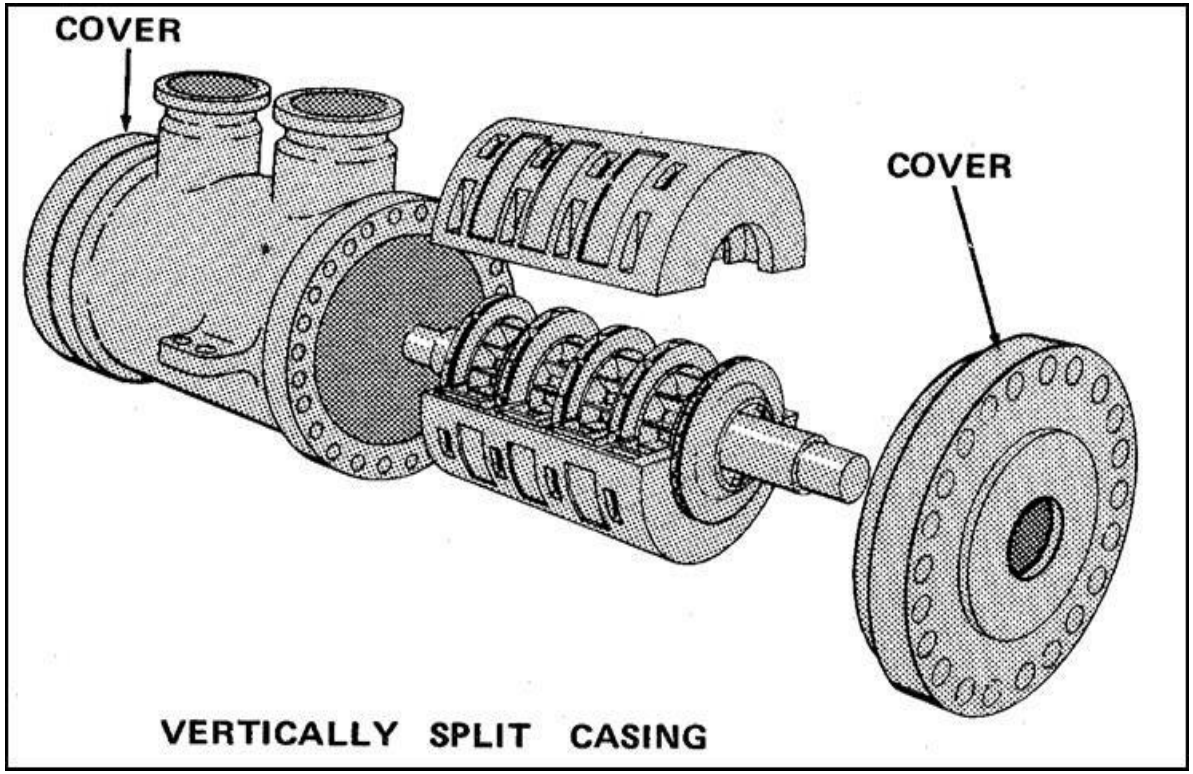
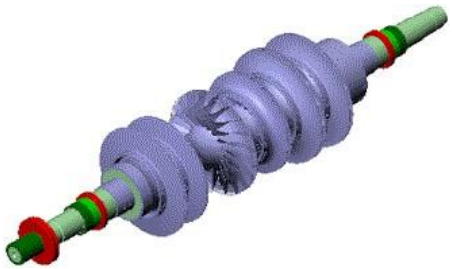
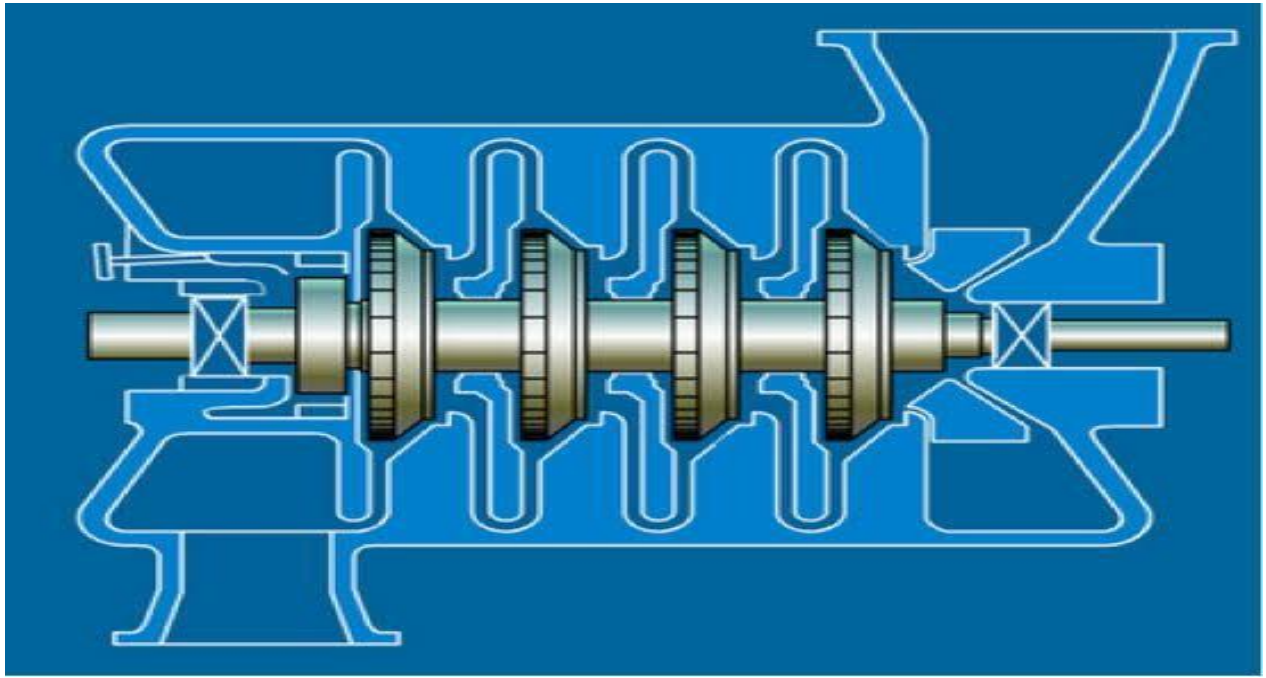
CENTRIFUGAL COMPRESSOR





Presented by: RK RANA

CENTRIFUGAL COMPRESSOR



CENTRIFUGAL COMPRESSOR

COMPRESSION: ***A process through which the volume of a gas is reduced by increasing its pressure***

COMPRESSOR:*A mechanical device used to increase the pressure of compressible gases.*

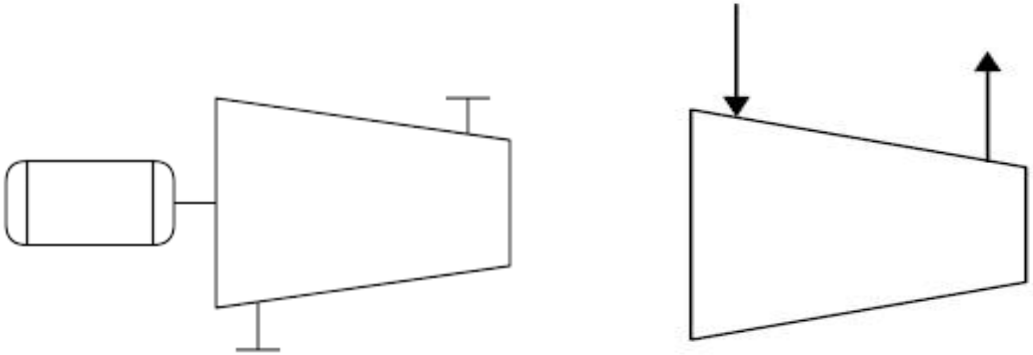
CENTRIFUGAL COMPRESSOR:

A centrifugal compressor is a machine in which gas is compressed by an impeller or Impellers rotating at high speed during operation.

A simple centrifugal compressor has four components: inlet, impeller/rotor, diffuser, and collector.

Capacity of a compressor

- *Volume of gas handled in a unit time.*
- *Its units are cubic feet per minute(ft3/min)*
- *Standard cubic feet per minute measures the flow rate of gas under standard pressure and temperature conditions.*

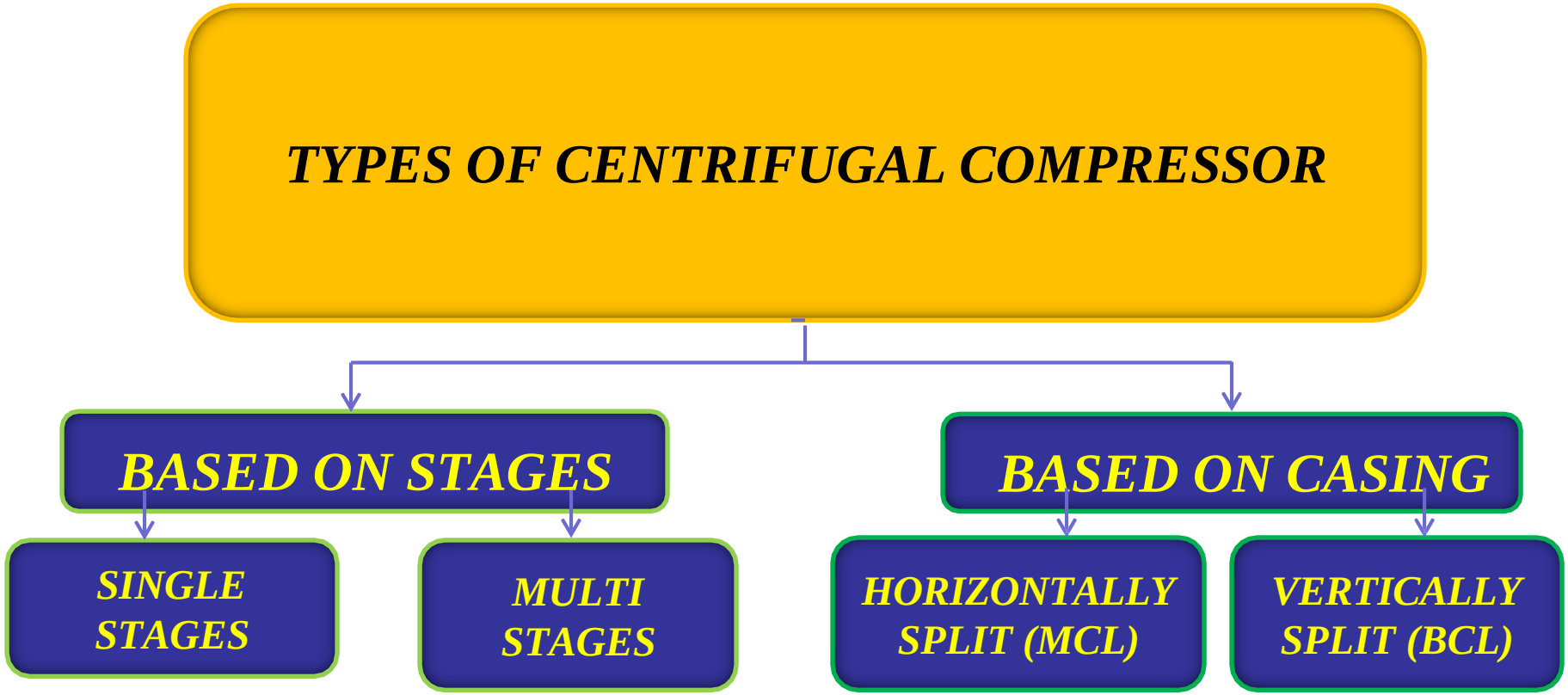


CENTRIFUGAL COMPRESSOR

Principle

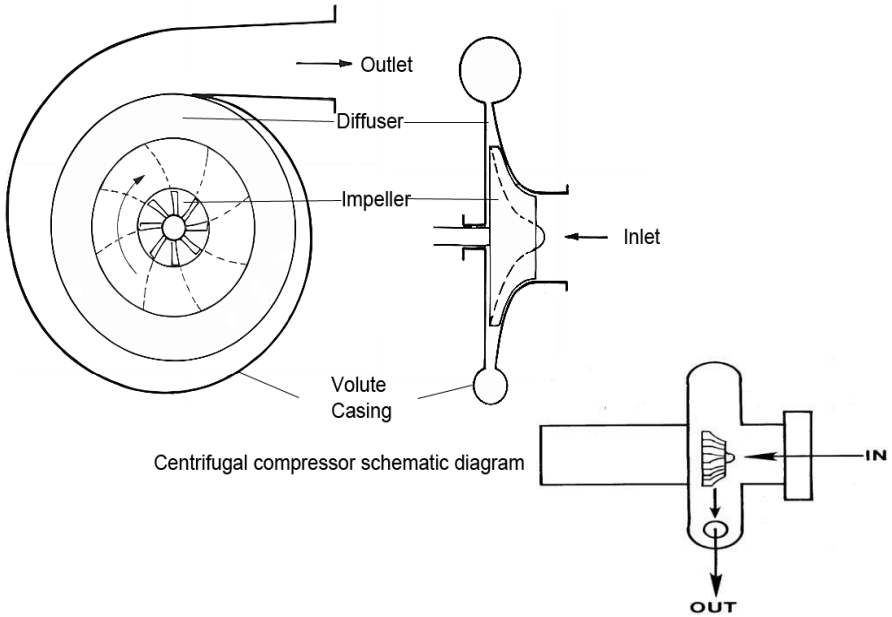
The Principle of Centrifugal Compression:

1. The air reaches the center of the impeller.
2. Air is forced outward by centrifugal force.
3. Diffuser gradually reduces the air velocity.
4. Velocity energy is converted to higher pressure.

