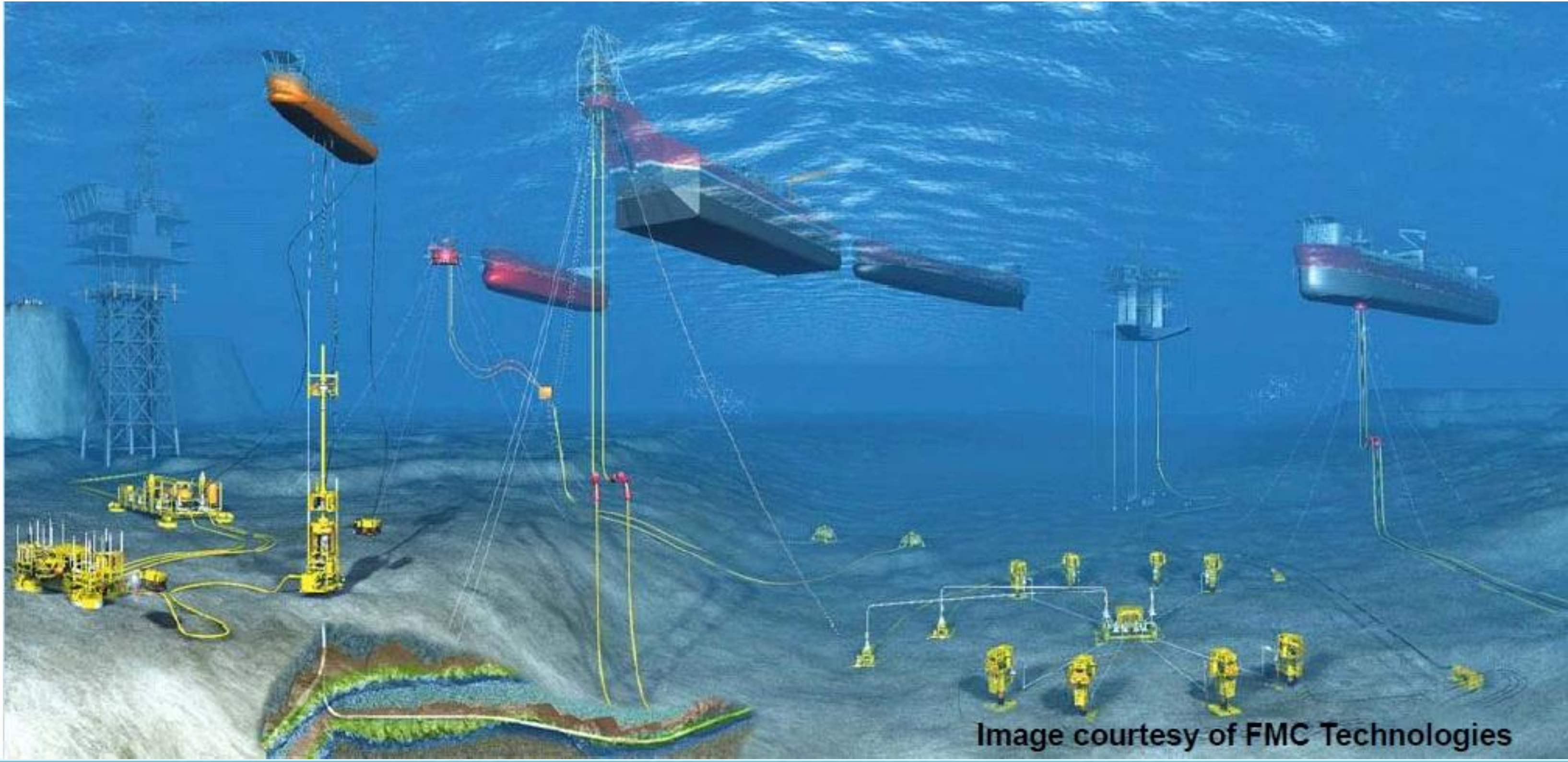
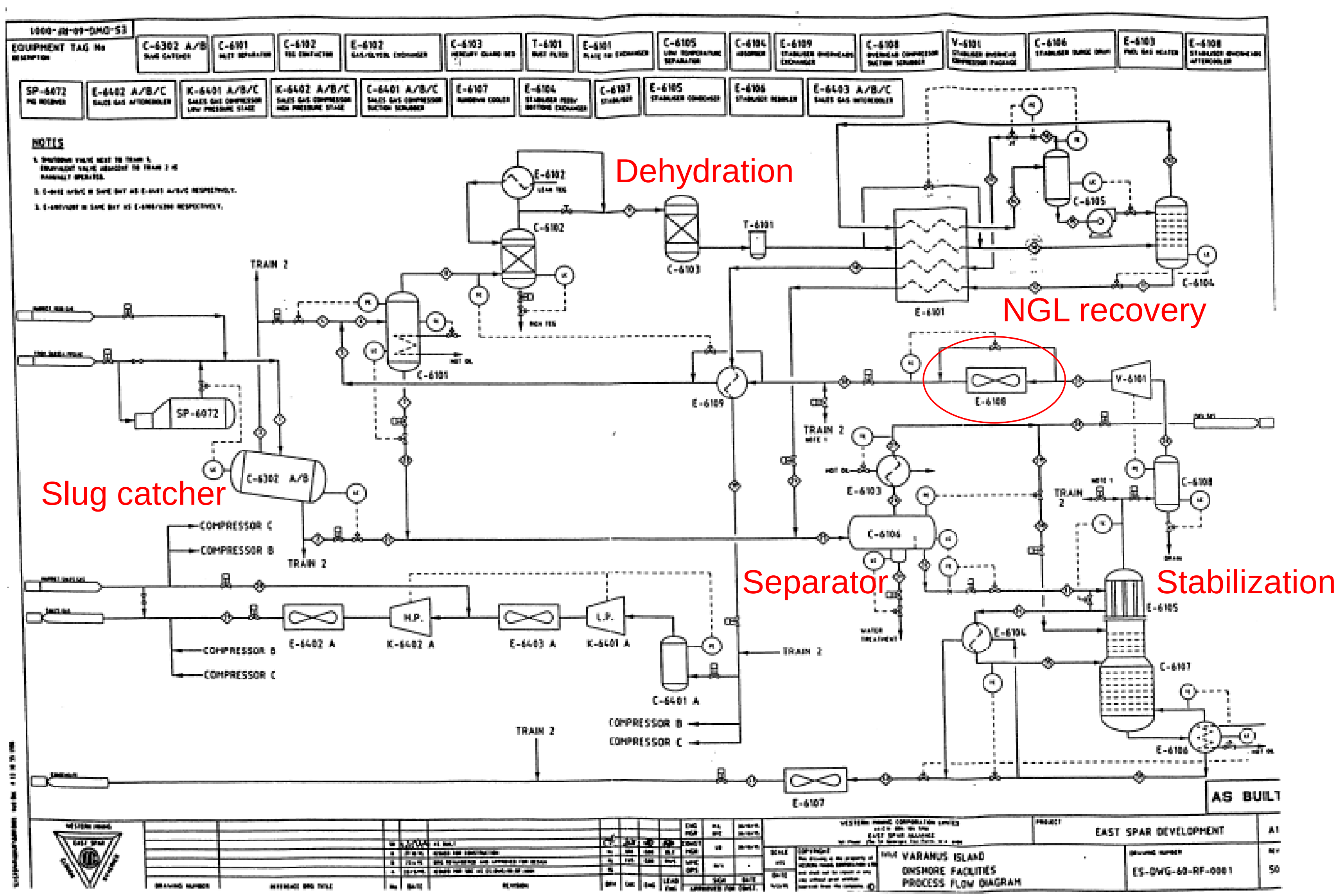


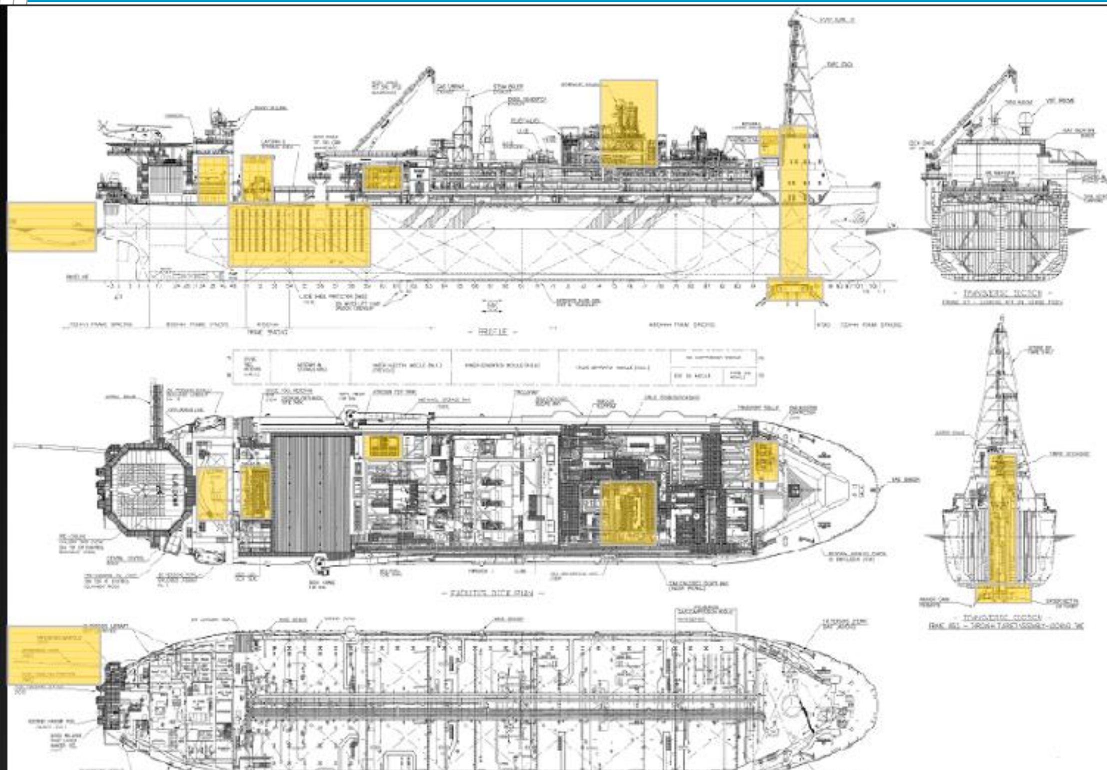
Offshore Equipment

Yutaek Seo

Flash Gas Compressor (East spar)



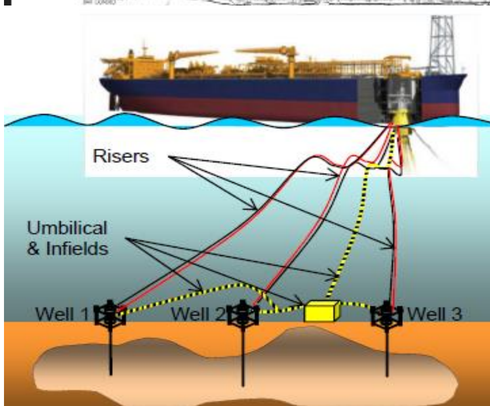
Booster compressor



- Turret
- Side Impact
- ICS Upgrade
- Gas Dehy.
- Booster Gas Co.
- MeOH Skid
- Metering Unit
- Offloading

Gas Dehy.

