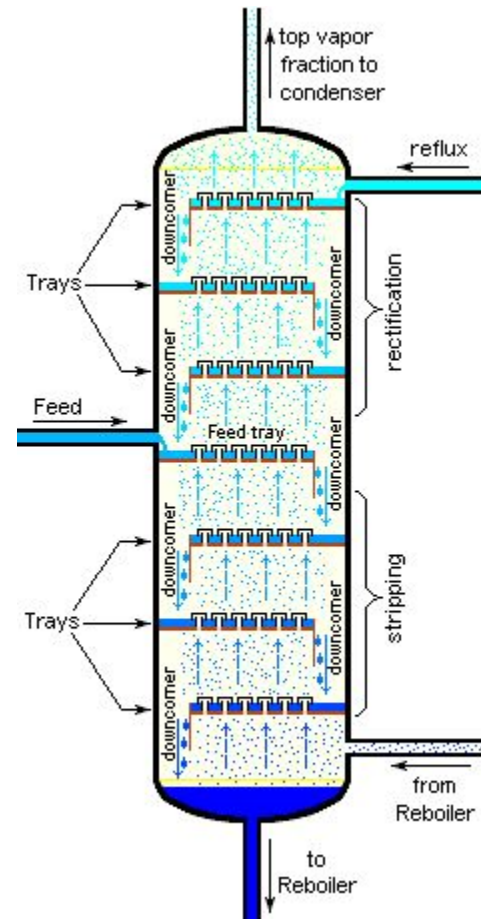
# Common Static Equipment used in Oil & Gas field

## Towers and Columns “internals”

Towers may contain trays. If the tower contains trays, the vessel is called a tray tower, or synonymously a tray column.

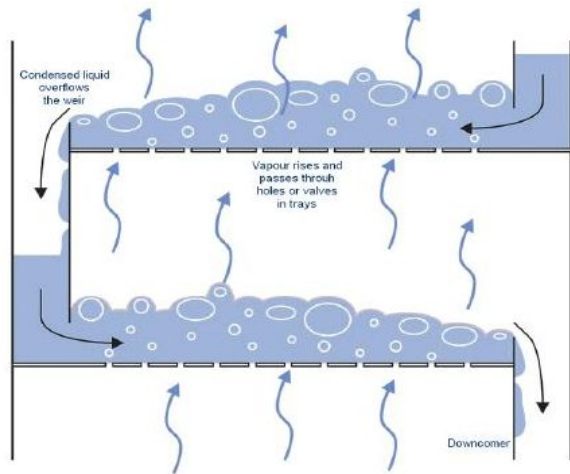
Trays are generally divided into three categories:

- Sieve Trays
- Valve Trays
- Bubble Cap Trays

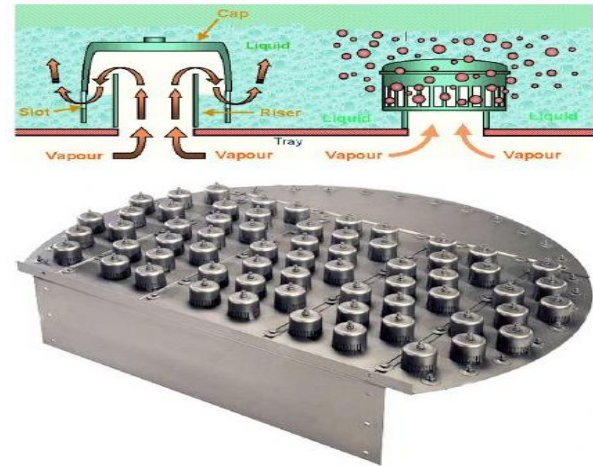


# Common Static Equipment used in Oil & Gas field

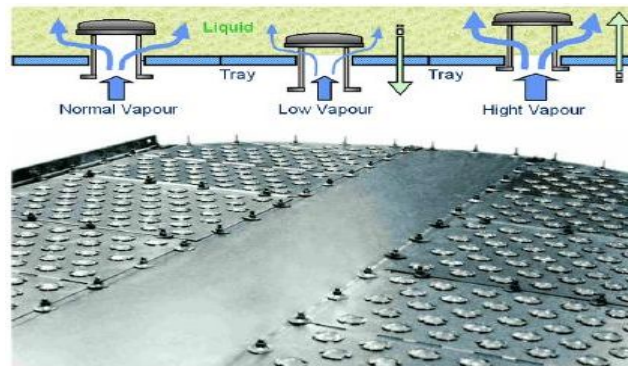
## Towers and Columns



Sieve  
Trays



Bubble Cap Trays

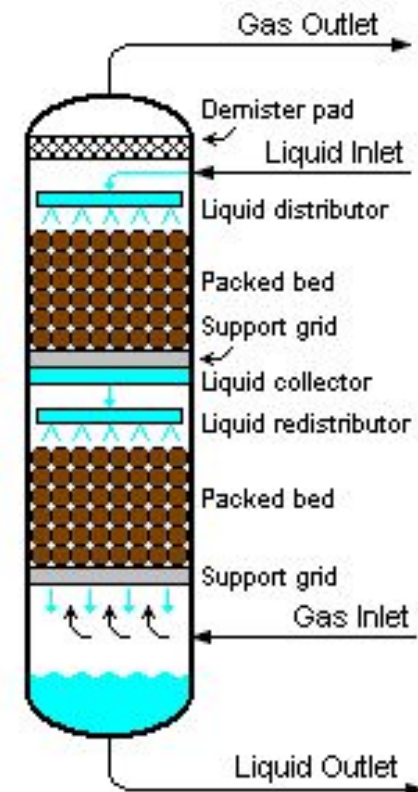


Valve

# Common Static Equipment used in Oil & Gas field

## Towers and Columns “internals”

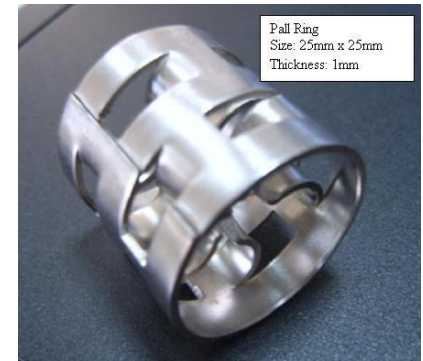
Tower may contain **packing**. If the tower contains a packing, the vessel is called a **packed tower**, or **packed column**.



# Common Static Equipment used in Oil & Gas field

## Towers and Columns “internals”

### Random Packings



(a)



(b)

### Structured Packings

# Common Static Equipment used in Oil & Gas field

---

## Towers and Columns “internals”

### Packing Versus Trays:

A tray column that is facing throughput problems may be debottlenecked by replacing a section of trays with packings. This is because: Packings provide extra interfacial area for liquid/vapour contact efficiency of separation is increased for the same column height packed columns are shorter than trayed columns

# Common Static Equipment used in Oil & Gas field

---

## **Towers and Columns**

Tower/Column Applications;

- Distillation
- Stripping
- Absorption
- Extraction.

# Common Static Equipment used in Oil & Gas field

---

## Towers and Columns

What are the basis for Towers classification?

# Part – 2

## Static Equipment

# Common Static Equipment used in Oil & Gas field

---

## Heat Transfer Equipment

The various types of heat transfer equipment are generally defined by the function fulfilled in a process. Following are typical heat transfer equipment used in processing industries.

### As example for heat transfer equipment:

- ☐ Shell & Tube Heat Exchanger (ISO 16812 or API 660)
- ☐ Air Cooled Heat Exchangers (ISO 13706 or API 661)
- ☐ Plate Heat Exchangers for General Refinery Services. (ISO 15547 or API 662)

# Common Static Equipment used in Oil & Gas field

---

## Heat Transfer Equipment

### Heat Exchangers

Heat is exchanged between two streams. Exchangers are used to remove heat from streams which are required to be cooled, and transfer heat to streams which are required to be heated.

### The basic design data:

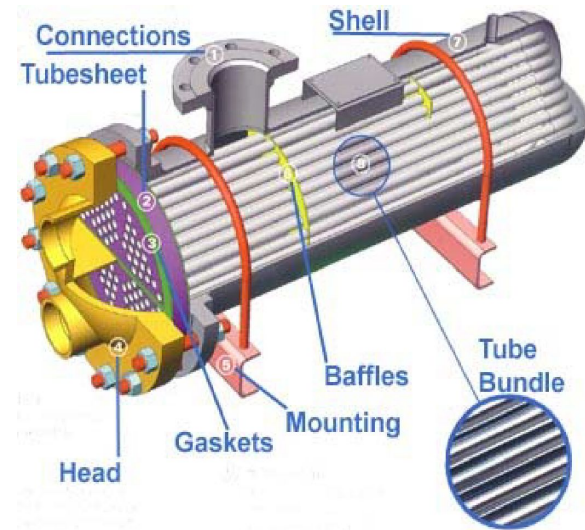
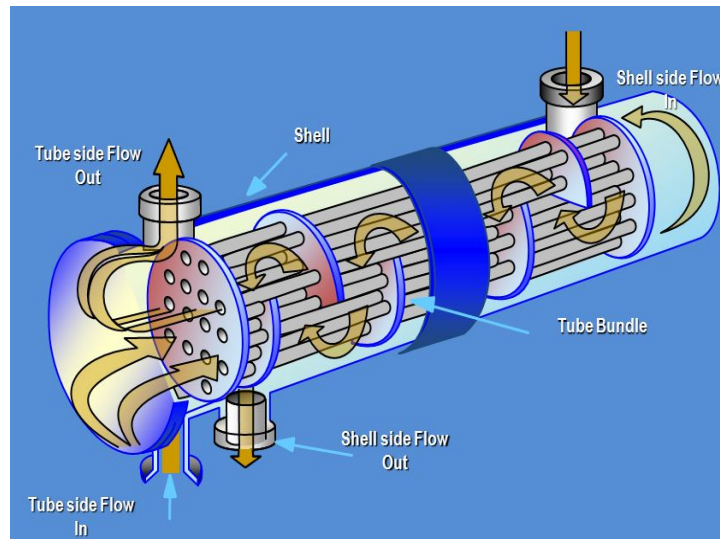
- $Q$  = total heat transfer
- $\Delta T$  = temperature difference between the two media
- " $U$ " is a function of many variables;
- " $A$ " is the area of retaining wall between the two flowing media.