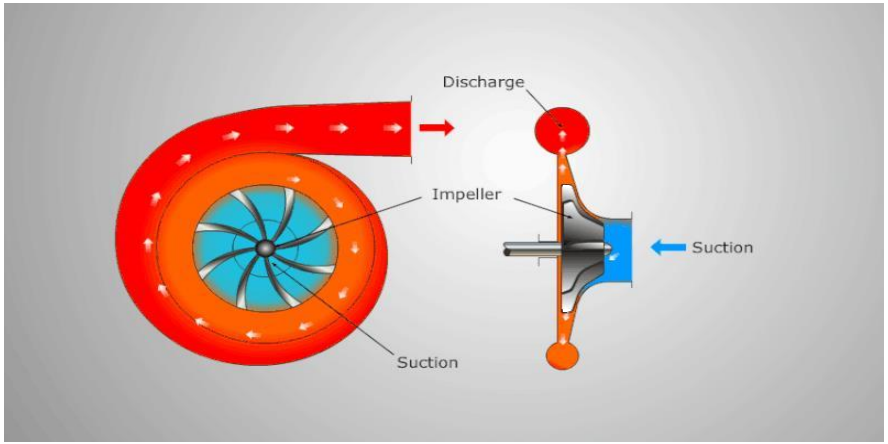

TYPES OF CENTRIFUGAL COMPRESSOR
BASED ON STAGES
BASED ON CASING
SINGLE STAGES
MULTI STAGES
HORIZONTALLY SPLIT (MCL)
VERTICALLY SPLIT (BCL)

COMPRESSOR SINGLE STAGE

- *A single-stage centrifugal compressor is defined as the combination of one impeller with its associated inlet guide vane and diffuser.*



Centrifugal compressor schematic diagram



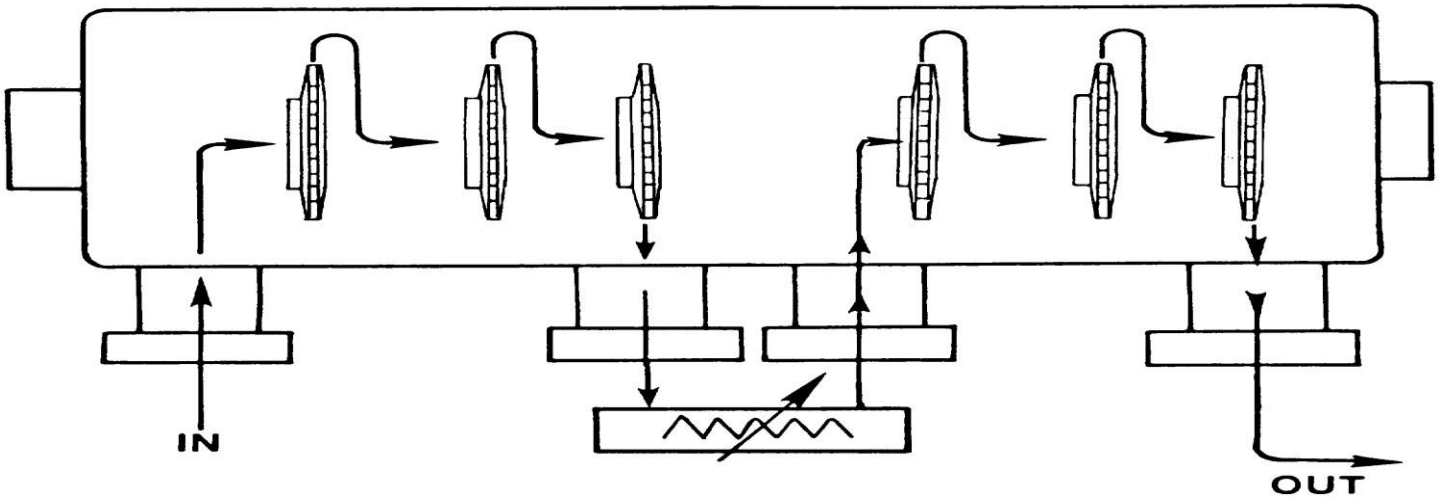
CENTRIFUGAL COMPRESSOR TYPES
(On the basis of stages)

Multi - Stage Centrifugal Compressor

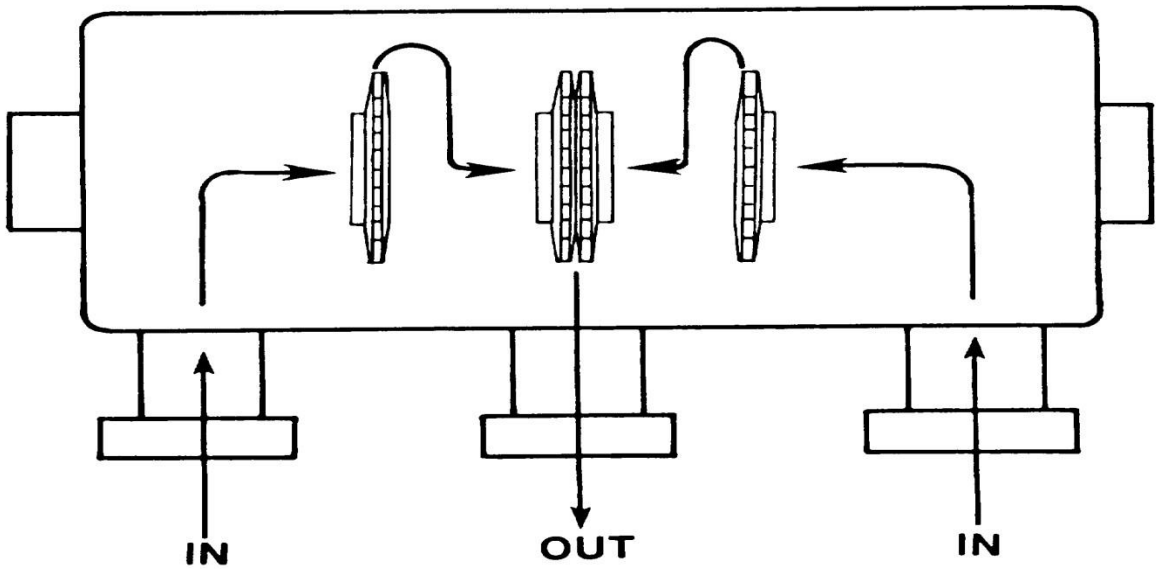
- ***A multi-stage compressor employs more than one impeller to impart energy to the gas.***
  - ***The velocity is added to gas by the impeller of each stage.***
- ***This velocity is converted into pressure within the diffuser. Thus, each impeller adds to the total energy (pressure) of the gas.***

On the basis of stages

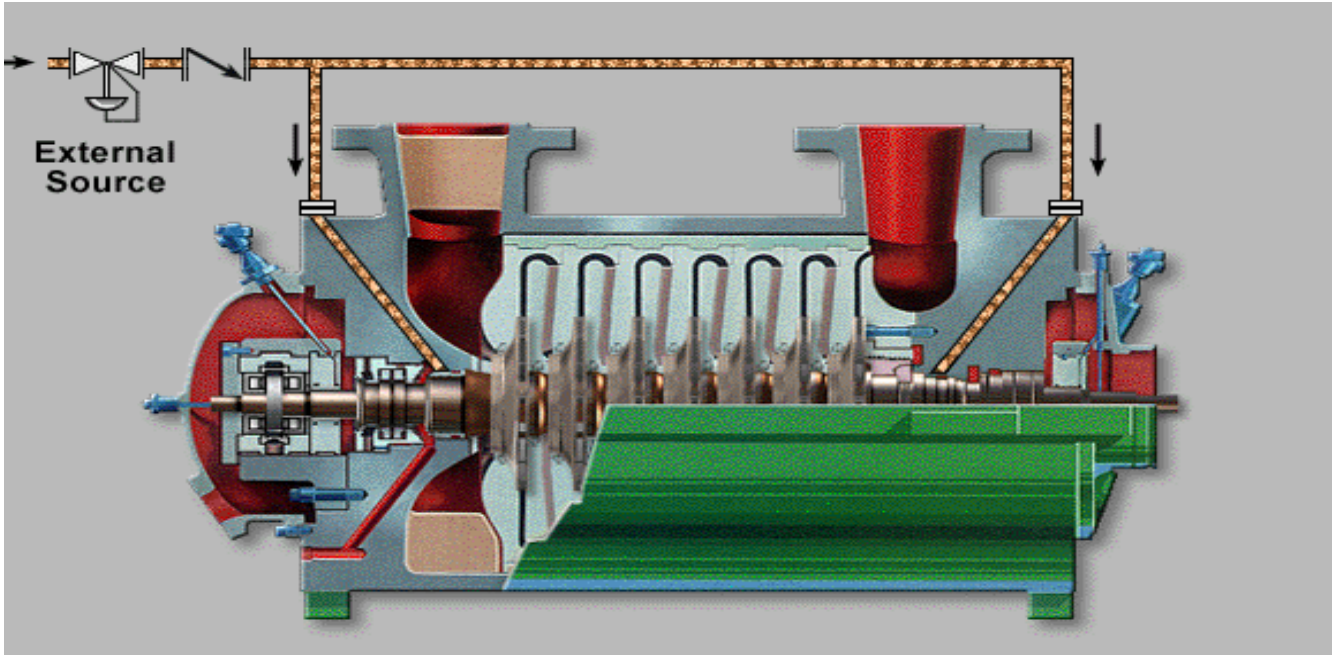
Multistage compressor with single intercooler.



Multistage compressor with double inlet

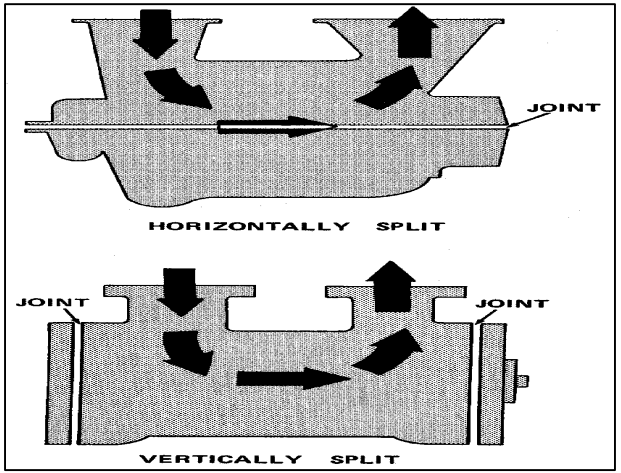


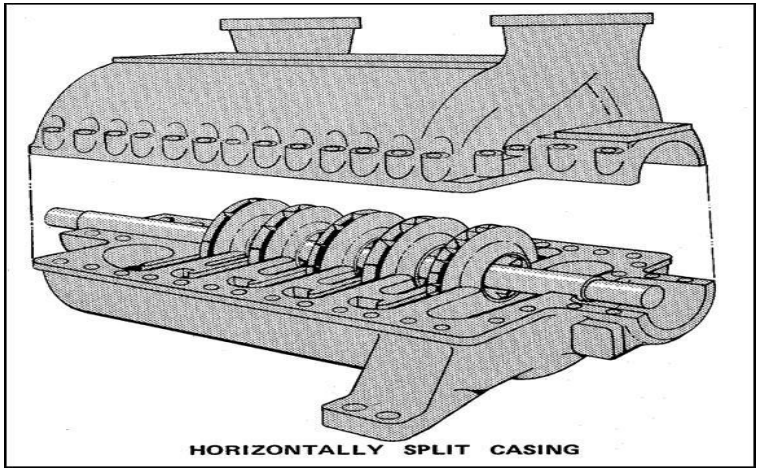
MULTI STAGE COMPRESSOR



CENTRIFUGAL COMPRESSOR TYPES

(On the basis of casing design)





Centrifugal Compressor with Horizontal Split Casing

- ***Compressors with Horizontal Split casings. Consisting of half casings joined along the horizontal center line, Employed for operating pressure below 60 bar.***

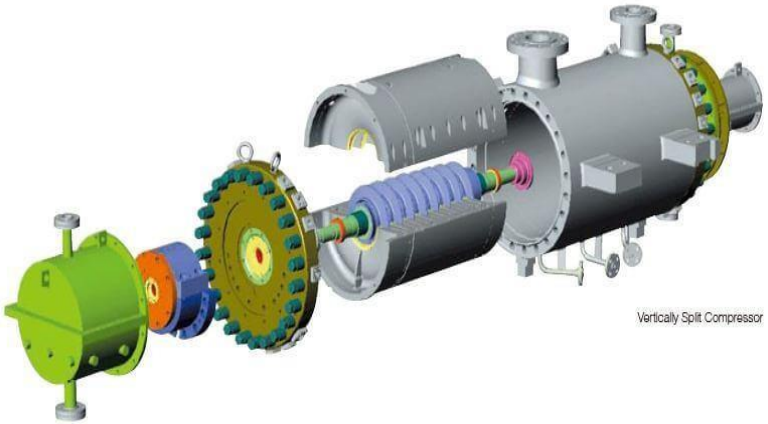
HORIZONTALLY SPLIT COMPRESSORS

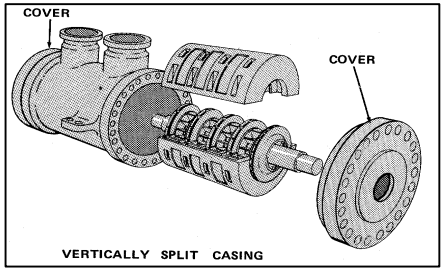
- ***This design is generally used at low pressure up to 60 bar.***
- ***The two halves of the casing are joined at the horizontal centerline by hydraulically tightened stud bolts and nuts.***
- ***Horizontally split casing is preferred as accessibility to compressor internals' is easier.***

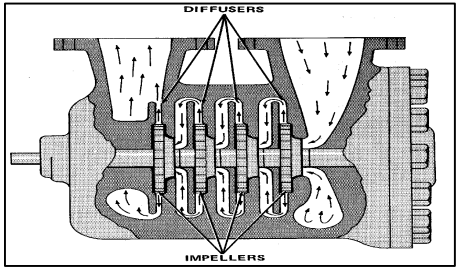
Centrifugal Compressor with Vertical Split Casing

- *with Vertical Split casing/Barrel Type.*

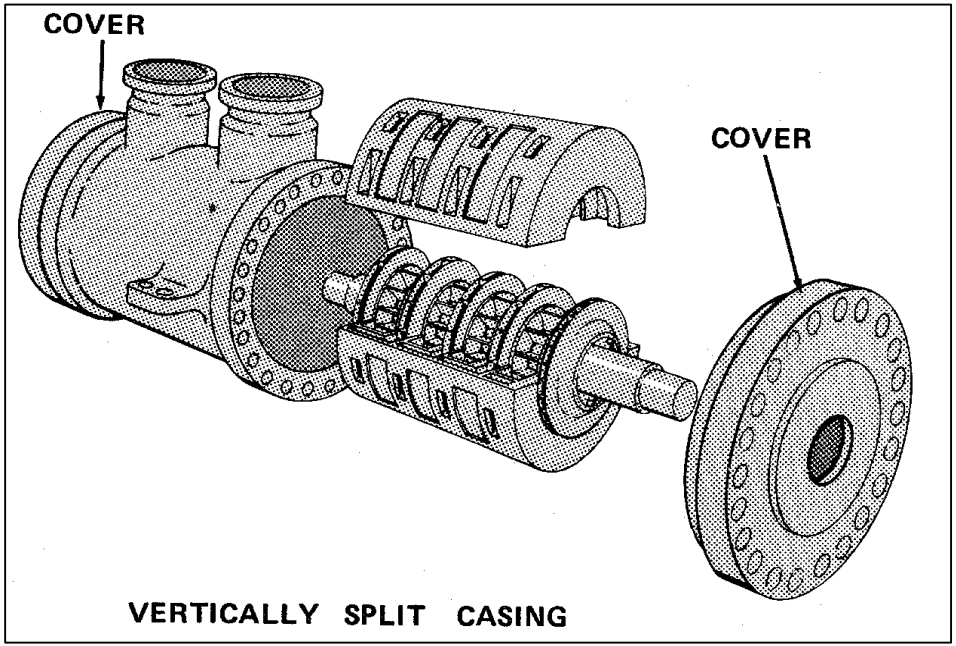
- *Vertical split casings are formed by cylinder closed by two end covers; hence 'barrel type' used to refer these compressors, Employed for high pressure services up to 685 bar.*

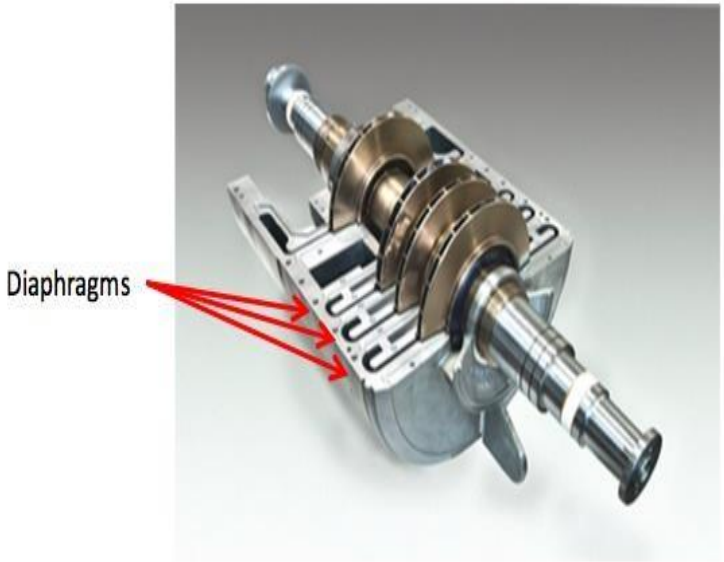






Centrifugal Compressor with Vertical Split Casing





NOMENCLATURE OF NP COMPRESSORS

GE NUOVO PIGNONE COMPRESSOR TAG

(A)	(B)	(C)	(D)	(E)	(F)	(G)
2 – 3	M	C	L	45	7	A (200 bar-a)
D	B	C	L	30	6	B (350 bar-a)
	P	C	L	100	2	C (500 bar-a)
	S	R	L	60	3	D (700 bar-a)
						E (>700 bar-a)