Metering Skid



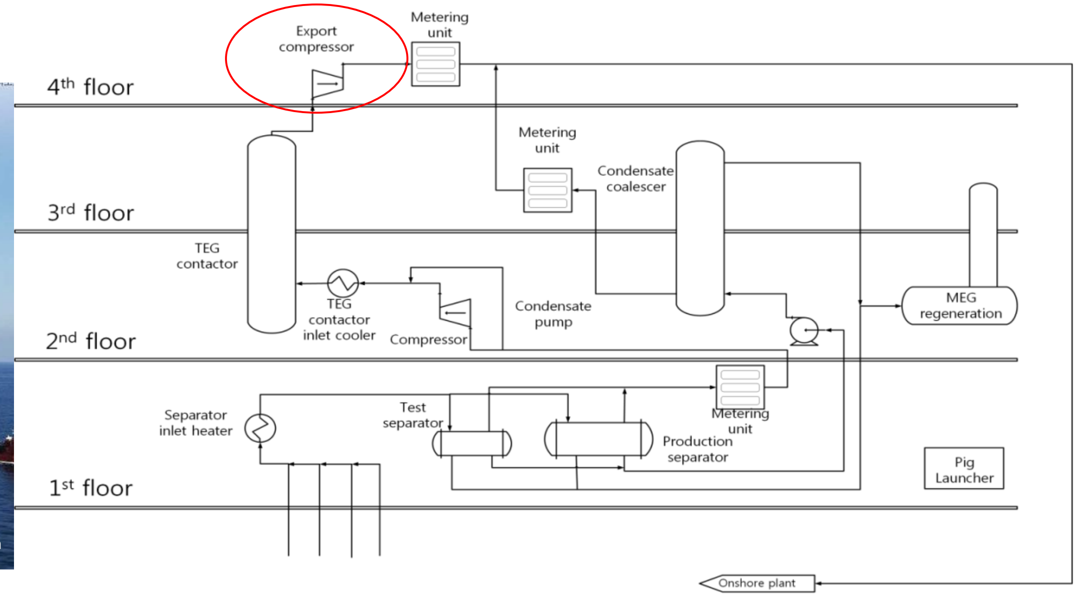
Swivel de-stack

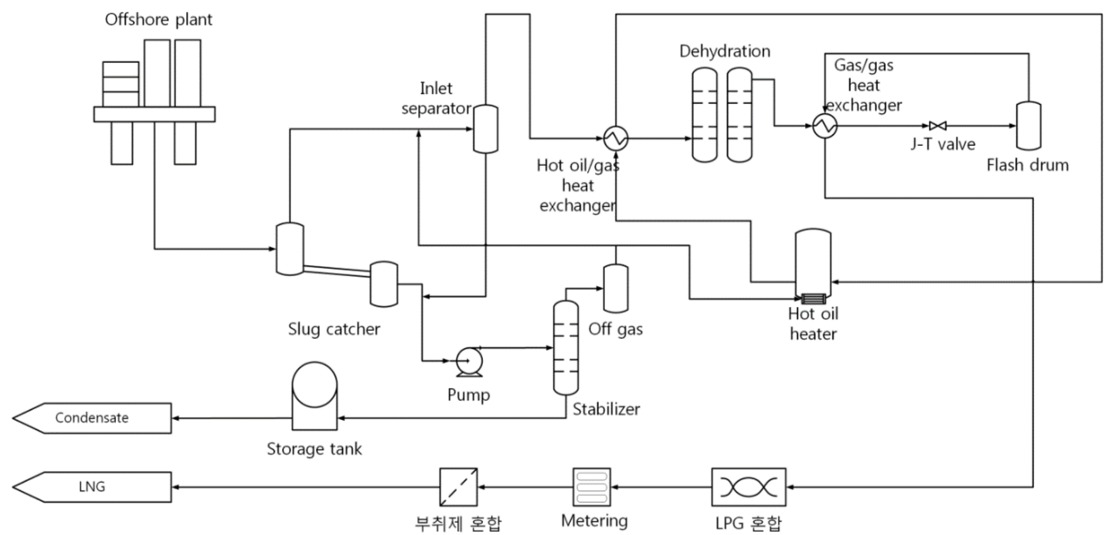
Booster Gas Compressor

MeOH Skid

Gas export compression (Donghae-1 Platform)

동해-1 가스전 조감도

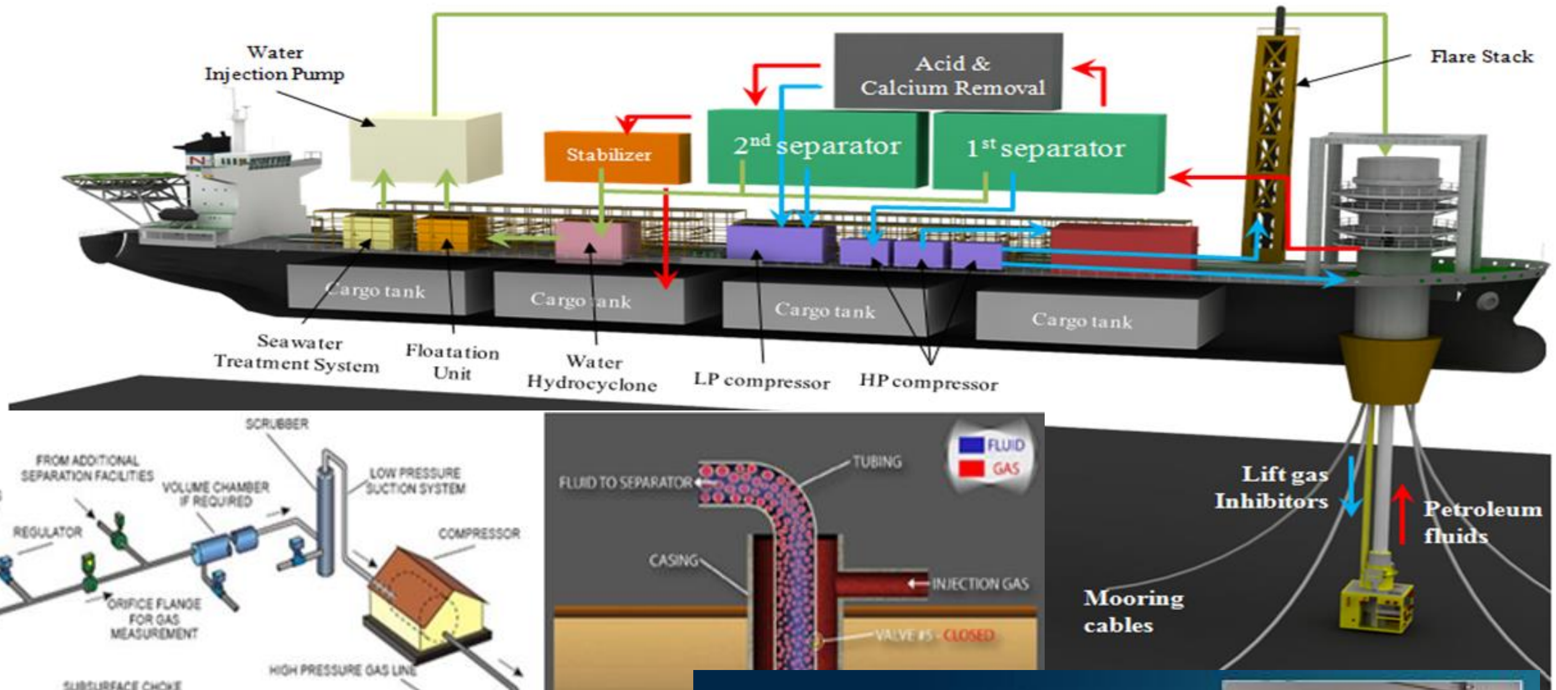


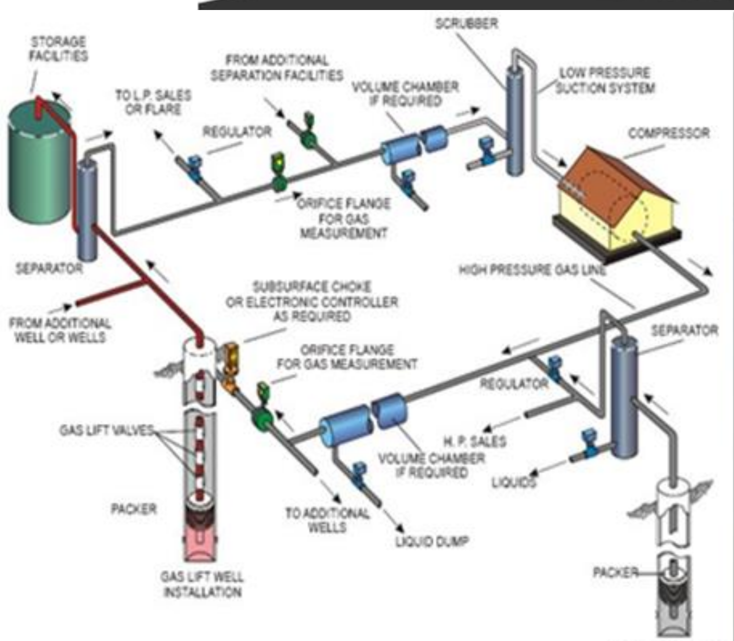


Gas compression in offshore platform

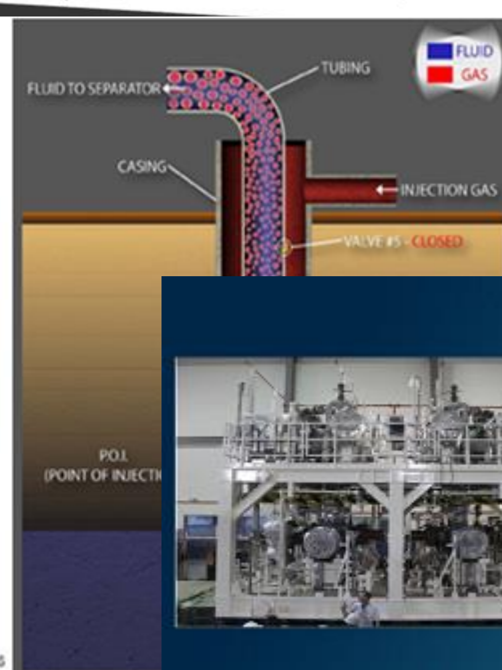
- Gas from Separators, Surge Tanks and export gases if any from other process platforms are compressed to about 90-100 kg/cm^2 pressure.
- Normally Gas turbine driven Centrifugal compressors (PGC's-Process Gas Compressors) are used.
- Gases compressed in PGC's is dehydrated to prevent formation of GAS HYDRATES. Gas hydrates are formed at low temperatures when moisture is present in Hydrocarbon gases. These gas hydrates are ice like substance which prevent the smooth flow or block the flow of gases in gas flow lines.
- Gas Hydrates can be formed in Adjustable Choke Valves ,PCV's & GLV's in GI Lines where Throttling of gases give rise to low temperatures.(Joule Thomson effect).This can affect production phenomenally from Gas lift wells

