

MOTOR & MEP

NOTES

for

MEO CLASS 4 COC

SPECIAL THANKS To **SAMANT SIR** for his phenomenal efforts and expertise of the marine field.

Also THANKS to **JOEL PINTO** for your efforts in teaching us and making us understand the concepts well.

PUMPS

- * Pumps only transfer fluid from 1 point to another
- * The pressure builds up due to resistance in flow.

TYPES

- ↳ Positive Displacement Pumps
- ↳ Roto-Dynamic Pumps

CENTRIFUGAL PUMP

CLYDE

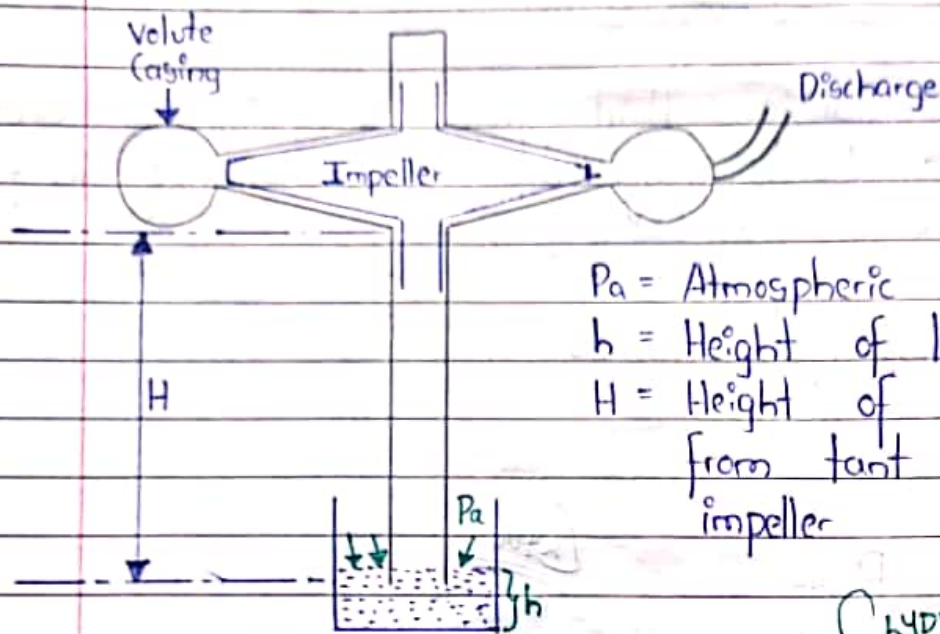
- * Rate of discharge is high
- * Direction sensitive pump
- * **Not require relief valve**
- * It can handle water & oils
- * But it cannot handle air

Application - SW pump
FW pumps
ICW pumps
LO pumps

- * Centrifugal pumps onboard have a volute casing
So as area increases, velocity drops but pressure increases
- * Hence we can say CF pumps convert **KE $\rightarrow$ PE**

Other types of casing are :

- vortex casing
- diffuser casing



P_a = Atmospheric pressure
 h = Height of liq in tank
 H = Height of suc pipe from tank to eye of impeller

* When p_r at eye of impeller is lesser than the p_r at suction pipe, then only the pump will be able to take suction

→ Pressure at suction = $(P_a + h)$

→ Pressure at eye of impeller = $(P_a + h) - \text{Losses}$

* Losses :

* Frictional losses → too many bends, valves, obstructions

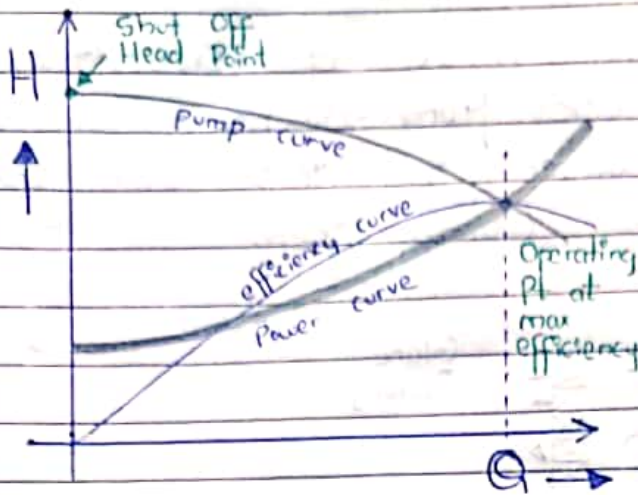
* Vapour losses → vapours given out by volatile fluids (LPG, LNG, petrol)

* Suction lift

* Now if $(P_a + h) - \text{Losses}$ is +ve, then only pump will be able to take suction. This is called Net Positive Suction Head.

H-Q Characteristics

CLYDE



* As flowrate goes on increasing, the head goes on decreasing

* This is because the frictional losses goes on increasing

* Also as the flowrate goes on increasing,

the power req to run pump also goes on increasing

* Hence if we start pump with discharge vlv open, more power is required to run pump & hence high starting current.

CAVITATION :-

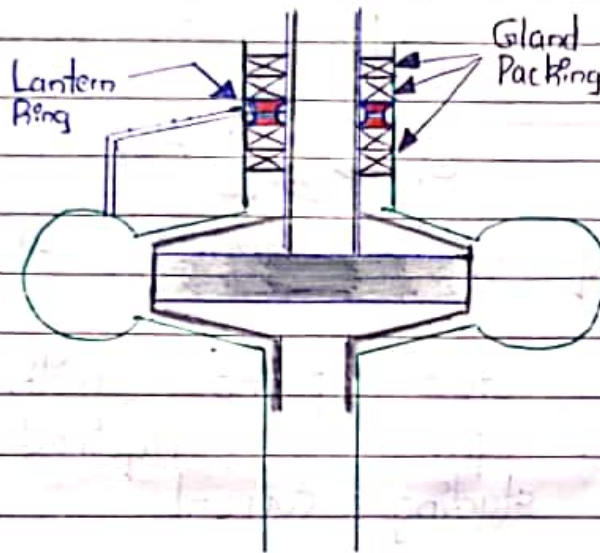
- Water can evaporate even below 100°C if the static pressure is low enough
- This will cause the pressure to fall below vapour pressure leading to formation of bubbles
- These bubbles go and collapse where pr is above the vapour pressure and like that several bubbles collapse causing damage

Factors causing cavitation

- ① High impeller speed
- ② Small dia of suc pipe
- ③ High temp of fluid
- ④ $\text{NPSH}_r \geq \text{NPSH}_a$

Lantern Ring :-

- * It is a hollow ring made of brass/tflon which receives water from discharge of pump and allows this water to drop over the gland packing thus cooling them



CLYDE

Gland Packing :-

How to cut

- Cut with a sharp knife
- Do not cut with hacksaw or blade to avoid fraying of the edges
- Cutting can be done either

* Skive cut



45° Cut

* Butt cut



90° Cut

How to remove gland packing

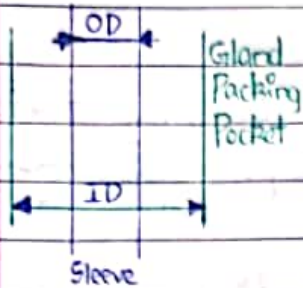
- It can be removed either by gland extractor or a cock screw



Cock Screw

How to select packing size & material.

- For SW/FW pumps = Hemp packing
- For high temp oil pumps = Graphite packing



$$= \frac{OD \text{ of sleeve} - ID \text{ of gland pocket}}{2}$$

- Clean the gland pocket well before inserting the new gland
- Never reuse the gland packing.
- Always tighten gland when pump is running to check the leakage.
- Always allow for drop by drop leakage in a controlled manner.
- This will ensure the packing is neither too tight nor too loose.

Mechanical Seal :-

- There are 2 parts of a mechanical seal
 - ① Moving part (carbon or graphite)
 - ② Stationary part (ceramic or silicon carbide)
- Both surface have a smooth seal surface over each other.
- Mech seals are costly but unlike packing, they have a longer life.

Condition to decrease efficiency of CF pump

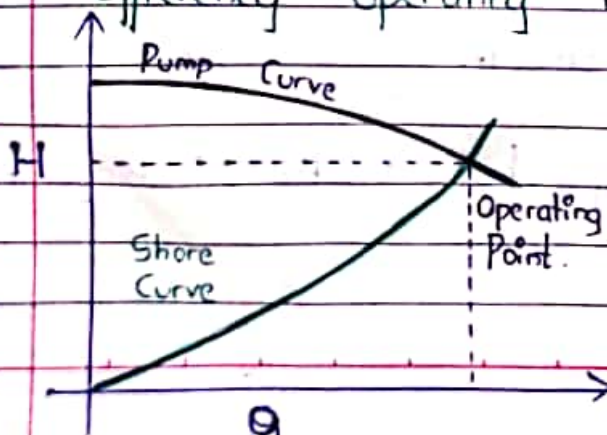
- ① Heat generated due to packing
- ② Rubbing betⁿ wear rings & more impeller-casing clearance
- ③ Throttled discharge vlv
- ④ Double volute design
- ⑤ Corroded internal pump passages causing turbulence
- ⑥ Obstructions, restrictions inside pipe passages

Why CF Pump Does not have relief vlv?

- because by seeing the H-Q characteristics, we already know the max pressure (head) which will build up when the discharge vlv completely shut.
- So pipeline, casing etc are made taking into consideration this max. pressure

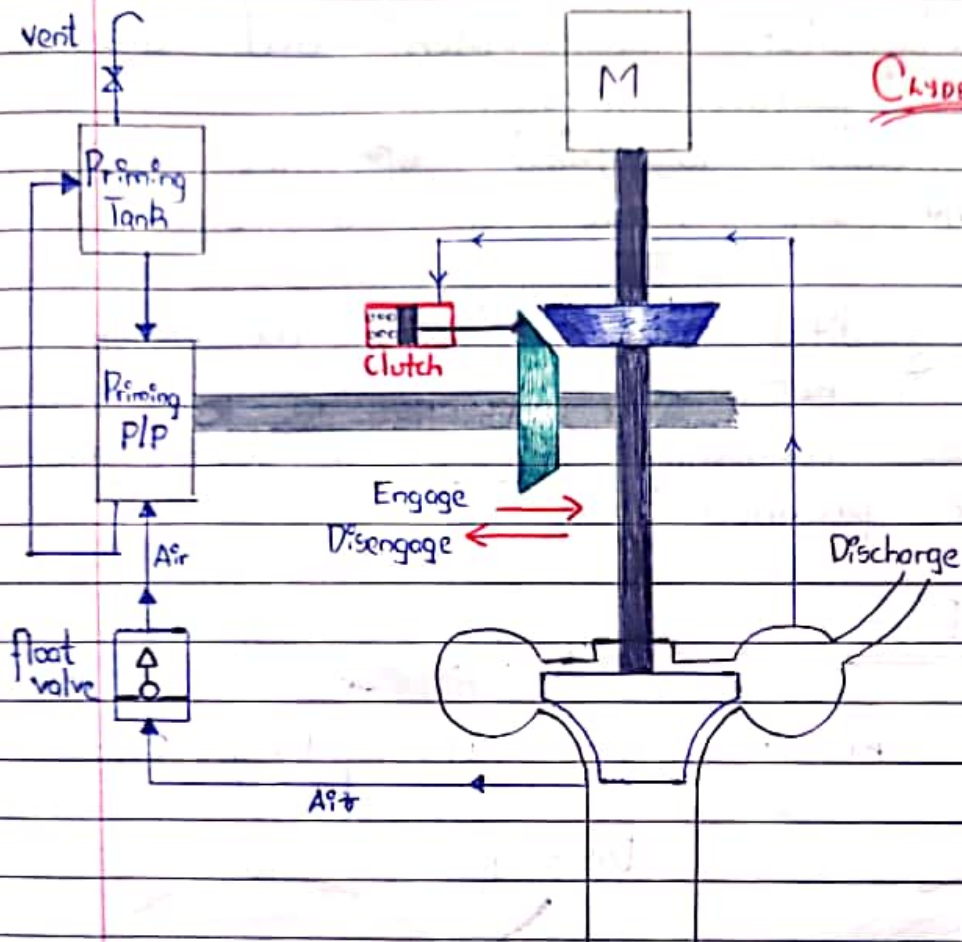
What is Pump-Shore Characteristic Curve?