# Common Static Equipment used in Oil & Gas field

## Heat Transfer Equipment

### Main Types & Components of Heat Exchangers

#### A - Shell and Tube Heat Exchanger

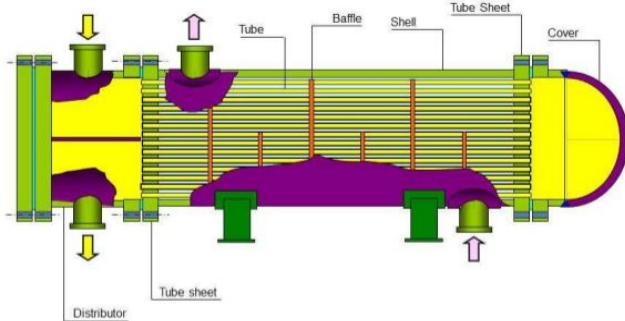


# Common Static Equipment used in Oil & Gas field

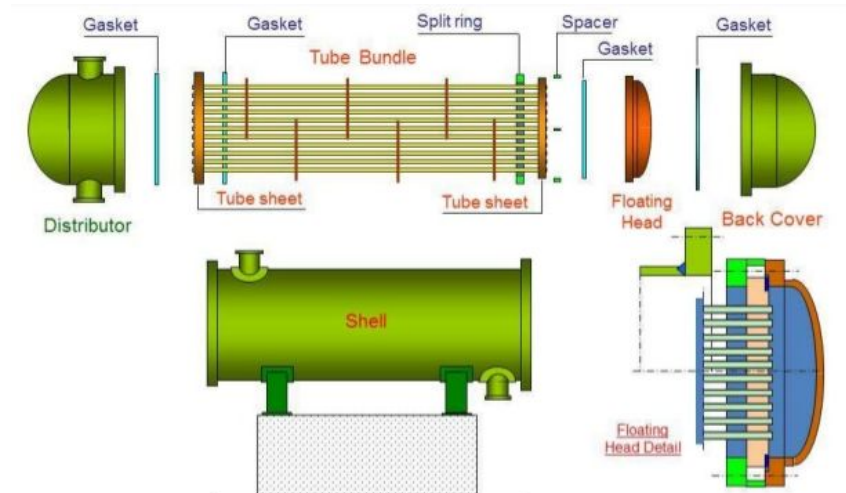
## Heat Transfer Equipment

The shell and tube heat exchanger is further divided into three categories as

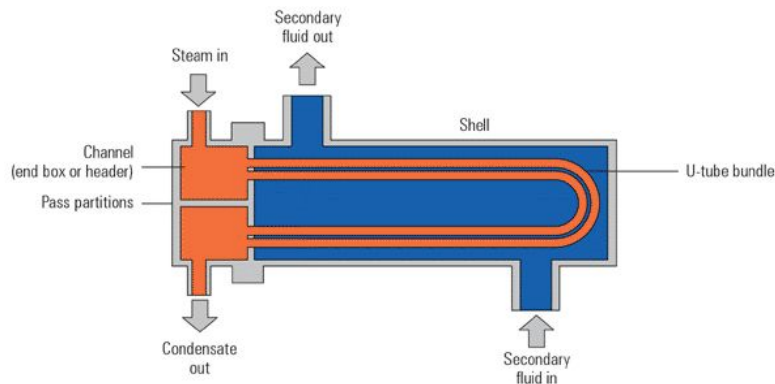
### 1. Fixed tube sheet



### 3. Floating head



### 3. U - Tube

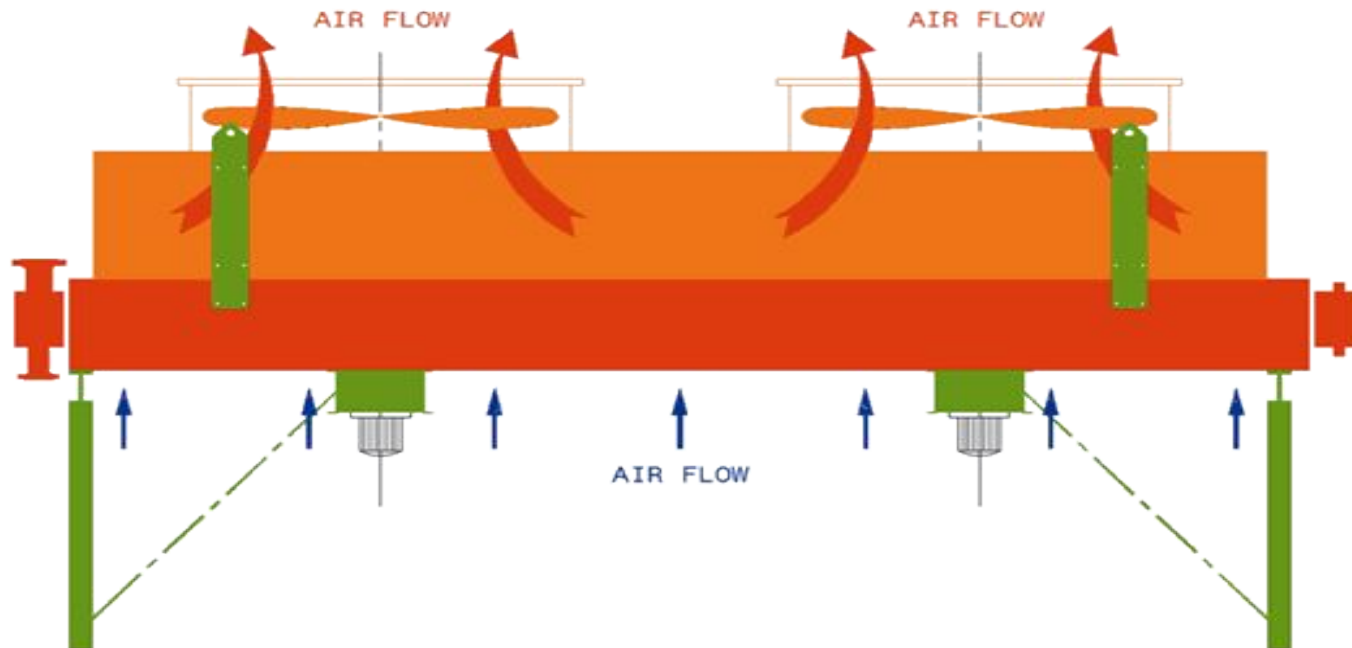


# Common Static Equipment used in Oil & Gas field

## Heat Transfer Equipment

### B- Air Cooled Heat Exchangers

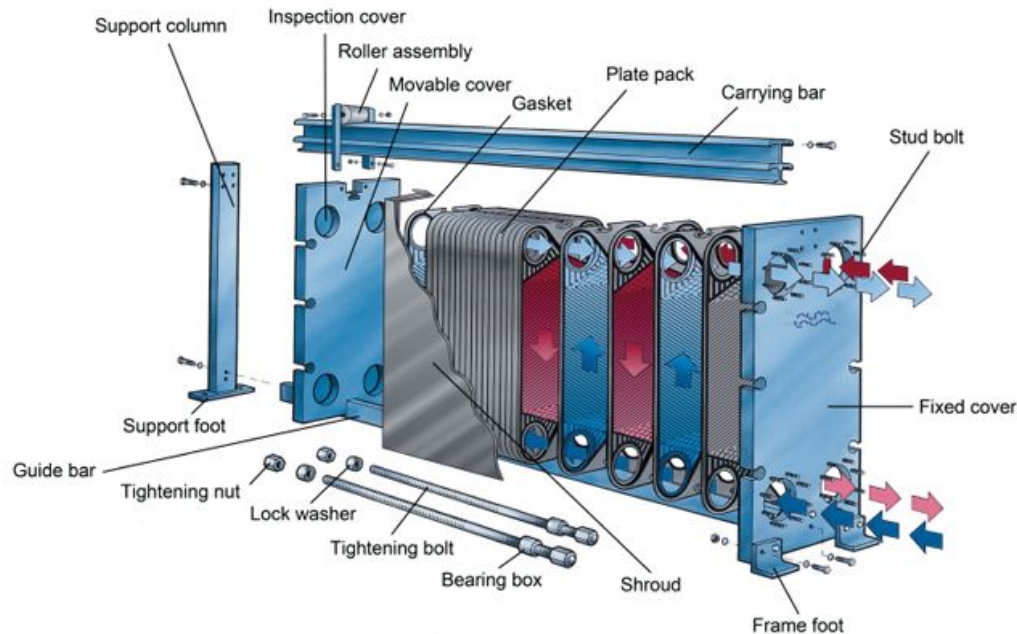
Cold air being blown over the tubes, which containing the process fluids for cooling.



# Common Static Equipment used in Oil & Gas field

## Heat Transfer Equipment

### C- Plate Heat Exchangers



# Common Static Equipment used in Oil & Gas field

---

## Heat Transfer Equipment

What is the common types of Heat Exchangers in O&G?

# Common Static Equipment used in Oil & Gas field

---

## **Pipes, valves & fittings**

### Pipe design

Pipes are designed according to:

- ✓ Maximum Steady State Pressure
- ✓ Temperature
- ✓ Flow rate
- ✓ Chemical characteristics of fluid

# Common Static Equipment used in Oil & Gas field

---

## **Pipes, valves & fittings**

### Pipes materials

#### **Pipes materials can be:**

- ✓ Metals and alloys
- ✓ Plastic
- ✓ Glass (for laboratory and special application)
- ✓ Composites

#### **Selection bases;**

- ✓ Design data (mechanical, chemical)
- ✓ Economics consideration

# Common Static Equipment used in Oil & Gas field

## Pipes, valves & fittings – Piping Schedule

| Nominal pipe size mm/<br>inch | OD mm | 20            | 30            | STD           | 40            | 60             | XS             | 80             | 100             | 120             | 140             | 160             | XXS             |
|-------------------------------|-------|---------------|---------------|---------------|---------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 15<br>1/2                     | 21.3  |               |               | 2.77<br>1.27  | 2.77<br>1.27  |                | 3.73<br>1.62   | 3.73<br>1.62   |                 |                 |                 | 4.78<br>1.95    | 7.47<br>2.55    |
| 20<br>3/4                     | 26.7  |               |               | 2.87<br>1.69  | 2.87<br>1.69  |                | 3.91<br>2.20   | 3.91<br>2.20   |                 |                 |                 | 5.56<br>2.90    | 7.82<br>3.64    |
| 25<br>1                       | 33.4  |               |               | 3.38<br>2.50  | 3.38<br>2.50  |                | 4.55<br>3.24   | 4.55<br>3.24   |                 |                 |                 | 6.35<br>4.24    | 9.09<br>5.45    |
| 32<br>1 1/4                   | 42.2  |               |               | 3.56<br>3.39  | 3.56<br>3.39  |                | 4.85<br>4.47   | 4.85<br>4.47   |                 |                 |                 | 6.35<br>5.61    | 9.70<br>7.77    |
| 40<br>1 1/2                   | 48.3  |               |               | 3.68<br>4.05  | 3.68<br>4.05  |                | 5.08<br>5.41   | 5.08<br>5.41   |                 |                 |                 | 7.14<br>7.25    | 10.15<br>9.56   |
| 50<br>2                       | 60.3  |               |               | 3.91<br>5.44  | 3.91<br>5.44  |                | 5.54<br>7.48   | 5.54<br>7.48   |                 |                 |                 | 8.74<br>11.11   | 11.07<br>13.44  |
| 65<br>2 1/2                   | 73.0  |               |               | 5.16<br>8.63  | 5.16<br>8.63  |                | 7.01<br>11.41  | 7.01<br>11.41  |                 |                 |                 | 9.53<br>14.92   | 14.02<br>20.39  |
| 80<br>3                       | 88.9  |               |               | 5.49<br>11.29 | 5.49<br>11.29 |                | 7.62<br>15.27  | 7.62<br>15.27  |                 |                 |                 | 11.13<br>21.35  | 15.24<br>27.68  |
| 90<br>3 1/2                   | 101.6 |               |               | 5.74<br>13.57 | 5.74<br>13.57 |                | 8.08<br>18.63  | 8.08<br>18.63  |                 |                 |                 | -<br>-          | -<br>-          |
| 100<br>4                      | 114.3 |               |               | 6.02<br>16.07 | 6.02<br>16.07 |                | 8.56<br>22.32  | 8.56<br>22.32  |                 | 11.13<br>28.32  |                 | 13.49<br>33.54  | 17.12<br>41.03  |
| 125<br>5                      | 141.3 |               |               | 6.55<br>21.77 | 6.55<br>21.77 |                | 9.53<br>30.97  | 9.53<br>30.97  |                 | 12.70<br>40.28  |                 | 15.88<br>49.11  | 19.05<br>57.43  |
| 150<br>6                      | 168.3 |               |               | 7.11<br>28.26 | 7.11<br>28.26 |                | 10.97<br>42.56 | 10.97<br>42.56 |                 | 14.27<br>54.20  |                 | 18.26<br>67.56  | 21.95<br>79.22  |
| 200<br>8                      | 219.1 | 6.35<br>33.31 | 7.04<br>36.81 | 8.18<br>42.55 | 8.18<br>42.55 | 10.31<br>53.08 | 12.70<br>64.64 | 12.70<br>64.64 | 15.09<br>75.92  | 18.26<br>90.44  | 20.62<br>100.92 | 23.01<br>111.27 | 22.23<br>107.92 |
| 250<br>10                     | 273.1 | 6.35<br>41.77 | 7.80<br>51.03 | 9.27<br>60.31 | 9.27<br>60.31 | 12.70<br>81.55 | 12.70<br>81.55 | 15.09<br>96.01 | 18.26<br>114.75 | 21.44<br>133.06 | 25.40<br>155.15 | 28.58<br>172.33 | 25.40<br>155.15 |

# Common Static Equipment used in Oil & Gas field

## Pipes, valves & fittings

### Flanges

Flanges are mechanical devices used to connect elements in piping system where it is necessary to disconnect equipment or parts of the piping for maintenance.

#### **There are several types of flanges:**

- ✓ Screwed
- ✓ Slip-on
- ✓ Welding neck
- ✓ Socket-weld flanges
- ✓ Lap joint (with free flange)
- ✓ Blind
- ✓ Spectacle Blind

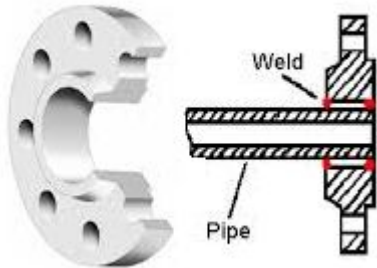


# Common Static Equipment used in Oil & Gas field

## Pipes, valves & fittings

### Flanges

Slip-on Flange



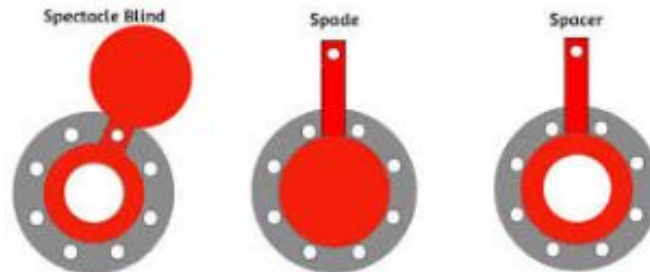
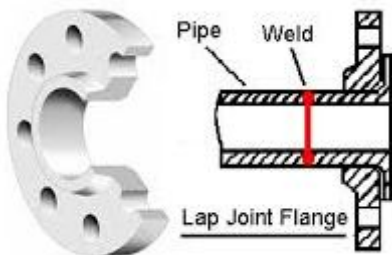
Screwed Flange