Gas lift compressor

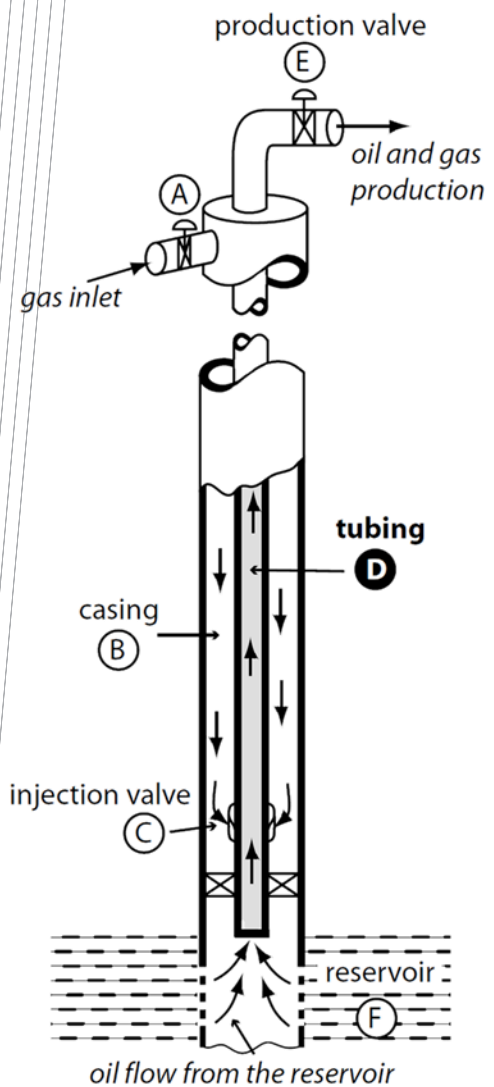


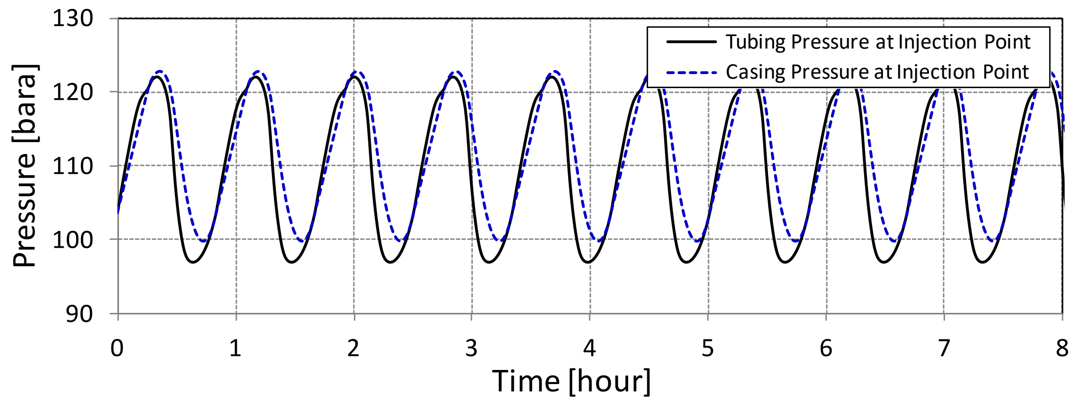


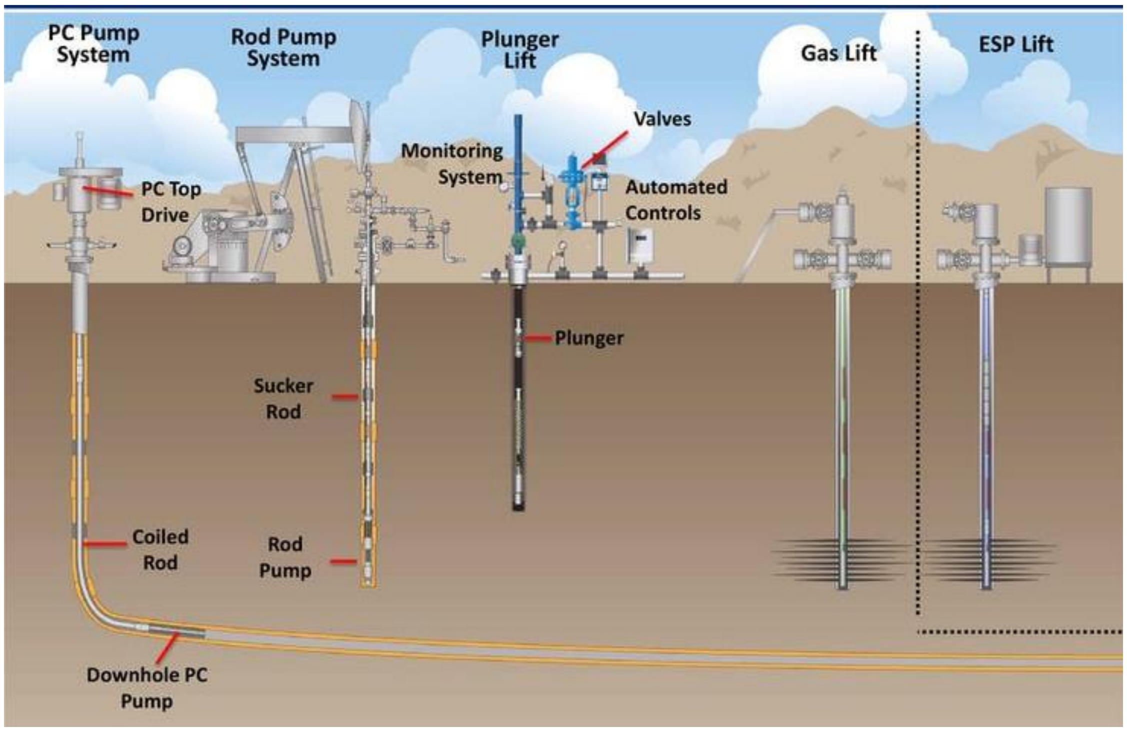
Basic Components for a Gas Lift System



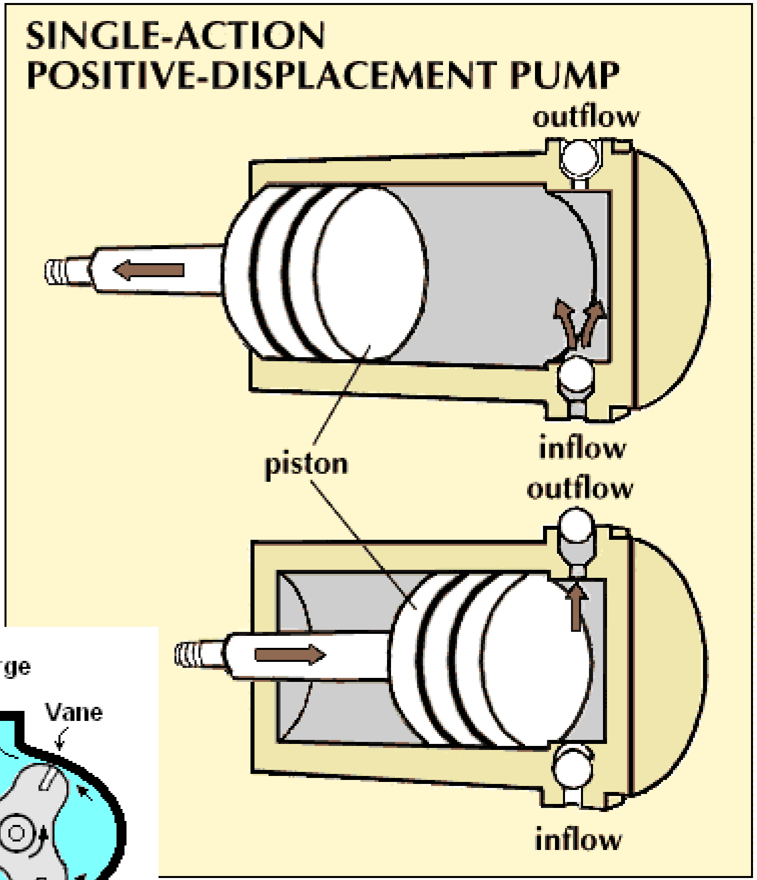
Casinghead gas compressor

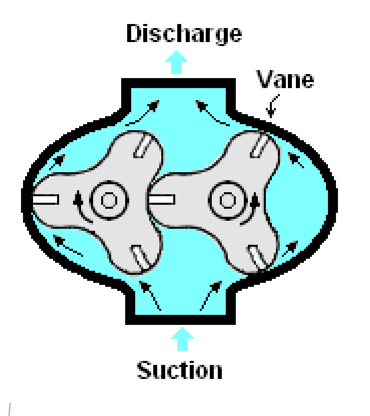




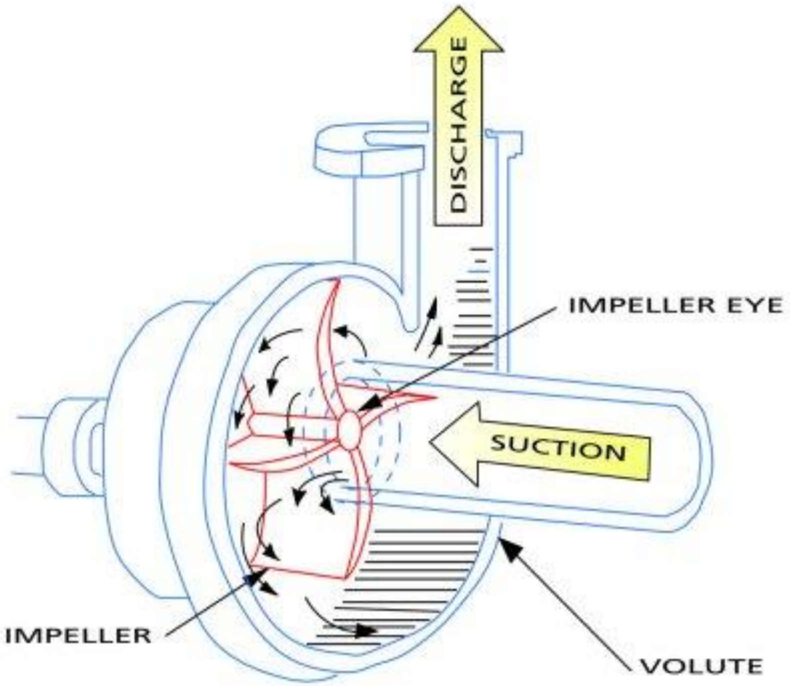


Positive displacement pump vs Kinetic pump

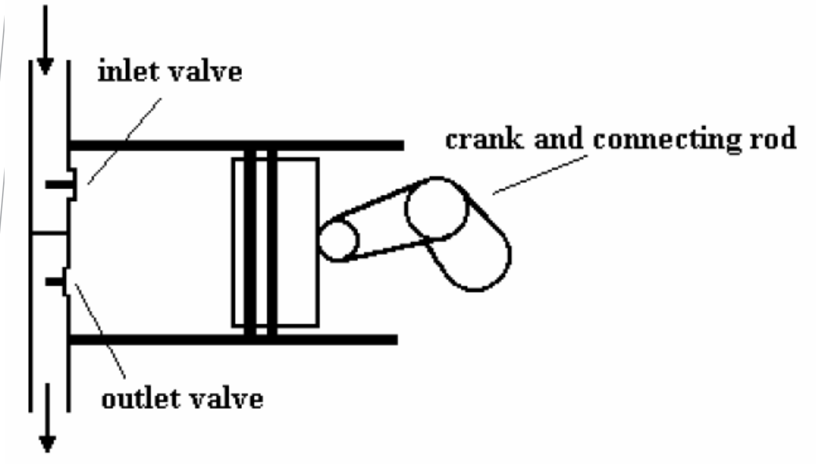


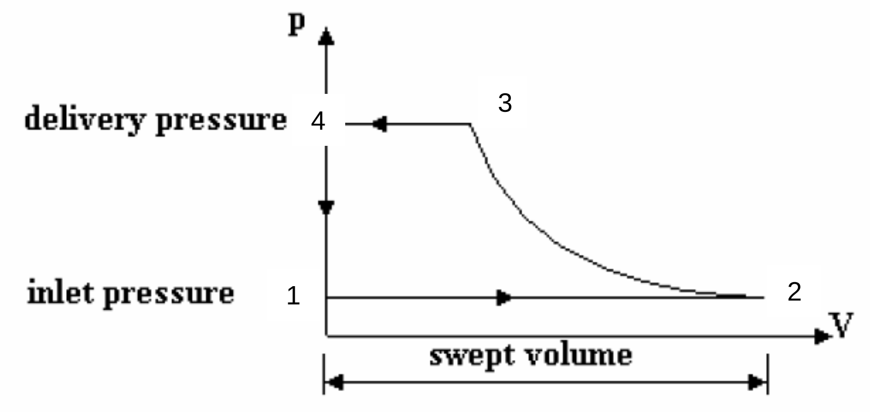


Kinetic or Centrifugal pump



Theoretical background



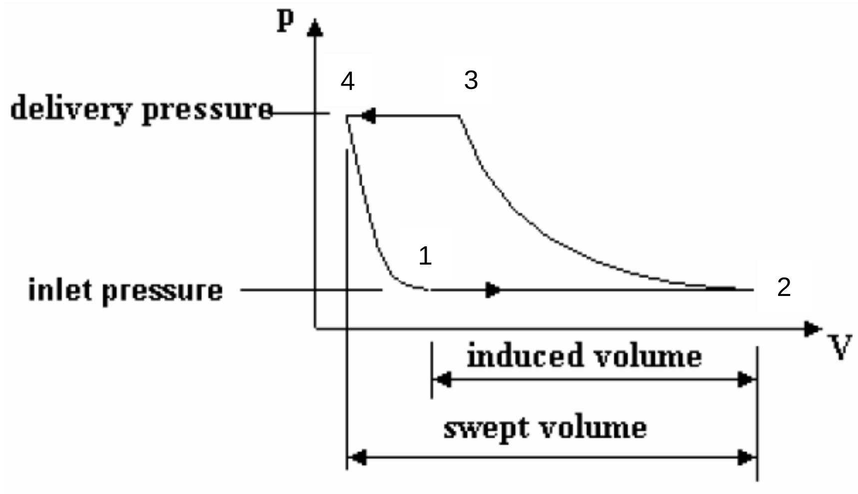


If no restriction at the valves,

1. Gas is induced from 1 to 2 at the inlet pressure.
2. Then trapped inside the cylinder and compressed to point 3. At point 3, pressure reaches delivery pressure and outlet valves open.
3. Air is then expelled at the delivery pressure and the volume reached point 4
4. Completing expulsion, pressure comes back to point 1

Volumetric efficiency

- In reality, the piston cannot expel all the gas and there is trapped gas between the piston and the cylinder head (clearance volume), resulting small volume of gas loss from point 4 to point 1.