- Whenever we go to various ports to discharge, our shore characteristics keeps changing because sometimes tanks of shore are nearby & sometimes far away.
- So before starting discharge, this curve is analyzed taking these factors into consideration & allowing p/p to run at the max efficiency operating range.



- A set rpm is decided in order to get max discharge
- This characteristic is imp for discharge pumps of tankers.

Self Priming Arrangement for CF Pump



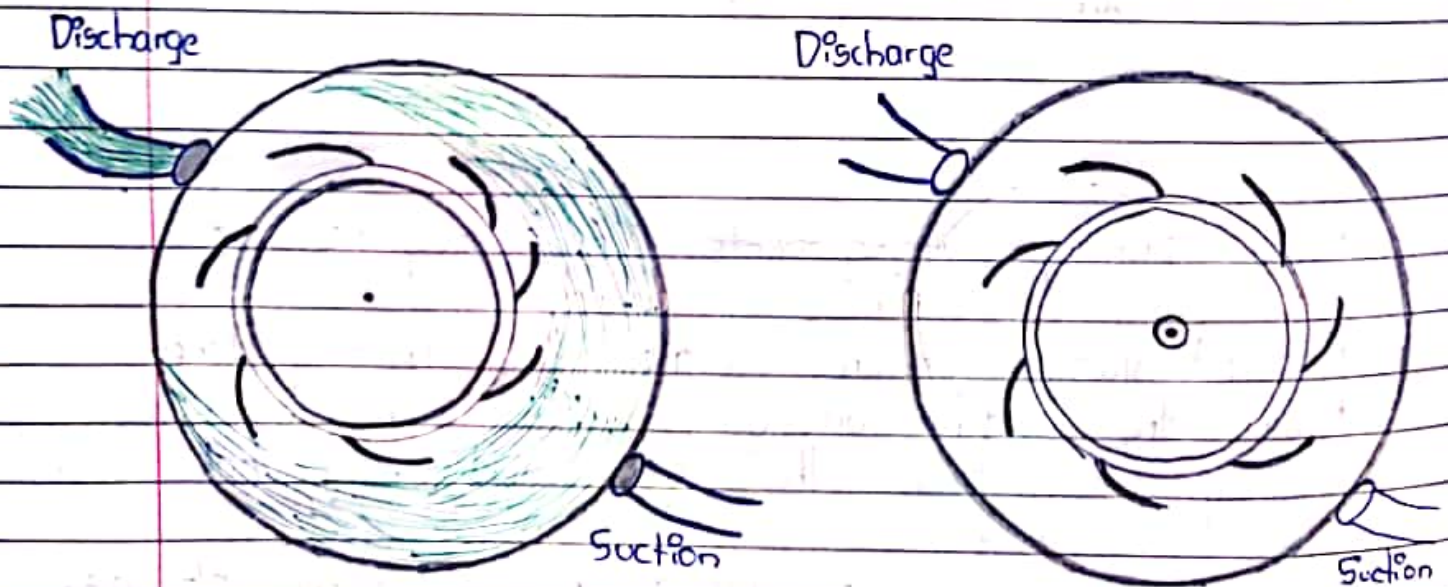
- * Self priming arrangements are required for **emergency fire pump onboard**.
- * First always ensure water in Priming Tank
- * Now the clutch arrangement is such that, the spring will push the gear and now both gears are in mesh.
- * So as the CF p/p rotates, now priming p/p also rotates
- * Priming p/p is usually water ring pump
- * Now this p/p will suck air from p/p through a float valve & deliver it to tank.
- * At the tank the air is constantly removed

- * Once this happens, the plp casing will start completely filling with water.
- * Now discharge of plp will go & act against spring of the clutch and dis-engages the priming plp.
- * Also since water is filled up, the float of float vlv will move up & block the discharge.
- * In stopped condition, the priming mechanism is engaged & kept.
- * We can also manually engage & dis-engage by a lever provided.

CLYDE

Water Ring Pump

- * It is also known as vacuum ring pump



- * When the rotor center and the casing center are concentric, the plp will be ideal & no suction / discharge will take place.
- * Once the rotor becomes eccentric from casing center, the suction & discharge will take place.

Types Of Impeller



- ① Fully closed impeller (Double shrouded)
- ② Semi closed impeller (Single shrouded)
- ③ Open impeller (No shroud)

Material Of Impeller

- * For SW Impeller & Casing - Brass
- * For FW Impeller - SS & Casing - Cast steel

Boiler Feed Water Pump

2 or more impellers in series to increase pressure

(NPSH)_{available} should always be more than (NPSH)_{required}

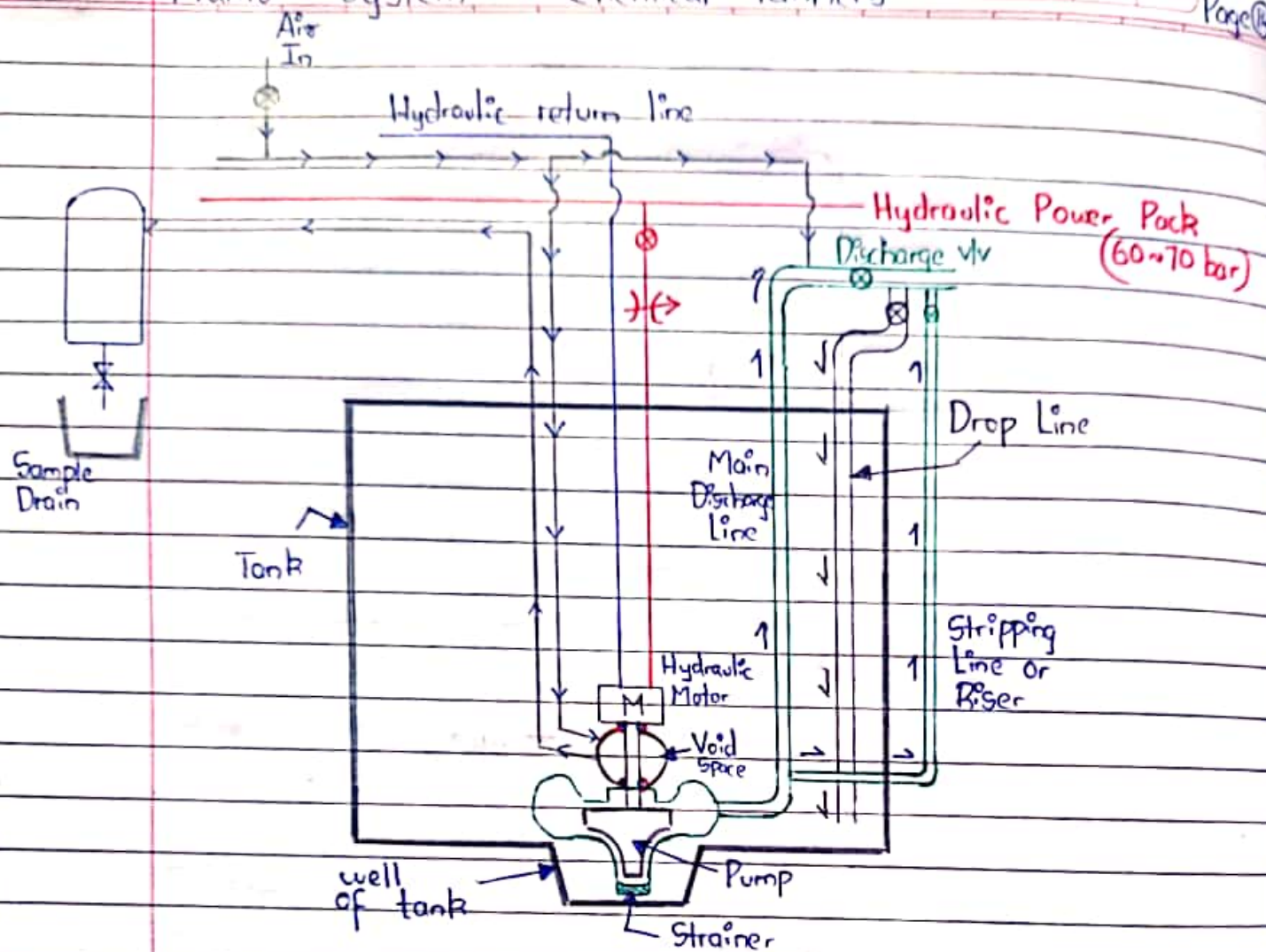
- $NPSH_r$ = design npsb
- $NPSH_a$ = depends on where we fit the pump

Frans System → Chemical Tankers

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- * This is a submerged CF pump
- * The hyd power pack controls the speed of pump
- * As level in tank goes down, discharge vlv has to be throttled & pump to be run slow
- * For stripping, main discharge vlv kept closed & air connection is given, so the pump will now deliver discharge chemical to stripping line
- * Betⁿ p/p seal & hyd motor seal, there is a void space or cofferdam.
- * In this space, air is blown through & collected in tank to ensure hyd oil & cargo is not mixed.
- * Sample drain should be empty.

RECIPROCATING PUMP

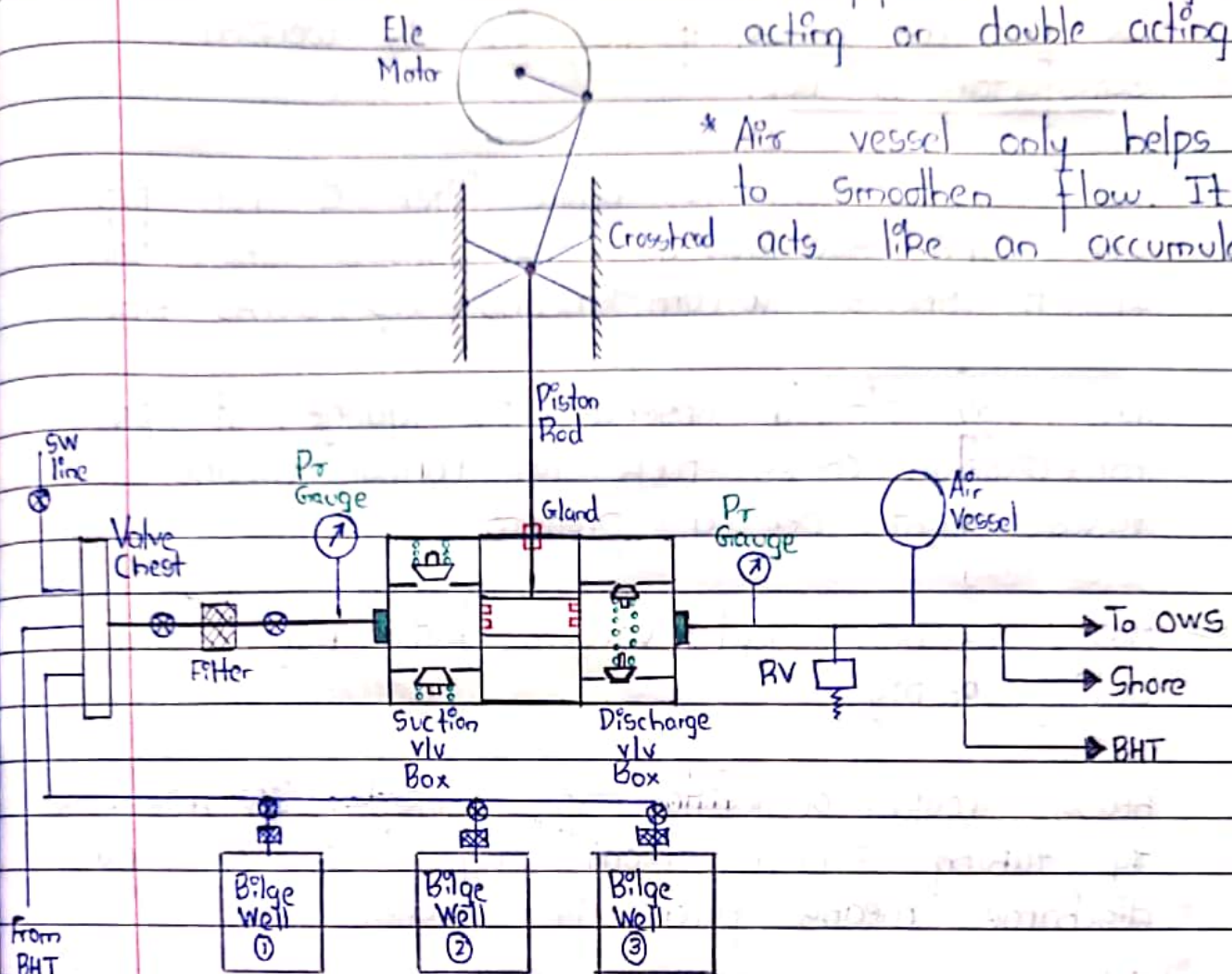
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* This plp can be single acting or double acting

* Air vessel only helps to smoothen flow. It Crosshead acts like an accumulator.