A - Index "2" or "3" are referred to the number of inlet - "D" stands for double inlet with equal condition

B - TYPE OF CASING M = middle split B = barrel P = pipeline S = single volute

C - TYPE OF IMPELLER C = closed R = open (twisted blade)

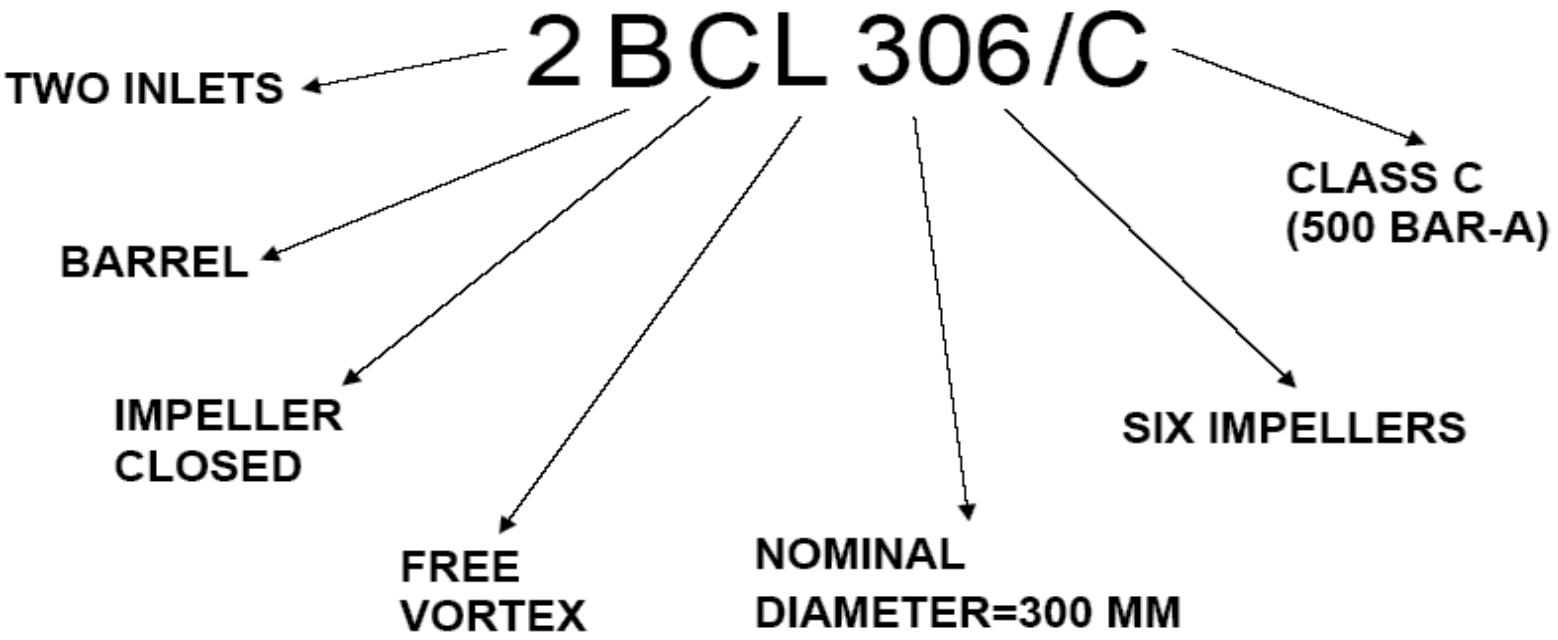
D - DIAPHRAGM TYPE L = free vortex

E - SIZE OF IMPELLER (diameter in cm)

F - NUMBER OF IMPELLERS

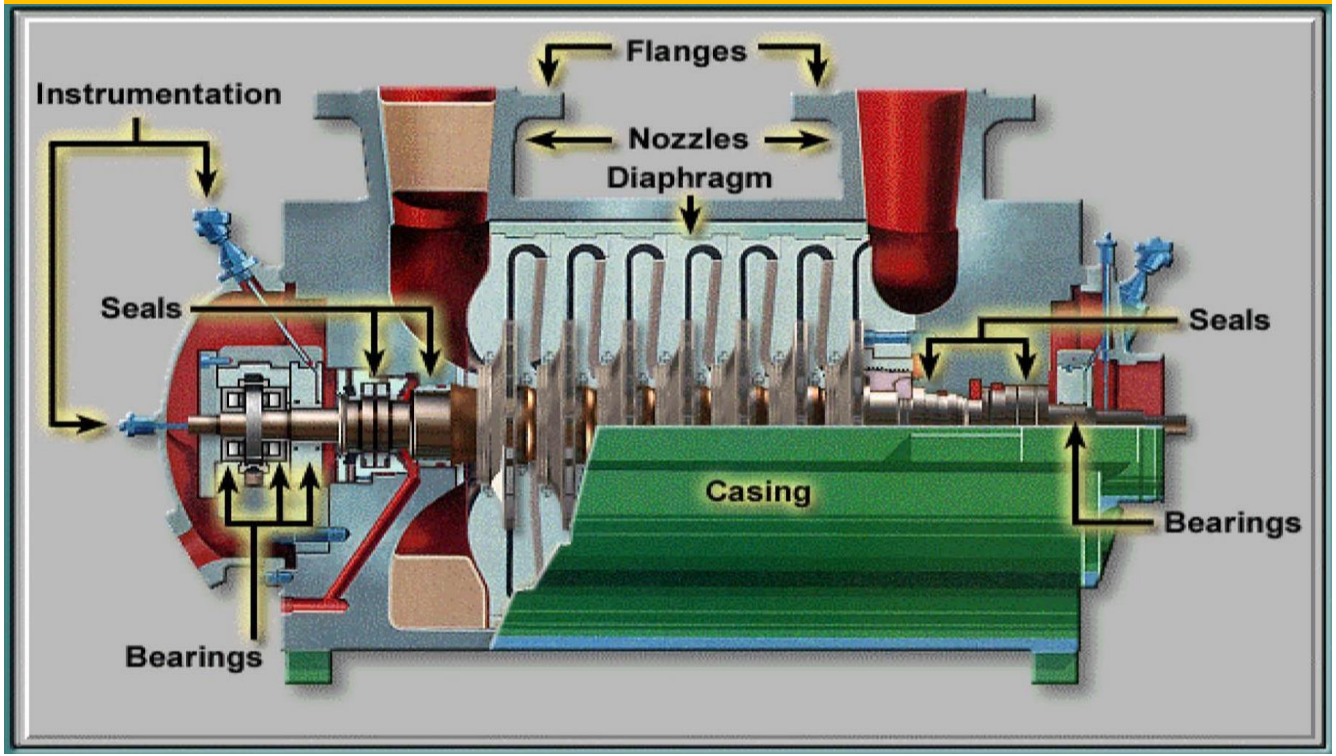
G - CLASS OF CASING - TEST PRESSURE (for BCL only)

EXAMPLE

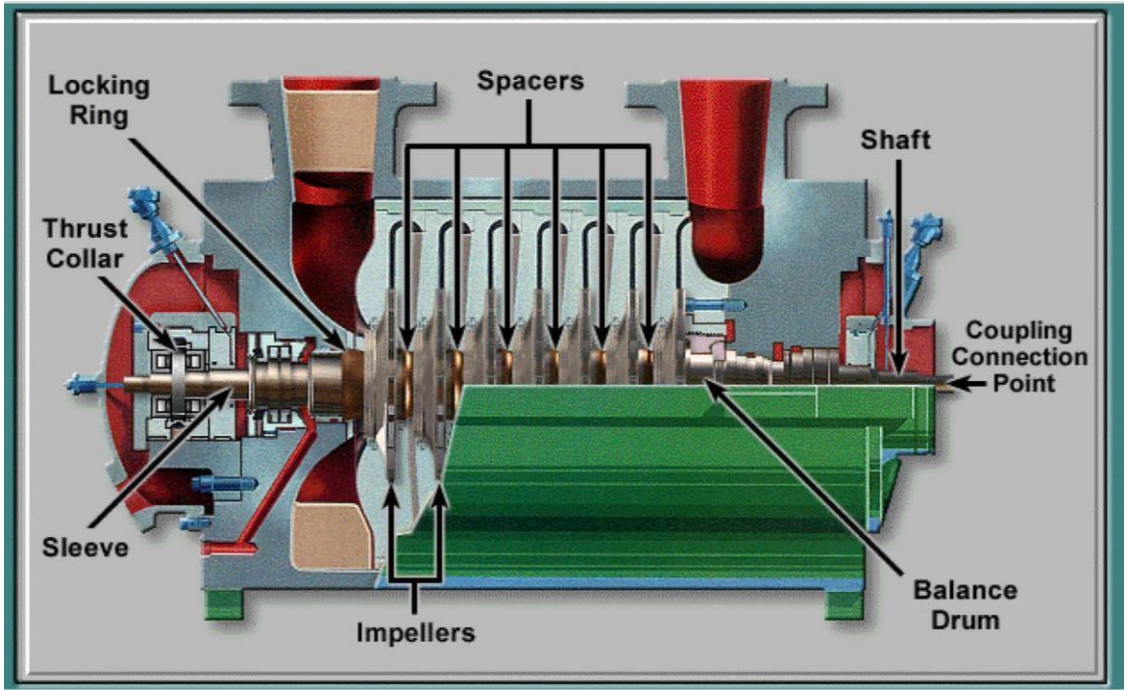

2 B C L 306/C
TWO INLETS
BARREL
IMPELLER
CLOSED
FREE
VORTEX
NOMINAL
DIAMETER=300 MM
SIX IMPELLERS
CLASS C
(500 BAR-A)

COMPONENTS OF A CENTRIFUGAL COMPRESSOR

STATOR PARTS



COMPONENTS OF A CENTRIFUGAL COMPRESSOR.
ROTOR PARTS



Construction of centrifugal compressor

Major components of a centrifugal compressor include:

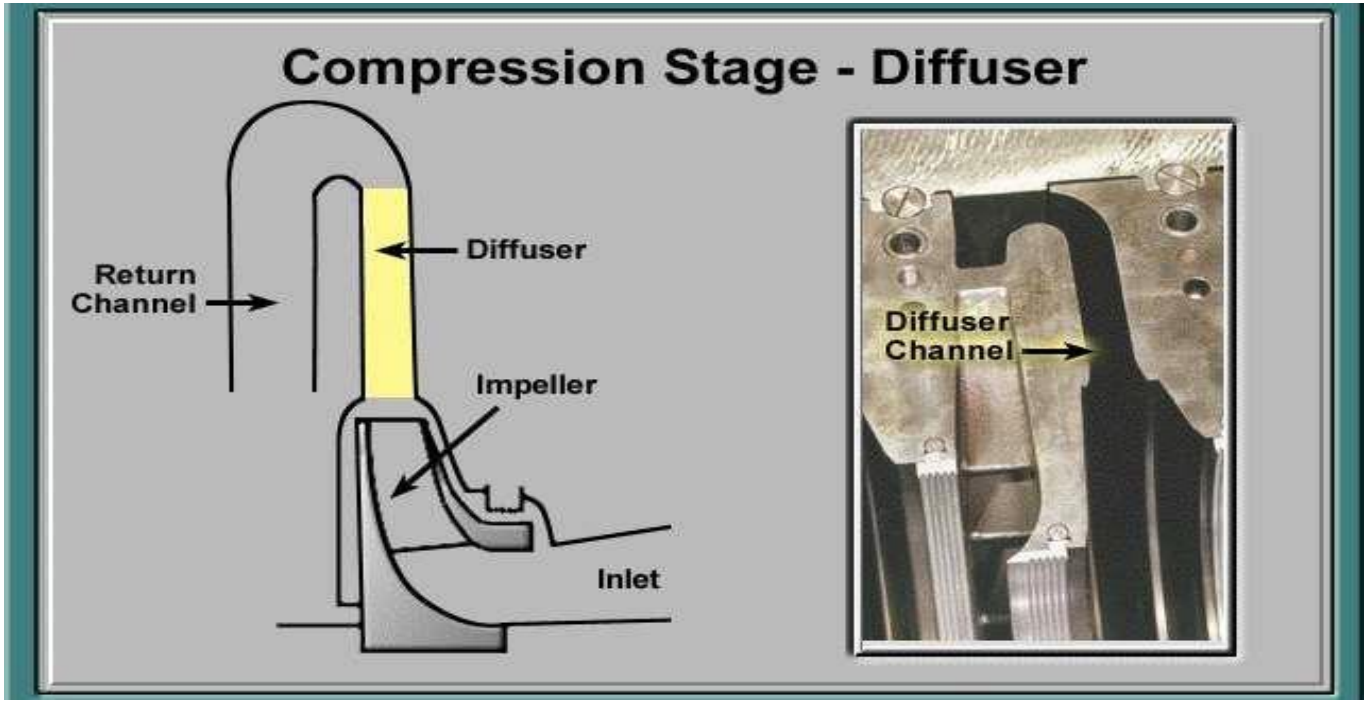
1) Impeller: ***As the impeller rotates, it moves the gas toward the outer rim of the impeller and its velocity increases.***

2) Diffuser: ***As the gas leaves impeller, it flows into a passage-way called the diffuser. The diffuser being larger in volume, the velocity of gas decreases and its pressure increases***

3) Volute: ***Gas passes from diffuser into the volute. In the volute, the conversion of velocity energy to pressure energy continues.***

4) Casing: ***It is the outer cover of a centrifugal compressor which contains inlet and discharge nozzles.***

Construction of centrifugal compressor



COMPONENTS OF A CENTRIFUGAL COMPRESSOR

- *ROTOR SHAFT*
- *SPACERS*
- *IMPELLER*
- *THRUST COLLAR*
- *COUPLING HUB*
- *DIAPHRAGM*
- *RETURN CHANNEL*
- *INTERSTAGE SEALS*
- *SHAFT END SEALS*
- *BEARINGS*

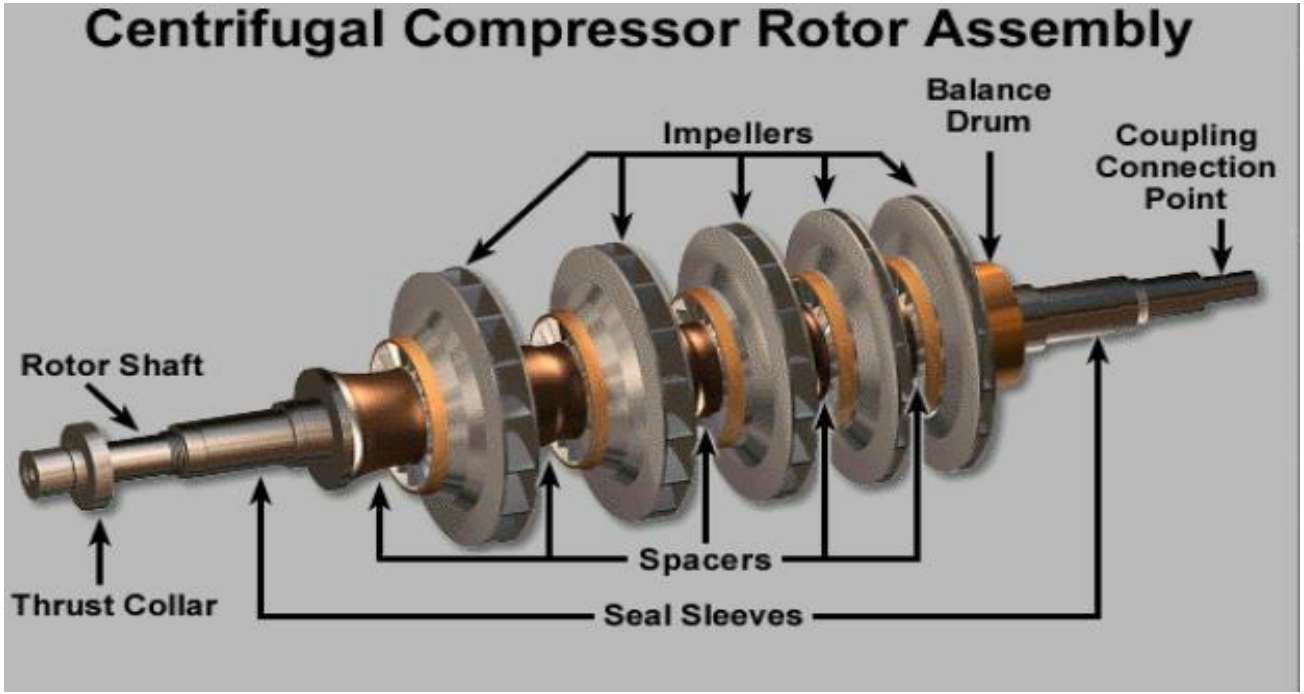
ROTOR SHAFT

- ***The shaft serves as the main element of the rotor, transmitting the torque from the driver to the impellers.***
- ***The largest diameter is located in the middle of the shaft and supports the impellers and spacer pieces.***