- Volumetric efficiency is

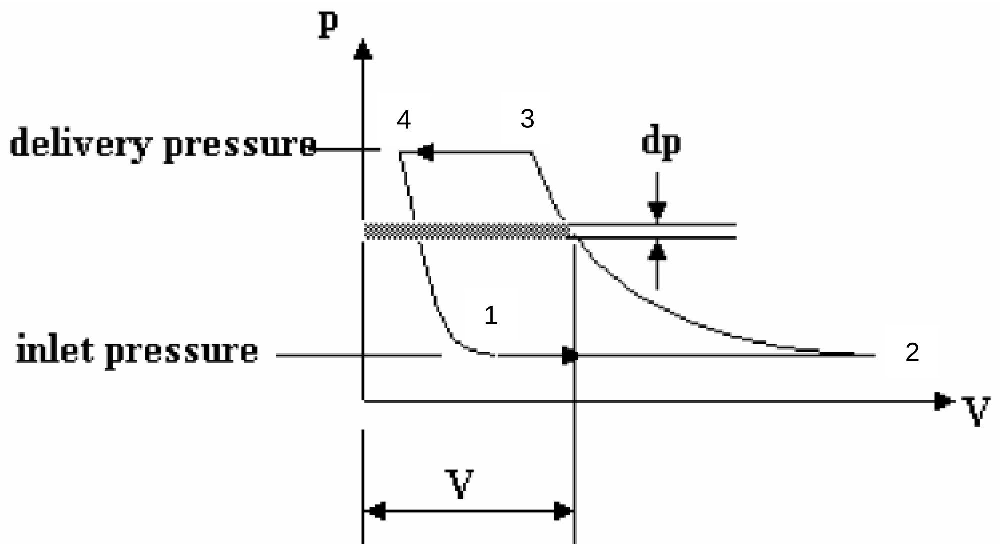
$$\eta = \frac{Induced\ volume}{Swept\ volume}$$

- The clearance ratio is

$$c = \frac{Clearace\ volume}{Swept\ volume}$$

Indicated power

- The work per cycle can find by integrating with respect to the pressure axis



- The work is defined as

$W = mRT_2 \times \left(\frac{n}{n-1}\right) \times \left(r^{\frac{n-1}{n}} - 1\right)$, where $r = \frac{P_d}{P_s} = \frac{P_3}{P_2}$

- If the process was isothermal and n =1

$W = mRT_2 \ln\left(\frac{p_3}{p_2}\right)$, η(isothermal efficiency) $= \frac{Isothermal\ work}{Acutal\ work} = \frac{(n-1)T_2 \ln(\frac{P3}{P2})}{n(T_3 - T_2)}$

Reciprocating compressor

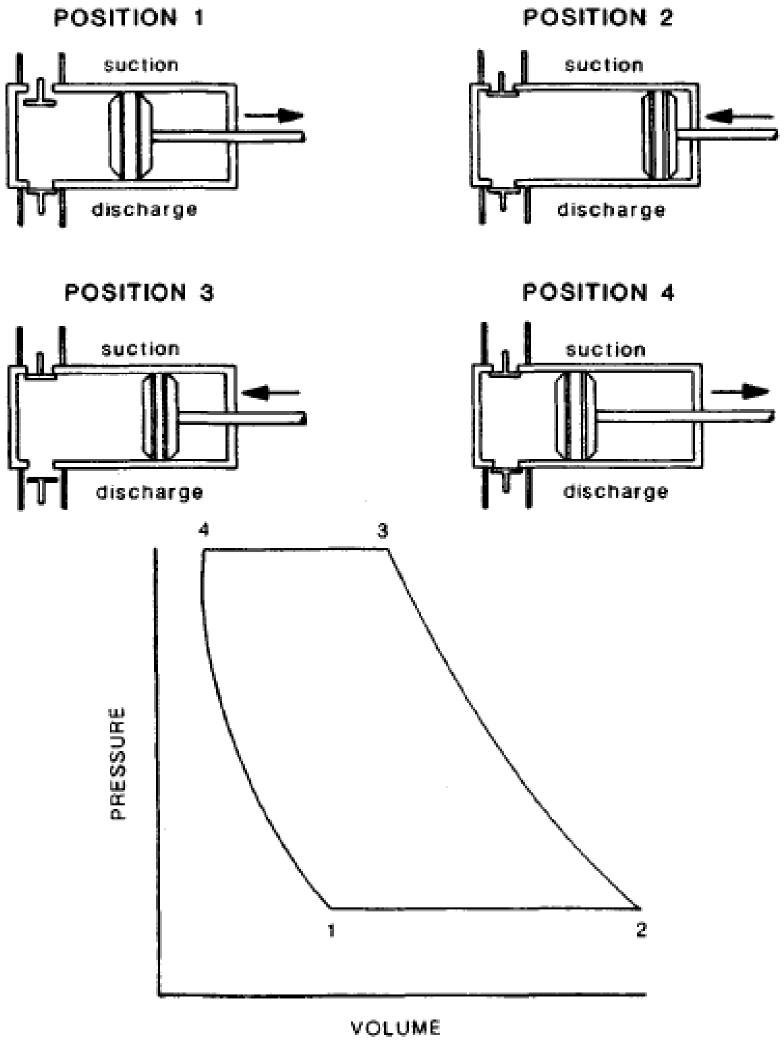


Figure 10-1. Reciprocating compressor action.

High speed: 900 to 1200 rpm
Slow speed: 200 to 600 rpm

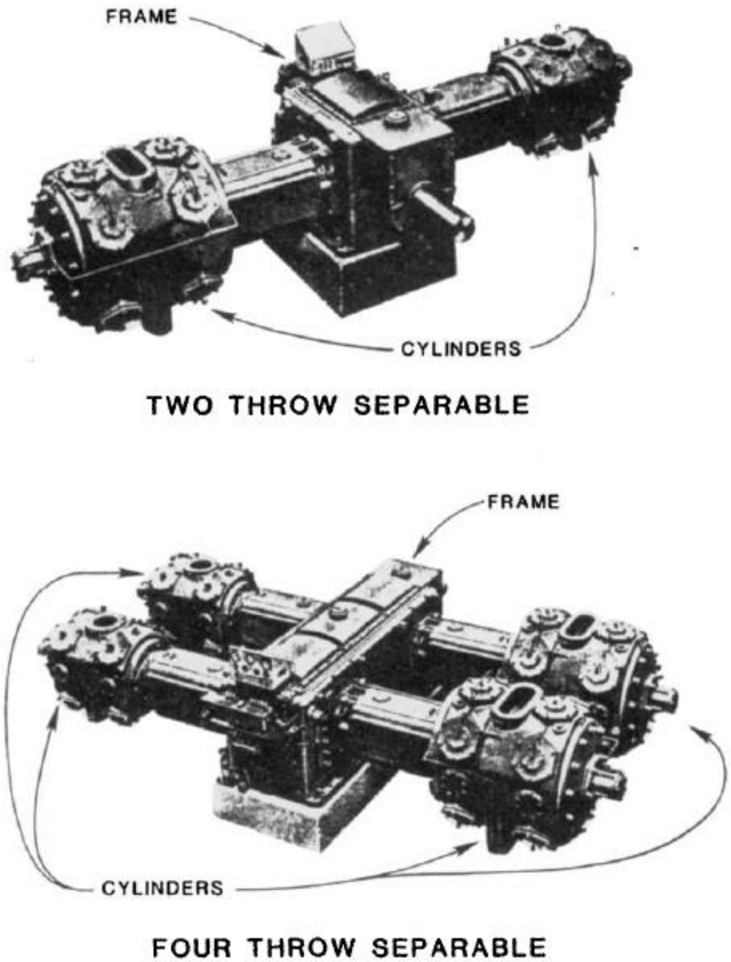
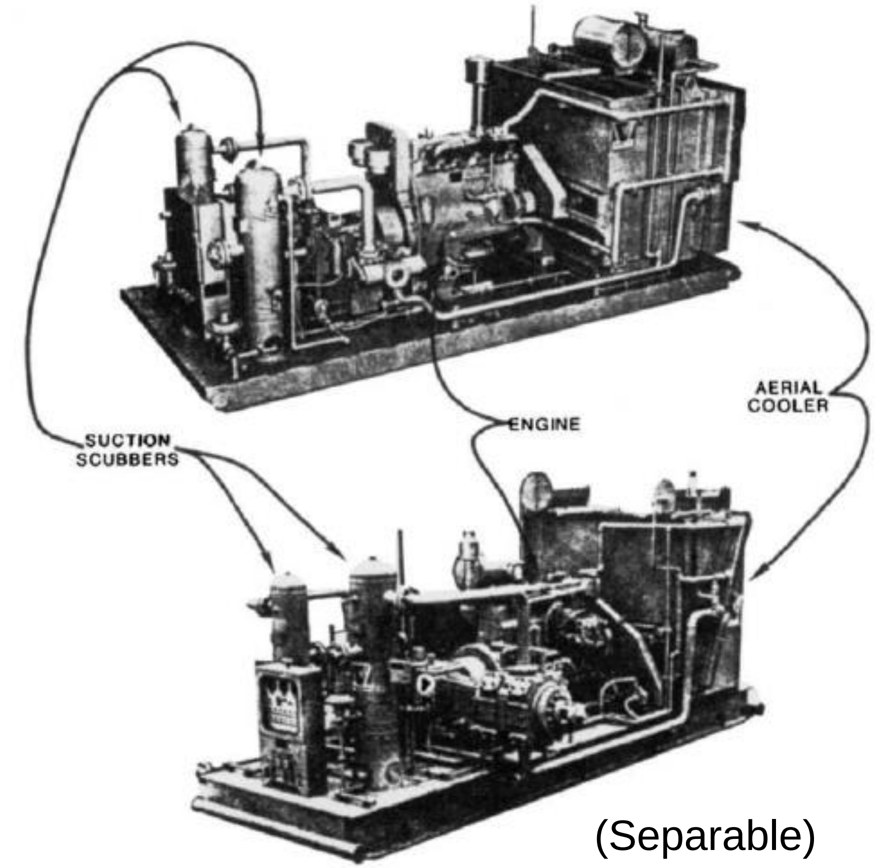