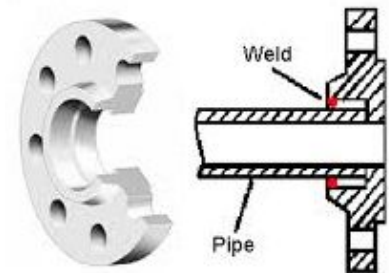
WN Flange



Lap joint Flange



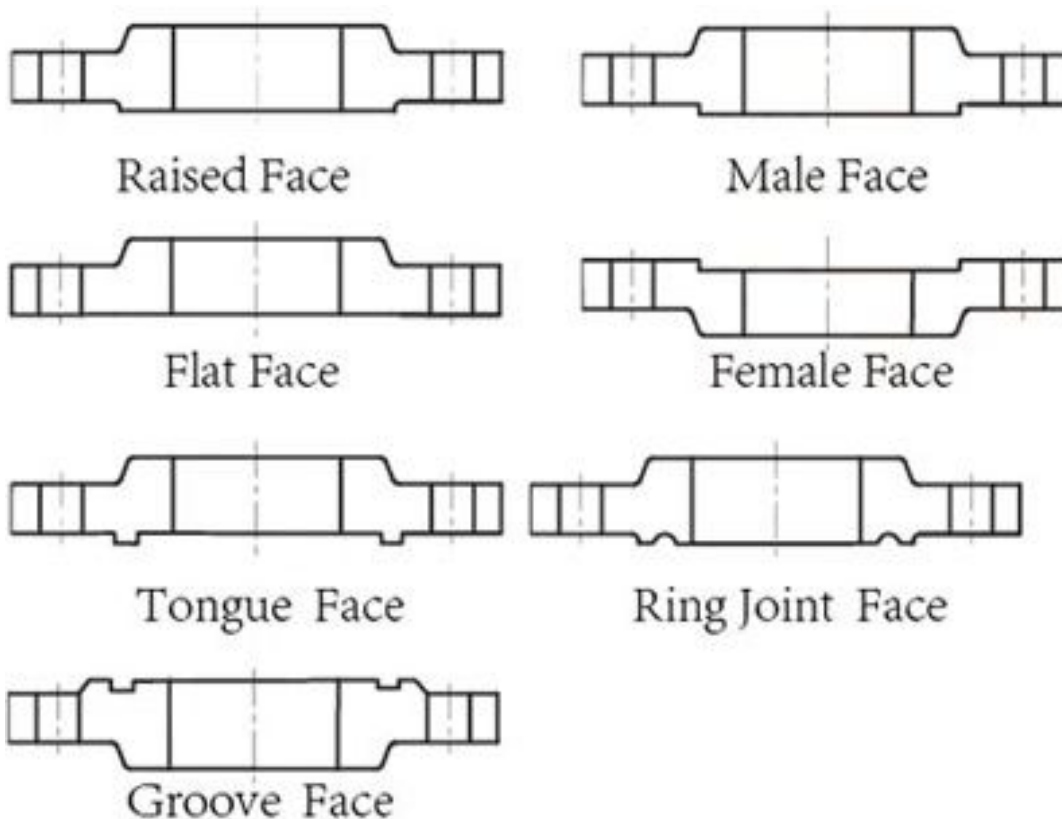
Socket-weld Flange



# Common Static Equipment used in Oil & Gas field

## Pipes, valves & fittings

### Flange Face



# Common Static Equipment used in Oil & Gas field

## Pipes, valves & fittings

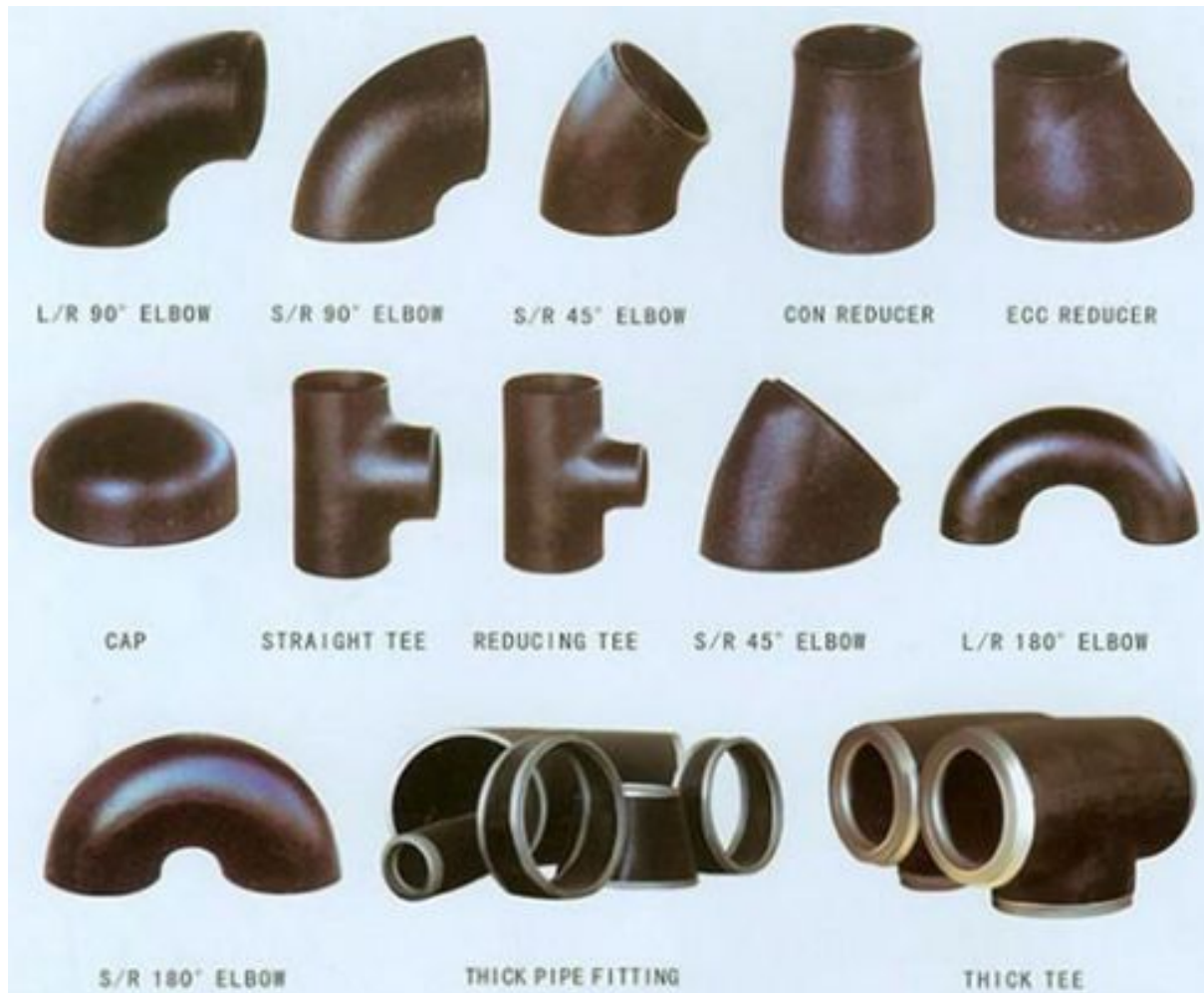
**Pressure - Temperature Ratings**  
For Steel Pipe Flanges and Flanged Fittings  
American National Standard ANSI B16.5 - 1988

| Class        | 150 lb.                     | 300 lb. | 400 lb. | 600 lb. | 900 lb. | 1500 lb. | 2500 lb. |
|--------------|-----------------------------|---------|---------|---------|---------|----------|----------|
| Pres<br>psig | 450                         | 1125    | 1500    | 2225    | 3350    | 5575     | 9275     |
| Temp °F      | Maximum Allowable Pres psig |         |         |         |         |          |          |
| -20 to 100   | 285                         | 740     | 990     | 1480    | 2220    | 3705     | 6170     |
| 200          | 260                         | 675     | 900     | 1350    | 2025    | 3375     | 5625     |
| 300          | 230                         | 655     | 875     | 1315    | 1970    | 3280     | 5470     |
| 400          | 200                         | 635     | 845     | 1270    | 1900    | 3170     | 5280     |
| 500          | 170                         | 600     | 800     | 1200    | 1795    | 2995     | 4990     |
| 600          | 140                         | 550     | 730     | 1095    | 1640    | 2735     | 4560     |
| 650          | 125                         | 535     | 715     | 1075    | 1610    | 2685     | 4475     |
| 700          | 110                         | 535     | 710     | 1065    | 1600    | 2665     | 4440     |
| 750          | 95                          | 505     | 670     | 1010    | 1510    | 2520     | 4200     |
| 800          | 80                          | 410     | 550     | 825     | 1235    | 2060     | 3430     |
| 850          | 65                          | 270     | 355     | 535     | 805     | 1340     | 2230     |
| 900          | 50                          | 170     | 230     | 345     | 515     | 860      | 1430     |
| 950          | 35                          | 105     | 140     | 205     | 310     | 515      | 860      |
| 1000         | 20                          | 50      | 70      | 105     | 155     | 260      | 430      |

# Common Static Equipment used in Oil & Gas field

## Pipes, valves & fittings

### Fittings



# Common Static Equipment used in Oil & Gas field

---

## Pipes, valves & fittings

### Flange gasket

The types most commonly used are:

- ✓ Non-metallic flat type: it is the most used gasket in the field of low temperature and medium pressures.
- ✓ Metallic
- ✓ Ring-joint

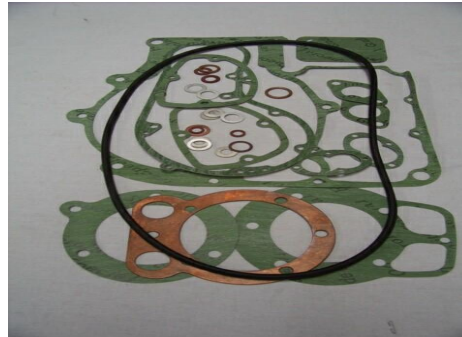
# Common Static Equipment used in Oil & Gas field

---

## Pipes, valves & fittings

### Flange gasket

Non-metallic



Metallic



Ring-joint



# Common Static Equipment used in Oil & Gas field

---

**Pipes, valves & fittings**

**Explain how to specify a WN Flange?**

# Common Static Equipment used in Oil & Gas field

---

## Valves

Valves are mechanical equipment designed to interrupt or regulate a fluid flow.

Common Valves types in O&G industry:

- ✓ Gate valves
- ✓ Globe valves
- ✓ Ball valves
- ✓ Butterfly valves
- ✓ Check valves
- ✓ Pressure Safety Valves

# Common Static Equipment used in Oil & Gas field

---

## Valves

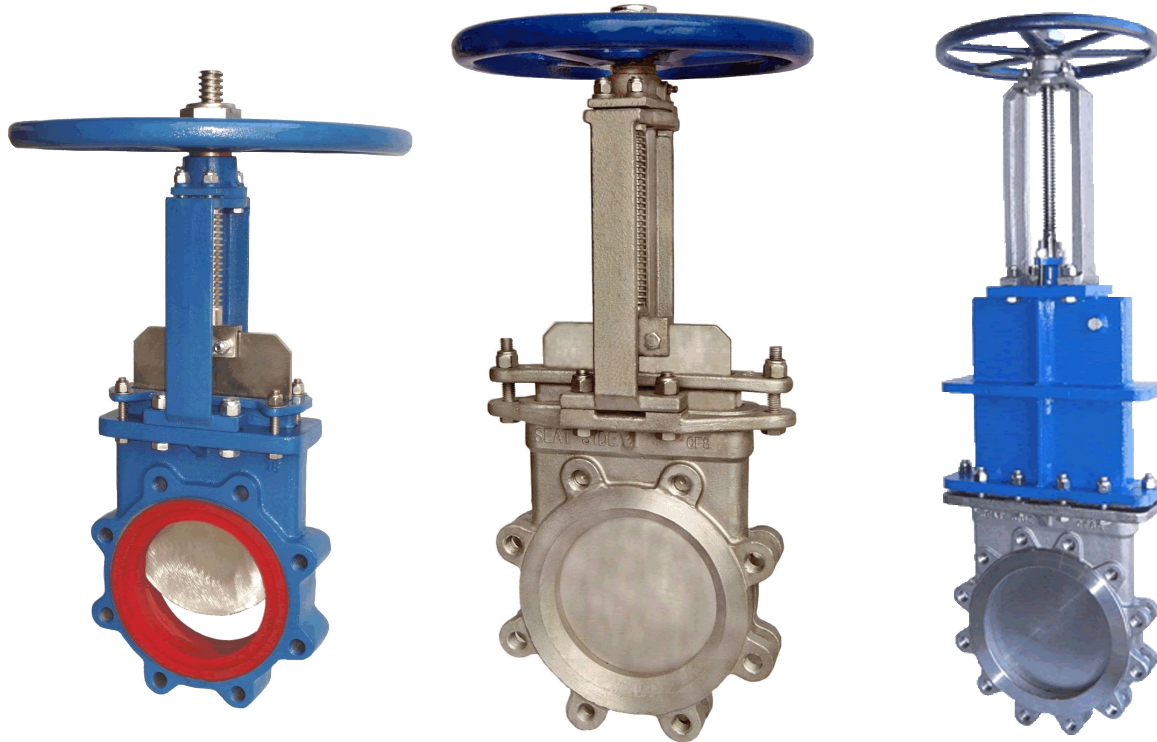
Selection of valves is carried out on the base of:

- ✓ Design Data (mechanical, chemical)
- ✓ Function Required (regulation, control, isolation, pressure relief)

# Common Static Equipment used in Oil & Gas field

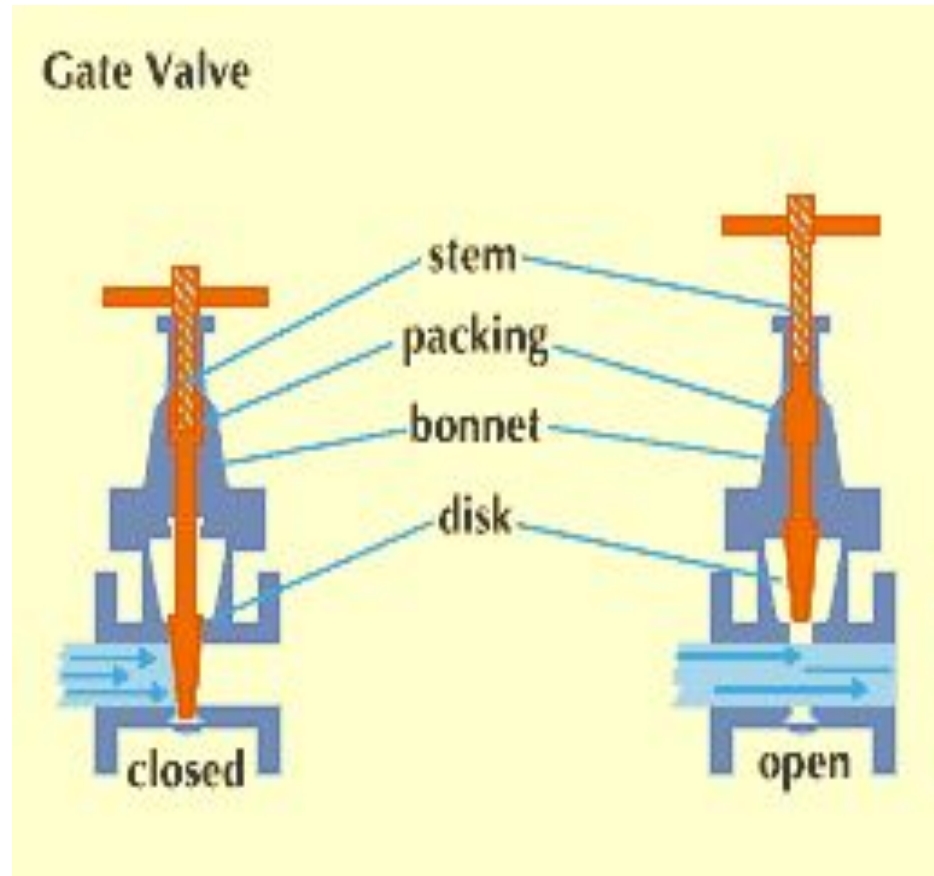
---

## Gate Valves



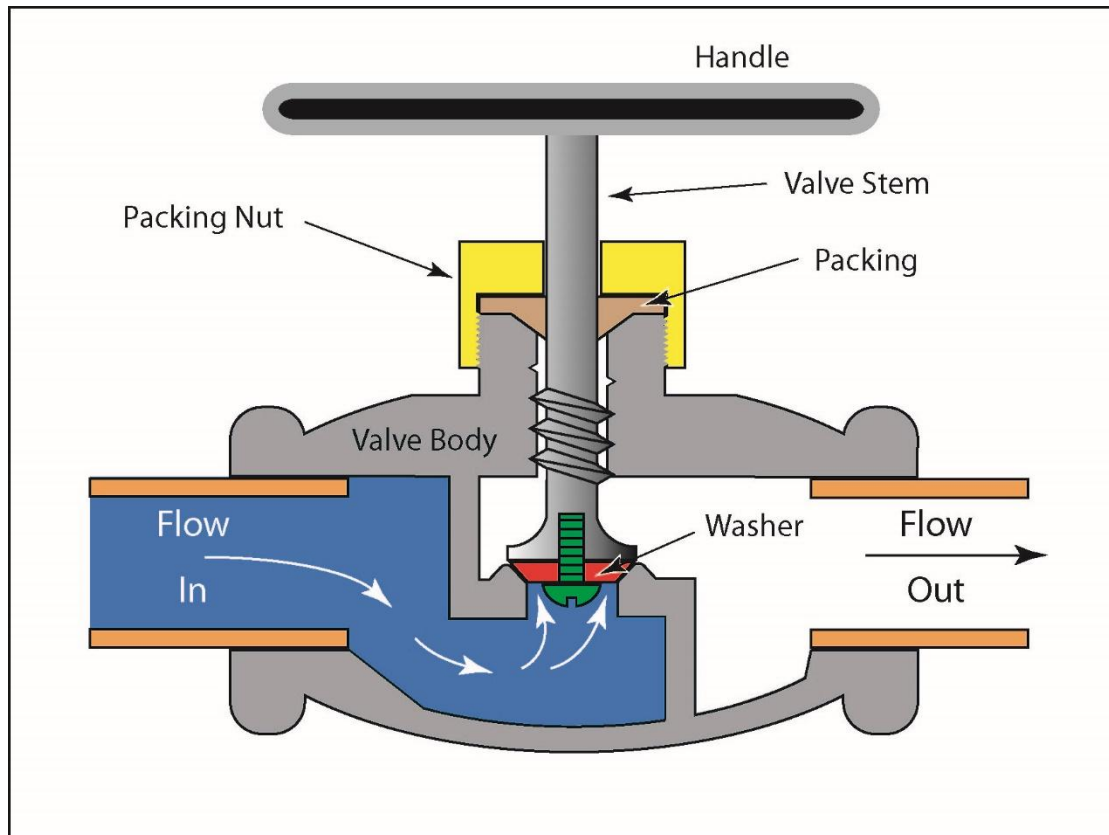
# Common Static Equipment used in Oil & Gas field