* When piston moves down, top suc vlv will open & fill area above piston.

* At same time as piston comes down, bottom discharge vlv will open & discharge

* Vice-versa happens when piston moves up.

* This plp does not require priming

* It provides a smooth flow & no churning

* It is not a direction sensitive pump.

* But rate of discharge is very low of this pump

Case ①

We started plp, but bilges not getting empty

So first we check, if our plp is working satisfactory or not.

So close suction vlv before filter & run plp. Check the suc pr gauge. It should show vaccum. If it shows vaccum means. Plp works fine

Now stop plp & observe pr gauge, if pr immediately comes back to normal means valves might be a problem

Case ②

Now we have good vaccum, but bilges not getting empty

Reason could be filter is choked. In this case try taking suction from any tank, but no discharge means filter is choked.

Case ③

Now you are able to empty bilge well ①. Then you changed over to bilge well ② & now no discharge takes place.

This can be due to bilge well ① vlv still kept open & plp has sucked air or bilge well ② filter is choked

Case ④

If you open valves of bilge well ① & ③, plp develops vaccum. but after opening vlv for bilge well ②, vaccum drops

This means bilge well ② filter leaking

Case ⑤ All valves and filters of all bilge wells are OK but still plp cannot develop vacuum.

This clearly indicates, air in system due to hole in pipeline

In this case, remove the common main line NR valve, close suction to pump & start the SW.

SW will go in entire line & where hole is there, water will start coming out.

Pipeline Holed

- Devcon
- Cordobond
- Cycle tube
- Rubber piece with jubilee clamp
- Cement box

Used as, Bilge plp

GEAR PUMP

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- * It consists of 2 gears

Drive Gear

Driven Gear

- * Both gears are made of case hardened steel

nitriding, carburising, cyaniding → Case Hardening Methods

- * It can handle air, oils of various viscosity
- * It does not require priming
- * It cannot handle water as gears will get overheated and damaged

Used as , Fo transfer plp
LO transfer plp
AE attached plp for LO

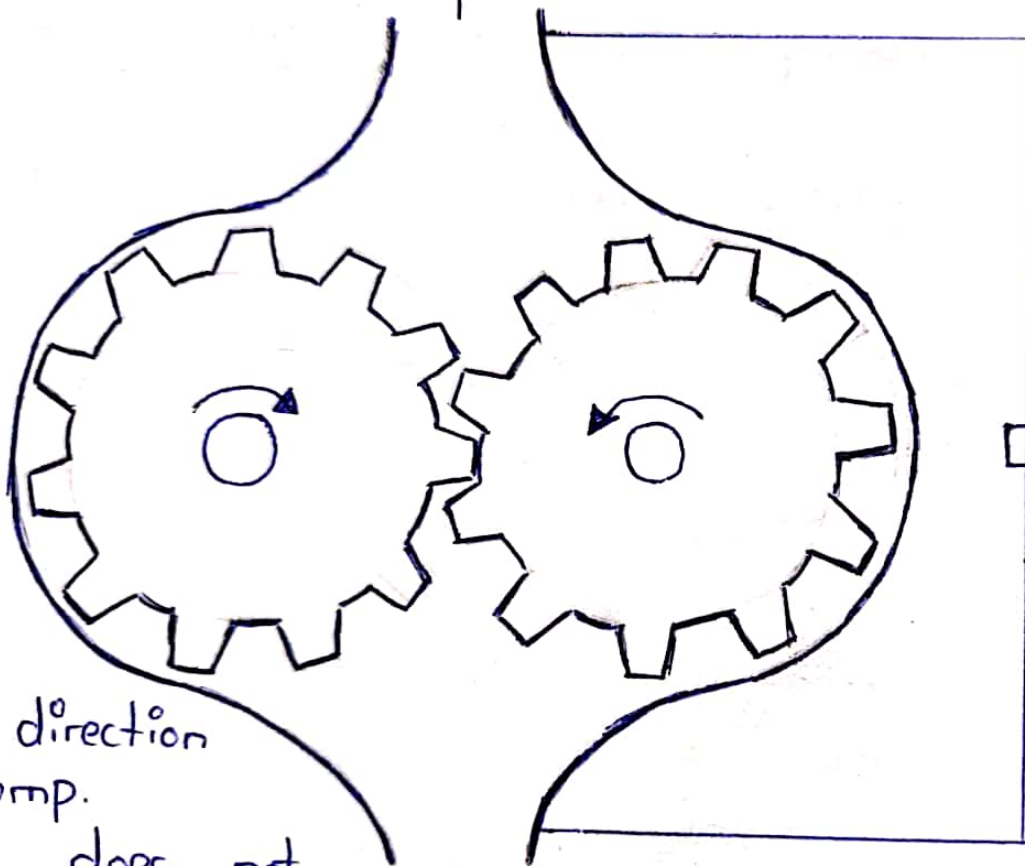
- * In this plp, flow can be controlled by flow control valve
- * This plp also has a relief valve

ump

s
ment
ch
o oil
a direction
pump.
ump does not
priming.

ef vlv is provided

Discharge



* Gears are supported by bush bearing.

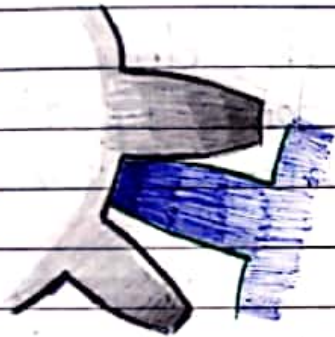
Gears - Nitride steel
Casing - Cast steel

* It is a positive displacement pump

Maintenance

- * Clearance betⁿ casing & gear should be checked
If clearance increases, discharge will drop
as liquid will try to go back.
- * So remove the casing & driven end &
use feeler gauge betⁿ gear teeth & casing.
- * Also remove & pr test relief valve

BACKLASH



- * Backlash need to allow for expansion due to heat
- * If no backlash, teeth will damage or motor will overload.

Method ① - Pass a lead wire betⁿ 2 teeth & measure the thickness of pressed lead wire

Method ②
- Feeler Gauge method

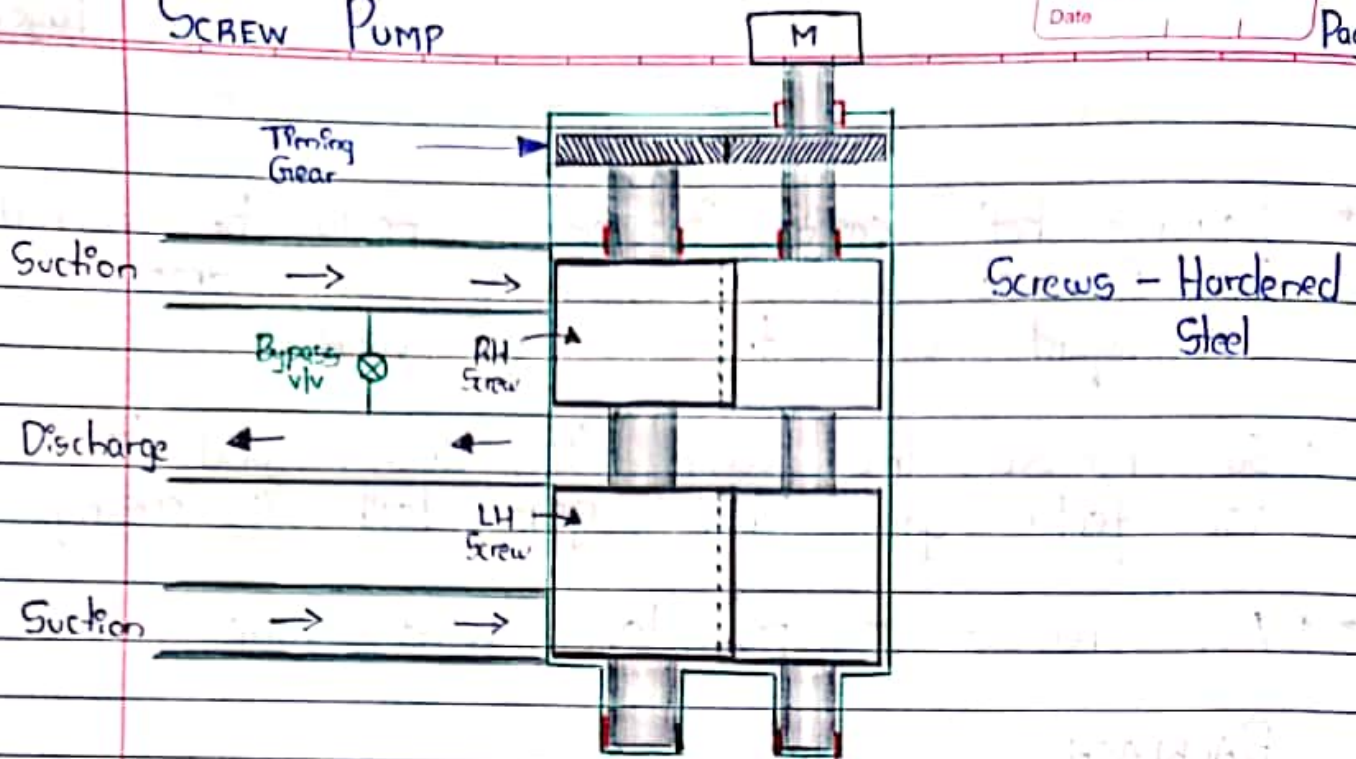
- * Without any method, hold one gear & move the other, if it moves means plp has backlash

SCREW Pump

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- * Screws are not driving each other.
- * The driving job is being done by timing gear
- * Timing gears help to synchronize movement of both screws

* If timing gears are not properly fit, the suction & discharge will be affected.

* This plp generally used for very high viscosity fluids.

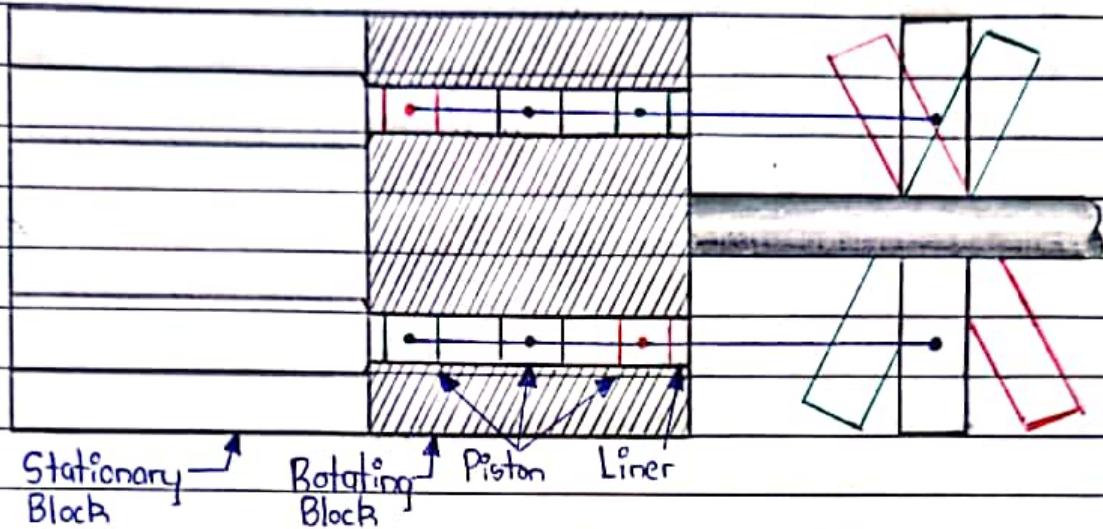
Maintenance

→ Clearance betⁿ screw & casing must be checked

Used as , Fo transfer pump
Cargo pump.