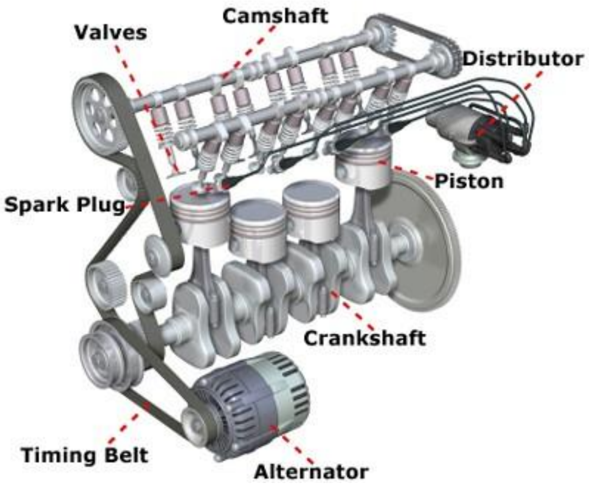
Figure 10-2. High-speed reciprocating compressor frames and cylinders. (*Courtesy of Dresser-Rand Company.*)

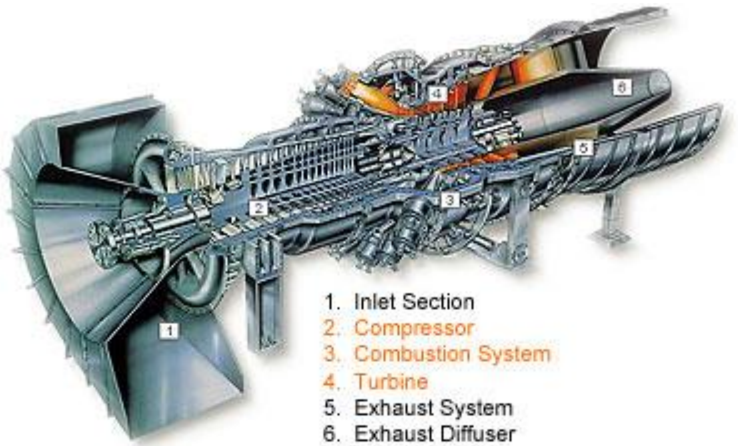
High speed engine-driven compressor



(Separable)

Figure 10-3. High-speed reciprocating compressor packages. (*Courtesy of Dresser-Rand Company.*)





High-speed Reciprocating compressors

Size
- Numerous sizes from 50 hp to 3000 hp.
- 2, 4, or 6 compressor cylinders are common.

Advantages
- Can be skid mounted.
- Self-contained for easy installation and easily moved.
- Low cost compared to low-speed reciprocating units.
- Easily piped for multistage compression.
- Size suitable for field gathering offshore and onshore.
- Flexible capacity limits.
- Low initial cost.

Disadvantages
- High-speed engines are not as fuel efficient as integral engines (7,500 to 9,000 Btu/bhp-hr).
- Medium range compressor efficiency (higher than centrifugal; lower than low-speed)
- Short life compared to low speed
- Higher maintenance cost than low speed or centrifugal

Low speed integral engine compressor

Tend to operate at 400 ~ 600 rpm,
Some operates as low as 200 rpm.

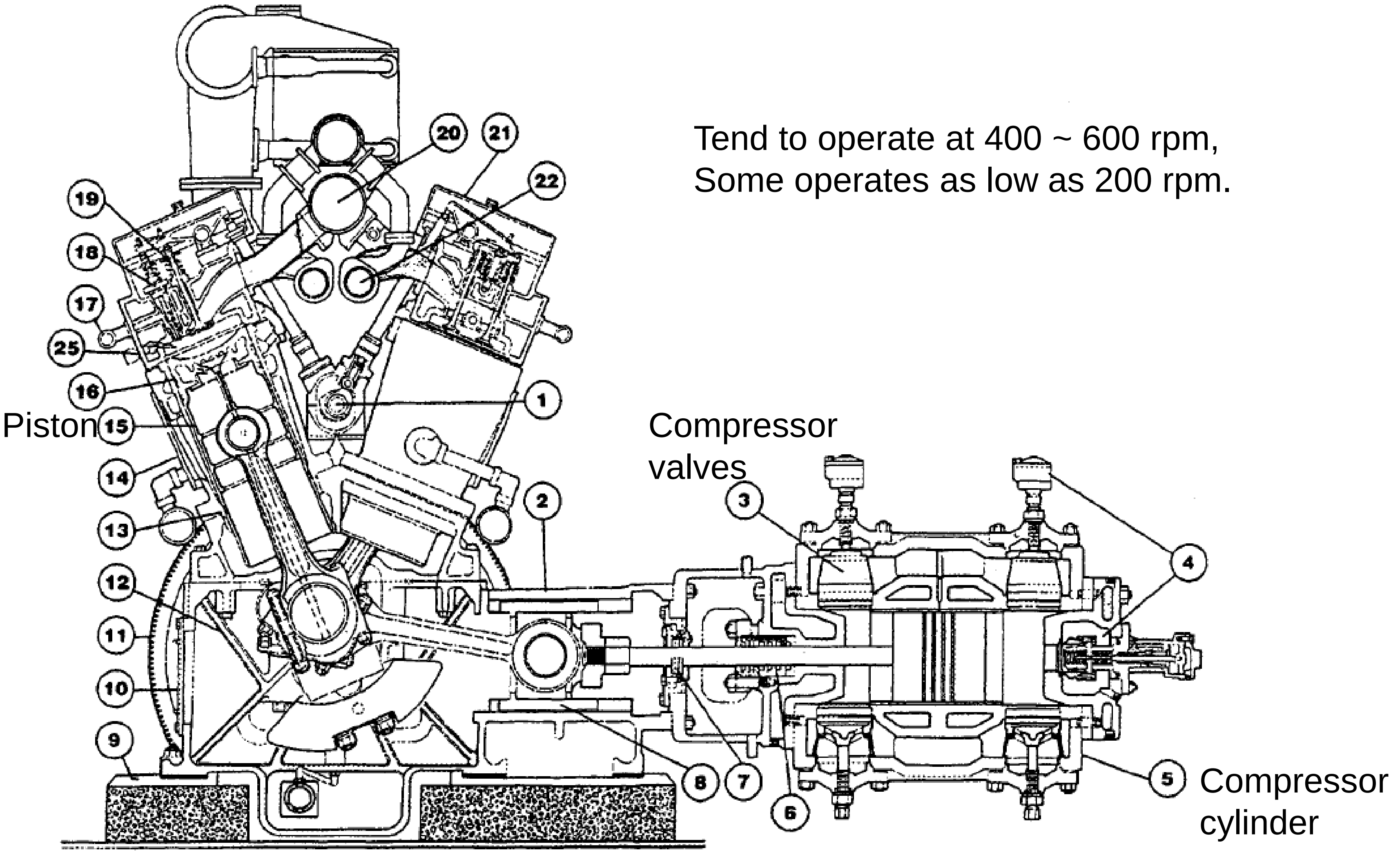


Figure 10-4. Sectional view of integral engine compressor. (*Courtesy of Dresser-Rand Company.*)

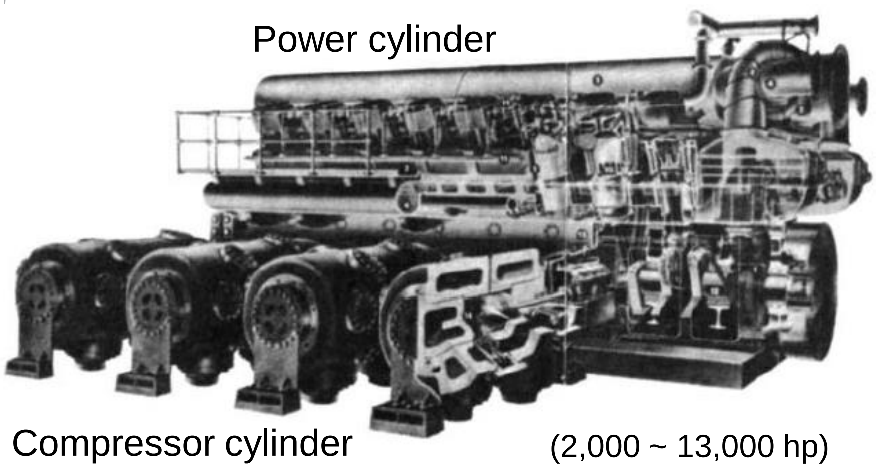


Figure 10-5. Integral engine compressor. (*Courtesy of Cooper Industries Energy Services Group.*)

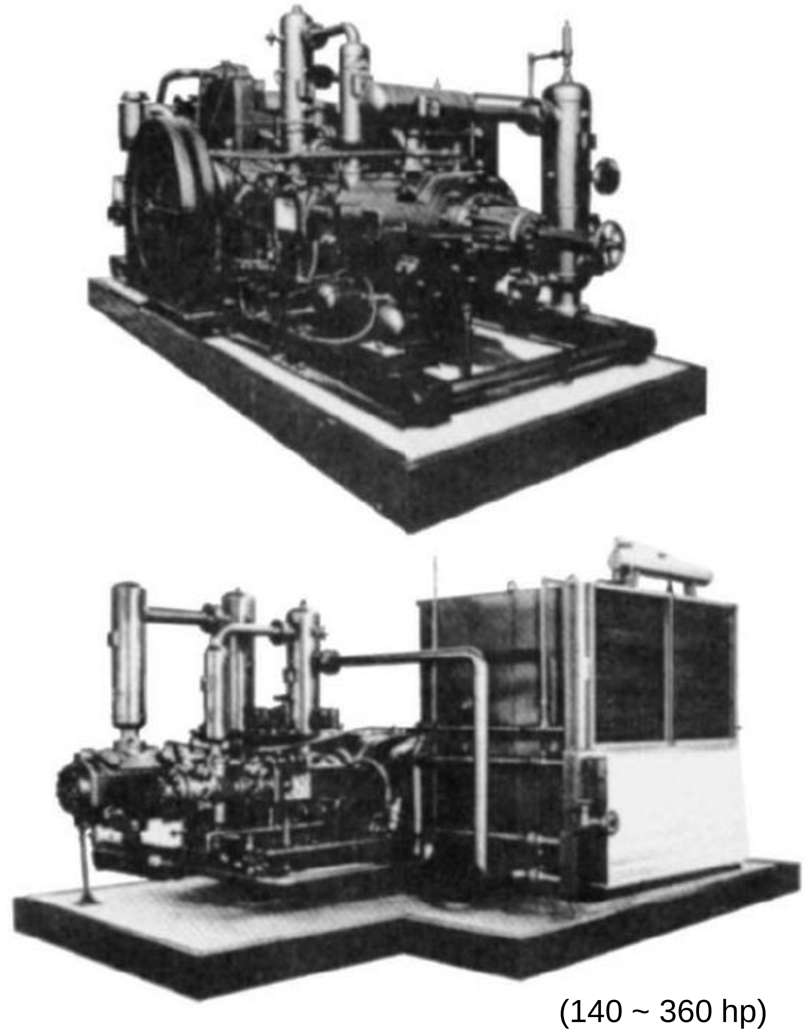


Figure 10-6. Small-horsepower skid-mounted integrals. (*Courtesy of Cooper Industries.*)

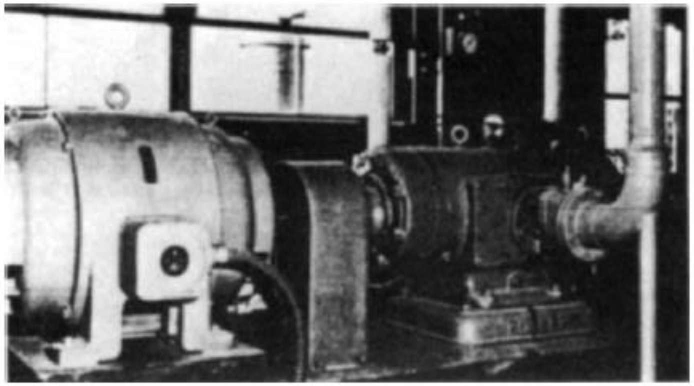
Low-speed Reciprocating compressors

Size
• Some one and two power cylinder field gas compressors rated for 140 hp to 360 hp.
• Numerous sizes from 2,000 hp to 4,000 hp.
• Large sizes 2,000 hp increments to 12,000 hp.
• 2 to 10 compressor cylinders common.