ROTOR SHAFT & SPACERS

- *The shaft is made out of forged alloy steel and the impellers, spacers and the balancing drum are shrunk fitted on it.*
- *Spacers located between impellers determine the axial position of each impeller. Spacers of stainless steel material are used to protect the shaft against gas erosion and corrosion.*
- *Journal bearing zones of the shaft is ground and burnished with the diamond burnishing technique to improve the surface finish.*

ROTOR SHAFT & SPACERS



ROTOR SHAFT – PROBE AREA

- ***The final surface finish of sensing areas to be observed by radial vibration probes shall be a maximum of 1.0 µm.***

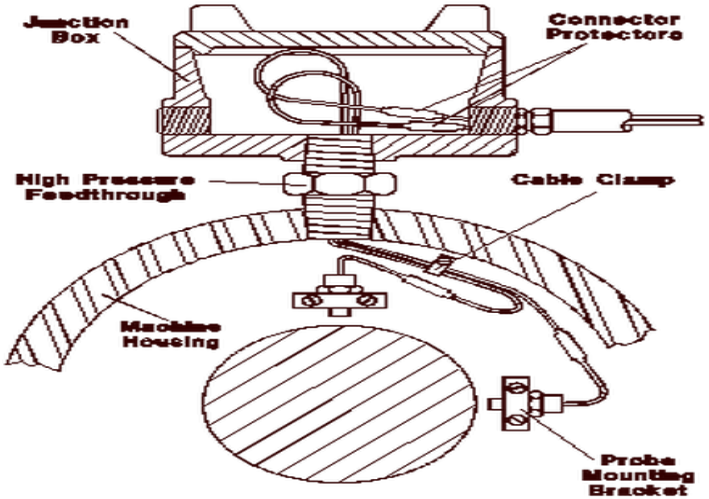
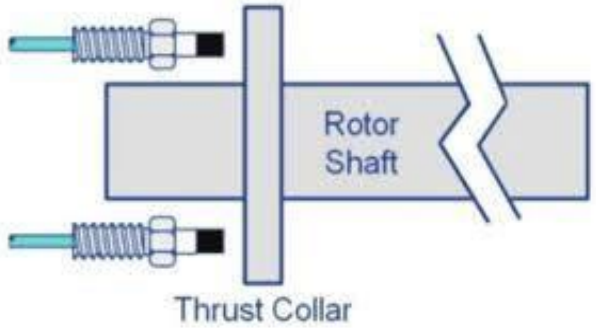
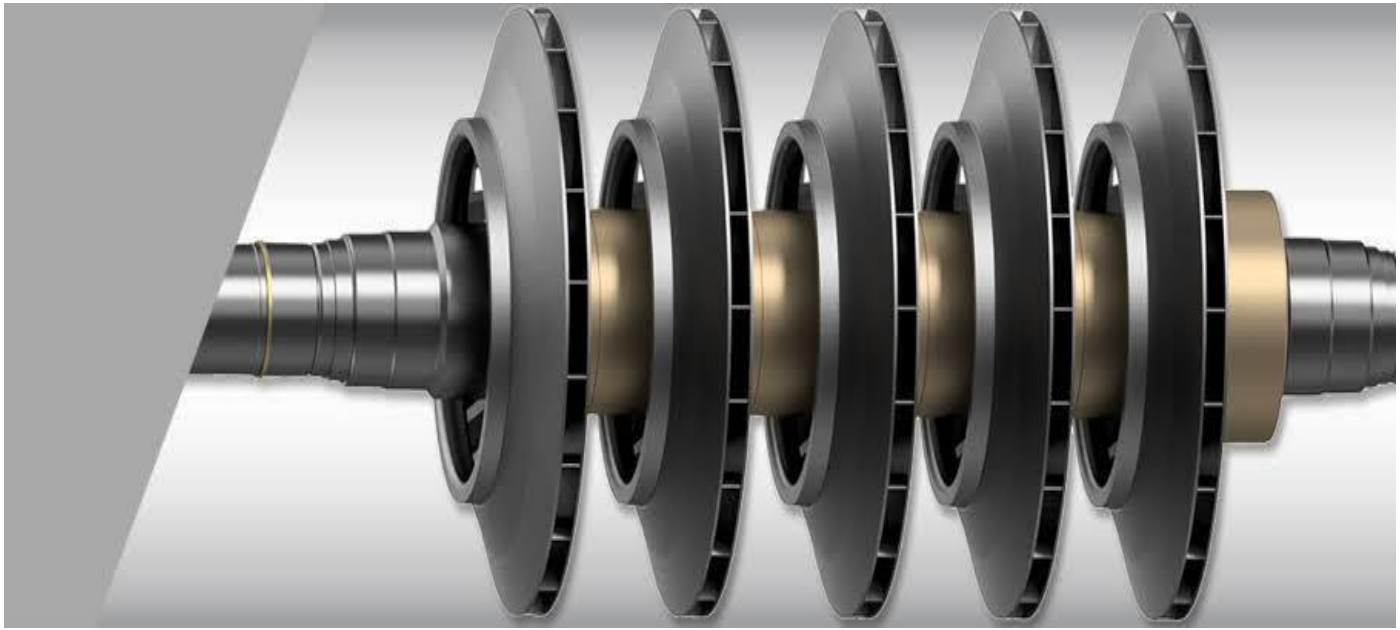


Figure 8: Internal probe mounting utilizing High Pressure Feedthrough



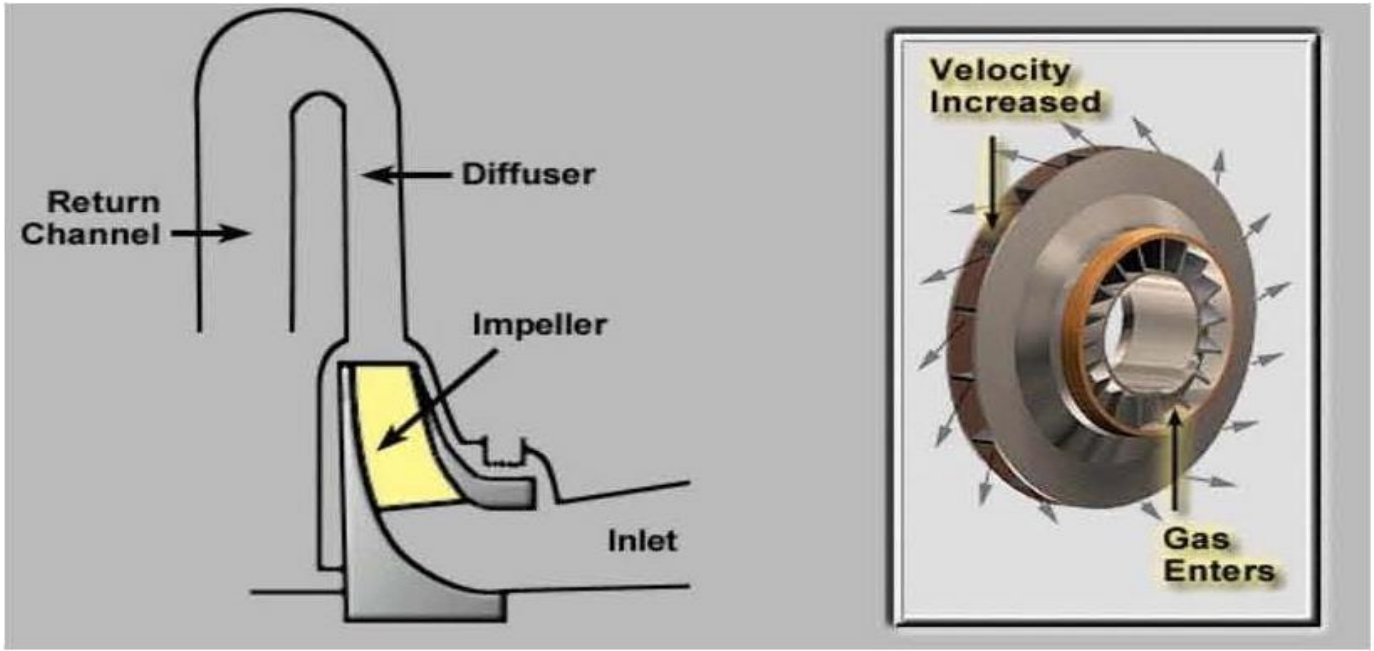
ROTOR SHAFT



IMPELLER

- ***The part of centrifugal compressor that moves the gas is the impeller.***
- ***As the impeller rotates, it moves the gas toward the outer rim of the impeller and thus its velocity increases.***
- ***The impellers add energy (velocity) to the gas.***

IMPELLER


Return Channel
Diffuser
Impeller
Inlet
Velocity Increased
Gas Enters

IMPELLER

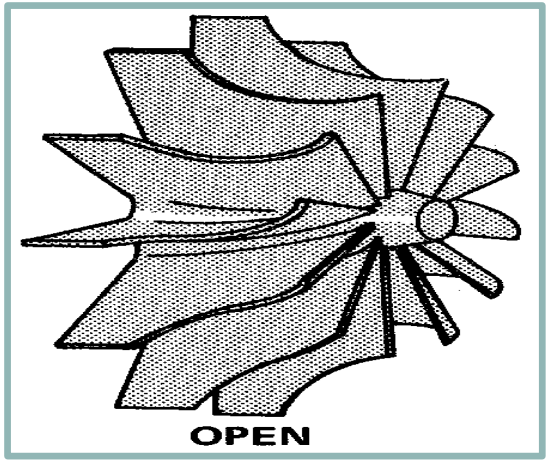
OPEN IMPELLER

SEMI-CLOSED IMPELLER

CLOSED IMPELLER

OPEN IMPELLER

- ***These are used for large heads and small to large flow in single stage compressors only.***
- ***The flow is least controlled.***



SEMI-CLOSED IMPELLER

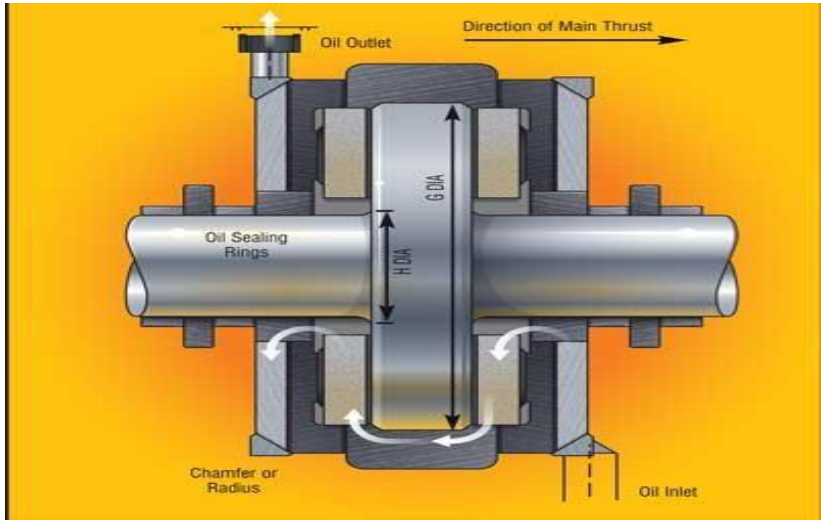
These are used for large flow, usually in single stage compressors, or as the first stage in multistage compressors.

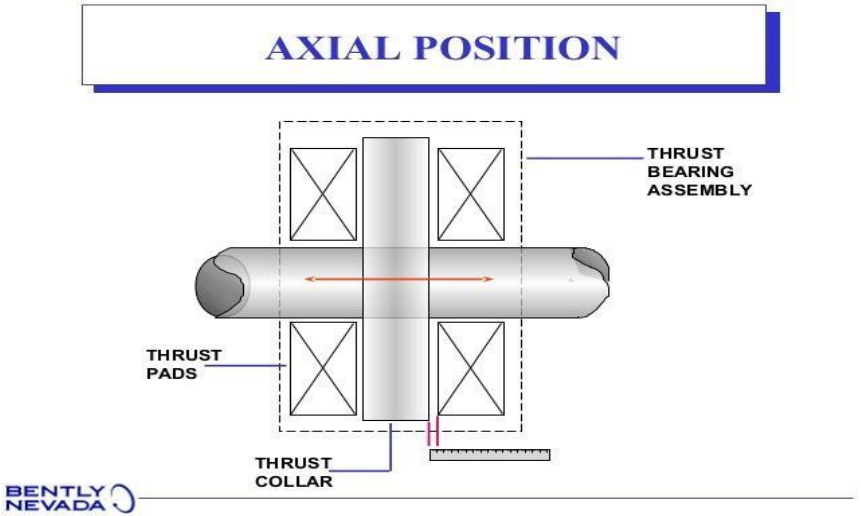
CLOSED IMPELLER

- ***Multistage compressors usually have enclosed impellers.***
- ***The flow of gas is best controlled in enclosed impellers.***
- ***To prevent vibration the impeller is shrunk onto the shaft and prevented from turning on the shaft by a key and is well balanced.***

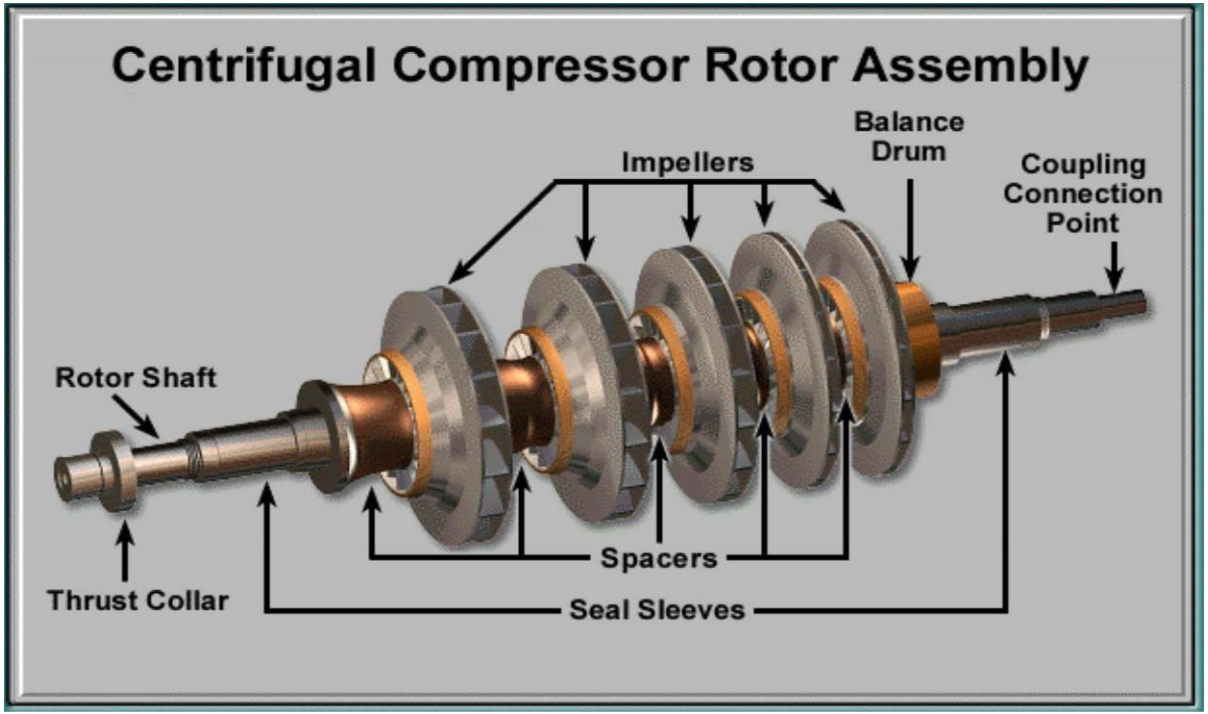
THRUST COLLAR

- ***The thrust collar transmits the rotor thrust to the thrust bearings and fixes the axial position of the rotor.***