## Gate Valves



# Common Static Equipment used in Oil & Gas field

## Globe Valves



# Common Static Equipment used in Oil & Gas field

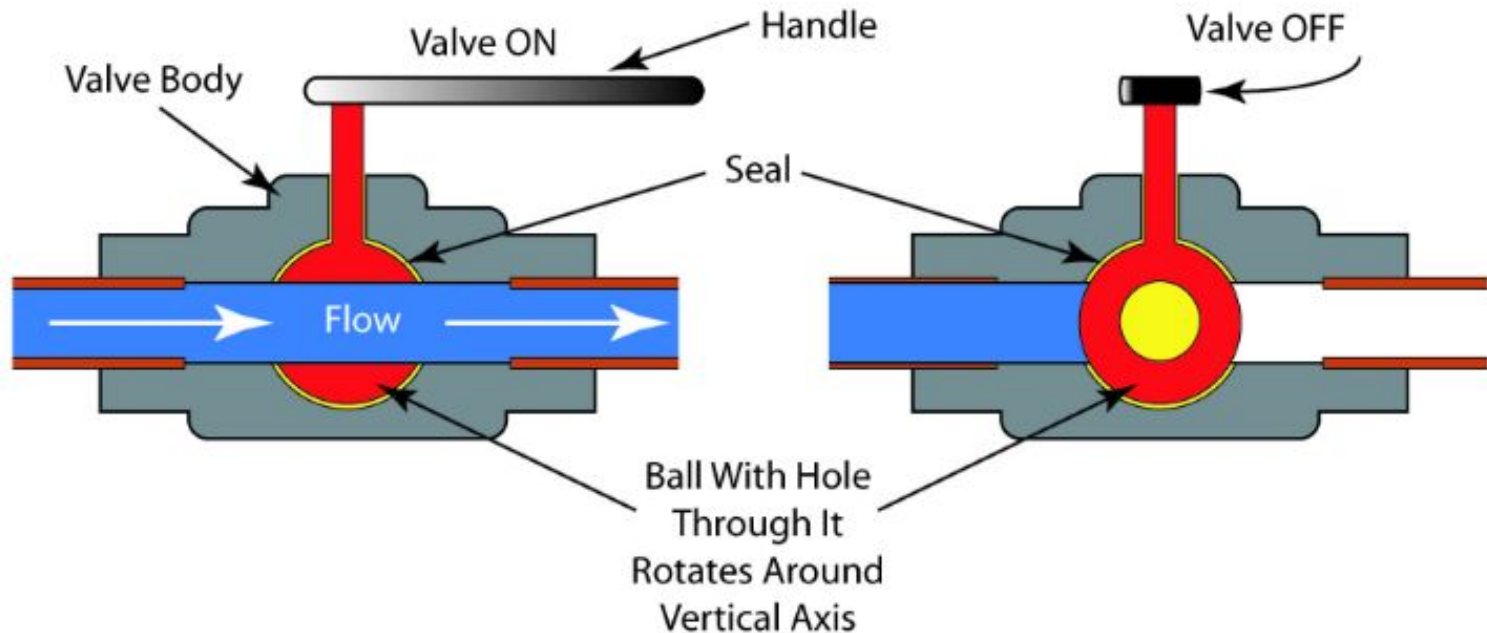
---

## Ball Valves



# Common Static Equipment used in Oil & Gas field

## Ball Valves



# Common Static Equipment used in Oil & Gas field

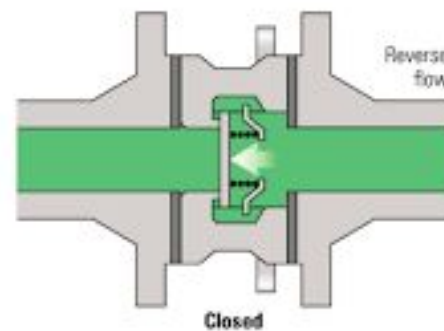
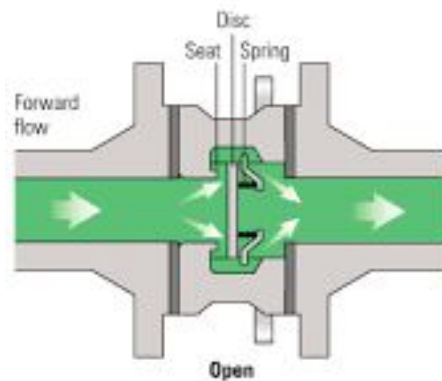
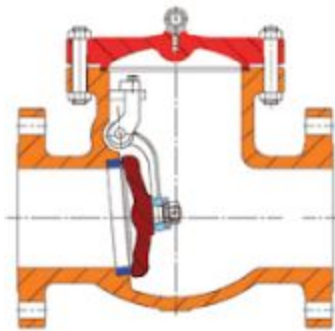
---

## Butterfly Valves



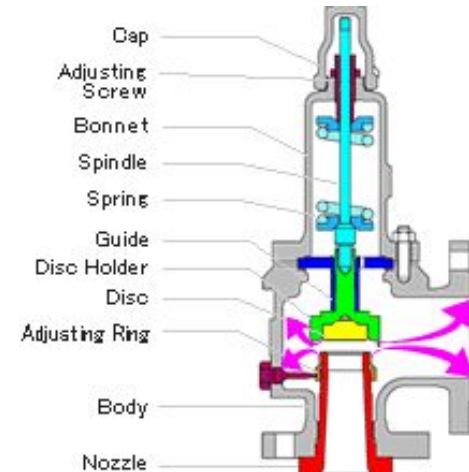
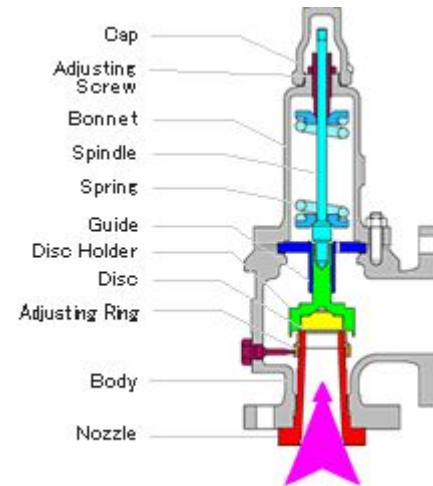
# Common Static Equipment used in Oil & Gas field

## Check Valves



# Common Static Equipment used in Oil & Gas field

## Pressure Safety Valves



## Common Static Equipment used in Oil & Gas field

---

**Explain the different types of Valves & application**

End of Static Equipment

**Thank You**

# Part - 1

# Rotating Equipment

# Common Rotating Equipment used in Oil & Gas field

---

Rotating Equipment related STD;

API 610

API 674 & API 676

API 618

API 617

API 616

Centrifugal pumps

Positive displacement pumps

Reciprocating Compressors

Centrifugal Compressors

Gas Turbines

# Common Rotating Equipment used in Oil & Gas field

---

## Pumps

Pumps are used to transform mechanical energy supplied by a driver (electric motor or combustion motor, or turbine) into hydraulic energy (mainly pressure). The increase in pressure of the propelled fluid usually serves to:

- Lift the fluid;
- Increase flow speed;
- Overcome back pressure;
- Overcome pressure drops.

# Common Rotating Equipment used in Oil & Gas field

---

## Pumps Types

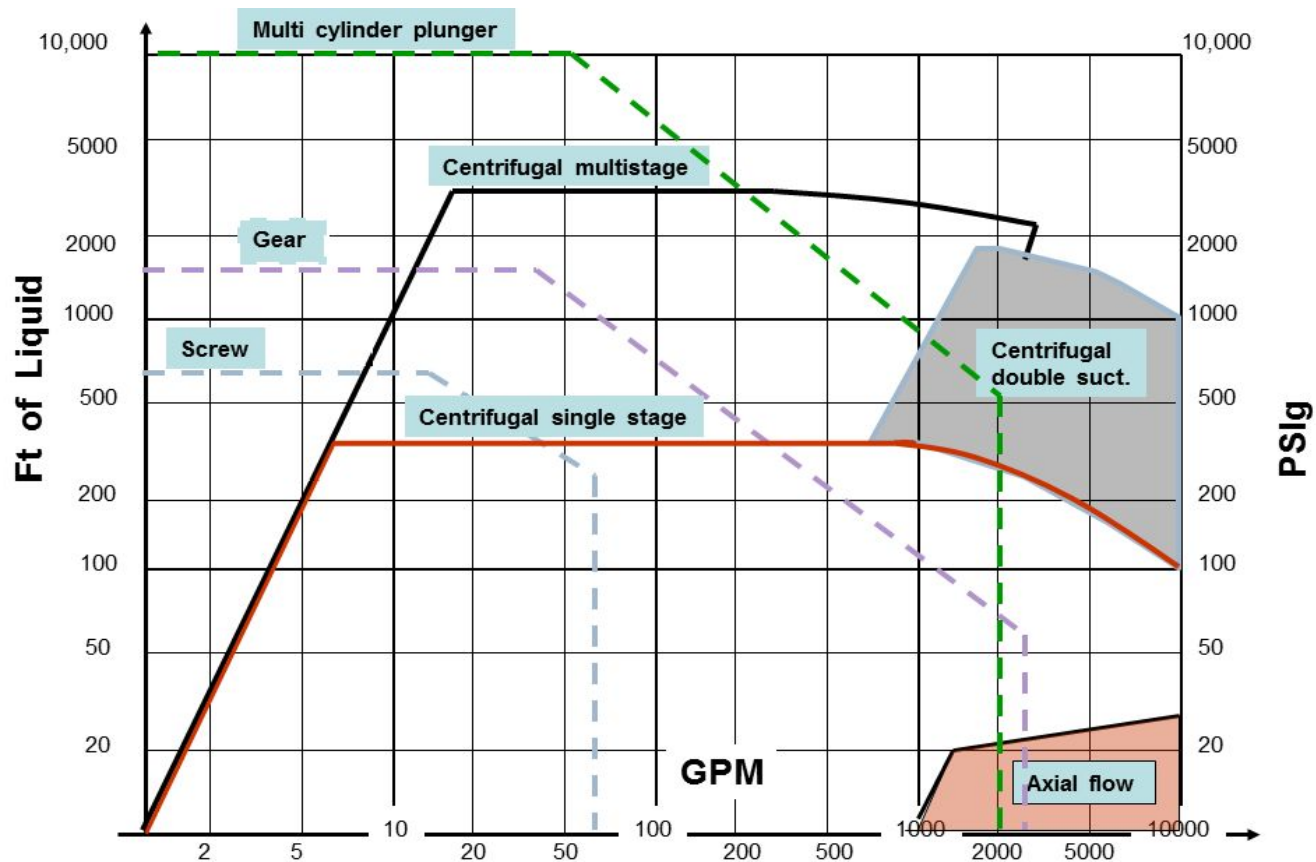
Pumps divided into two main categories;

- *Centrifugal pumps*
- *Positive displacement pumps*
  - Reciprocating pumps
  - Rotary pumps.