Advantages
• High fuel efficiency (6-8,000 Btu/bhp-hr).
• High efficiency compression over a wide range of conditions.
• Long operating life.
• Low operation and maintenance cost when compared to high speeds.

Disadvantages
• Usually must be field erected except for very small sizes.
• Requires heavy foundation.
• High installation cost.
• Slow speed requires high degree of vibration and pulsation suppression.

Vane-type rotary compressor



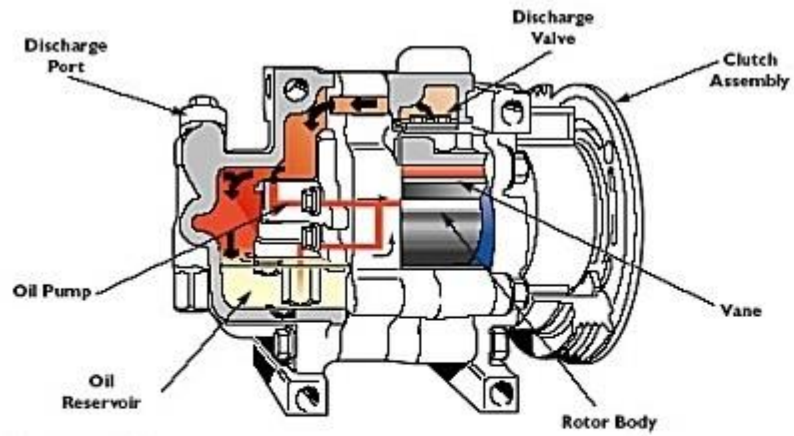


Figure 10-7. Vane-type rotary compressor. (*Courtesy of Dresser-Rand Company.*)

: Limited to low pressure service
: Less than 100 to 200 psi discharge
: Used for vapor recovery compressor and vacuum pump

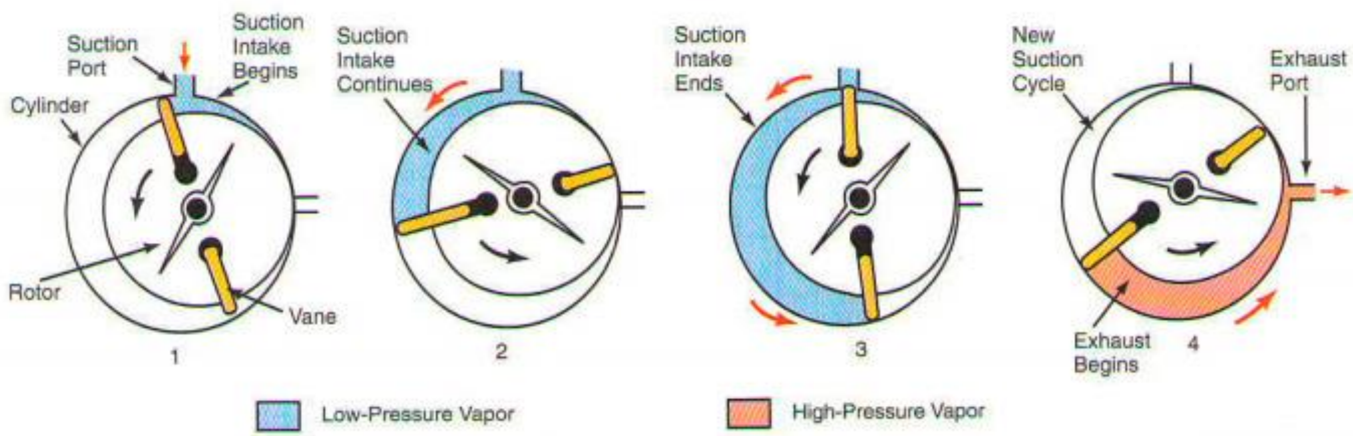


Figure 4-52. *A rotary blade compressor. Black arrows indicate direction of rotation of rotor. Red arrows indicate refrigerant vapor flow.*

Size

• Common sizes up to 250 bhp, but mostly used for applications under 125 bhp.
• Available in sizes to 500 bhp.
• Discharge pressures to 400 psig.
• Single- or two-stage in tandem on same shaft.

Advantages

• Good in vacuum service.
• No pulsating flow.
• Less space.
• Inexpensive for low hp vapor recovery or vacuum service

Disadvantages

• Must have clean air or gas.
• Takes 5 to 20% more horsepower than reciprocating.
• Uses ten times the oil of a reciprocating. Usually install after-cooler and separator to recycle oil.

*bhp (Brake Horsepower) = 746 watt

Helical-Lobe (Screw) Rotary compressor

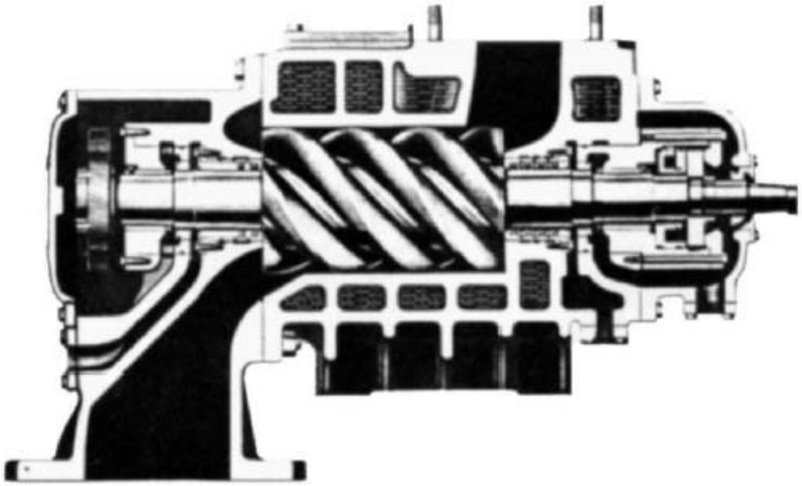
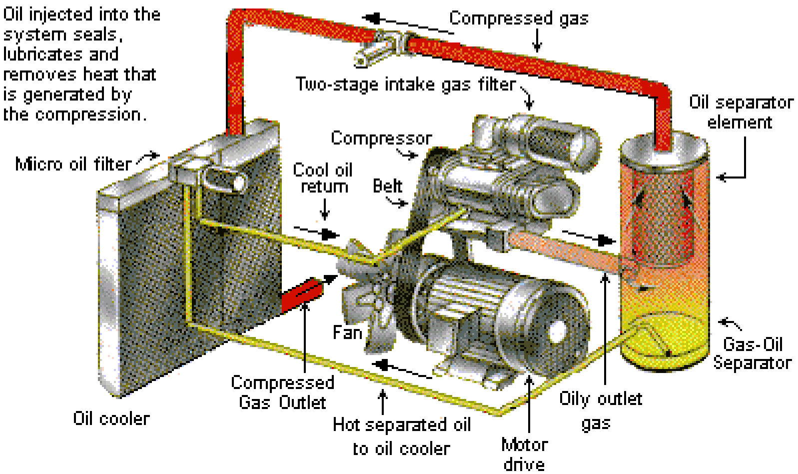
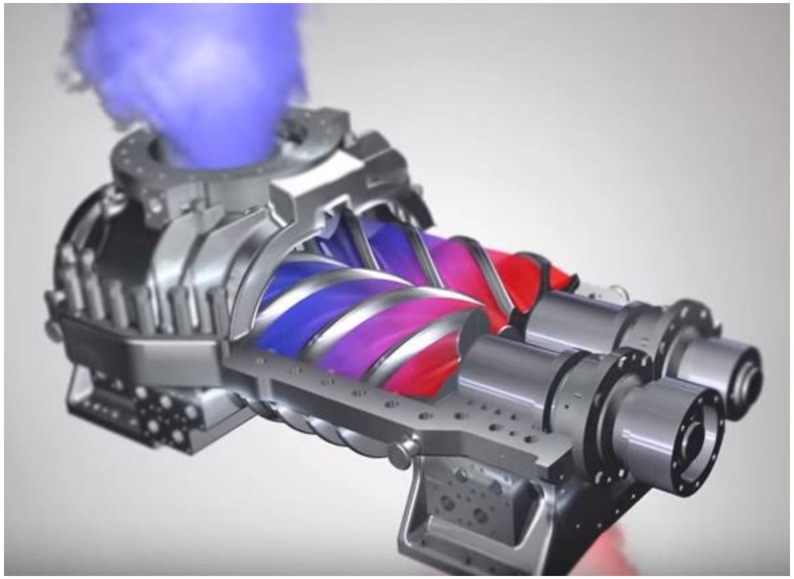


Figure 10-8. Screw-type rotary compressor. (*Courtesy of Dresser-Rand Company.*)





: Limited to 250 psig discharge
: Maximum 400 hp in hydrocarbon service

Size
• Up to 6,000 hp in air service, but more common below 800 hp.
• Up to 400 hp in hydrocarbon service.
• Discharge pressures to 250 psig.
• Single- or two-stage in tandem on same shaft.

Advantages
• Available as non-lubricated especially for air service.
• Can handle dirty gas.
• Can handle moderate amounts of liquids, but no slugs.
• No pulsating flow.
• At low discharge pressure (<50 psig) can be more efficient than reciprocating.

Disadvantages
• In hydrocarbon service needs seal oil with after-cooler and separator
to recycle oil.
• At discharge pressure over 50 psig takes 10 to 20% more horsepower than
reciprocating.
• Low tolerance to change in operating conditions of temperature, pressure, and ratio.

Centrifugal compressor

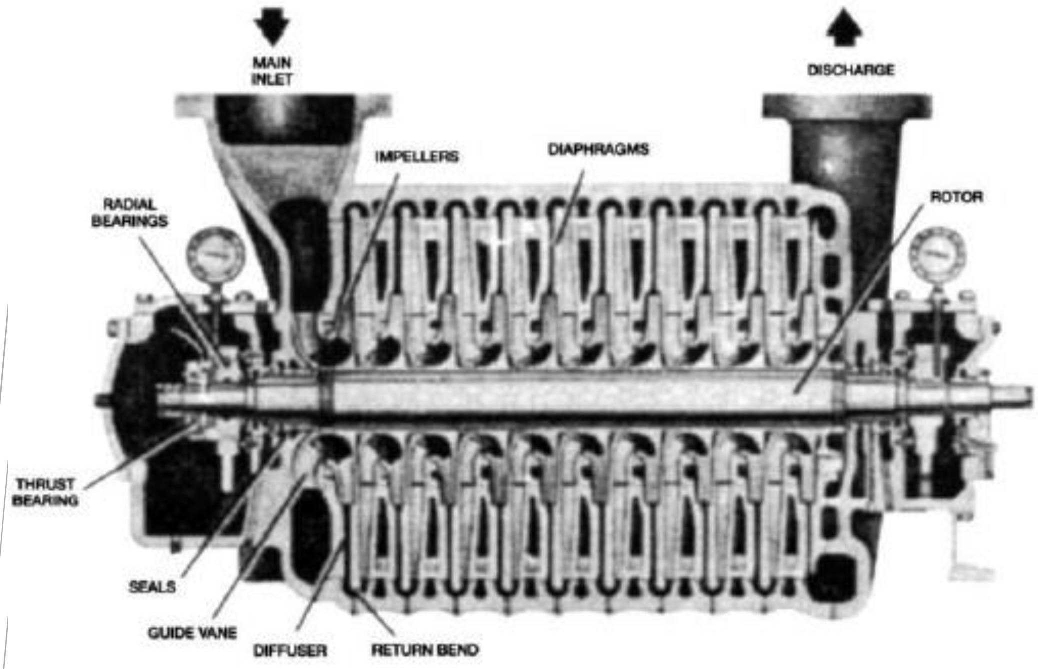
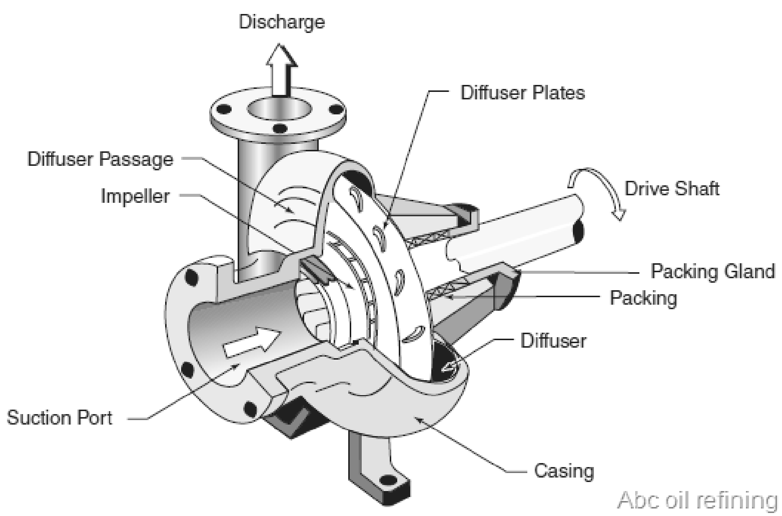
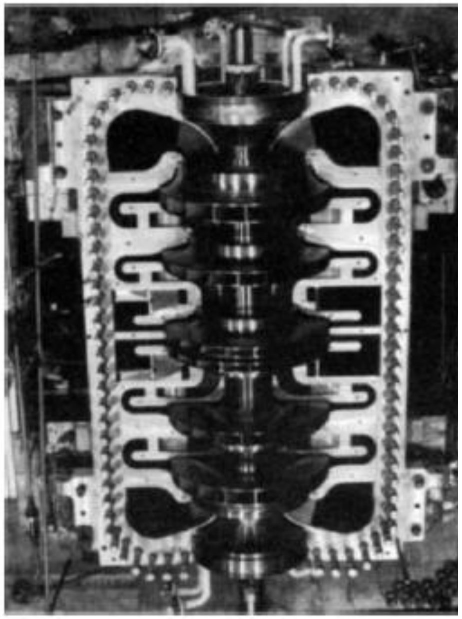