AXIAL DISPLACEMENT Pump

- It is also called Swash Plate Pump



- * It consists of 2 blocks, stationary & rotating
- * As swash plate tilts from 1 side to other the pistons in moving block are either pulled or pushed.
- * When the swash plate is stationary, there is no suction nor discharge
- * As the swash plate turns to green side the piston on top will undergo suction & piston at bottom will undergo discharge
- * As the swash plate turns to red side the piston at bottom will undergo suction & piston at top will undergo discharge.
- * Max angle of swash plate is 22°
- * Quantity & direction of flow can be changed
- * Constant speed unidirectional pump.

RADIAL DISPLACEMENT PUMP

- It is also called Hale-Shaw Pump.

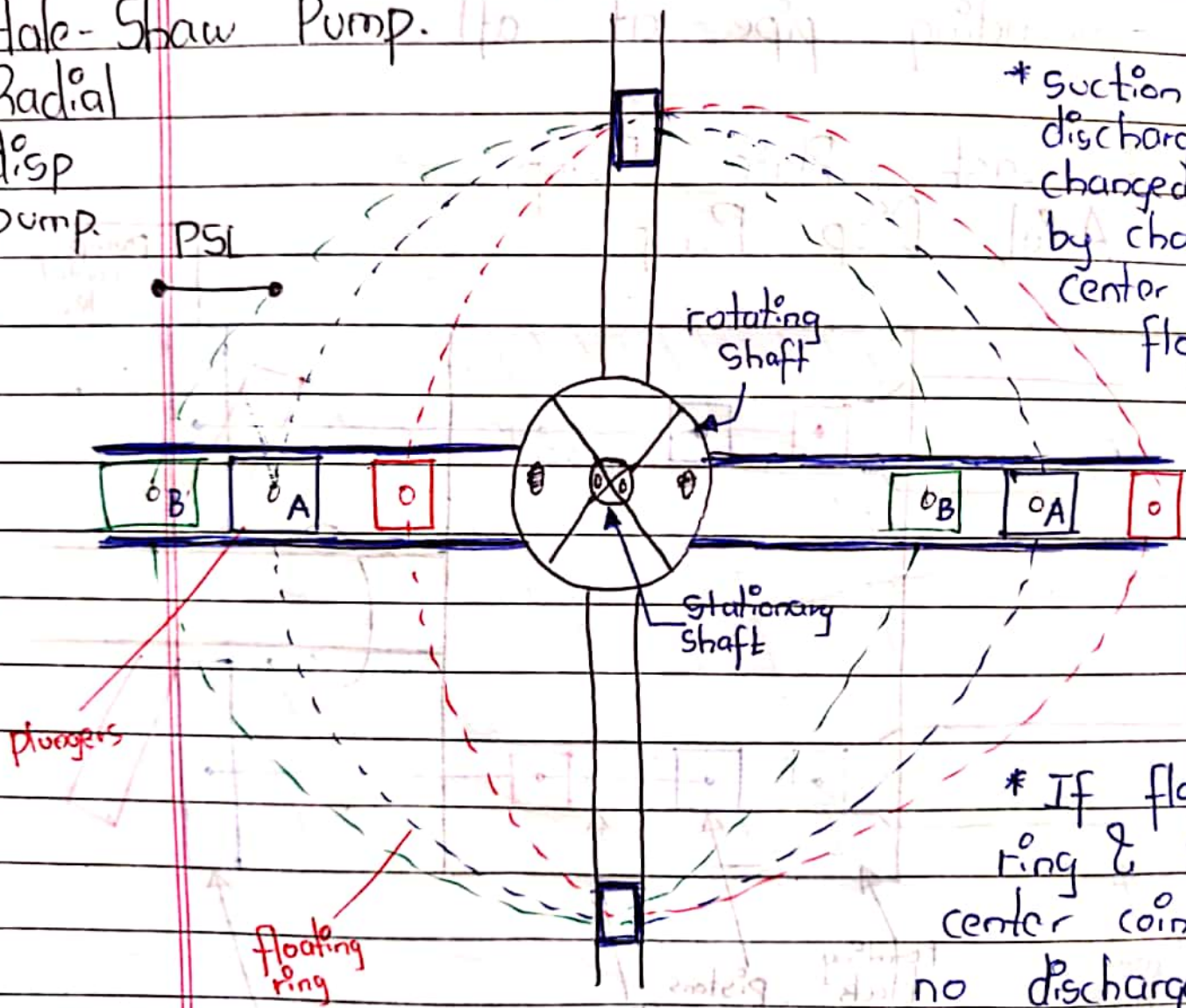
- * This pump consists of a floating ring.
- * If floating ring center & shaft center coincide there won't be any discharge.
- * Once the floating ring becomes eccentric, the suction & discharge will take place.
- * When plunger is away from center, suction will take place.
- * When plunger is towards the center, discharge will take place.
- * Quantity & direction of flow can be changed.
- * Constant speed unidirectional pump.

Hale-Shaw Pump.

Radial
disp
pump.

PSI

* Suction & discharge is changed just by changing center of floating ring.



HEAT EXCHANGERS

- As the name suggests, HE works on principle of heat transfer.
- The amount of heat transfer shows the efficiency of heat exchanger.

Rate of Heat Transfer (Q) = $u \times A \times n \times \Delta t$

u = Overall coef of HE

which depends on material of tubes/plate

A = Surface area

n = No of turns / passes

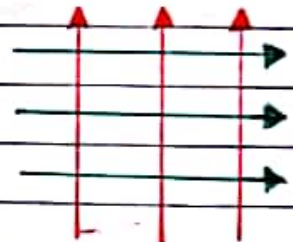
Types of Flow in HE



Parallel Flow



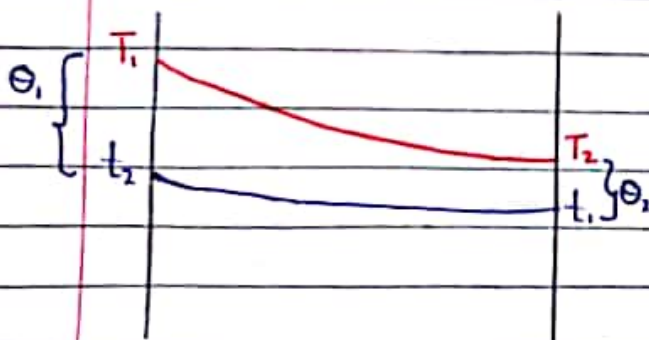
Counter Flow



Cross Flow

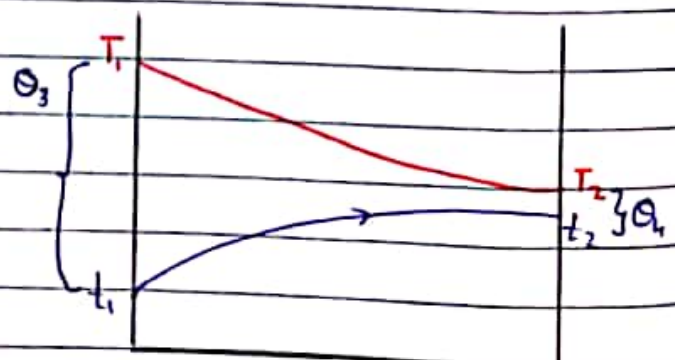
LMTD - Log mean temp difference

Higher LMTD better will be heat transfer



Counter Flow

Here $\Theta_1 > \Theta_2$



Parallel Flow

Here $\Theta_3 \gg \Theta_4$

$$LMTD = \frac{\theta_1 - \theta_2}{\ln \theta_1 / \theta_2}$$

Temp difference at either ends of HE = $\theta_1 - \theta_2$

$$LMTD = \frac{\theta_1 - \theta_2}{\ln \theta_1 - \ln \theta_2}$$

$$LMTD = \frac{\theta_3 - \theta_4}{\ln \theta_3 - \ln \theta_4}$$

- * LMTD of counterflow >>> LMTD of parallel flow
- * Hence in marine industry we mostly use counterflow as heat transfer rate is faster.
- * LMTD is logarithmic avg of temp difference betⁿ hot & cold fluid at each end of HE
- * Parallel flow is preferred in food processing industry

Types Of Fluid Flow

① Laminar flow :-

Here no pressure to flow but it forms a boundary layer at surface resulting in scale formation & deposition at layer.

② Turbulent flow :-

Here this is pressure to flow so no deposits but due to high velo it causes erosion of tube materials.

- * Reynold's no. will determine if flow is laminar or turbulent
- * We do not want laminar nor we want turbulent
- * Our flowrate to be approx $2\text{ m/s} \sim 3\text{ m/s}$

SHELL & TUBE HE

tubes = Al Brass, Cupro-nickel

tube plate = Cast naval brass

Casing = CI or gunmetal

baffles = Copper or rolled naval brass

sacrificial anode = Zinc

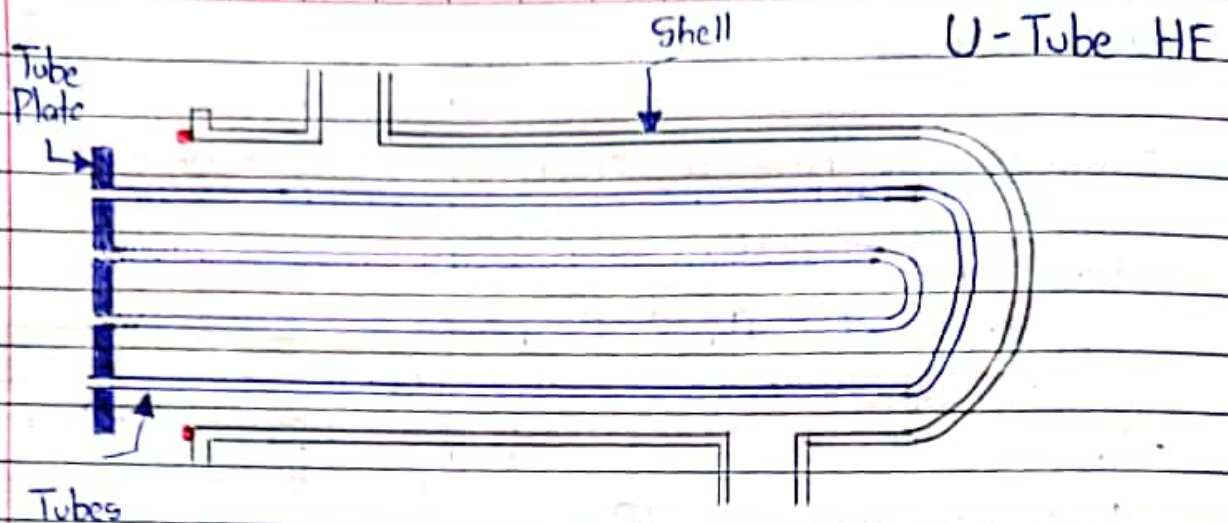
- ↳ U type HE (here we can remove entire tube stack)
- ↳ Fixed tube HE (tubes fixed to shell on both sides)
- ↳ Floating tube HE (tubes fixed to only 1 end)