# Common Rotating Equipment used in Oil & Gas field

## Pumps classification

Typical range performance of common pump types



# Common Rotating Equipment used in Oil & Gas field

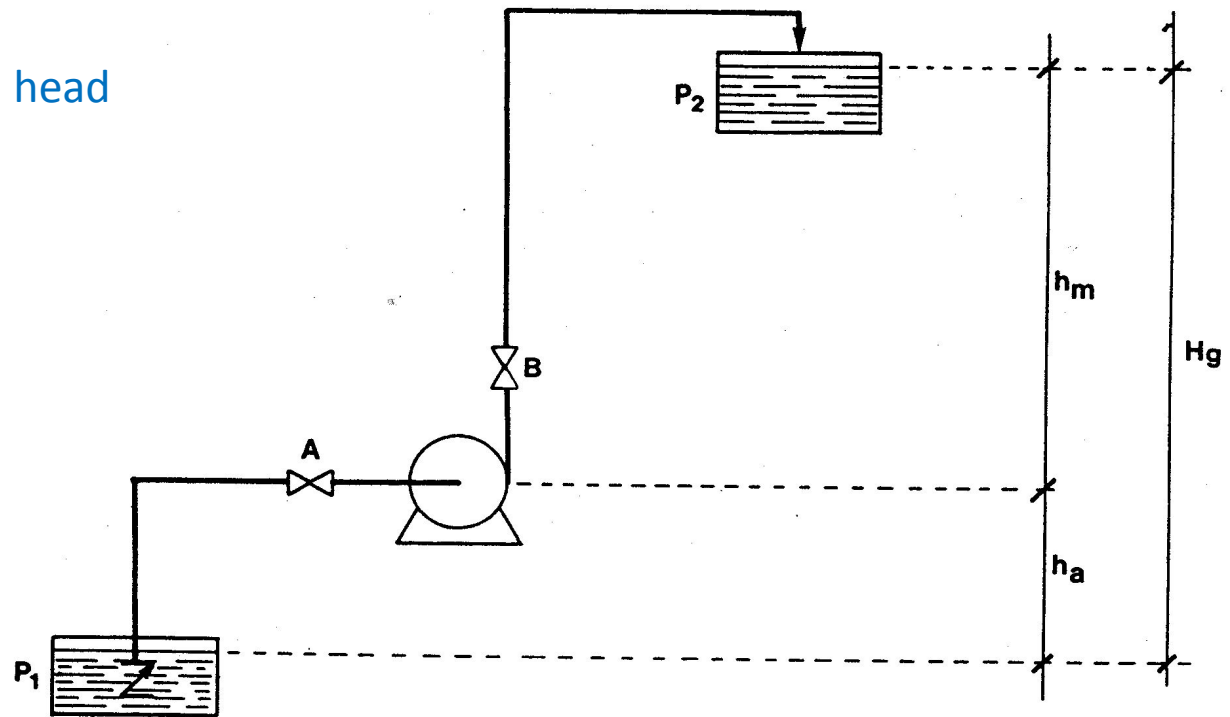
## Pump Installation Characteristics

$H_g$  = static head or total geodetic height

$h_a$  = suction head

$h_m$  = discharge head

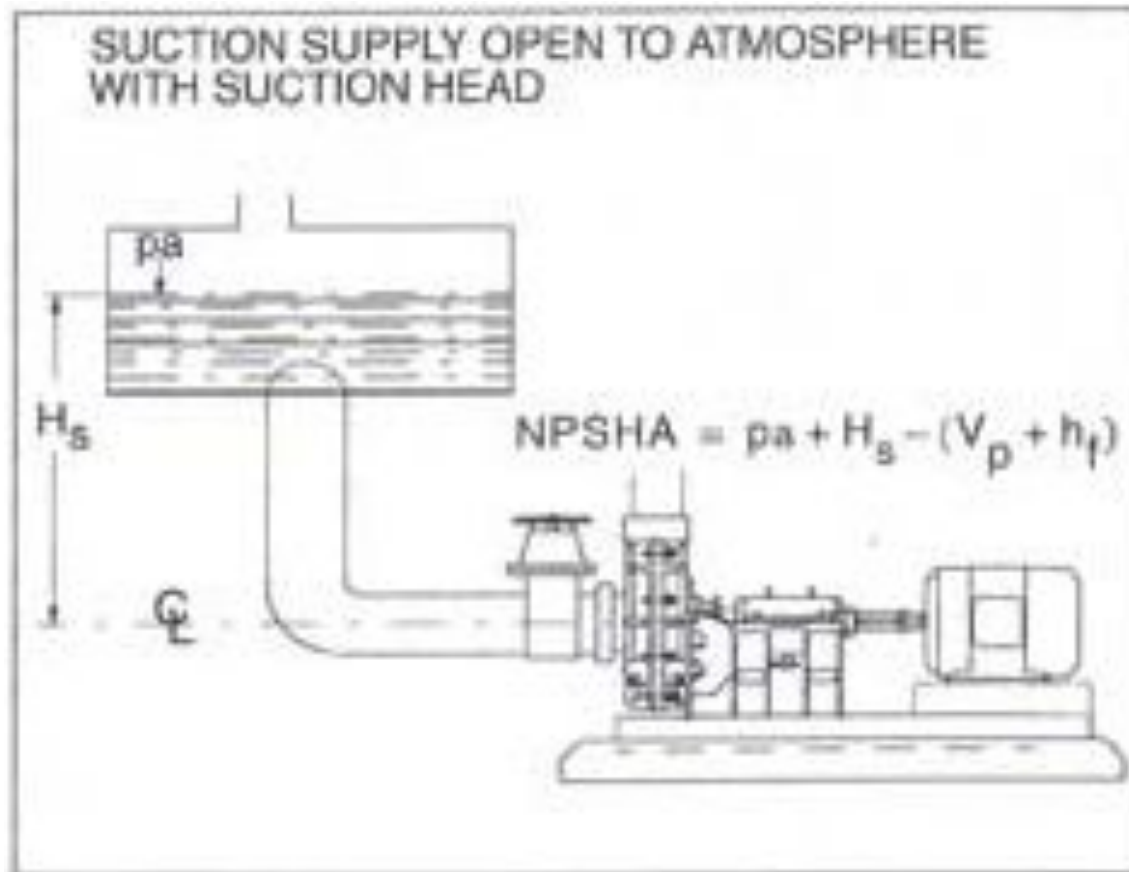
NPSH = net positive suction head



# Common Rotating Equipment used in Oil & Gas field

## Pump Net Positive Suction Head

$$\text{NPSH}_{\text{available}} > \text{NPSH}_{\text{required}}$$

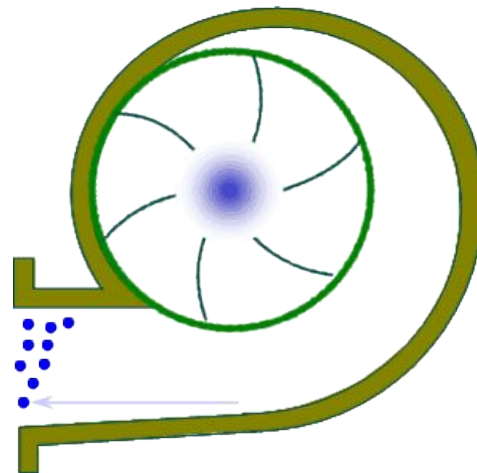
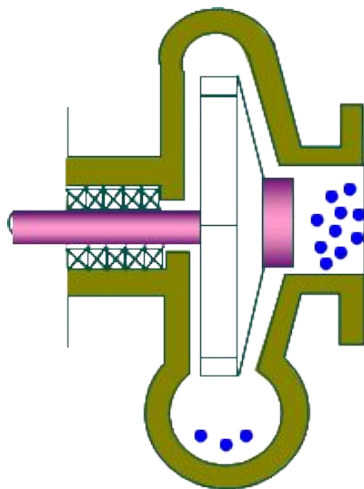


# Common Rotating Equipment used in Oil & Gas field

## Pumps Types

### Centrifugal pump operating principle

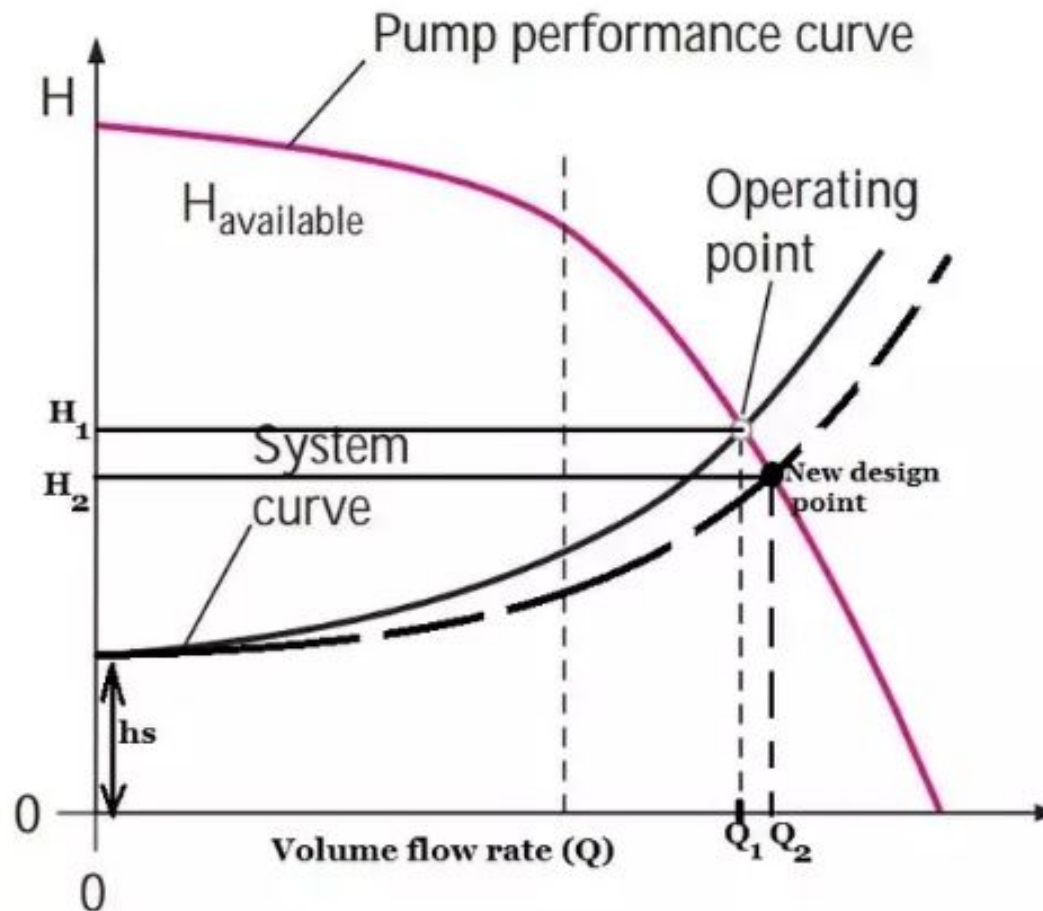
1. The liquid flows in along the axis of the pump via the distributor and the centrifugal force generated by the vanned wheel's rotation drives it toward the outside of the wheel.
2. It acquires high kinetic energy, which is converted into pressure energy in the manifold, where the cross-section increases.



# Common Rotating Equipment used in Oil & Gas field

## Pumps Types

### Centrifugal pump performance

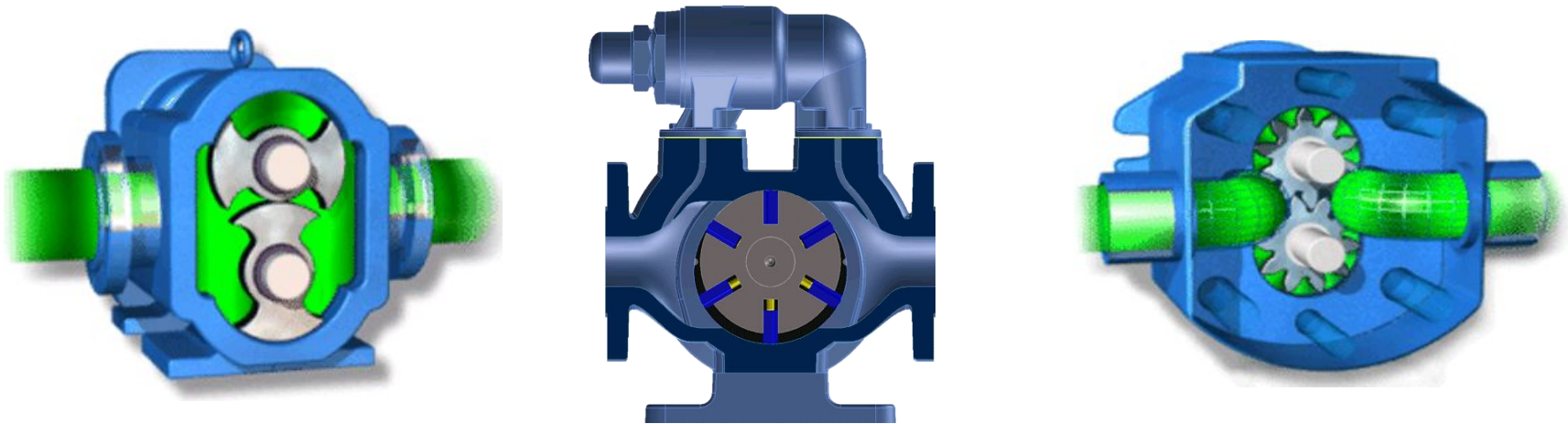


# Common Rotating Equipment used in Oil & Gas field

## Pumps Types

### Positive displacement pumps

**Rotary pumps** consist of a moving part which rotates actuated by a rotational movement around an axis which itself rotates in the pump barrel and induces movement of the pumped liquid by displacement of the volume from the suction point to the discharge point.



# Common Rotating Equipment used in Oil & Gas field

---

## **Pumps Types**

### Positive displacement pumps

#### **Reciprocating pumps**

A reciprocating pump is one with forward and backward operating action.