Figure 10-9. Centrifugal compressor. *(Courtesy of Dresser-Rand Company.)*



- Working principle
  1. The impeller forces the flow to spin faster and faster.
  2. The flow then typically flows through a stationary compressor causing it to decelerate
  3. This reduction in velocity causes the pressure to rise leading to a compressed fluid
- Range in size from 1000 hp to over 20,000 hp
- Have high ratios of horsepower per unit of space and weight
- Very popular for offshore applications



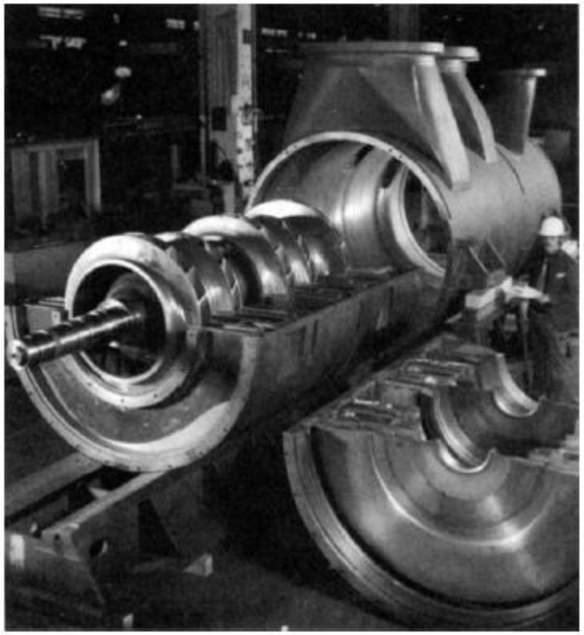


Figure 10-10. Horizontally split centrifugal compressor (top) and vertically split centrifugal compressor, barrel (bottom). (*Courtesy of Dresser-Rand Company.*)

- For the required gas velocities, they must rotate at very high speeds (20,000 to 30,000 rpm).
- Turbine drivers are also high speed and a natural match for centrifugal compressor
- Very common in booster compressor service (high volume, low ratio) and for very high flow rate gas-lift service.
- Cannot be used for high ratio, low-volume application

Size
• Starts about 500 hp.
• 1,000 hp increments to 20,000 hp.

Advantages
• High horsepower per unit of space and weight.
• Turbine drive easily adapted to waste-heat recovery for high fuel efficiency.
• Easily automated for remote operations.
• Can be skid mounted, self-contained.
• Low initial cost.
• Low maintenance and operating cost.
• High availability factor.
• Large capacity available per unit.

Disadvantages
• Lower compressor efficiency.
• Limited flexibility for capacity.
• Turbine drives have higher fuel rate than reciprocating units.
• Large horsepower units mean that outage has large effect on process or pipeline capabilities.

Specifying a compressor

- The number of stages

$$R = \left(\frac{P_d}{P_s}\right)^{1/n} < 3.0\text{~}4.0$$

- Horsepower

$$BHP = 22\,R\,n\,FQ_g \quad or$$

$$(\text{where}, \mathrm{k} = \frac{\mathrm{C_p}}{\mathrm{C_v}})$$

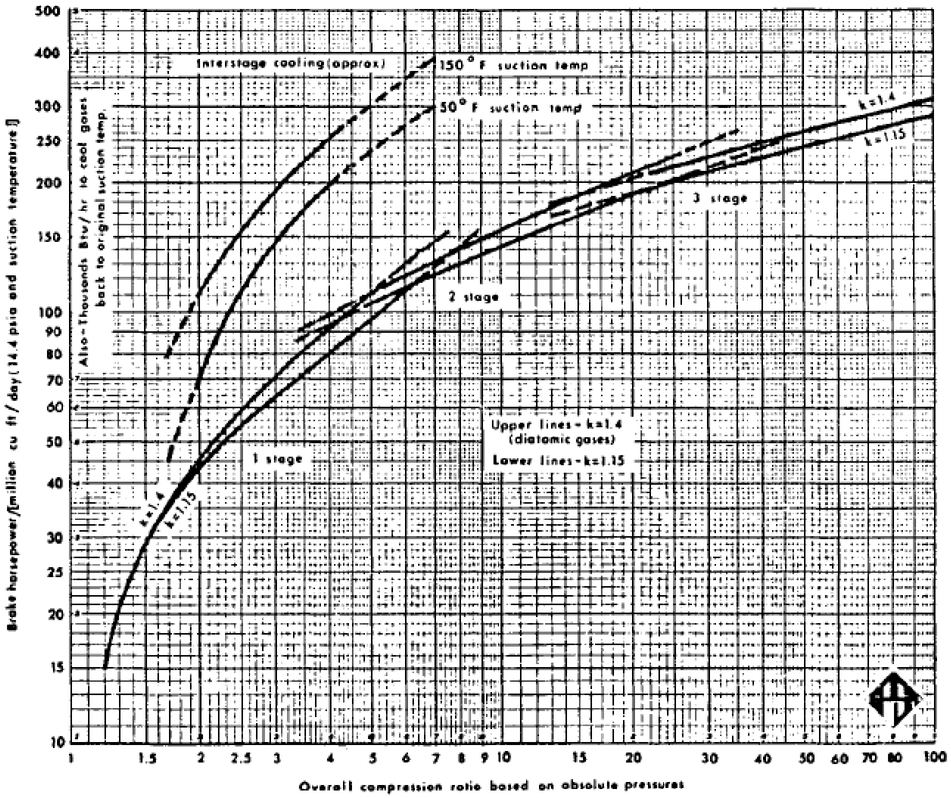


Figure 10-11. Curve for estimating compression horsepower. *(Reprinted with permission from GPSA* Engineering Data Book, *10th Ed.)*

Table 10-1
Example Compressor Type Selections

Service	Flow Rate MMscfd	R	n	Approx. bhp	Most Likely	Selection Alternate
Booster	100	2.0	1	4,400	Centrifugal	Integral (onshore only)
	10	2.0	1	440	High Speed	
Gas Lift	5	2.7	3	980	High Speed	
	20	2.7	3	3,920	Centrifugal	Integral (onshore only)
	100	2.7	3	19,602	Centrifugal	
Flash Gas	2	2.0	1	88	Screw	High Speed
	2	2.0	2	190	High Speed	Screw
	4	2.0	2	380	High Speed	
Vapor Recovery	0.1	4.0	1	9	Vane	Screw
	1.0	3.0	2	143	Screw	Vane
	2.0	3.0	2	286	High Speed	Screw

Stage compression

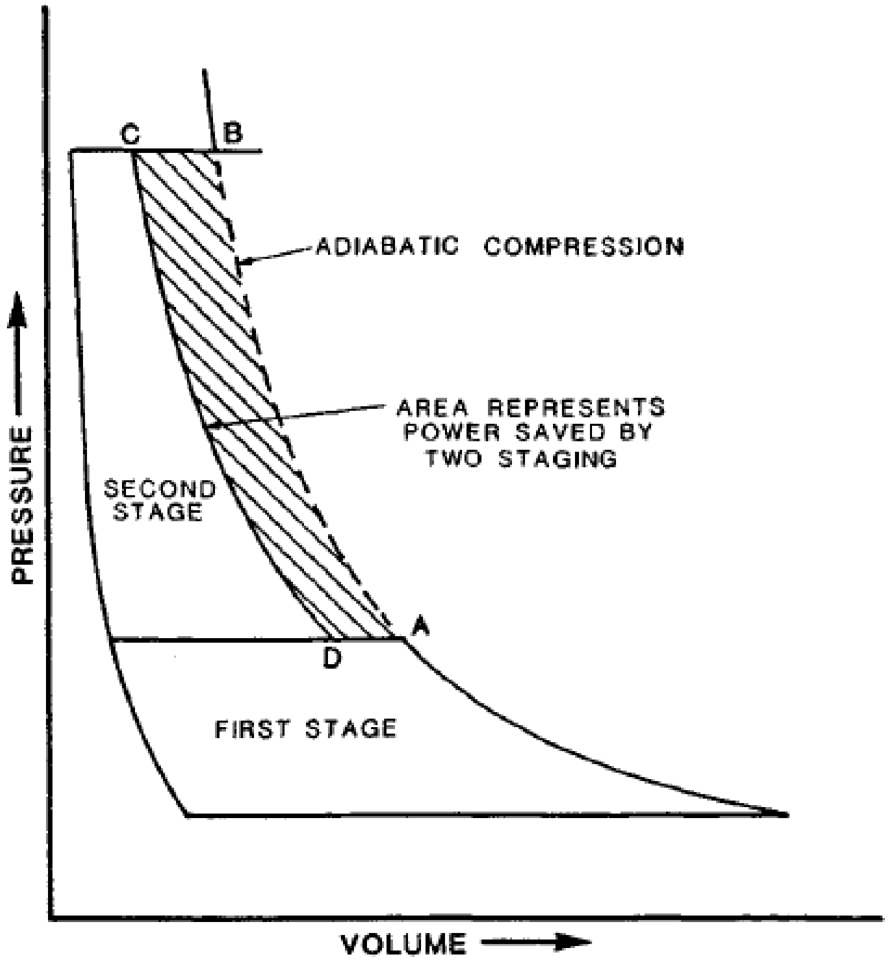


Figure 10-12. Horsepower reduction by multistaging (neglects interstage losses).

- The discharge temperature

$$T_d = T_s \left(\frac{P_d}{P_s}\right)^{\frac{k-1}{k} \times \frac{1}{\eta}}$$

- Brake horsepower

$$BHP = 0.0857 Z_{av} \left(\frac{Q_g T_s}{E}\right) \left(\frac{k\eta}{k-1}\right) \left[\left(\frac{P_d}{P_s}\right)^{\frac{k-1}{k} \times \frac{1}{\eta}} - 1\right]$$

Procedure to calculate the n and HP

1. First, calculate the overall compression ratio (Rt = Pd/Ps)- If the compressor ratio is under 5, consider using one stage. If it is not, select an initial number of stages so that R < 5. For initial calculations it can be assumed that ratio per stage is equal for each stage.