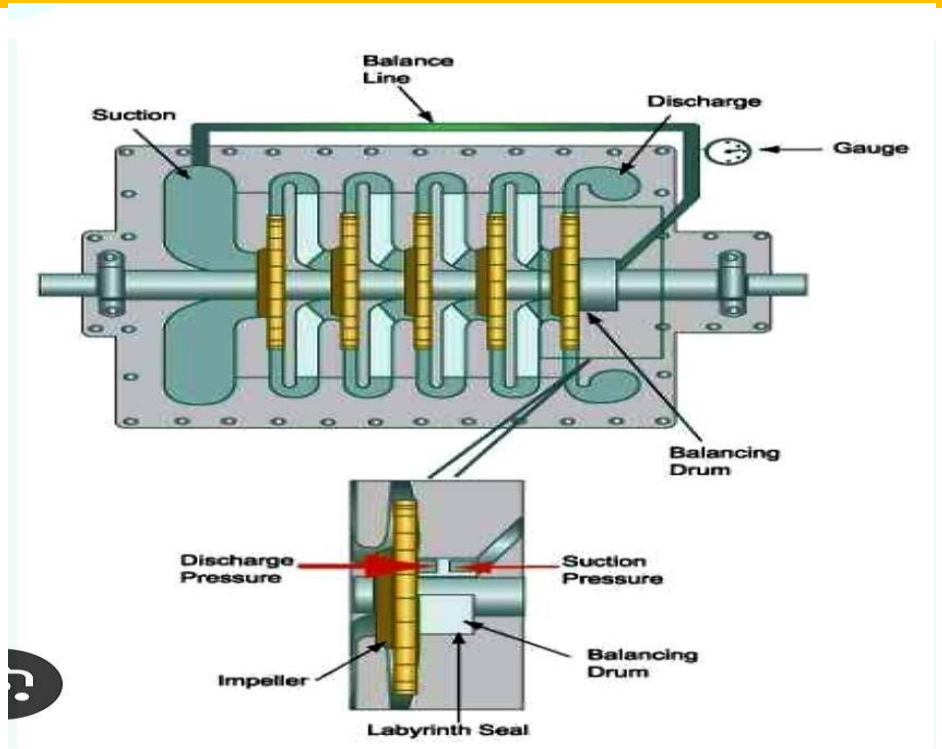
THRUST COLLAR



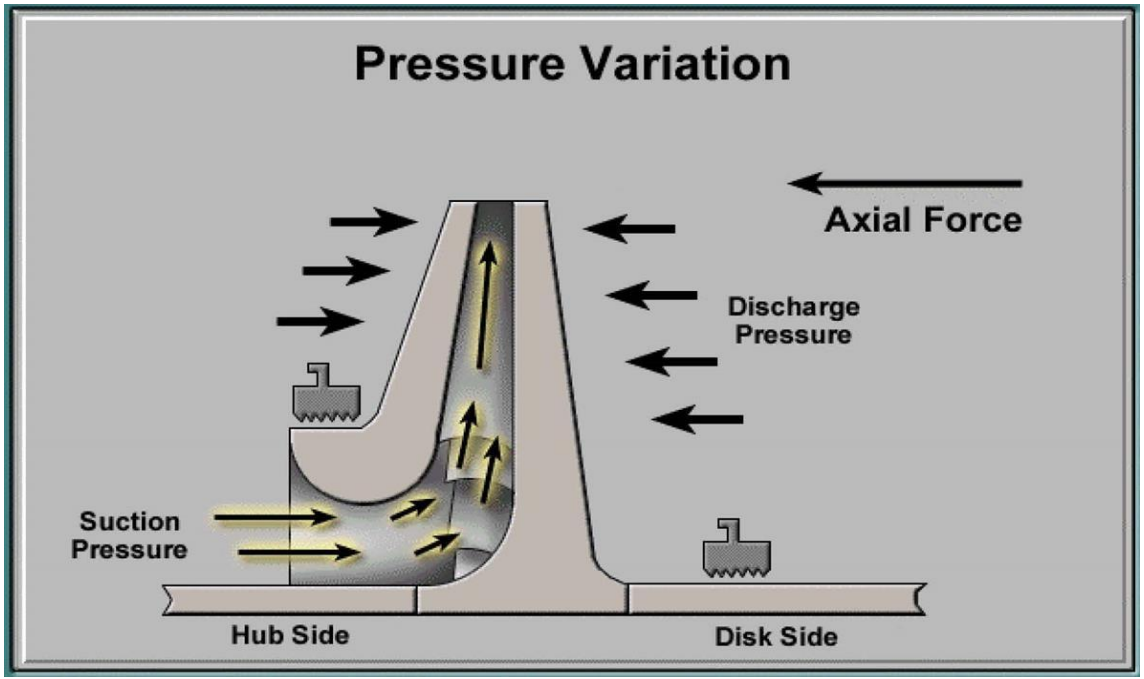
BALANCE DRUM

- ***The centrifugal compressor rotor is subjected to an axial thrust during operation.***
- ***The balance drum compensates for the majority of this thrust.***
- ***The balance drum is a device designed to balance axial thrust generated by impellers.***
- ***It is usually combined with a thrust bearing which serves to compensate a small amount of residual axial thrust.***

BALANCE DRUM



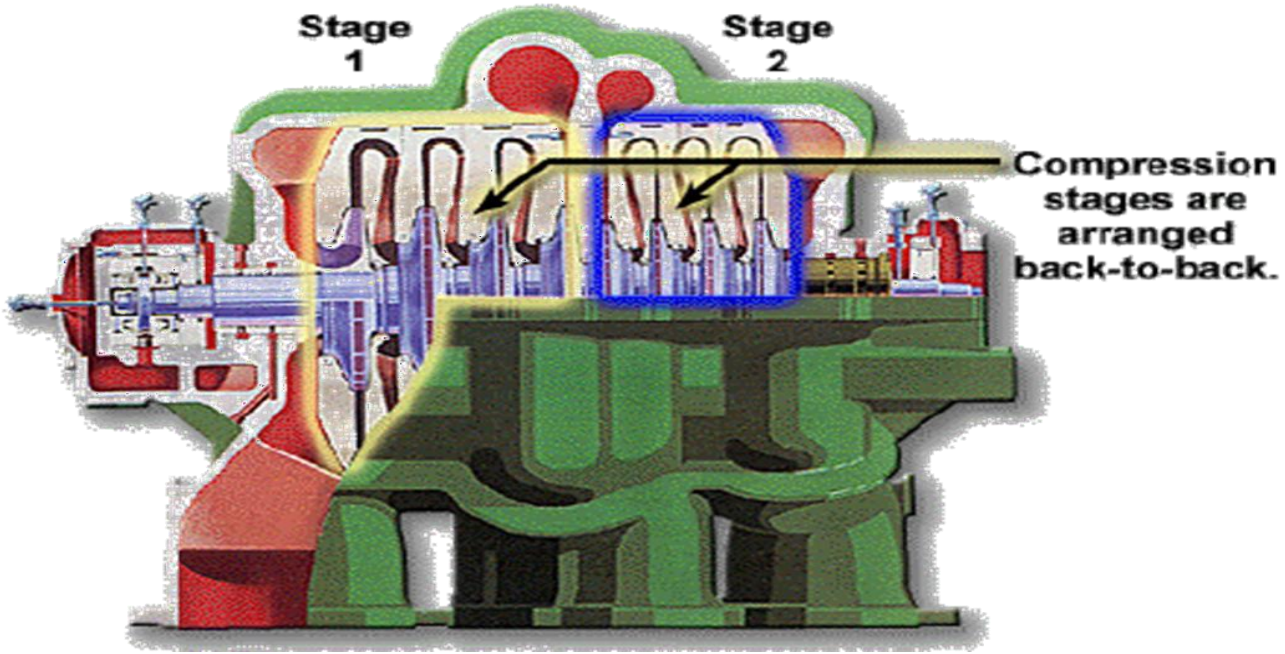
AXIAL FORCE ON IMPELLER



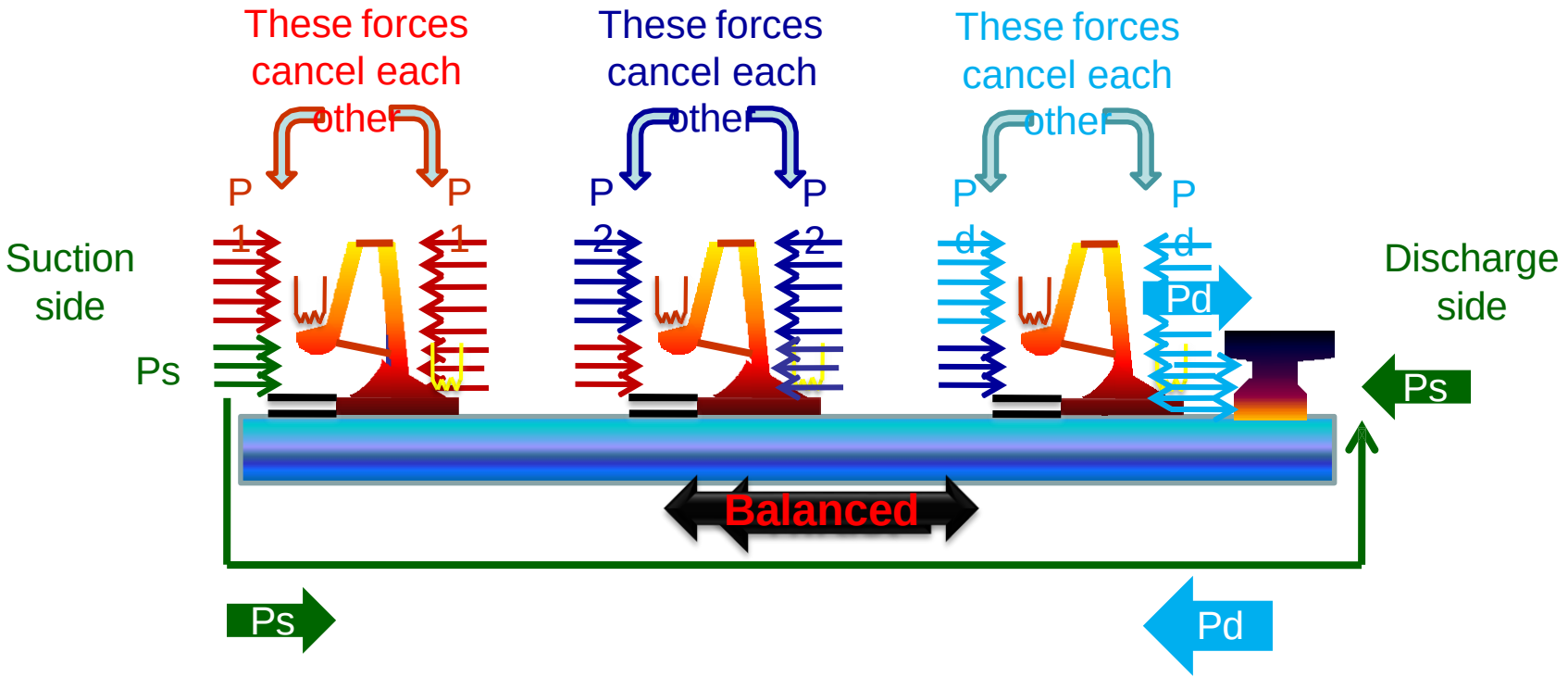
BALANCING OF AXIAL THRUST ON ROTOR

1) *BACK TO BACK ARRANGEMENT.*
2) *ADDING BALANCING DRUM.*
3) *THRUST COLLAR*

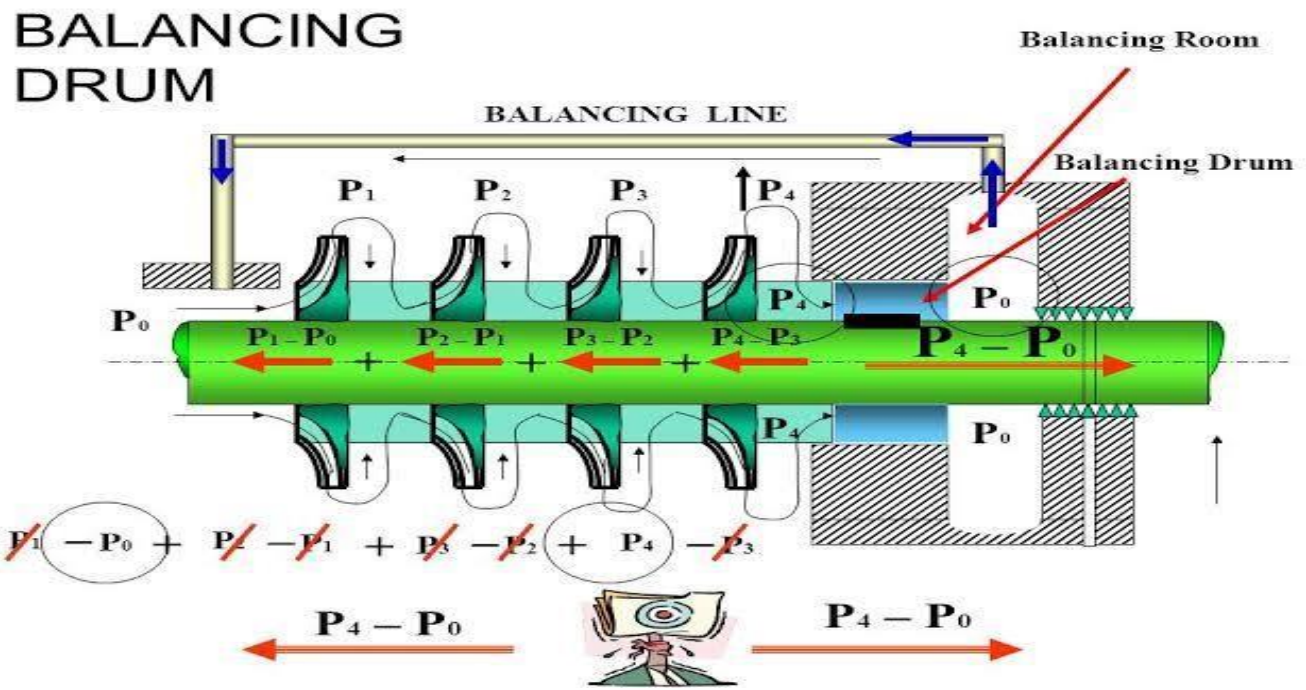
BACK TO BACK ARRANGEMENT



BALANCING DRUM



BALANCING DRUM

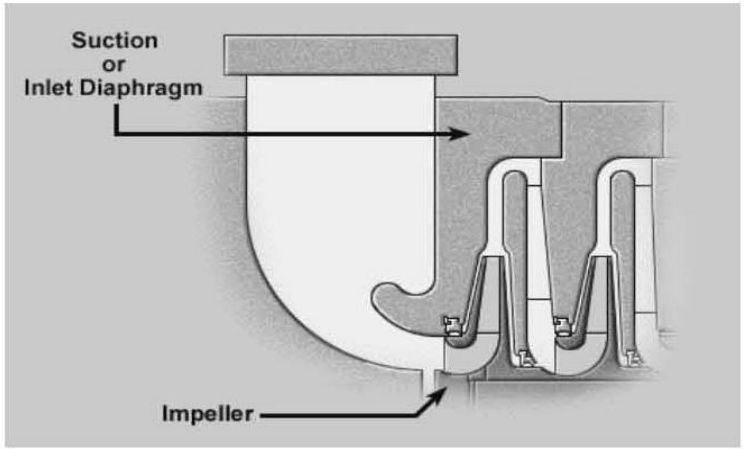


DIAPHRAGM ASSEMBLY

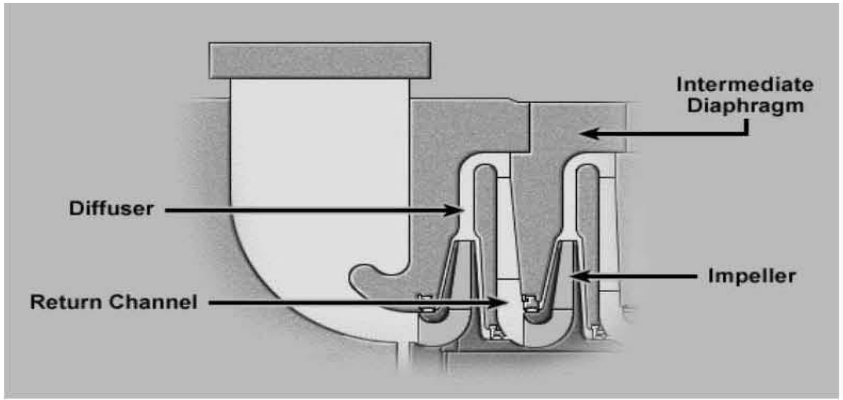
- ***A multistage centrifugal compressor contains diaphragms (stationary part).***
- ***The adjacent walls of diaphragms form a passage called diffuser.***
- ***To form the separation wall between one compressor stage.***
- ***Inside the diaphragms are channels (return passages) which return the gas to suction side of next impeller.***
- ***To convert the kinetic energy of the gas leaving the impeller into pressure energy.***