#### **Types of reciprocating pumps:**

1. Piston pump.
2. Plunger pump.
3. Diaphragm pump.

# Common Rotating Equipment used in Oil & Gas field

---

## **Pump Types**

### Positive displacement pumps

#### **Reciprocating pumps (Piston pumps);**

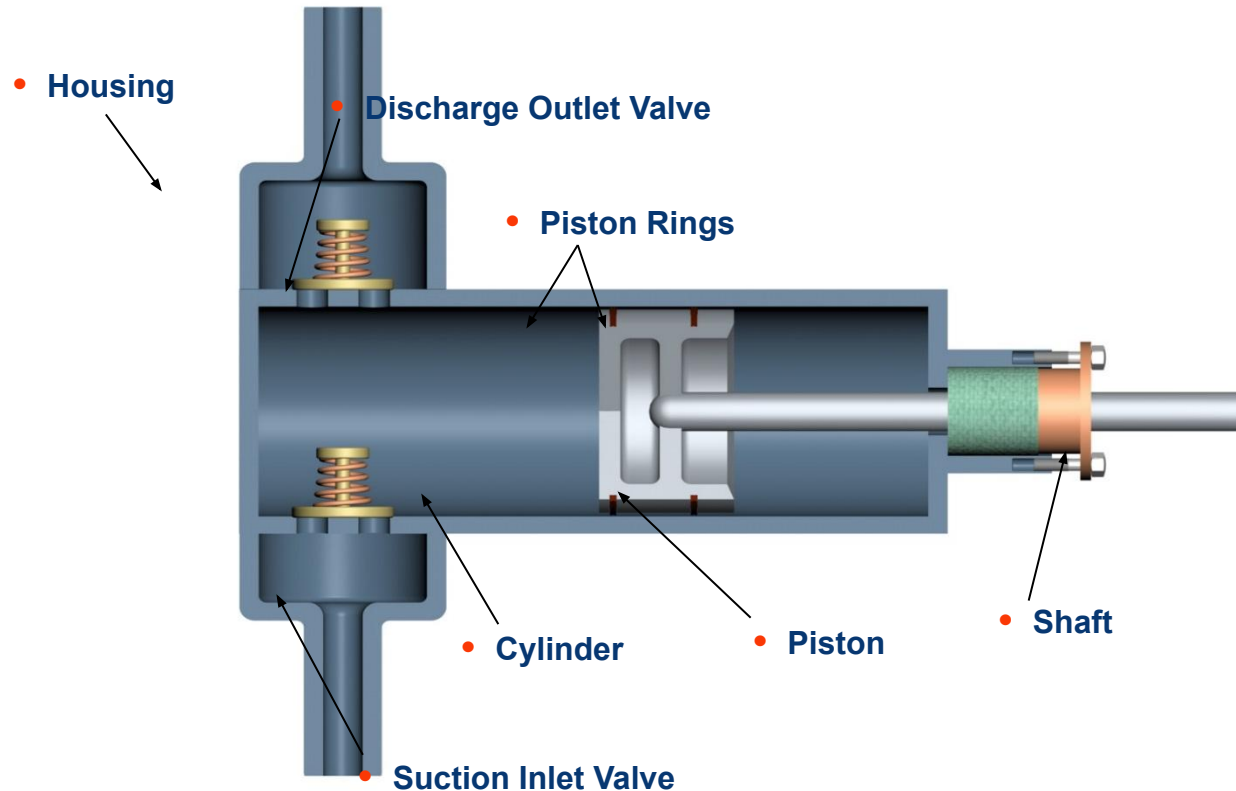
1. Single acting simplex pump
2. Single acting duplex pump.
3. Double acting duplex pump.
4. Single acting triplex pump.
5. Double acting triplex pump.

# Common Rotating Equipment used in Oil & Gas field

## Pump Types

Positive displacement pumps

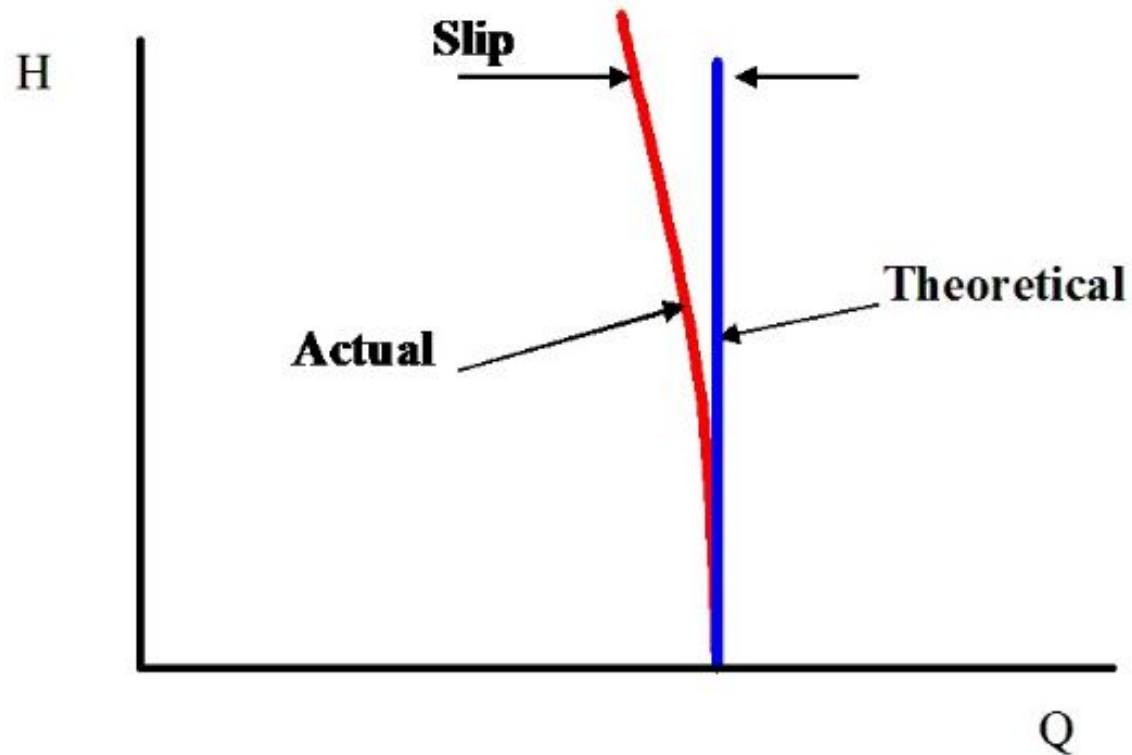
Reciprocating pumps



# Common Rotating Equipment used in Oil & Gas field

## Pump Types

### Positive displacement pumps Performance



## Common Rotating Equipment used in Oil & Gas field

---

**Explain the parameters affection centrifugal pump performance**

# Part - 2

## Rotating Equipment

# Common Rotating Equipment used in Oil & Gas field

---

**Compressors:** a machine used to added energy to a gas

Why the gas is compressed?

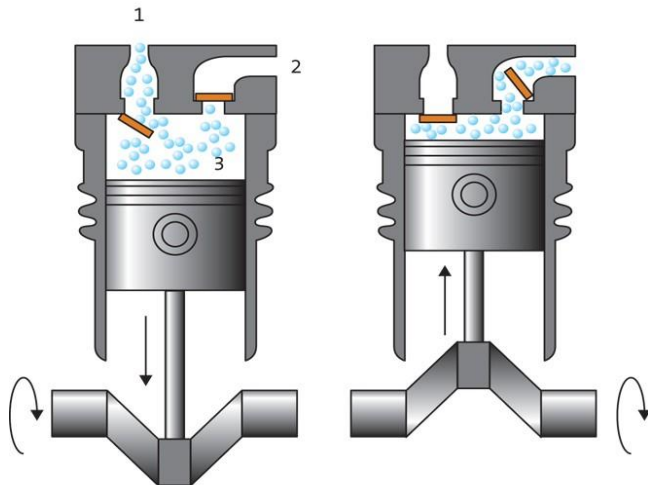
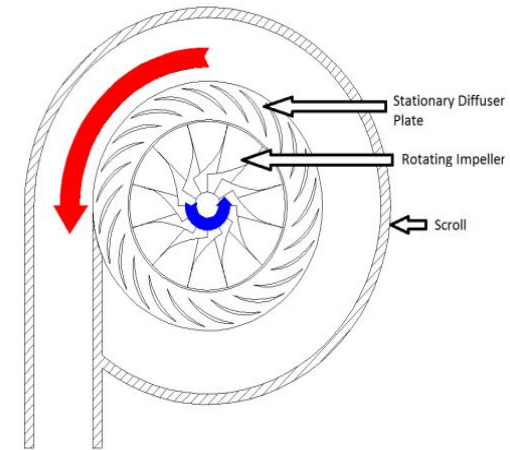
1. To move gases from place to place and to overcome friction in pipes & fittings.
2. To reduce the volume of vessels and equipment handling large amount of gas.
3. To liquefying the gas.
4. To increase the pressure of the gas to a level required in some chemical reactions.

# Common Rotating Equipment used in Oil & Gas field

## Compressors

### 1. Continuous-Flow Compressors

- ✓ Centrifugal Compressor
- ✓ Axial Flow Compressor

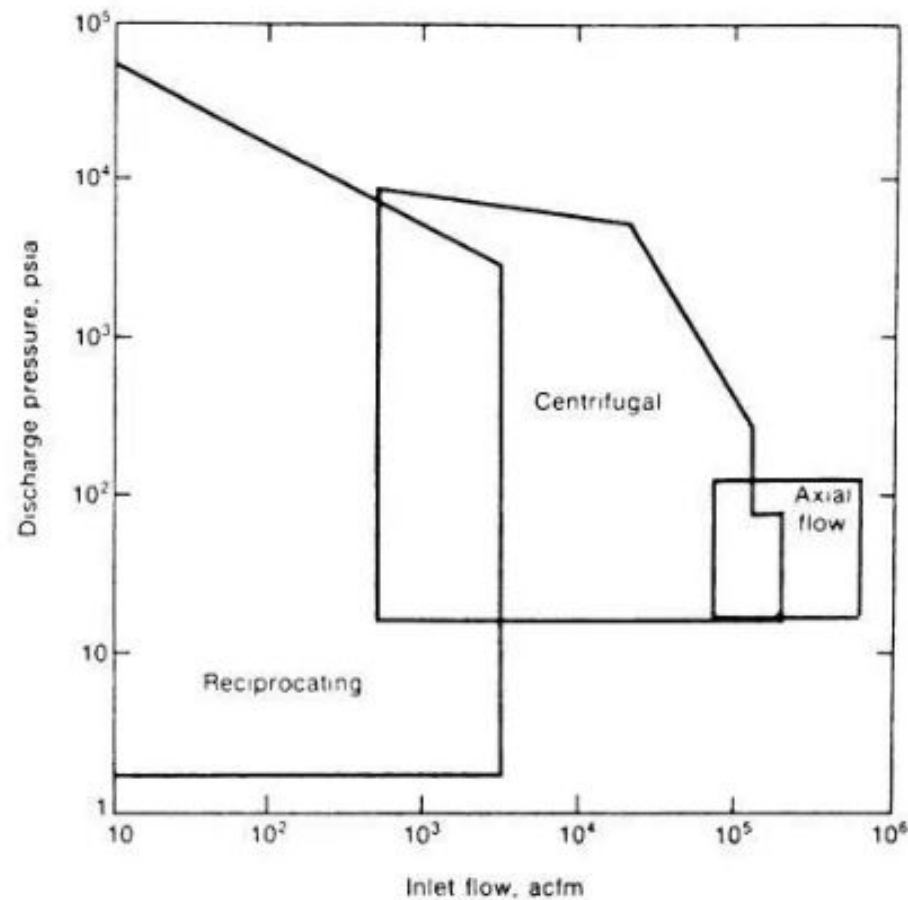


### 2. Positive Displacement compressors

- ✓ Reciprocating Compressor
- ✓ Rotary Compressor

# Common Rotating Equipment used in Oil & Gas field

## Compressors Selection Criteria



# Common Rotating Equipment used in Oil & Gas field

---

## Centrifugal Compressor Process Design Parameters

"*Design data*" to select a centrifugal compressor:

- *Rotational speed*
  - *Number of impellers*
  - *Impeller diameters*
  - *Compression efficiency*
  - *Power absorbed*
  - *Driver rating*
  - *Performance characteristics*
  - *Casing arrangement*
- For variable speed drives the "*normal speed*" is usually 90-97% of the *rated speed*, allowing for contingencies.
  - For constant speed drives, design is done for the *rated point*, i.e. on the 100% speed line.

# Common Rotating Equipment used in Oil & Gas field

## Centrifugal Compressor Process Design Parameters

The “*process design parameters*”:

- *Flow rate*
- *Gas composition*
- *Inlet pressure and temperature*
- *Outlet pressure*
- *Train arrangement (series, parallel, etc)*

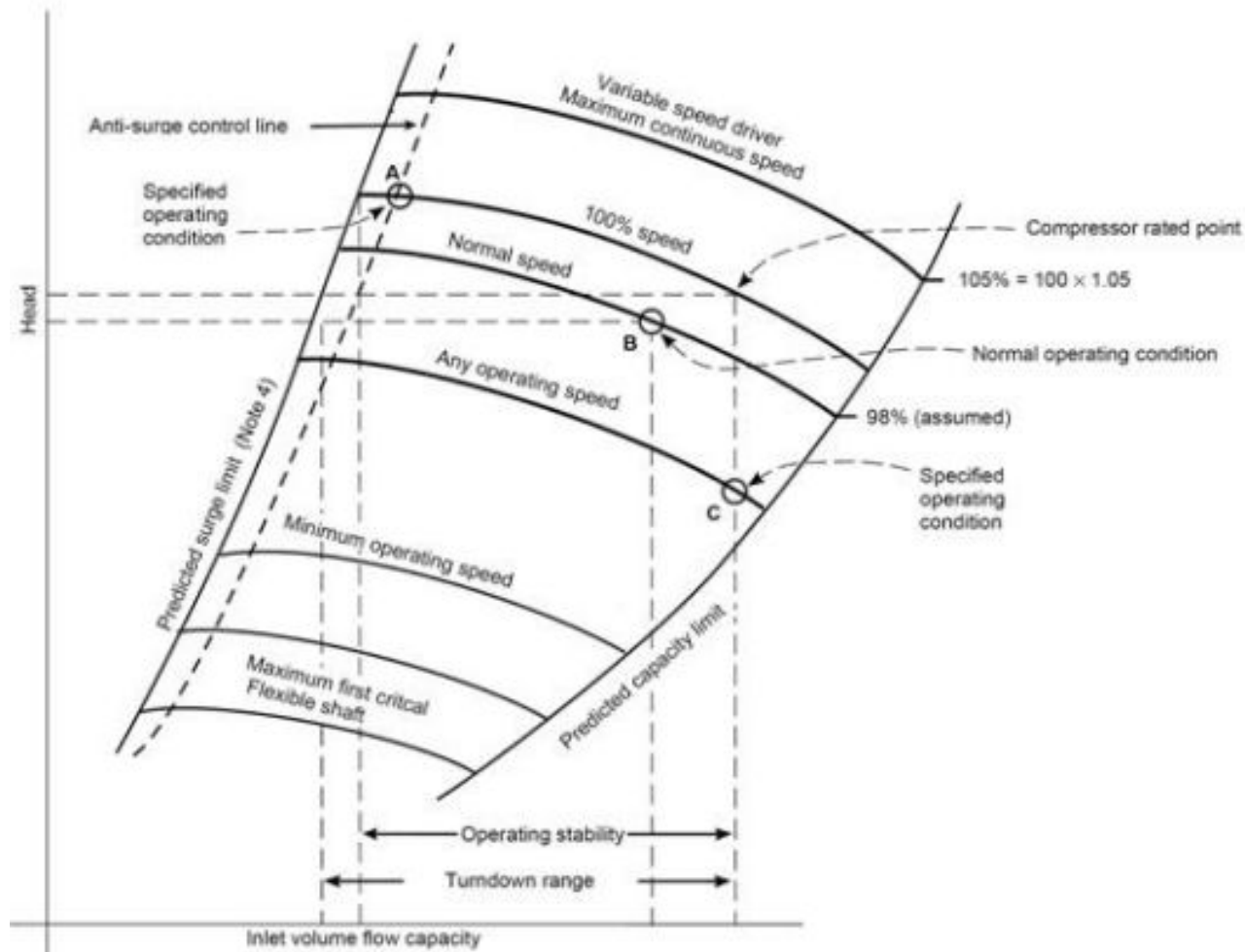
‘*Rated point*’ defined by API 617:

- *Highest volumetric flow rate*
- *Lowest molecular weight*
- *Highest head or pressure ratio*
- *Highest inlet temperature*

To avoid over-design, the usual practice is to select a “*normal operating point*” at which the machine is expected to operate for most of its life.