Purpose Of Baffles

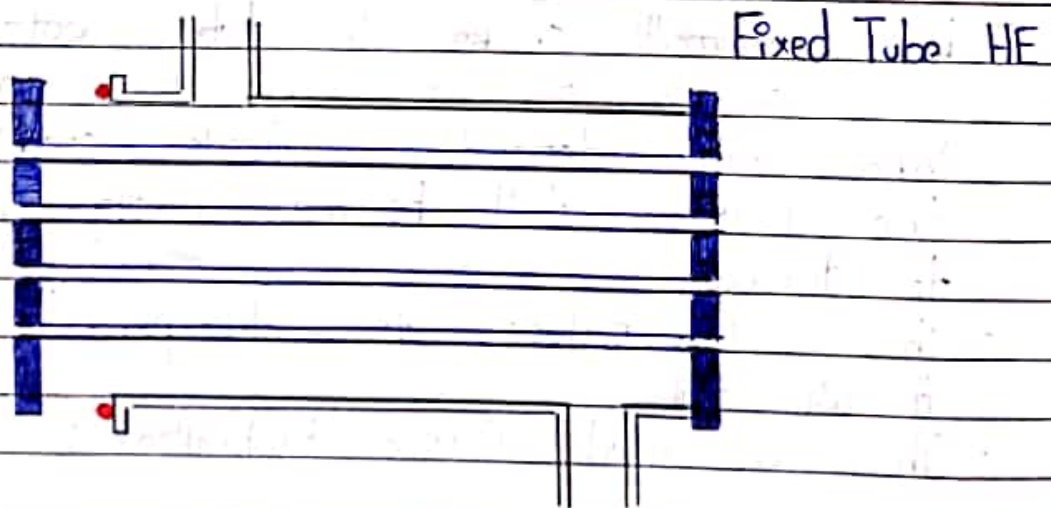
- * Gives rigid structural support to tubes
- * Increase dwell time
- * Increases heat transfer

Causes Of Tube Failure

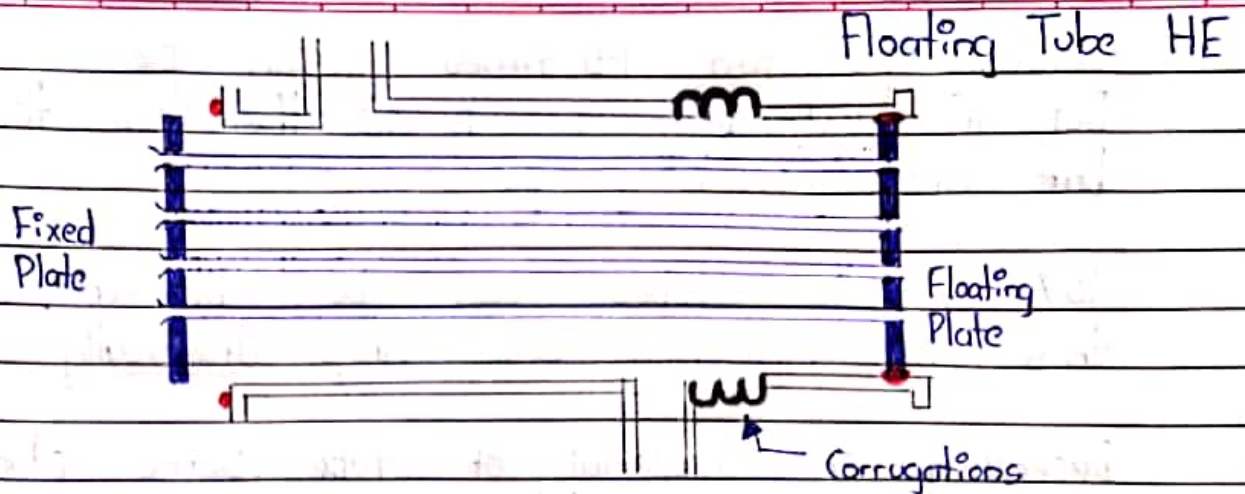
Corrosion, erosion, pitting, thermal stresses, cavitation, water/steam hammering, vibration/resonance



- We can take out entire tube stack & dip this into sulphuric acid for cleaning.
- Similarly shell can also be cleaned in place when tubes are removed.



- Here we cannot remove the tube stack.
- We can only insert a brush or wire to clean tubes.



- Here tubes are shrink fit and there is a floating plate on 1 end to take care for expansion.
- There are corrugations on shell to take care for expansion.

How To Detect Leaks

We can open the drain of shell to check for leak in tubes but exactly which tube is leaking we have another method.

- * Remove end cover
- * Drain tubes & shell
- * Blank shell outlet
- * Now from inlet fill the shell with working medium
- * Clamp removal end to face of shell
- * Use a +ve disp pump & start pressurizing the shell with a well calibrated pr gauge 1 bar above working pr
- * Now whichever tube is holed, liquid will start coming from that tube

- Generally pr test 1.5 times design pr
- But if equipment is old, the pr test 1 bar above working pr

10% of the tubes can be blanked, after this HE efficiency will drop drastically.

Depending on material of tube, same plugs are used to plug tube

- Cu plugs
- Brass plugs

PLATE TYPE HE

plates = titanium, aluminium or titanium brass
plates are corrugated for higher strength & surface area
rubber = nitrile rubber

Thickness of plate = 0.5 ~ 0.8 mm

Distance betⁿ plates = 3 ~ 5 mm

Cleaning Of Plates

- Insert tubes/plates in a bucket of SAF acid & clean with soft plastic brush
- Make sure you remove gasket & clean properly. & once cleaned, stick gasket back again.

- Q How to find out which plate has leakage/hole?
- Place the plate in front of a bright light & observe from other end

Tubes $\rightarrow$ Brass or Al Bronze
 Shell $\rightarrow$ Ordinary steel

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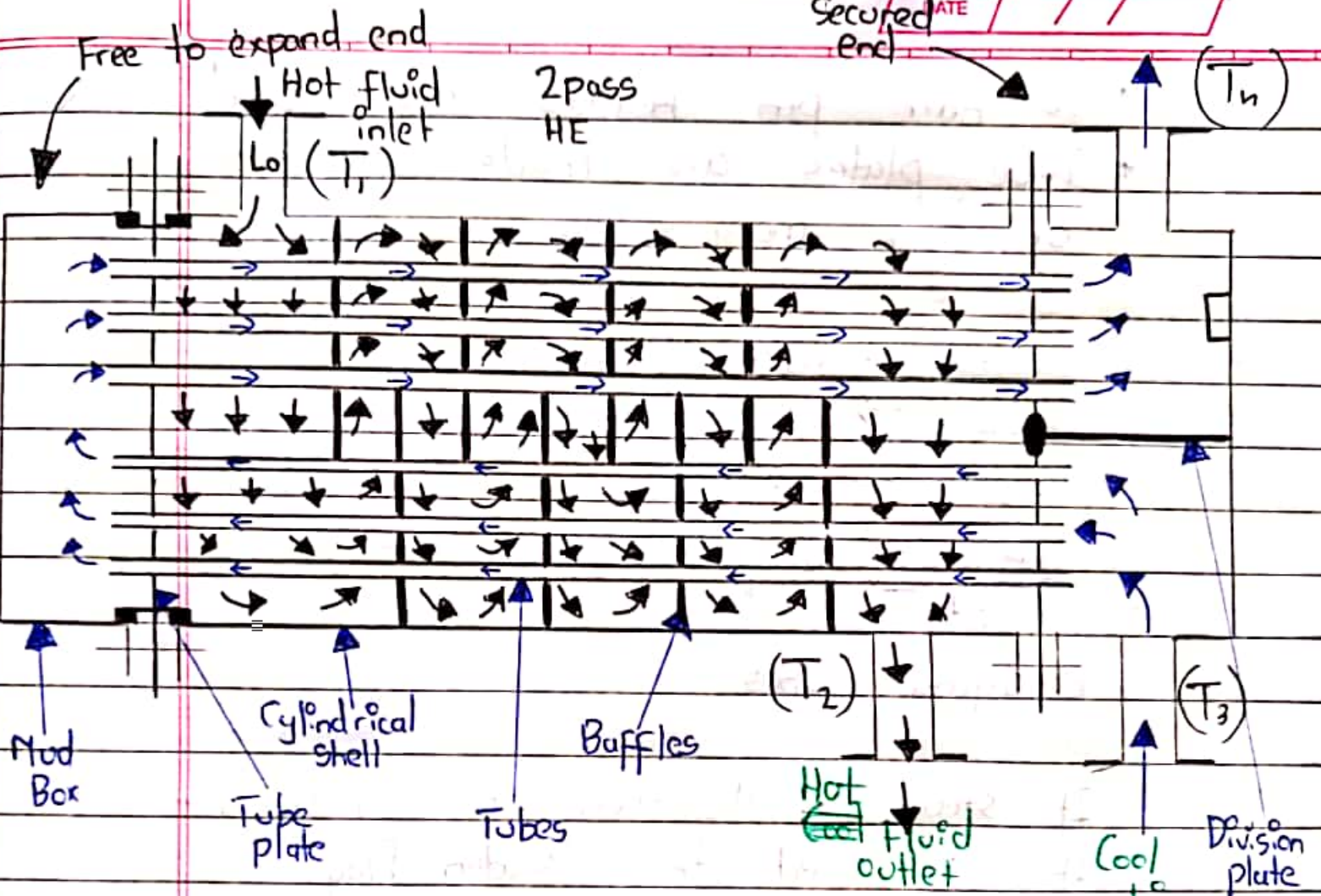
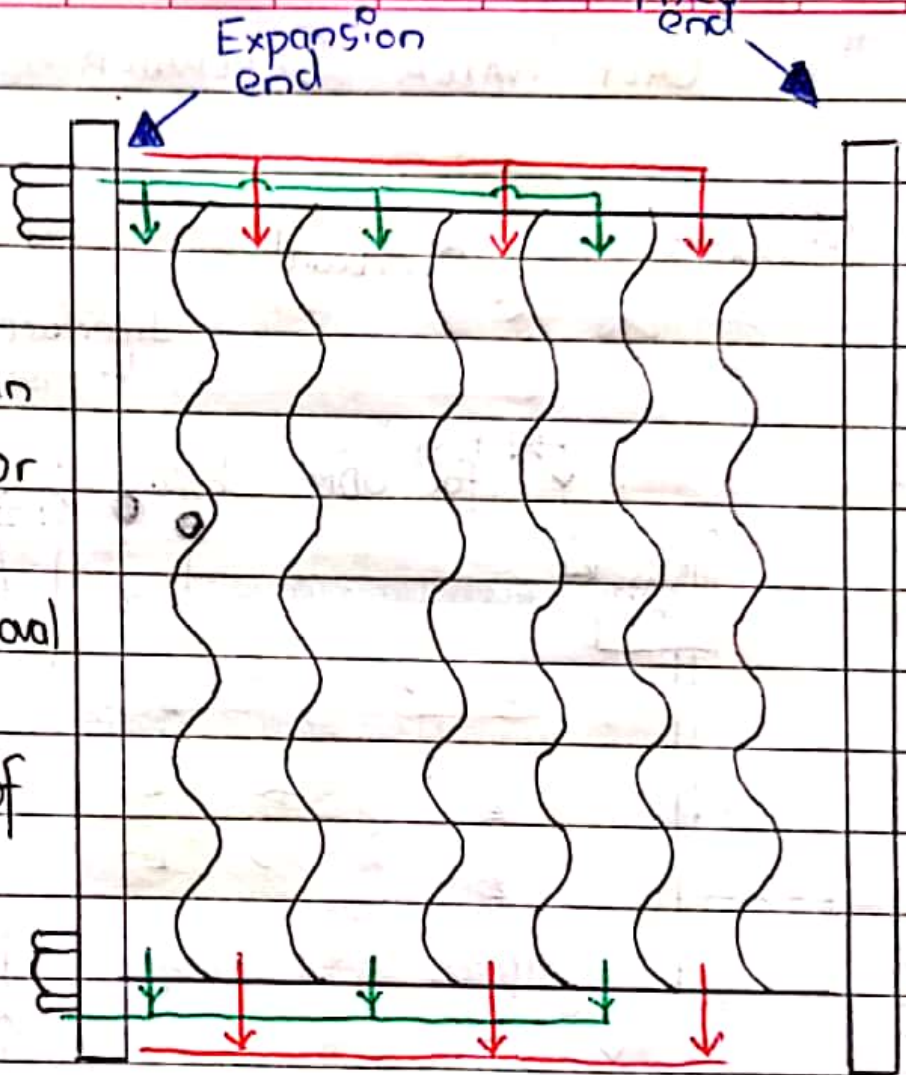


Plate Type

- * Plates are corrugated type
- * Heat transfer can be increased or decreased by addition or removal of plates
- * Plates → Made of titanium & helps to avoid corrosion.