2. Next, calculate the discharge gas temperature for the first stage. If the discharge temperature is too high (more than 3000F), a large enough number of stages has not been selected or additional cooling of the suction gas is required. If the suction gas temperature to each stage cannot be decreased, increase the number of stages by one and recalculate the discharge temperature.

3. Once the discharge temperature is acceptable, calculate the horsepower required, and calculate suction pressure, discharge temperature, and horsepower for each succeeding stage.

4. If R > 3, recalculate, adding an additional stage to determine if this could result in a substantial savings on horsepower.

Reciprocating compressor

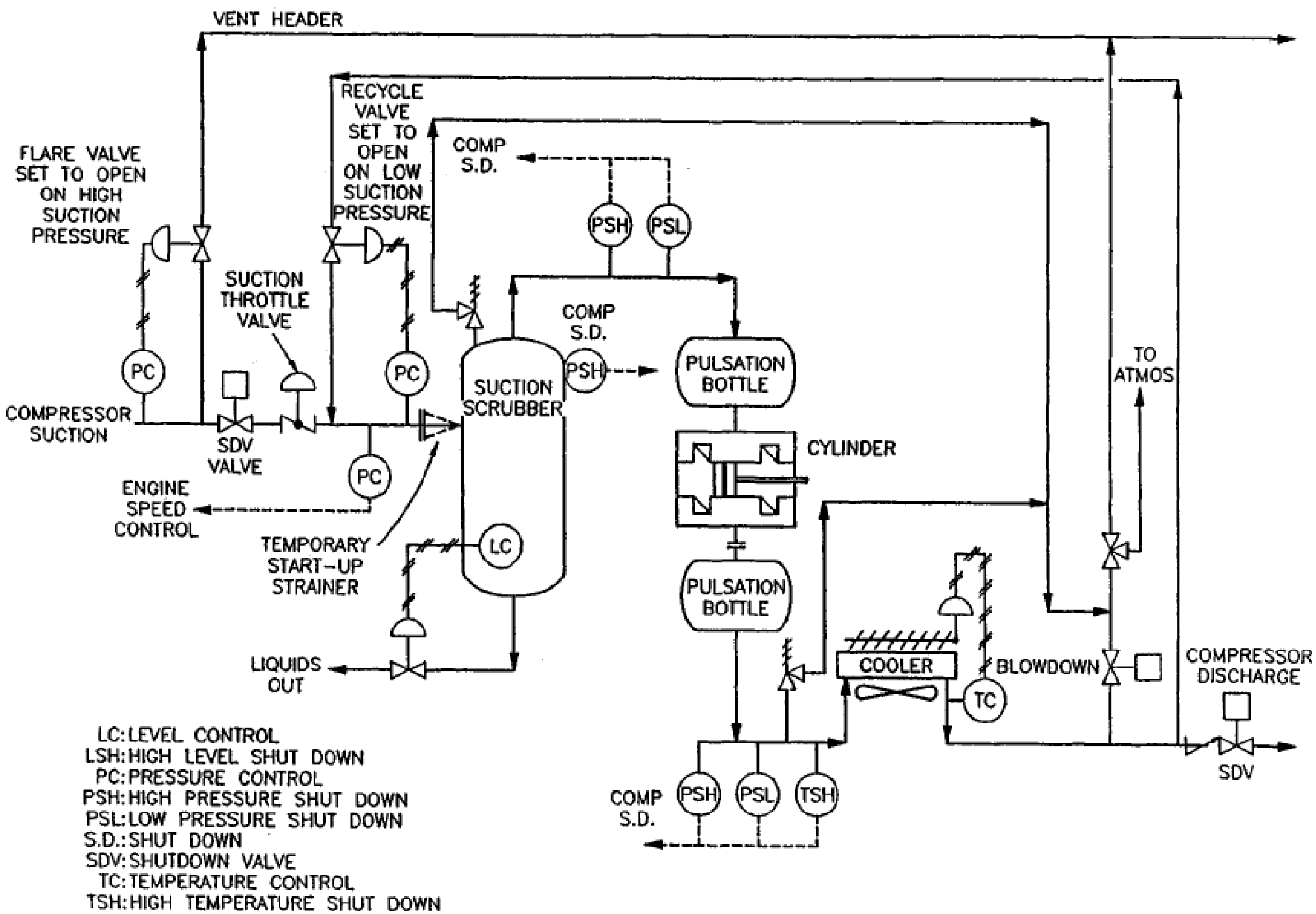


Figure 10-13. Example process flow diagram of reciprocating compressor.

- Process consideration
  1. Recycle valve
  2. Flare valve
  3. Suction pressure throttle valve
  4. Speed controller
  5. Blowdown valve
  6. Suction and Discharge shut-down valves, Discharge check valve
  7. Relief valve on each cylinder discharge
  8. Pulsation bottles
  9. Discharge coolers
  10. Suction scrubbers

Centrifugal compressor

- Surge control and stonewalling

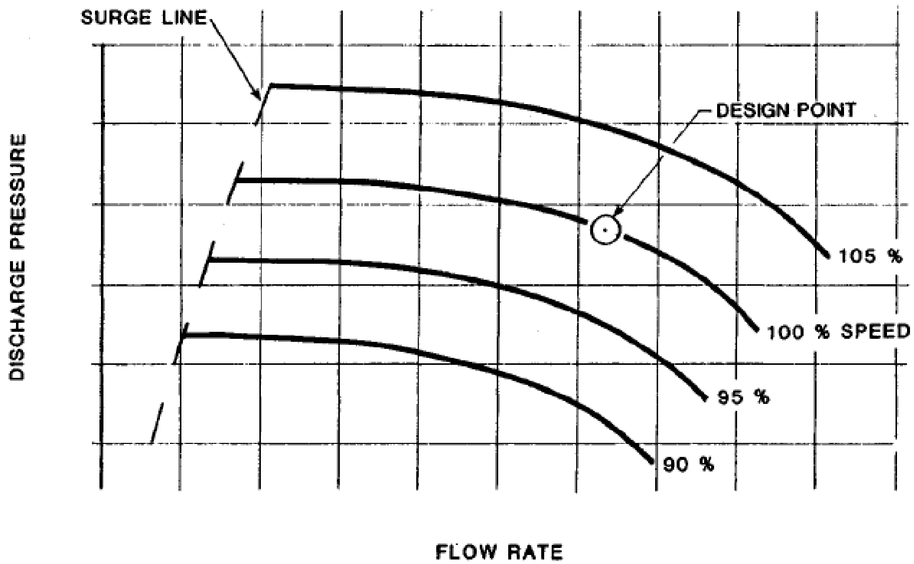


Figure 10-14. Typical centrifugal compressor curve showing surge.

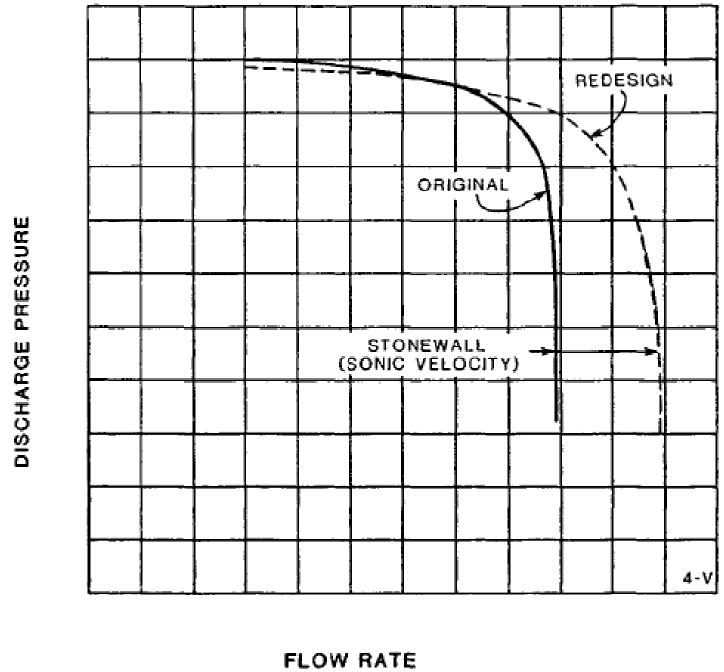


Figure 10-15. Graphic illustration of a "stonewall," or a choked flow condition.

Centrifugal compressor

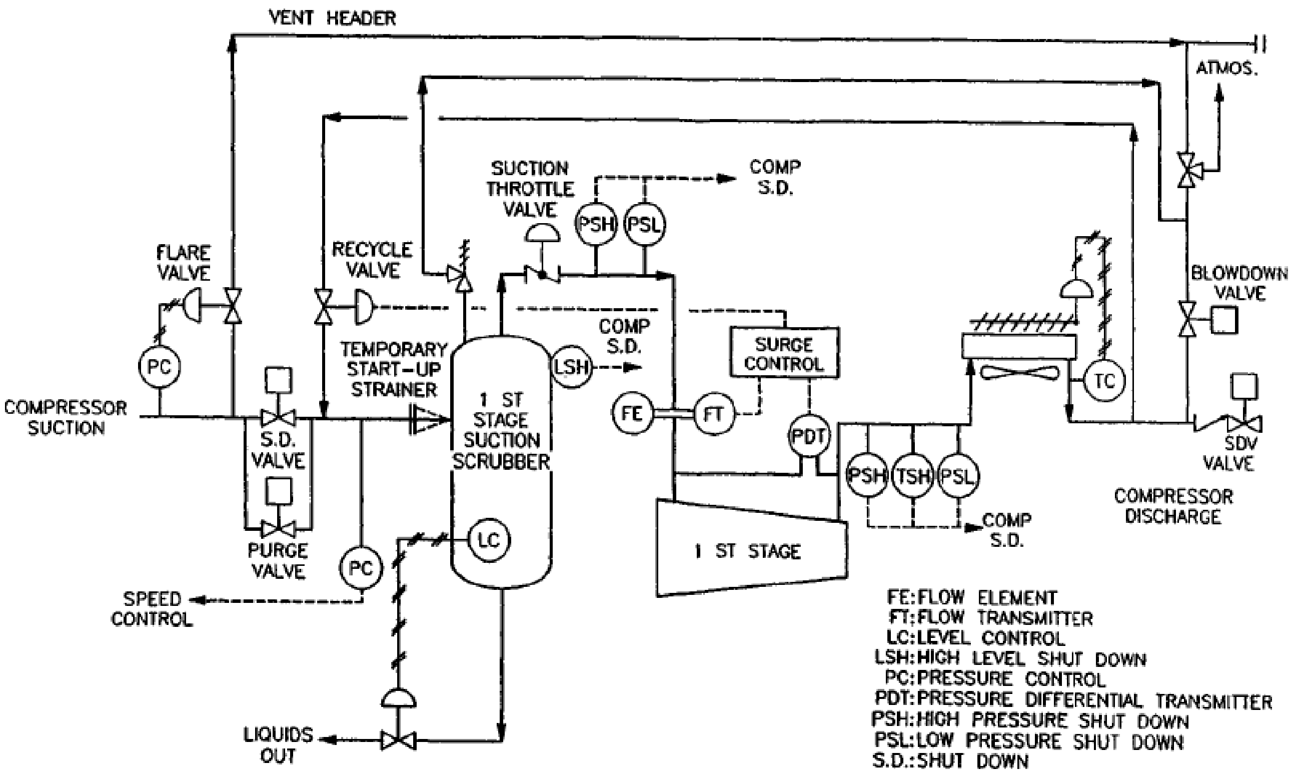


Figure 10-16. Example process flow diagram of centrifugal compressor.

- Process consideration
  1. Recycle (Surge control) valve
  2. Flare valve
  3. Suction pressure throttle valve
  4. Speed controller
  5. Inlet guide vanes
  6. Blowdown valve
  7. Suction and discharge shutdown valves and discharge check valve
  8. Discharge check valve (each stage)
  9. Relief valves
  10. Suction shut-down bypass (purge) valve
  11. Discharge coolers and suction scrubbers

Thank you, Question?