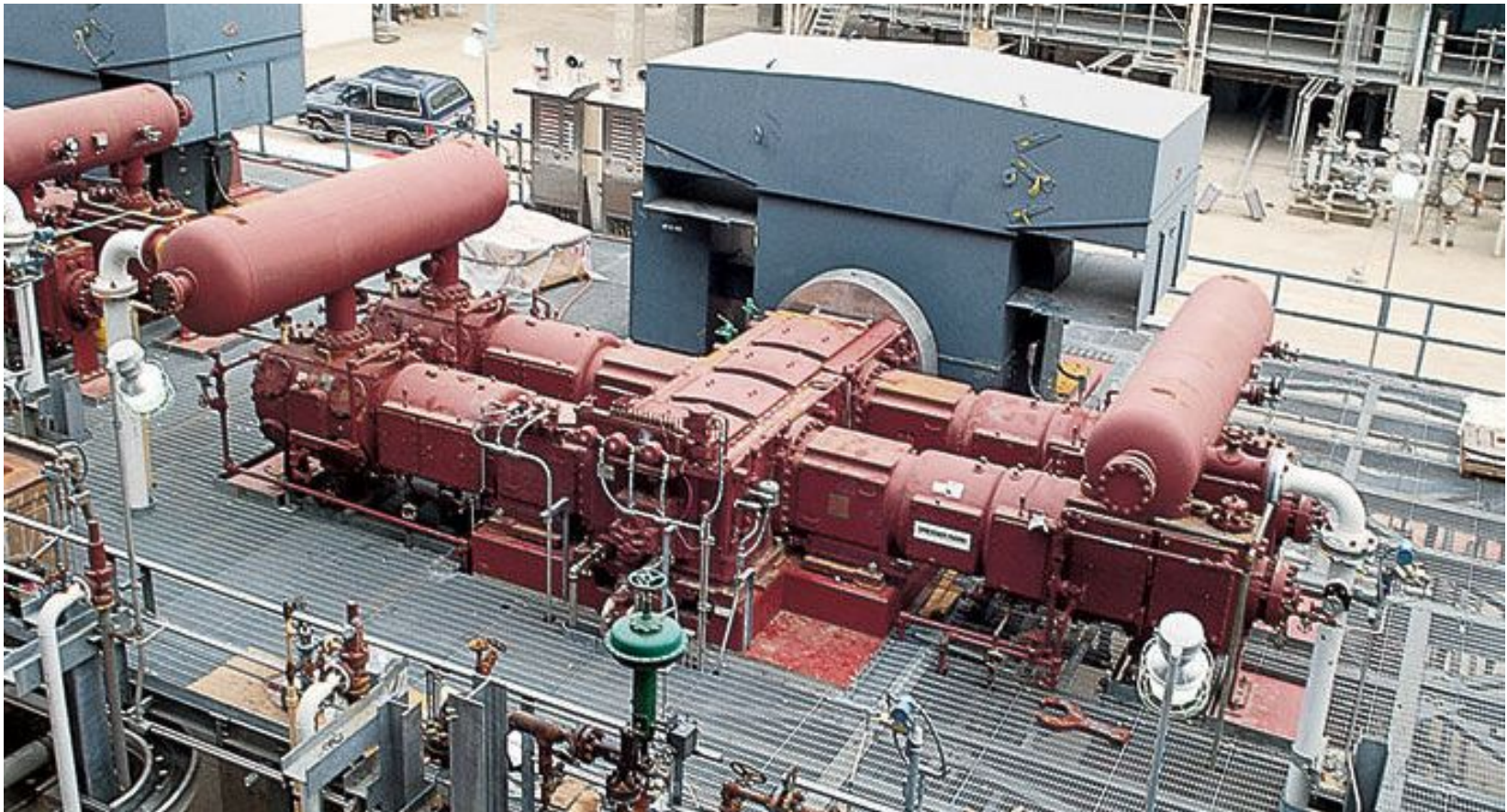
# Common Rotating Equipment used in Oil & Gas field

## Centrifugal Compressor Performance



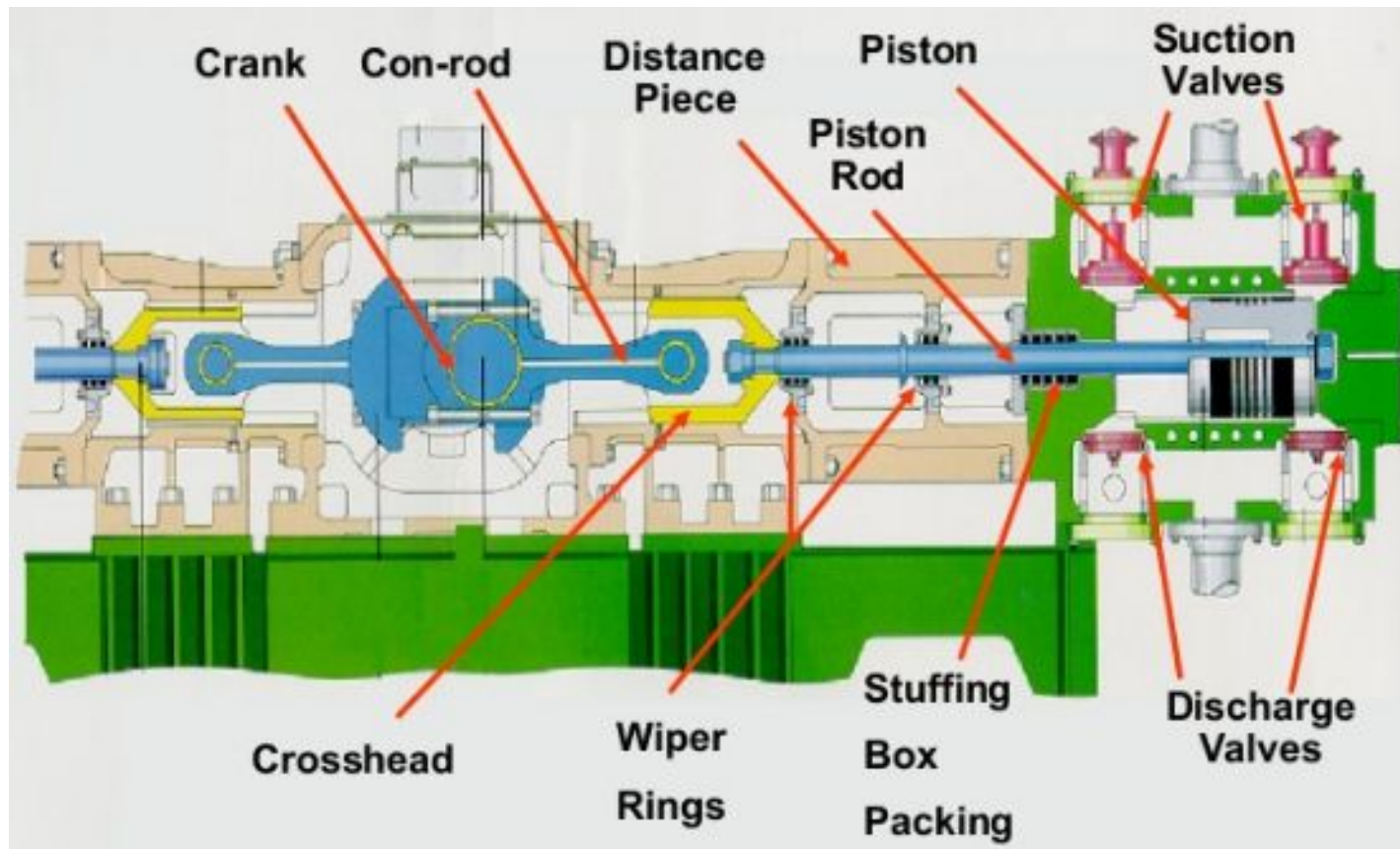
# Common Rotating Equipment used in Oil & Gas field

## Multi Stage Reciprocating Compressor



# Common Rotating Equipment used in Oil & Gas field

## Reciprocating Compressor



# Reciprocating Compressor

The diagram illustrates a thermodynamic cycle on a Pressure-Volume ( $P$ - $V$ ) plane. The vertical axis represents Pressure ( $P$ ) and the horizontal axis represents Volume ( $V$ ). The cycle consists of the following states and processes:

- State 1:** Initial state at pressure  $P_1$  and volume  $V_1$ .
- Process 1-2:** Isothermal expansion, represented by a curve where  $PV^n = C$ .
- State 2:** Intermediate state at pressure  $P_2$  and volume  $V_2$ .
- Process 2-3:** Isochoric cooling (constant volume).
- State 3:** State at pressure  $P_2$  and volume  $V_3$ .
- Process 3-4:** Isothermal compression, represented by a curve where  $PV^n = C$ .
- State 4:** State at pressure  $P_1$  and volume  $V_4$ .
- Process 4-5:** Isochoric heating (constant volume).
- State 5:** State at pressure  $P_1$  and volume  $V_3$ .
- Process 5-6:** Isochoric heating (constant volume).
- State 6:** State at pressure  $P_2$  and volume  $V_3$ .

Key volumes and their definitions are indicated below the diagram:

- Total Volume,  $V_1$ :** The volume at the start of the expansion process (1-2).
- Clearance Volume,  $V_3 = V_c$ :** The volume remaining in the cylinder at the end of the compression process (3-4).
- Effective Swept Volume,  $V_1 - V_4$ :** The volume swept by the piston during the expansion process (1-2).
- Swept Volume,  $V_1 - V_3 = V_s$ :** The total volume swept by the piston during the expansion process (1-2).

**Volume that remains inside the cylinder after the piston reaches the end of its inward stroke.**

**Actual Work =  $W_{act}$  = Area 1-2-3-4**

$$W_{net} = \text{Area (5-1-2-6)} - \text{Area (5-4-3-6)}$$

# Common Rotating Equipment used in Oil & Gas field

---

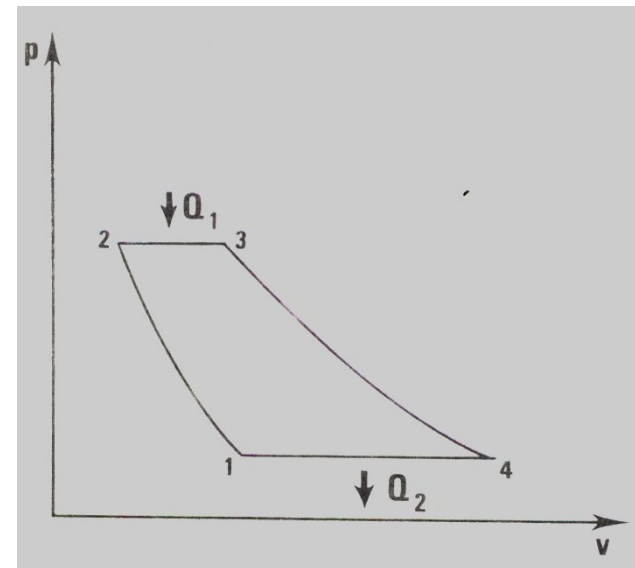
**Explain the basis of Compressor selection**

# Common Rotating Equipment used in Oil & Gas field

## Gas Turbine

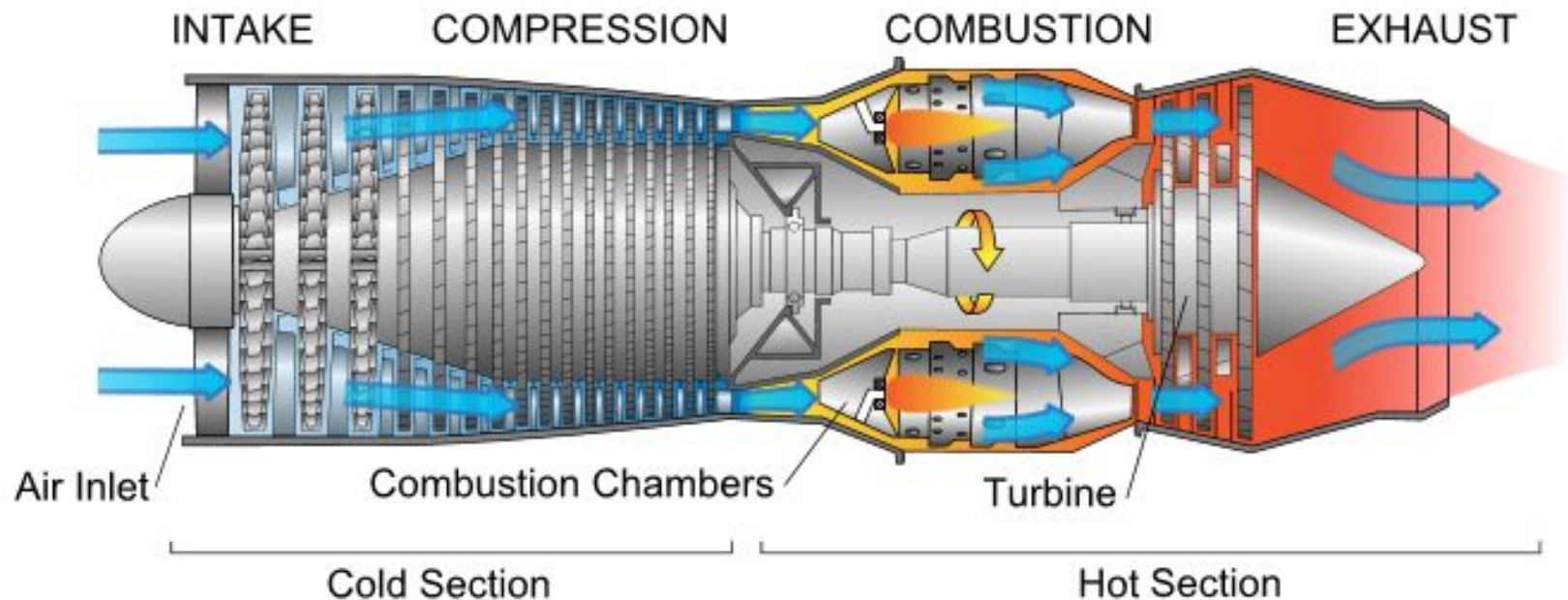
Gas turbines in which air is compressed, combustion occurs at constant pressure, and expansion over the turbine occurs back to the starting pressure.