- * But this makes pipes as anode & corrodes it.
- * Once plates are fouled, the plates need to be submerged in descaling compounds.

WELDING - Joining Of Metals

Clyde

TYPES

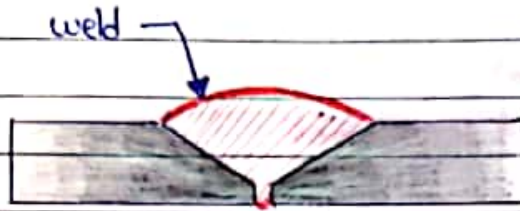
- ↳ Gas welding { $2500 \sim 3000^{\circ}\text{C}$ }
- ↳ Electric Arc welding { $5000 \sim 6000^{\circ}\text{C}$ }

In welding, the base metal & filler metal melts to get a homogenous weld of high strength

Safeties :-

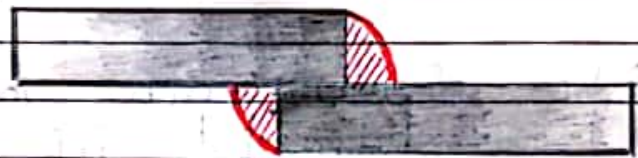
- ① Wear insulated rubber shoes
- ② Ensure fully body PPE
- ③ Wear goggles to protect your eyes
- ④ Make sure your clothes are dry.
- ⑤ Wear welding apron to avoid damage from sparks.
- ⑥ Make sure earthing is properly done
- ⑦ Ensure no combustible material near work
- ⑧ Make sure a portable fire extinguisher is ready.
- ⑨ Do not start work without risk assessment, tool box meeting & work permit.

Types Of WELDING JOINTS

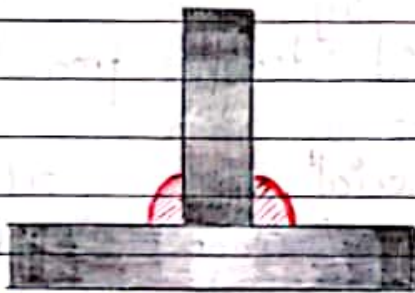


BUTT JOINT

CLYDE



LAP JOINT



TEE JOINT



CORNER JOINT

- * For welding we use a current transformer to obtain low voltage & high current.

But for boiler burner, we use low current, high voltage 25,000 V

- * This is because in welding we need the high current for longer time.

Q AC or DC for welding? CLYDE

- Both can be used but AC is most widely preferred.

- * In AC, we can step up or step down voltage & current but this cannot be done in DC

- * AC weld has good quality weld than DC as current fluctuates from + to - & - to +. So welding rod or job doesn't get overheated.

- * AC easily available on ship

AC welding rod is bigger than DC welding rod

TYPES OF ELECTRODE

Mild Steel

Stainless Steel

Bronze

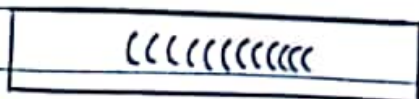
Nickel ferrite

Q How To Select Welding Rod?

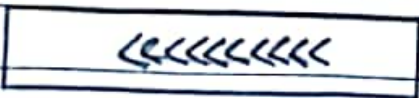
- material of welding rod will depend on metals we are welding.
- thickness of welding rod will depend on thickness of metals.
- * For welding steel metals - GP welding rod
- * If you have thick metals & you have selected a thin welding rod, now you will need more current to melt the base metal.
- * This will result in overheating.
- * Hence proper selection of welding rod is mandatory.
- * Also we need to adjust current also accordingly depending on type and thickness of metal.

Generally,
40~50V
20 Amps

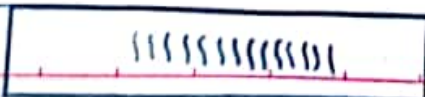
Before starting welding, check by doing a Test Weld.



Current : Normal

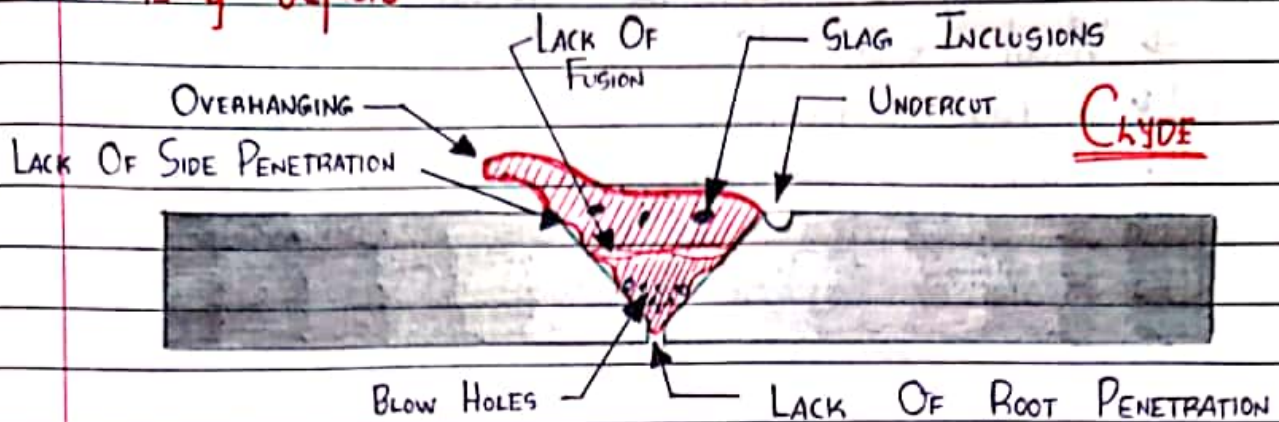


Current : Too High



Current : Too Low

Welding Defects



- ① Undercut - welding rod held at this place for a longer time thus cutting base metal & also high current
- ② Overhanging - due to low current
- ③ Lack of root penetration - welding rod too big or current too low
- ④ Slag inclusions - after 1 layer of welding, welder has not cleaned the joint & hence slag will form.
Slag forms due to flux coating of welding rod
- * When welding rod melts, the flux also melts and provides an envelope of inert gas which prevents oxidation of weld
- ⑤ Lack of fusion - High speed welding or low welding current
- ⑥ Blowholes - This mainly happens when welding rod or joint is wet
- ⑦ Splatter - Too high welding current or oil/water near joint. making drop of weld on surface

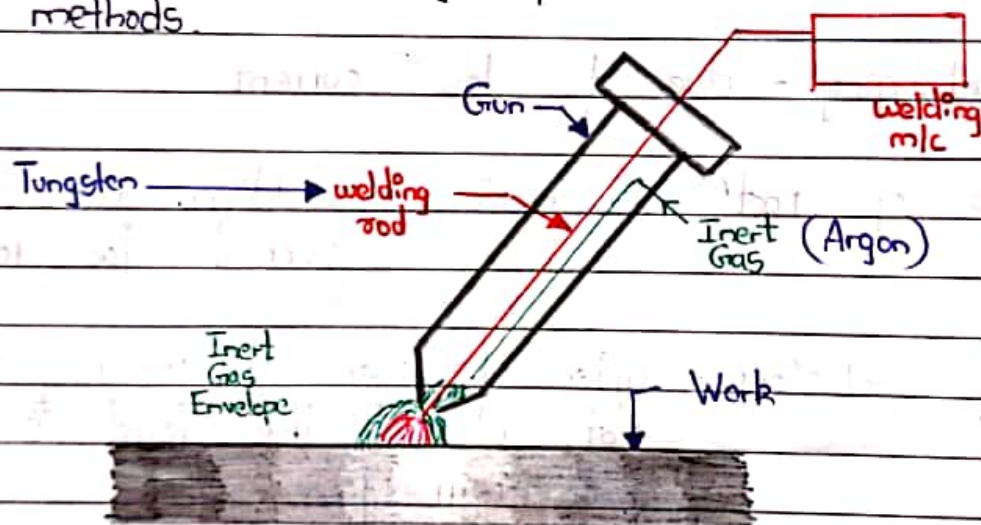
* Welding defects can be found by

- ↳ Visual examination
- ↳ X-ray technology
- ↳ Ultrasound testing
- ↳ DP testing
- ↳ Magnetic particle testing

* Tungsten inert gas welding

* Metal inert gas welding

We can achieve v high precision welds with this methods.



* Here arc made by electrode does not come in contact with air as it is shielded with inert gas

* In TIG welding, the welding rod does not melt but in MIG welding, the welding rod melts

* Here no need of flux

* In MIG welding, same electrode is used as that of base metal

* In TIG welding, DC current is used.

Flux

↳ Acid flux

↳ Alkaline flux

Which flux to be used will depend on material, current & welding temp.

Q How to weld CI metals

- * Here we cannot use GP electrode (mild steel) as it will result in formation of cracks
- * So we use (Ni-Fe) Nickel Ferrite electrode for CI welding
- * Firstly the joint has to be preheated by gas torch but not redhot.
- * And this with special electrode (Ni-Fe) & high current, we weld the CI metal.

WELDING TECHNIQUESCLYDEButt Welding

1G :- when plate is horizontal

2G :- when plate is vertical (weld horizontal)

3G :- when plate is vertical (weld vertical)

4G :- overhead welding.

Similarly for

Lap Welding

1F

2F

3F

4F

Pipe Welding

1G

2G

5G

6G

Q. Can we weld 1 thick & 1 thin metal & how?



- Firstly heat by the joint edge of thick metal & now strike the arc
- Select electrode as per the thick metal.
- Aim the arc at the taper of thick metal

Q Can CI & SS be welded?

- Yes but with a Ni-Fe electrode
- If you use CI rod, carbon will get deposited in weld making it brittle.
- Do small welds, then clean surface with wire brush & then hammer the weld to induce compressive stress in weld.

GAS Welding

- * It consists (O_2) Oxygen cylinder & (C_2H_2) Acetylene cylinder
- * Acetylene is a gas dissolved with acetone & stored in cylinder.

Perforated
honeycomb
structure
where
acetylene
is stored



Acetylene
Bottle

* This bottle has always to be kept in vertical position.

* Also when we open the bottle it has to be opened gradually, otherwise rate of evap. of acetylene from liquid to Gas will be so high that heat is generated & explosion can take place

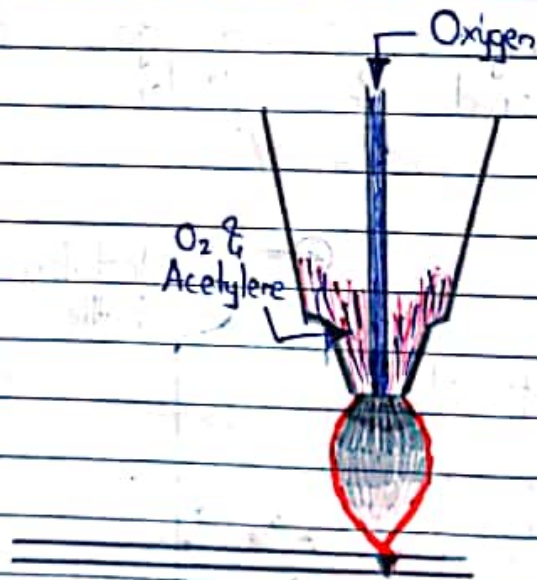
- * Do not drop, roll or hammer this bottle
- * Acetylene bottle has left hand thread
- * Oxygen bottle has right hand thread

- * Oxygen bottle — Blue Colour
- * Acetylene bottle — Red Colour
- * In acetylene line, there is a flash back arrestor which acts as NB valve
- * Flash back arrestor is fitted with a lever to enable them to easily reset after operation
- * Clean acetylene & O_2 nozzles with emery paper & pin

Gas Cutting Principle

- When a ferrous metal is heated to red hot condition & then exposed to pure O_2 , a chemical rxn takes place betⁿ heated metal & oxygen.