DIAPHRAGM ASSEMBLY

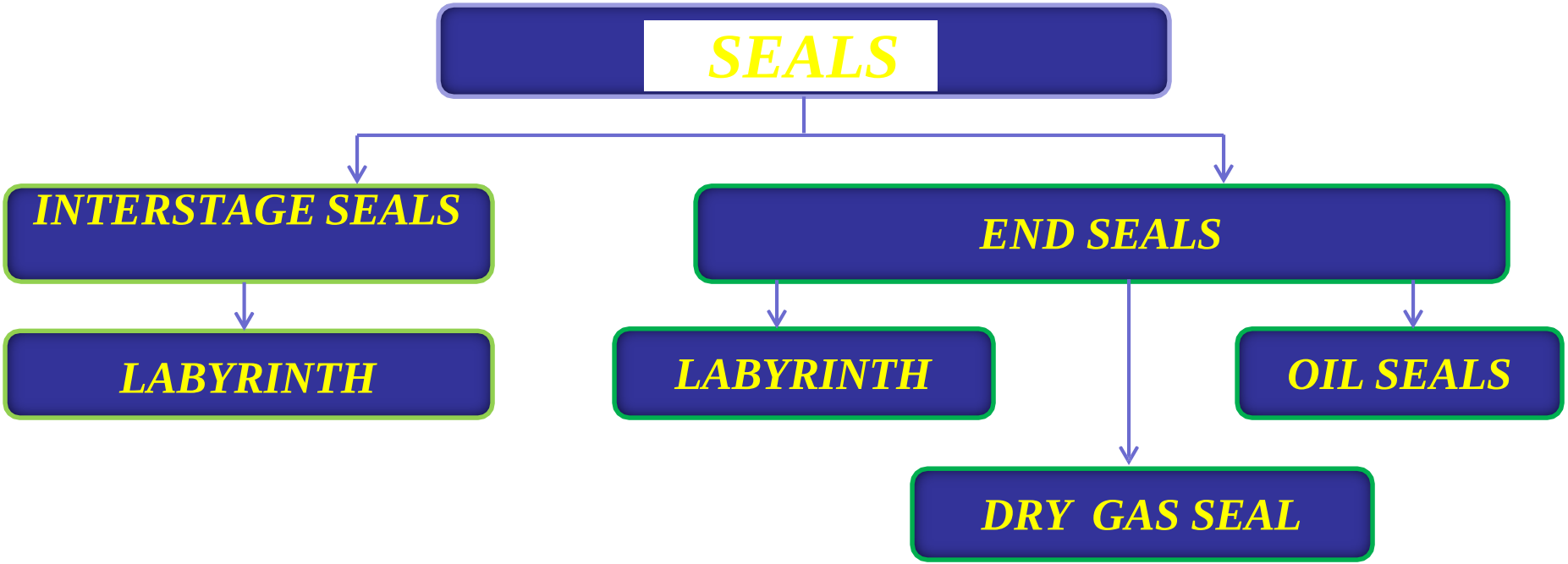
SUCTION DIAPHRAGM



INTERMEDIATE DIAPHRAGM



COMPRESSOR SEALS



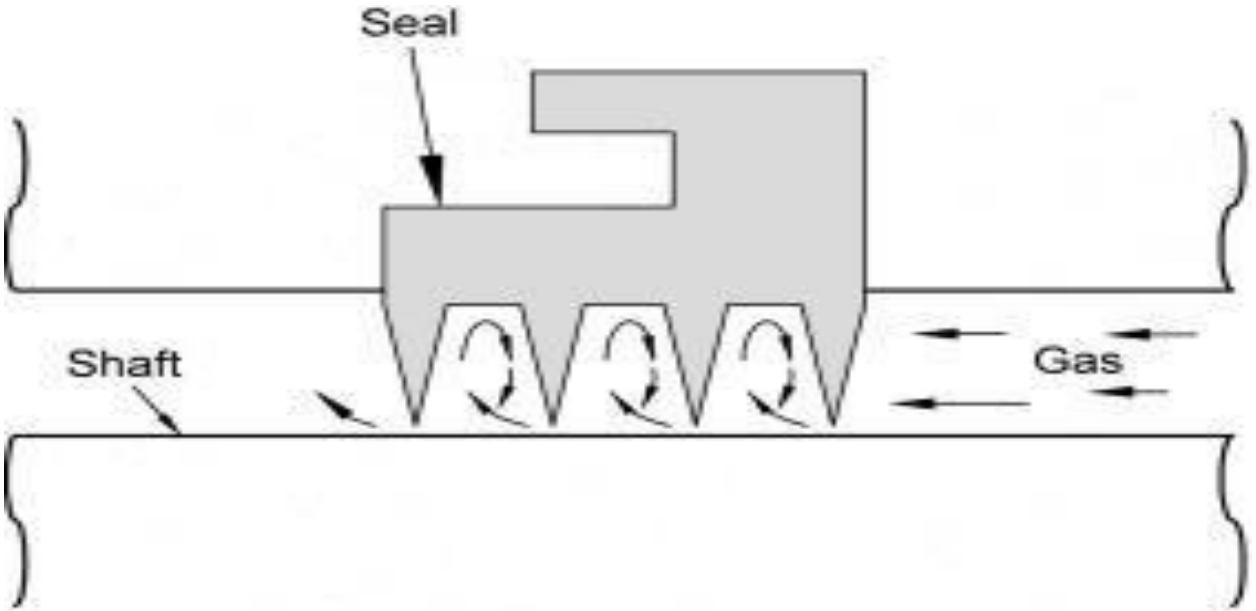
INTERSTAGE SEALS

- ***Rotor shaft passes through the diaphragms.***
- ***Since diaphragms and rotor are not attached to each other, the gas can flow from higher-pressure region to the lower pressure region through the space between shaft and diaphragms.***
- ***Seals are used between the shaft and the diaphragms to prevent leakage.***

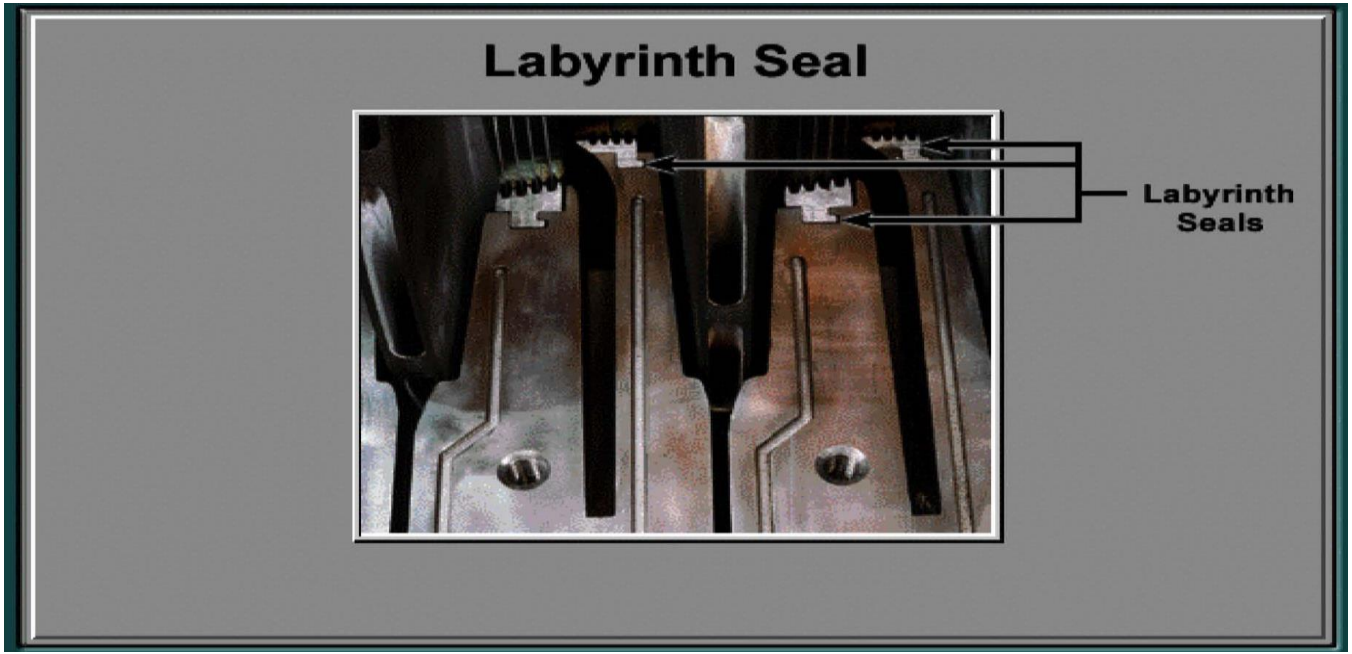
LABYRINTH SEALS

- *It is a set of metal rings or teeth that encircle the shaft but do not touch it.*
- *As gas enters space between teeth, it slows down and changes direction.*
- *The resulting turbulence resists the flow of gas.*
- *The rings or teeth are made of soft metal, and are sharp.*
- *Labyrinths do not prevent all leakage and are used in areas where it is acceptable to allow leakage.*
- *These are widely used as inter stage seals because pressure difference between stages is normally low*

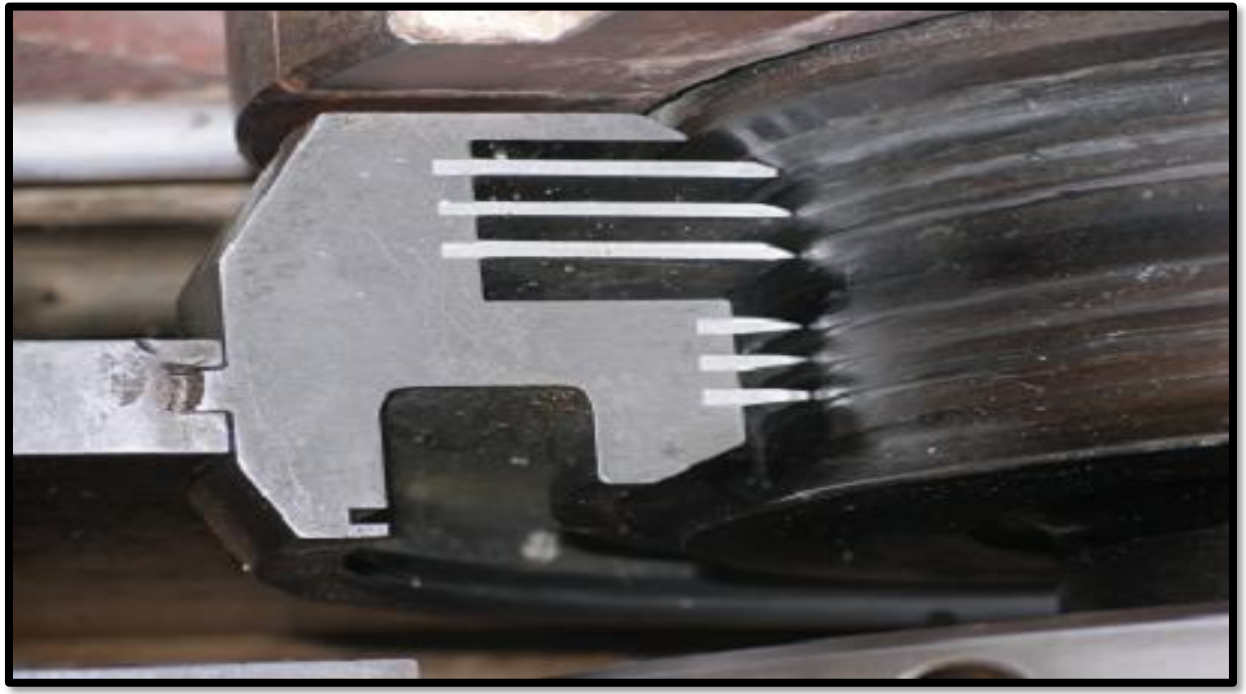
LABYRINTH SEALS



LABYRINTH SEALS



LABYRINTH SEALS



SHAFT END SEALS

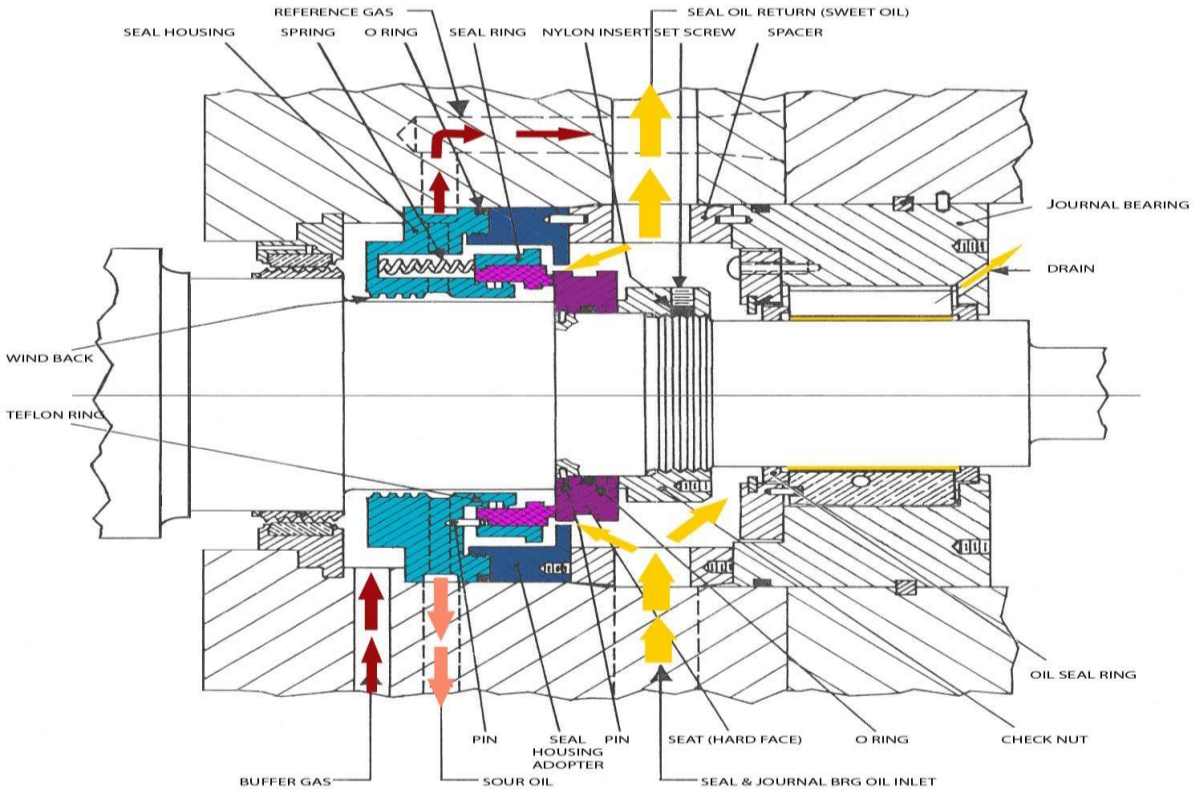
- *It increase compressor efficiency by avoiding process gas leakage.*
- *Prevent process gas contamination.*
- *Avoid contact between process gas and lube oil.*