**Brayton cycle:** thermodynamic ideal cycle.



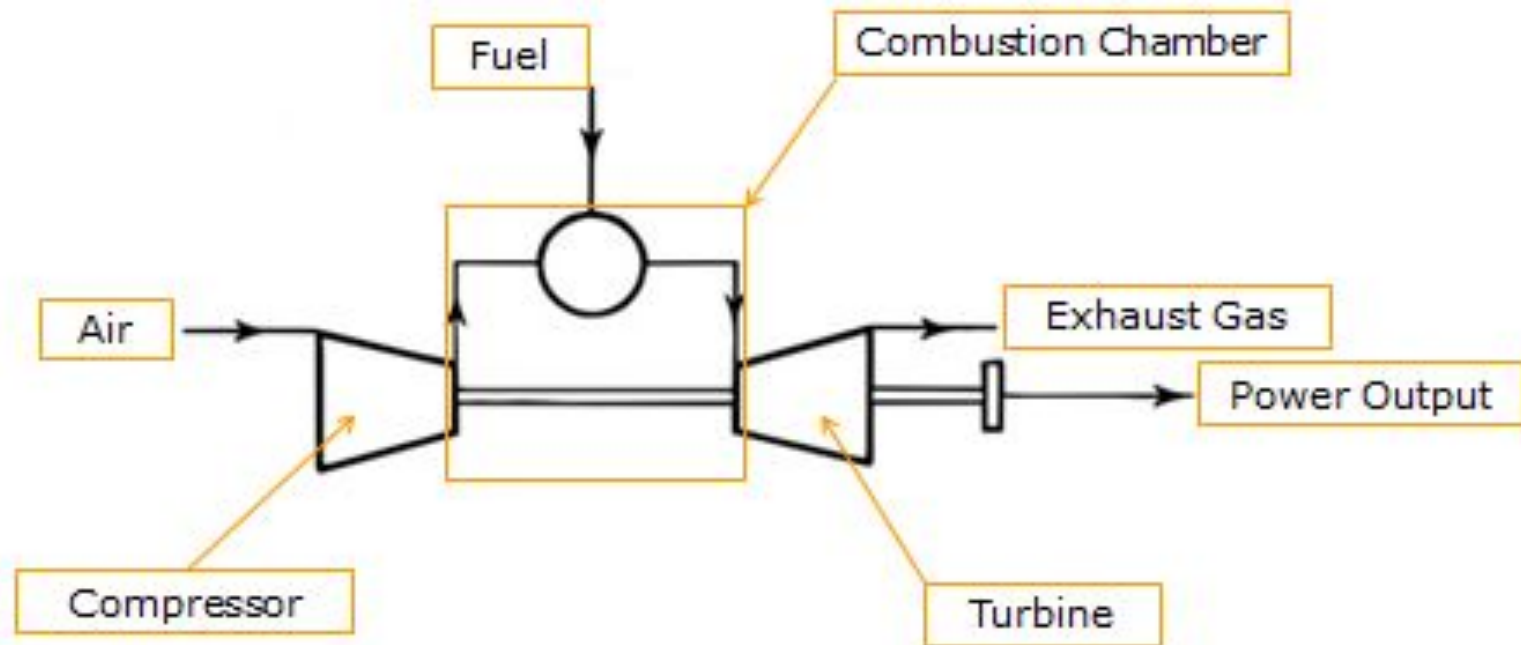
# Common Rotating Equipment used in Oil & Gas field

## Gas Turbine



# Common Rotating Equipment used in Oil & Gas field

## Gas Turbine Operating Parameters



Compressor, Air, Fuel, Combustion Chamber, Exhaust Gas, Power Output, Turbine

# Common Rotating Equipment used in Oil & Gas field

---

## Gas Turbine Operating Parameters

The performance of a gas turbine engine, meaning its power output and fuel consumption, is influenced by a variety of factors.



- *Environmental factors*

- Ambient Pressure
- Ambient Temperature
- Humidity



- *Inherent characteristics*

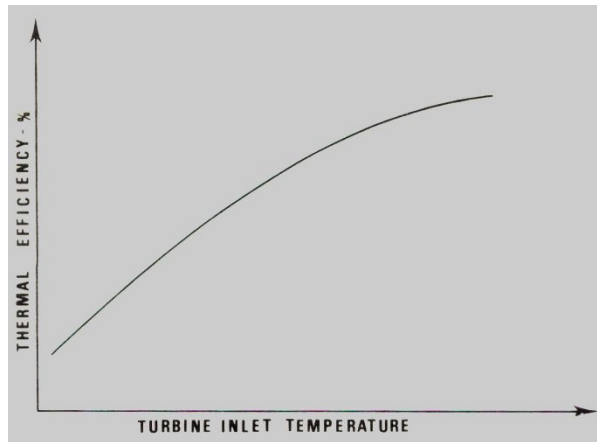
- Turbine inlet temperature
- Pressure Ratio
- Fuel Heating Value
- Thermal Efficiency

# Common Rotating Equipment used in Oil & Gas field

## Gas Turbine Operating Parameters

### TURBINE INLET TEMPERATURE

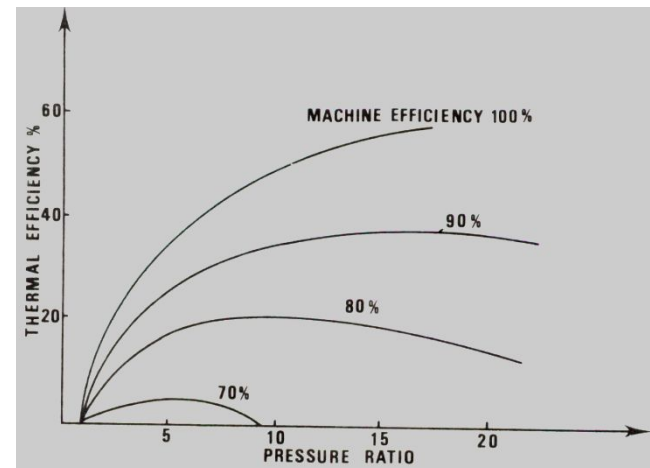
- It is this value that determines the highest effective energy state of the working fluid within the turbine.



Thermal Efficiency vs. Turbine Inlet Temperature

### PRESSURE RATIO

- Ratio of the discharged air pressure to suction air pressure.
- A measure of the internal energy imparted to the air by the compressor.



Effect of Machine Efficiency on Thermal Efficiency

# Common Rotating Equipment used in Oil & Gas field

## Gas Turbine Operating Parameters

### FUEL HEATING VALUE

- It is a measure of the available energy possessed by fuel.
- The ratio of HHV to LHV depends on the composition of the fuel.
- The greater the heating value, the smaller the quantity that must be burned for a given output.

### THERMAL EFFICIENCY

- Ratio of the work output (W) to the heat input ( $Q_1$ ) in the same energy units:

$$h = \frac{W}{Q_1}$$

- If  $Q_2$  = energy not converted into useful work :

$$W = Q_1 - Q_2$$

$$h = \frac{(Q_1 - Q_2)}{Q_1}$$

## Common Rotating Equipment used in Oil & Gas field

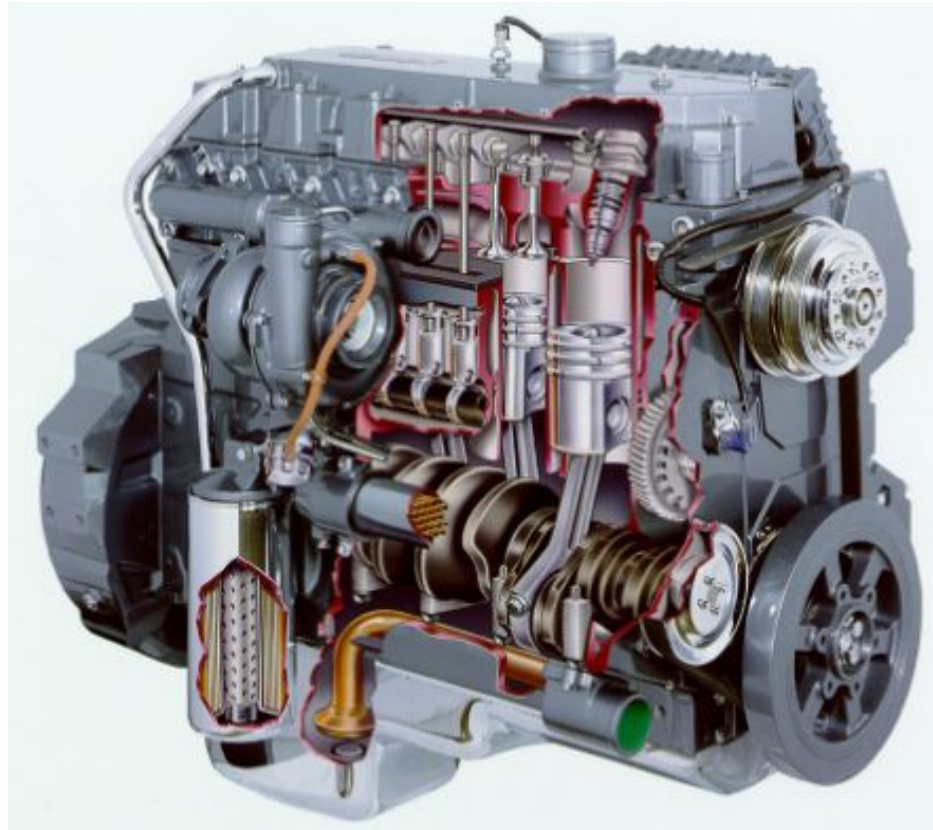
---

**Explain the Gas Turbine Operating Parameters**

# Common Rotating Equipment used in Oil & Gas field

## Reciprocating Engines

- ☐ Diesel Engine
- ☐ Gas Engine

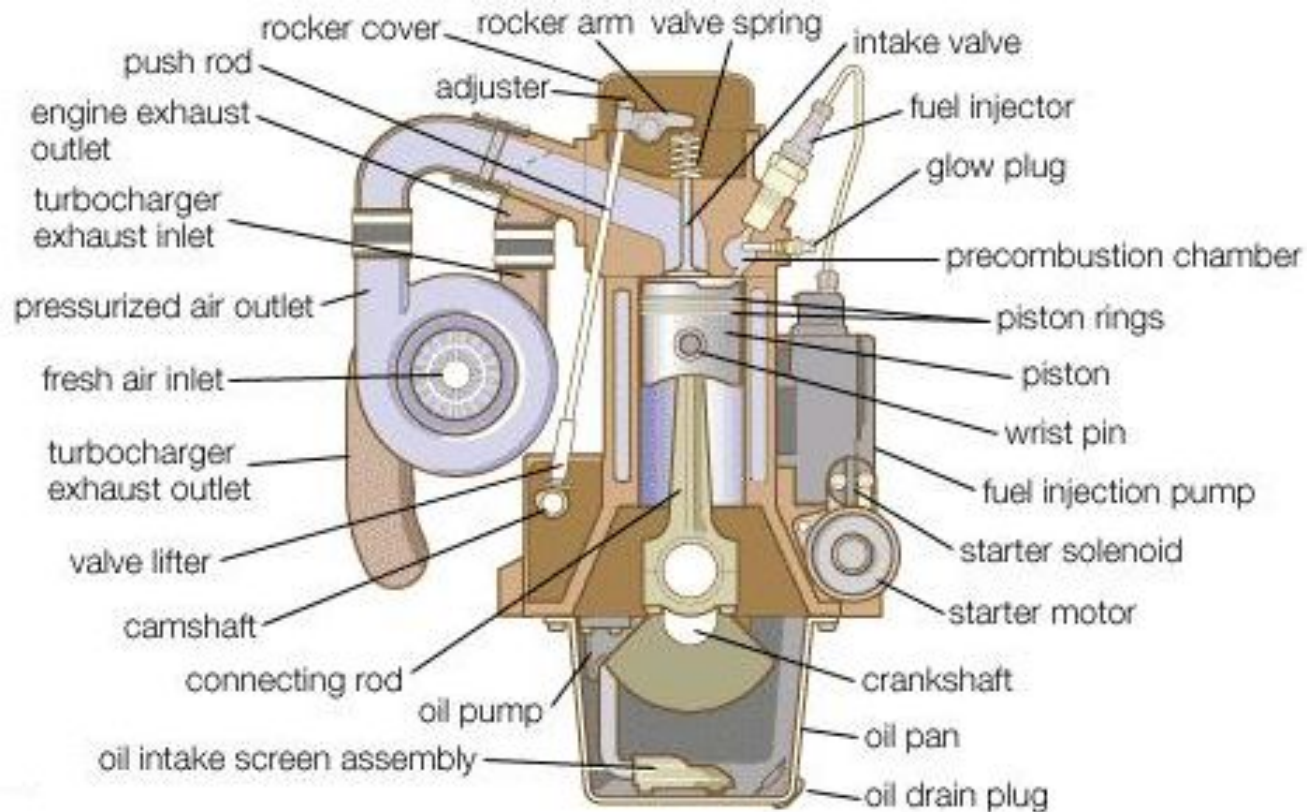


**Diesel Engine**

# Common Rotating Equipment used in Oil & Gas field

## Reciprocating Engines

### ❑ Diesel Engine



**Diesel Engine**

# Common Rotating Equipment used in Oil & Gas field

---

## Reciprocating Engines

### **Diesel Engine operating systems;**

- Fuel System
- Inlet Air System
- Exhaust System
- Lube Oil System
- Cooling System
- Starting System
- Protection System

## Common Rotating Equipment used in Oil & Gas field

---

**Explain Diesel Engines main components**

**Thank  
You**