- Due to this oxidation, large amount of heat is produced & cutting takes place



- * When O_2 & acetylene flame established, open knob for pure O_2
- * This will increase pressure & oxidize metal & cut metal

Brazing :- Joining of 2 metals without melting base metal.

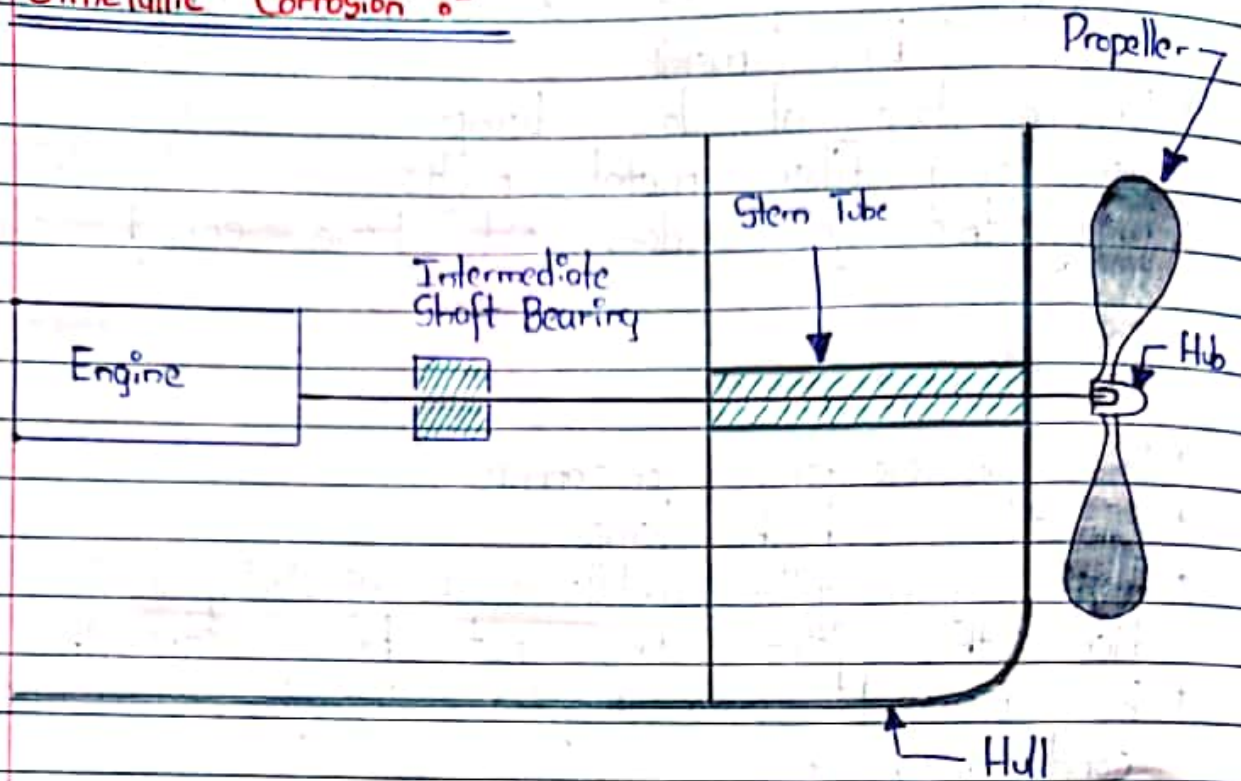
- * Brazing done at low temp.
- * Here only filler metal melts
- * Here this joint does not have enough strength

Soldering :-

CLIDE

- * Done for electronic components
- * Cannot use high temp
- * Here again filler metal melts (Soldering iron)
Here this joint does not have strength.
- * But we do not require strength, we need conductivity

Bimetallic Corrosion :-

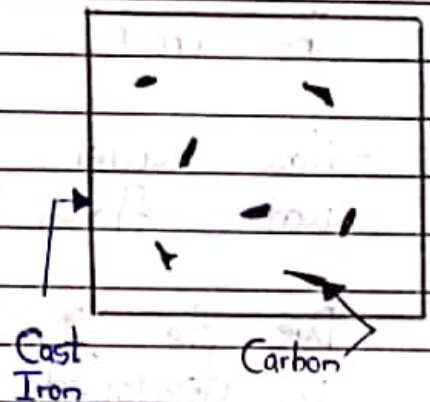


- * When engine is **Stopped**, shaft rests on main bearing.
- * Main bearings are inside housing
- * Housing is connected to girders & girders are connected to hull of ship
- * Hence shaft is fully earth
- * Now when engine is **Started**, hydrodynamic lubrication takes place at stern tube, intermediate shaft bearing, & engine main bearing
- * So now shaft fully floats over oil film
- * Now as propeller rotates, static charges are developed and now no grounding of shaft as shaft is lifted by oil film

- * These static charges goes on developing, when it becomes more than 80mV , sparking will occur betⁿ shaft & bearings
- * This will cause spark erosion
- * Due to this white metal from bearing will be removed & deposits on journal as scratches
- * To avoid this, on shaft we put 2 slip rings with carbon brushes & connect the shaft to hull to avoid spark erosion.

Graphitization :-

- Consider a CI plate having some percentage of carbon
- Now when this plate is immersed in SW, or even air, electrolytic action will take place
- This will make CI anode & Carbon cathode & CI will get corroded
- Soon only carbon will remain & material will become powder & loose its strength.
- We can only avoid this by putting Zinc blocks which acts as more anodic material.



* Same thing happens copper plate & zinc & that is called **Dezincification**

Graphitization — Cast Iron

Dezincification — Brass

Crevice Corrosion :-



- Due to cracks in metal, when water flows over these cracks, the water remains in the cracks.
- Now water in crevice is stagnant, but water flows freely above the crevice.
- Due to 2 different velocities, a potential is developed.
- This will make crack more anodic & corrosion starts to take place.
- Usually observed in boiler.
- Only option is electroplating to avoid crevice corrosion.

Fretting Corrosion :-

When 2 plates are bolted together but due to excessive vibration, there is a movement betⁿ each other.

This results in material getting removed

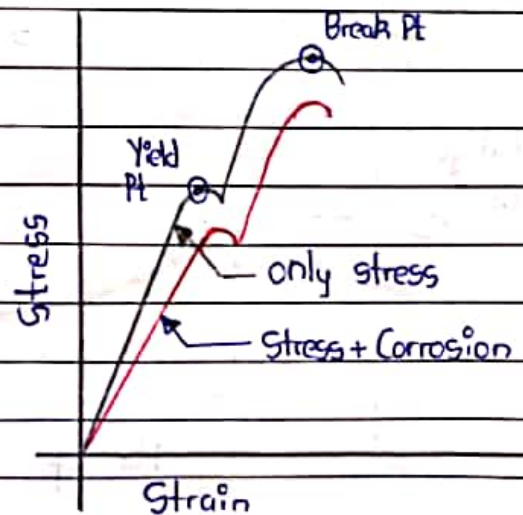
Observed in engine chokes & foundation



Stress Corrosion :-

* Observed in crankshaft, boiler drum & piston crown

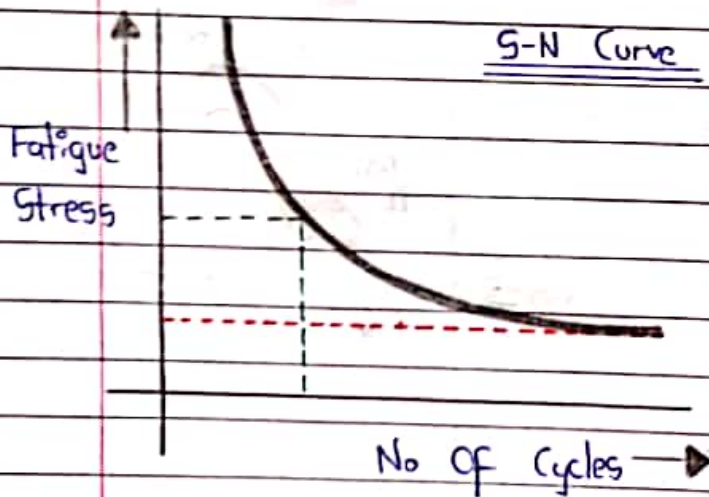
* If boiler drum is too acidic & due to lot of stress acting on drum, stress corrosion will take place



* Piston crown is also in contact with corrosive gases & large amounts of stress acts over it, stress corrosion will take place

FATIGUE :-

- * Continuous fluctuating stress or repeated stress or alternative stress, material can fail prematurely.
- * Fatigue always takes place under tension than in compression.
- * Best example is
 - bottom end bolts (4 stroke)
 - crankshaft (2 stroke)
- * Under fatigue there is a definite life of component.



* Acc to green dotted lines, if fatigue stress is that limit, the useful life of component reduces.

- * But acc to red dotted lines, if fatigue stress is that limit, useful life will be very long.
- * This is called Fatigue Endurance Limit.

Methods To Avoid Corrosion

- Cladding
- Electroplating
- ICCP
- Galvanizing

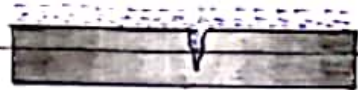
Anti-fouling paint - Tri Butyl Tin (TBT)

but TBT was banned due to damage to oysters

Anti-fouling convention - entry into force
17 Sept 2008

Now we use Foul Release Paint

Crevice Corrosion

- Consider you have a crack & some amount of water gets trapped in crack.
 - Now there is stagnant water in crack & flow of moving water above crack.
- 
- This will create a velocity difference & 2 potentials will develop.
 - It will make the crack $\rightarrow$ Anode due to which it loses electrons & material starts to be removed.
 - This will cause crack to become bigger.

Caustic Embrittlement

- Due to small cracks in tubes, water particles start escaping & salt stays back at cracks.
- When salt deposition exceeds certain value, the material will become brittle & will start to damage.
- This will reduce its strength & ultimately it will fail.
- This is called Caustic Embrittlement.

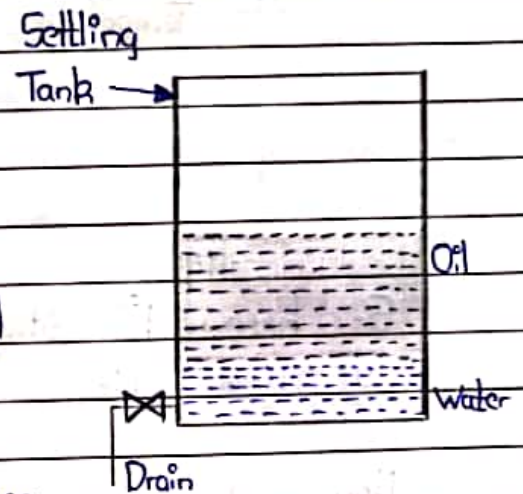
* * * PURIFIER * * *

Purpose : To remove or separate 2 liquids which are non-miscible

- * HFO & DO cannot be separated
- * DO & water can be separated.

Concept - Densities

- Inside the settling tank, water settles down at bottom while the oil remains on top.
- The settled water can be removed easily from drain.
- Now this separation takes place due to Stokes Law

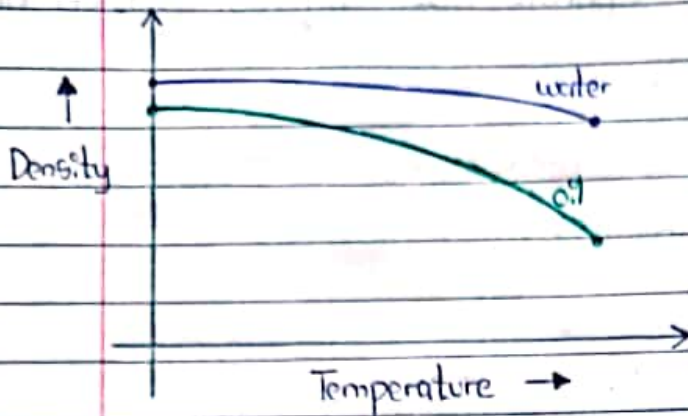


$$\text{Stokes Law} = \frac{\pi \times D^3 (P_w - P_o) \times g}{6}$$

where D = dia of water droplet
 P_w = density of water
 P_o = density of oil
 g = gravitational force

- Due to this difference in density betⁿ water & oil in presence of Gravitational Force, water can be drained from the tank.