1) MECHANICAL SEALS

2) DRY GAS SEALS

MECHANICAL SEALS

- ***This seal also consists of carbon face ring held in contact with the hard face by springs.***
- ***Flushing of seal faces is carried by oil at a pressure slightly higher than that of the gas pressure.***
- ***Some of the oil flow inside the casing, which is drained away as sour oil.***


REFERENCE GAS
SEAL OIL RETURN (SWEET OIL)
SEAL HOUSING
SPRING
O RING
SEAL RING
NYLON INSERT
SET SCREW
SPACER
JOURNAL BEARING
DRAIN
WIND BACK
TEFLON RING
OIL SEAL RING
PIN
SEAL HOUSING ADOPTER
PIN
SEAT (HARD FACE)
O RING
CHECK NUT
BUFFER GAS
SOUR OIL
SEAL & JOURNAL BRG OIL INLET

DRY GAS SEALS

- *There is an increased efficiency and a cost reduction in compressor usage.*
- *Dry Gas Seals are available as Single, Tandem Gas Seal units according to the number of seal rings.*

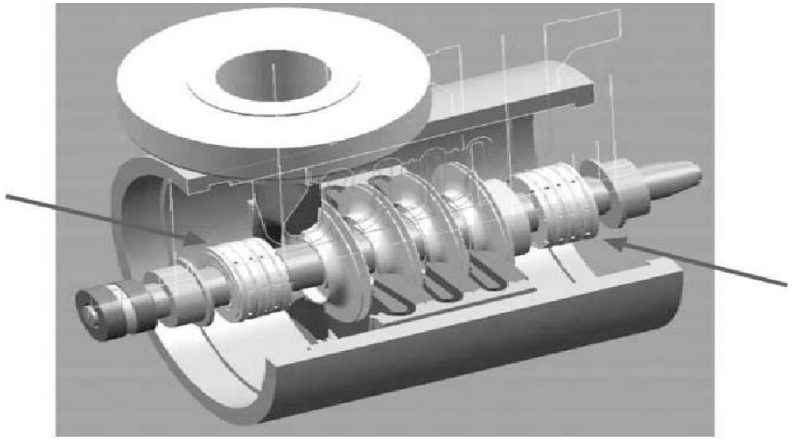
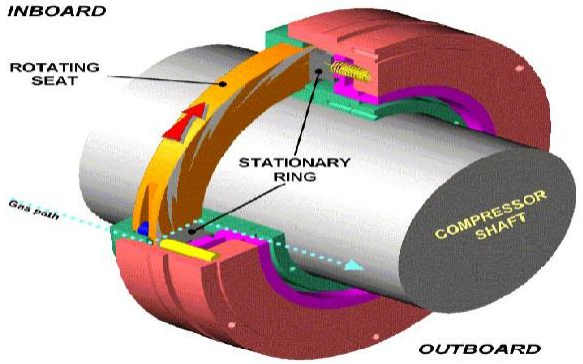
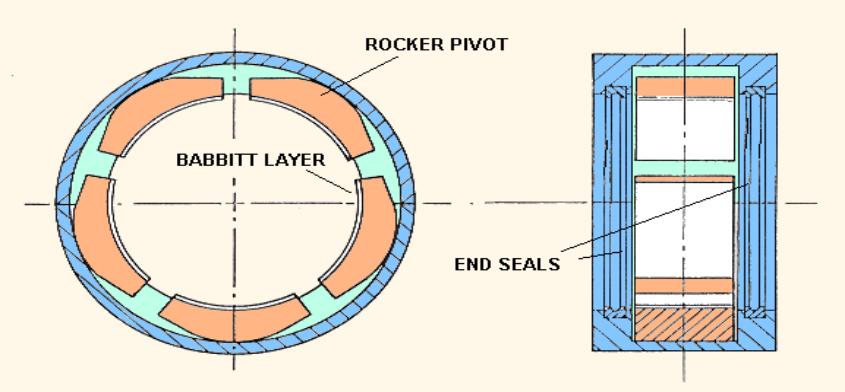


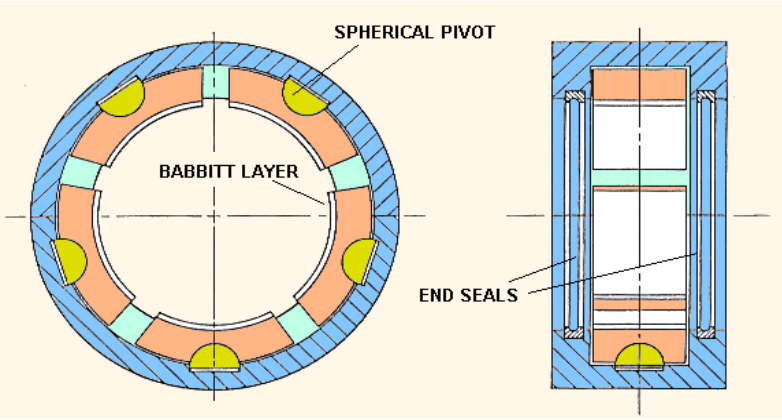
Figure 1 Shaft Seal Location



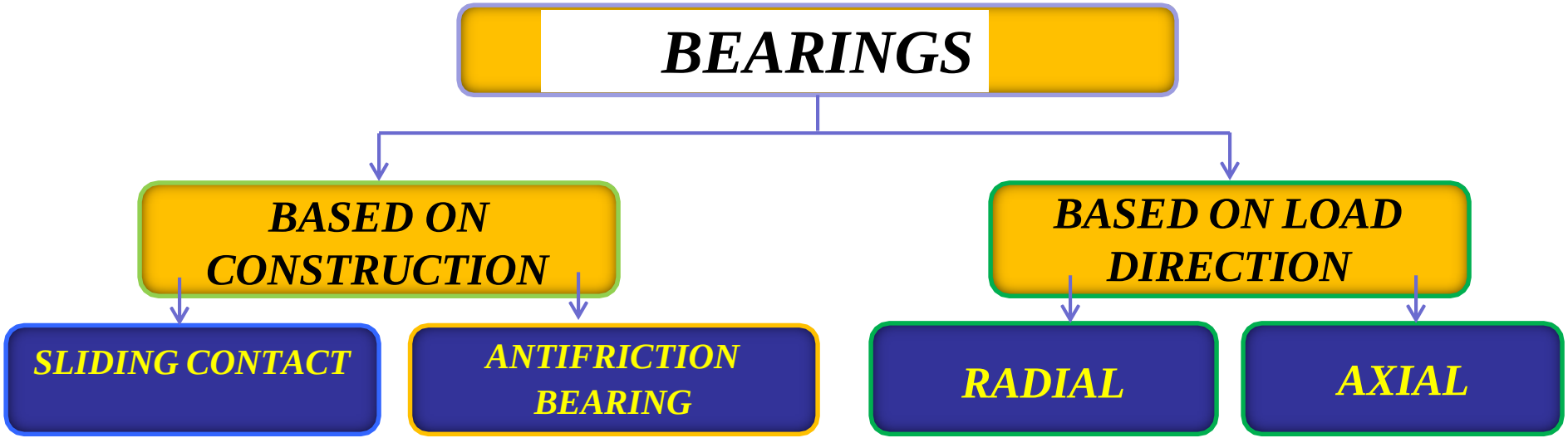
BEARINGS

- ***Bearings are used to support the machine shaft.***
- ***They prevent axial or radial motion.***



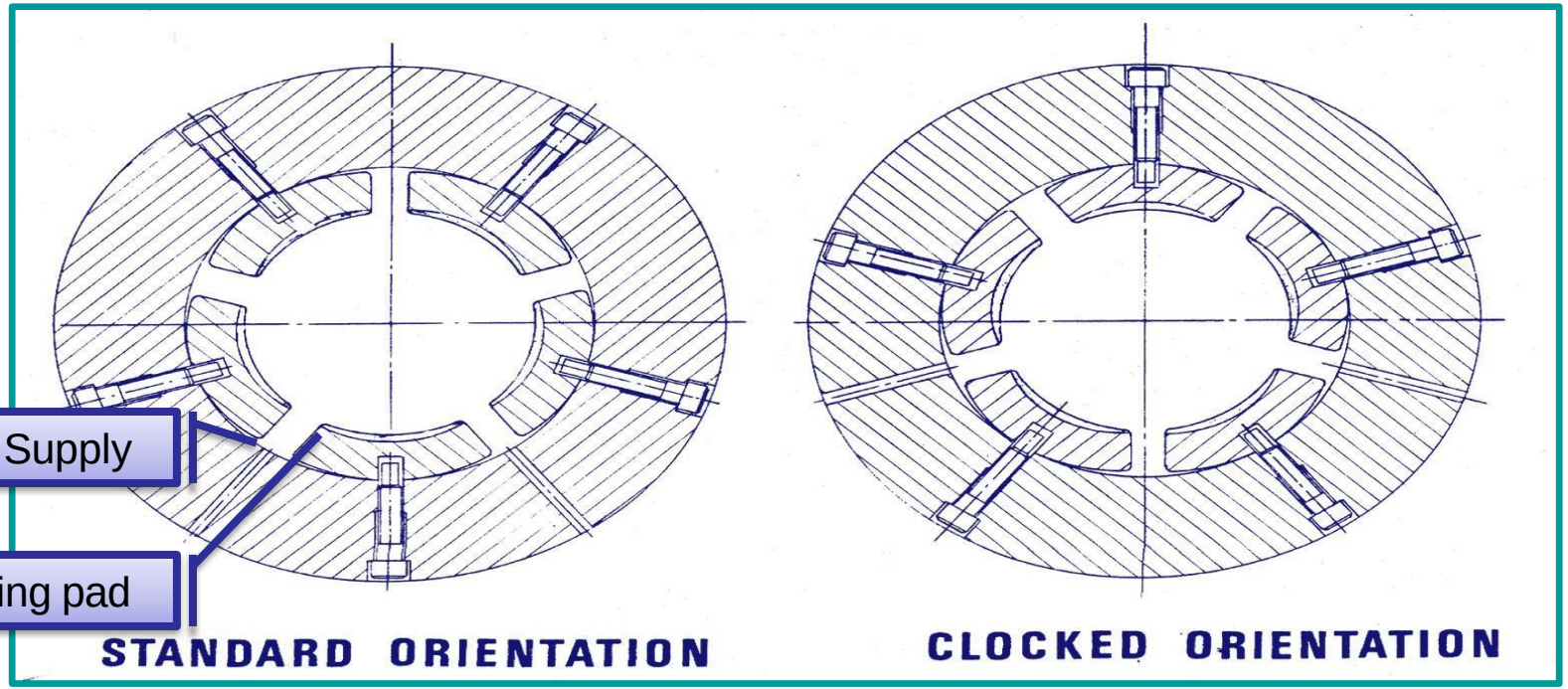


TYPES OF BEARING

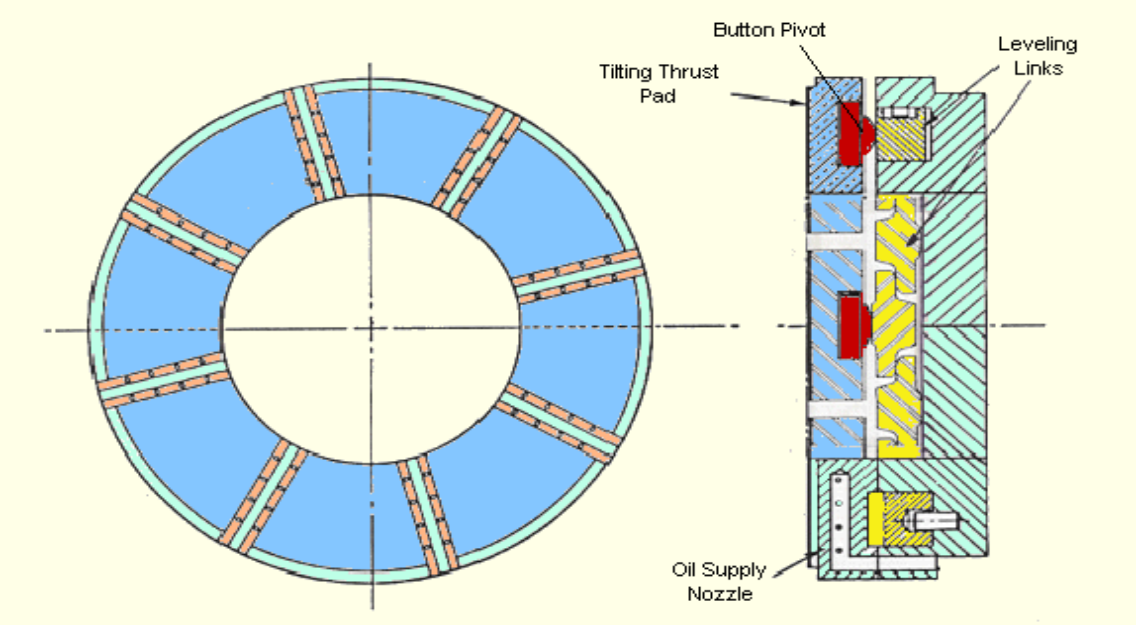


TILTING PAD RADIAL BEARING (UPPER HALF)

RADIAL BEARING ARRANGEMENT



TILTING PAD THRUST BEARINGS

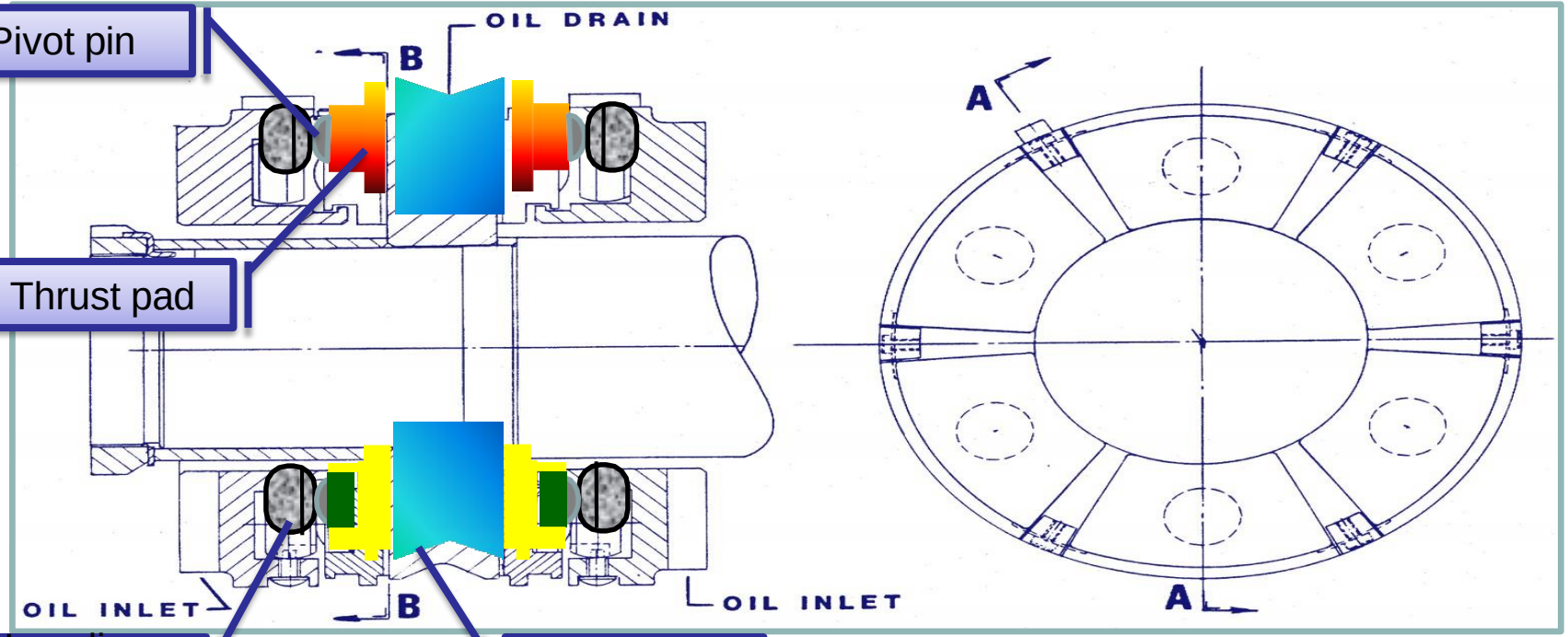


THRUST BEARI

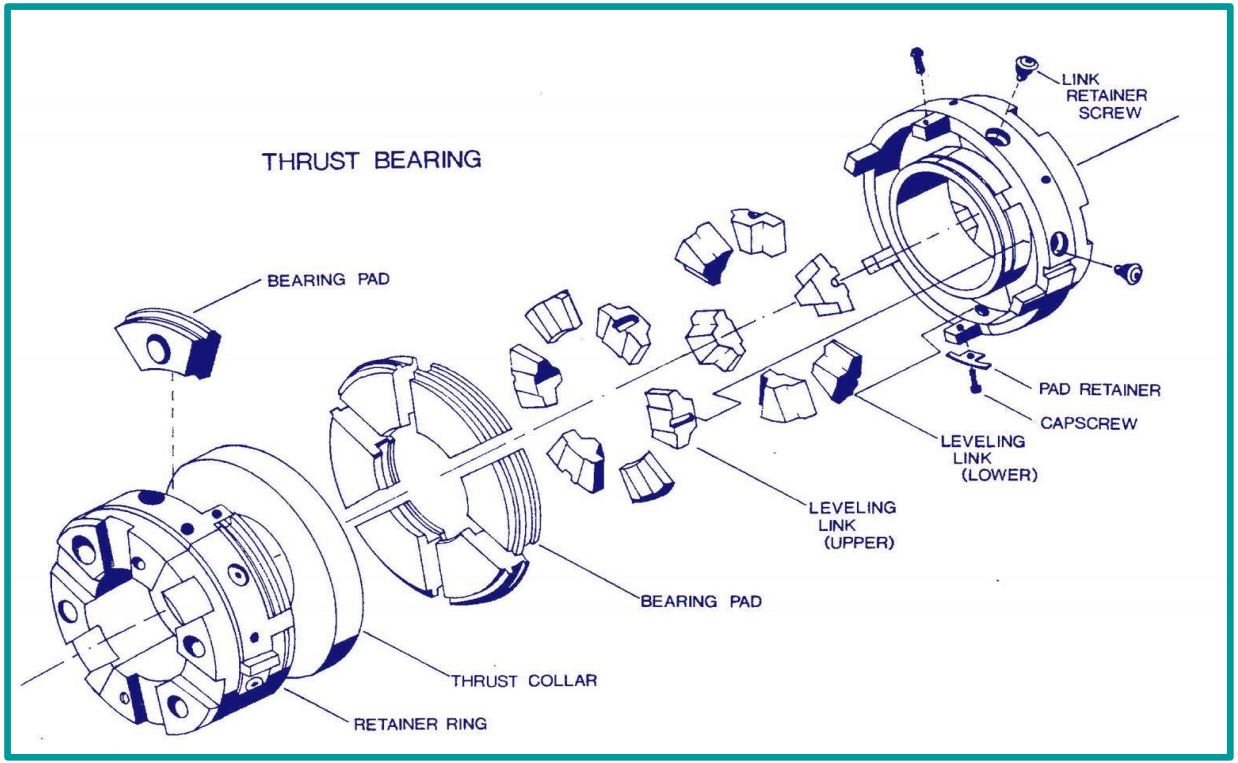
THRUST BEARING

- ***One of the most critical components of a centrifugal compressor is the thrust bearing.***
- ***Axial thrust is generated in a centrifugal compressor by the pressure rise through the impellers.***

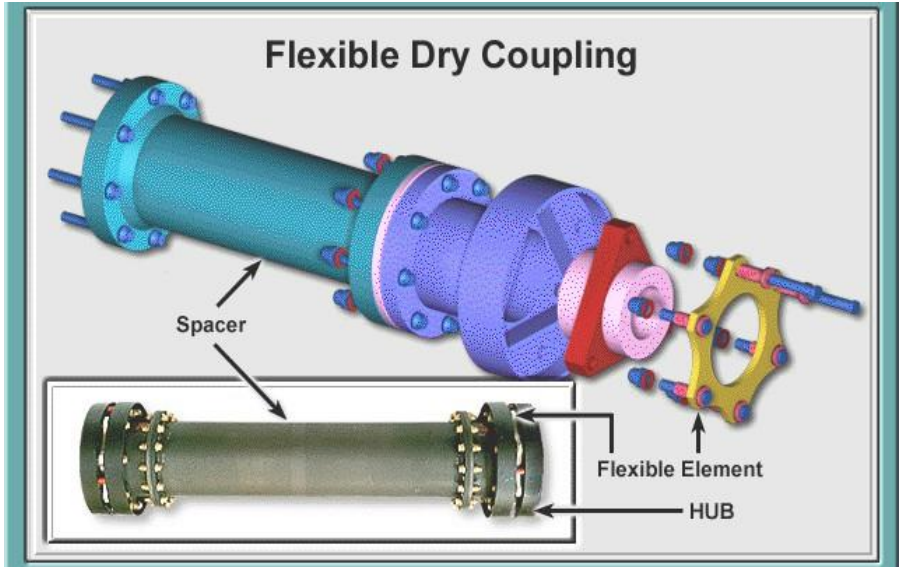
THRUST BEARING

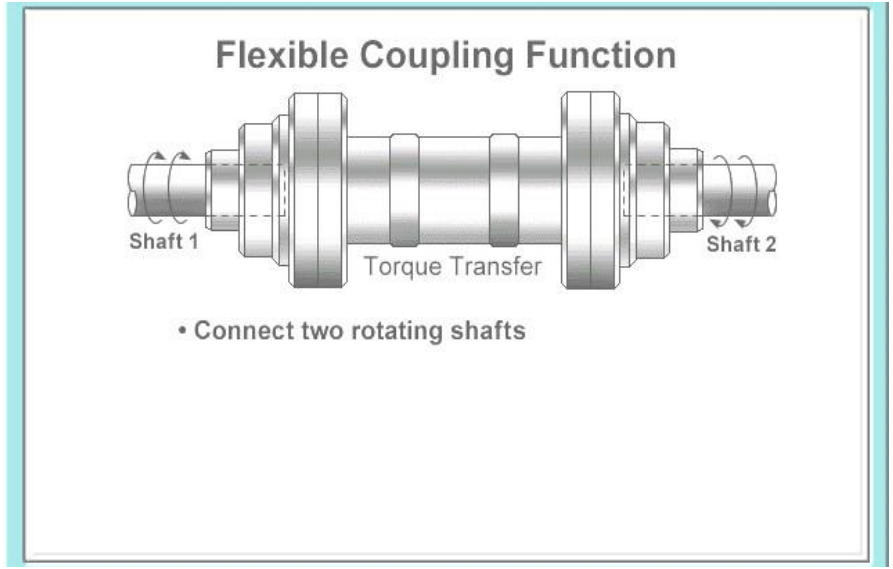


THRUST BEARING (EXPLODED VIEW)



COUPLINGS


Flexible Dry Coupling
Spacer
Flexible Element
HUB


Flexible Coupling Function
Shaft 1
Torque Transfer
Shaft 2
• Connect two rotating shafts

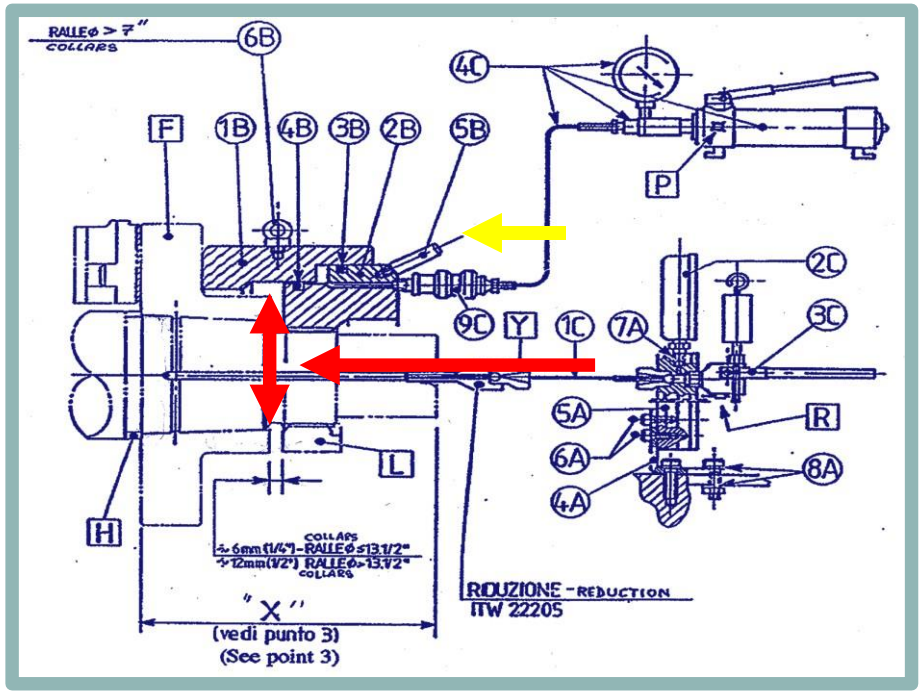
COUPLINGS FUNCTIONS

Efficient transmission of mechanical power from one shaft to the other.

To compensate for misalignment without inducing abnormal stresses and without significant loss of power.

To compensate the axial movement of coupled shafts, preventing either from exerting excessive thrust on other

HUB /COLLAR MOUNTING TOOL



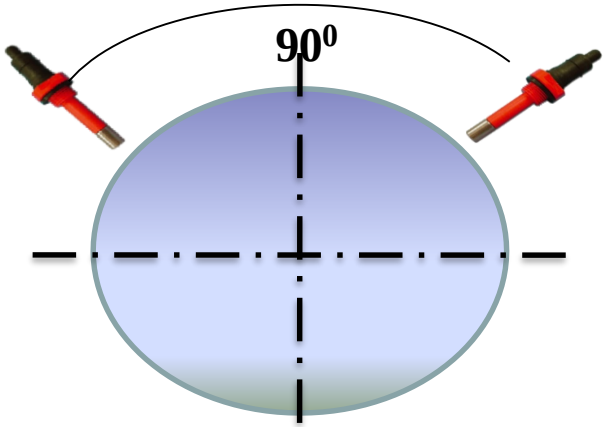
Oil responsible for expanding the hub

Oil responsible for pushing the hub

COMPRESSOR INSTRUMENTATION

- ***The instrumentation installed on centrifugal compressors is essential for checking their performance and activate a protection system if necessary.***
- ***Compressor manufacturers employ a variety of instruments for monitoring rotor radial vibration, axial displacement of the rotor and bearing temperature.***

PROBE POSITION & THERMOCOUPLE



Radial Vibration Probe

Journal thermocouple

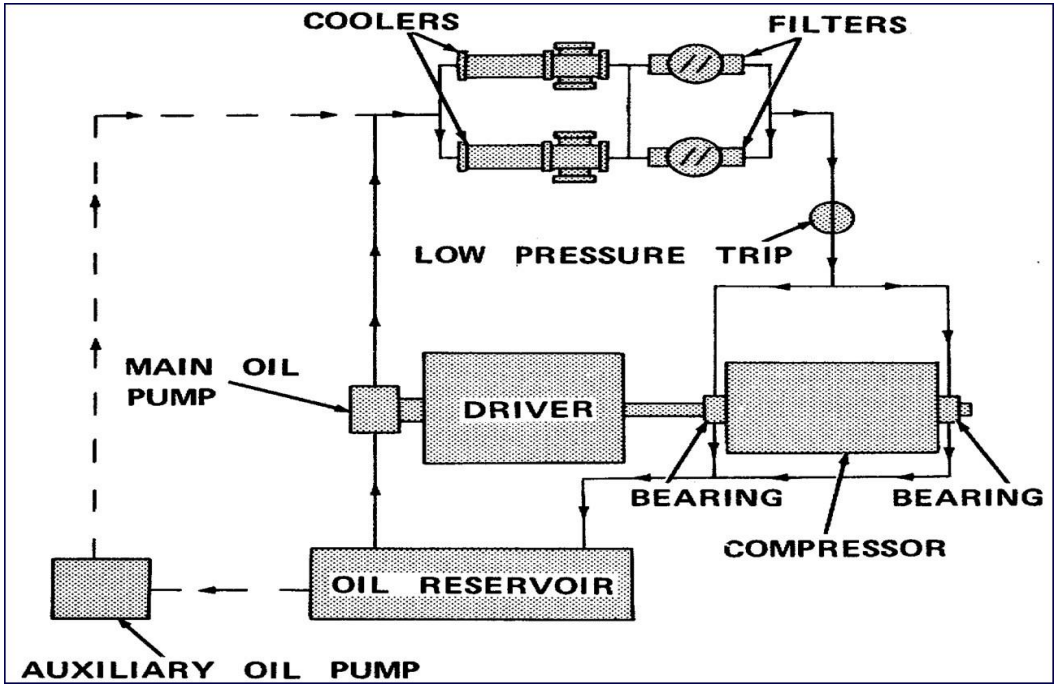
Thrust thermocouple

TEMPERATURE MONITORING

LUBRICATION CIRCUIT

- ***Oil Tank***
- ***Oil Pumps***
- ***Oil Filters***
- ***Oil Coolers***
- ***Pressure Control Valve (PCV)***

FORCE FEED LUBRICATION



SURGING

- *'Surging' is defined as 'A momentary back-flow' through the compressor from the discharge to the suction.*
- *Reversal rate is 30 to 120 cycles/sec*
- *Pressure rapidly fluctuates*
- *Noise generates*
- *Temperature increases*

INDICATION

- *Rapid flow fluctuations*
- *Rapid Pressure fluctuations*
- *Abnormal sound*
- *Temperature increase inside the compressor*
- *Shaft vibration*

Anti-surge

- ***Anti-surge protection is provided by a control valve which will either exhaust the gas or vapor from the compressor into the atmosphere, or recirculate it back to the compressor inlet.***