- But, if the difference in densities is more, the separation will be much better.



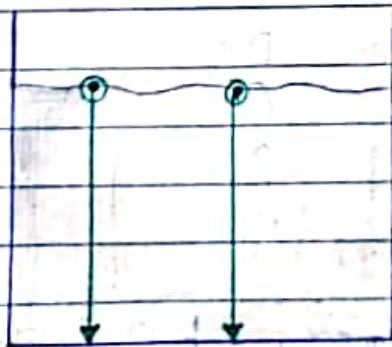
* From this graph, we observe, if we go on increasing temperature, there will be a large difference in densities betⁿ water & oil.

So by increasing temperature, the separation is faster.

So here 1st stage separation takes place in SETTLING TANK $\Rightarrow$ Gravitational Force

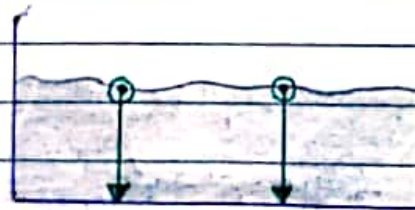
Now 2nd stage separation takes place in PURIFIER $\Rightarrow$ Centrifugal Force

Concept - Surface Area



Longer separation as distance to be travelled is more

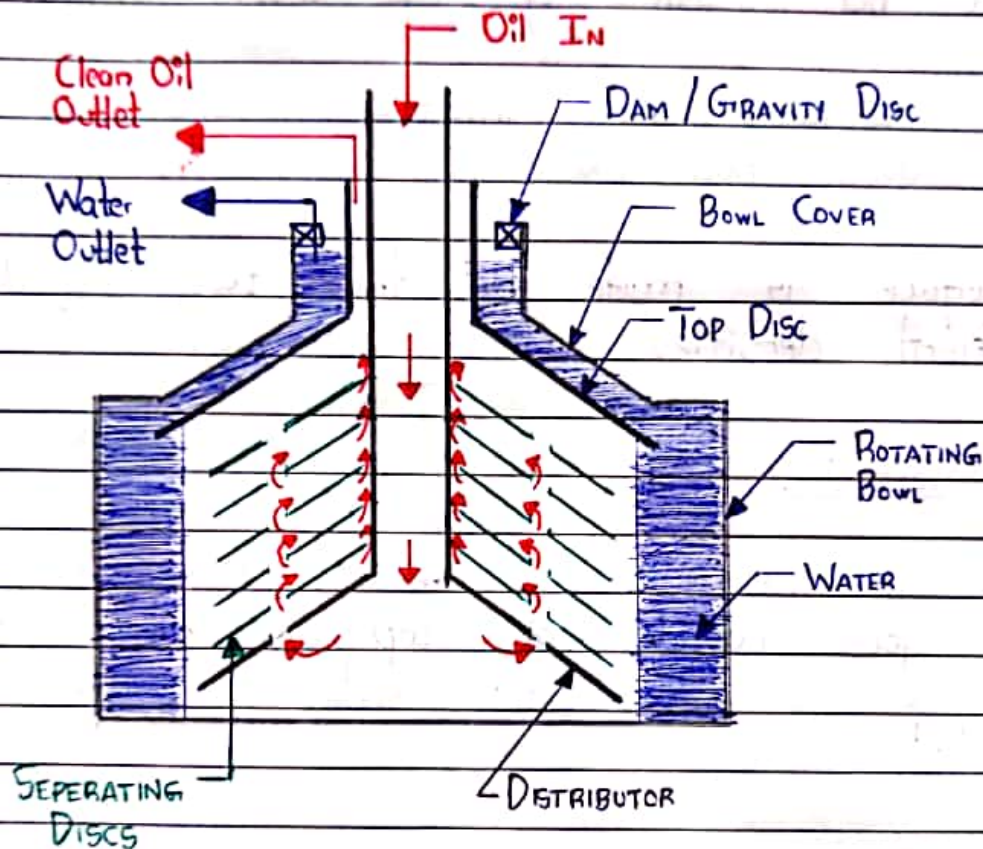
Less Surface Area



Slower separation as distance to be travelled is less

More Surface Area

- Otherwise we can add plates in case ① so that we can increase surface area for better & faster separation.



- * Top disc dia will always be greater than separating disc dia.
- * **Interface** is **maintained** outside of separating disc but inside of top disc.
- * Water is thrown out at periphery of bowl as it is heavier than oil.
- * Similarly oil being light remains on inner side of bowl.

* Purpose Of Gravity Disc :

CLYDE

* To maintain interface outside of separation disc but inside of top disc.

- It maintains the interface.

- It does not make the interface.

* Interface is made by the two liquids of different densities (water & oil)

Case ① OVERFLOW :

Now if the interface starts to shift outwards and goes outside of top disc, then oil will **overflow** to water side & purification is affected.

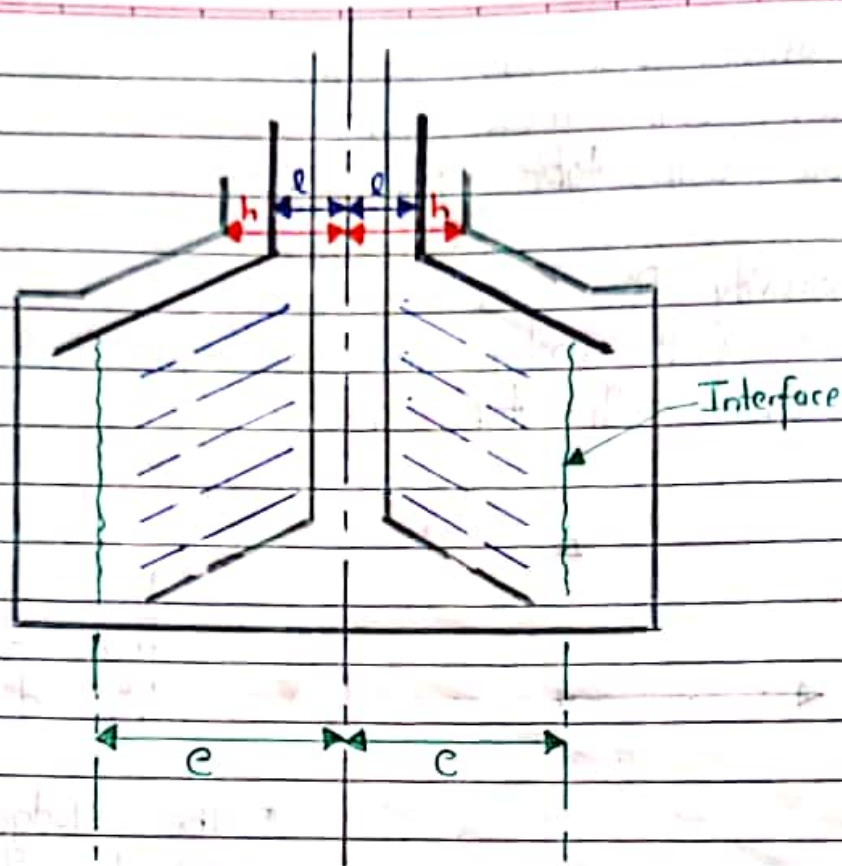
Case ② CARRY OVER :

Now if the interface starts to shift inwards and reaches the distribution holes of separation discs, then water will get **carry over** to oil side & purification is affected.

* Purpose Of Sealing Water :

- Sealing water is to initially make an interface betⁿ oil & water.

- If no sealing water is given & oil feed is started, oil will overflow as no interface is formed.



e = radius of interface to center

l = radius of clean oil outlet to center

h = radius of water outlet to center

$$\omega^2 \times P_w (e^2 - h^2) = P_o (e^2 - l^2) \times \omega^2$$

$\omega \rightarrow$ centrifugal force

CLUDE

$$P_w (e^2 - h^2) = P_o (e^2 - l^2)$$

- If LHS = RHS, interface will be outside disc stack & within top disc

Now l i.e. oil outlet has to be kept fixed.
We can only change h i.e. water outlet

- Now if ρ_o (Density of oil) increases
- That means **RHS increases**
- To balance this, we need decrease h (Gravity disc dia)
- This will **increase LHS**
- Now if ρ_o (Density of oil) reduces
- That means **RHS decreases**
- To balance this, we need increase h (Gravity disc dia)
- This will **decrease RHS**

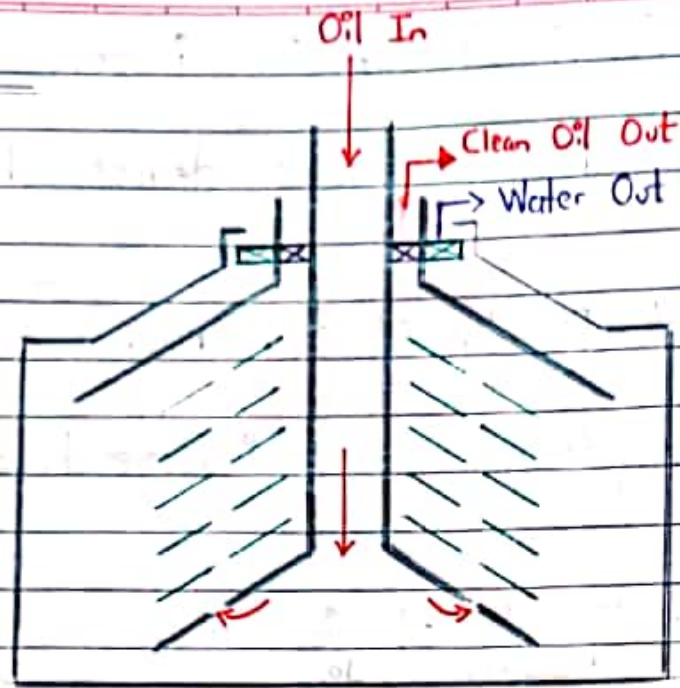
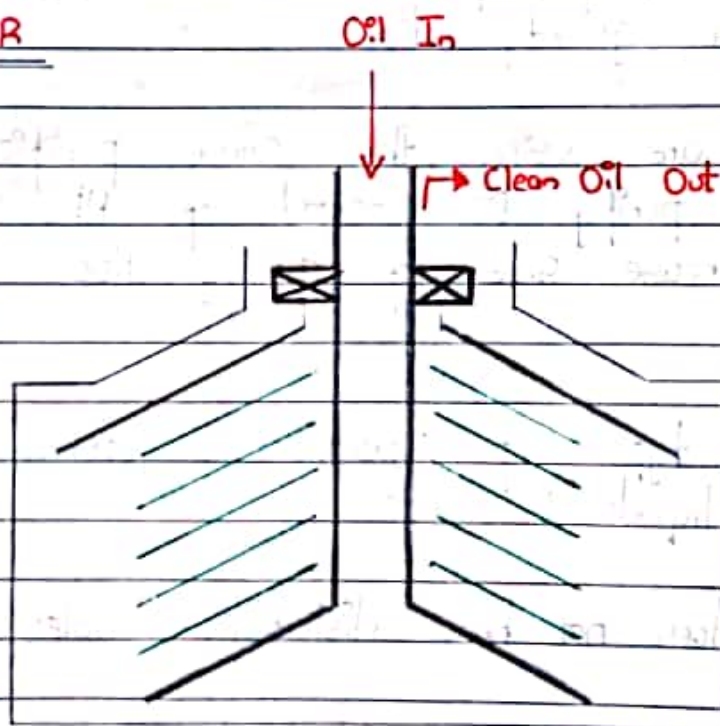
* So, if density of oil is more **CLYDE**
use smaller gravity disc

* And if density of oil is less
use bigger gravity disc

→ If you are using the same purifier but you want to purify DO instead of HFO
Then increase size of gravity disc

CLARIFIER

- * It is a type of separation system used to separate liquid & solids
- * Clarifier does not have distribution holes in the disc

PURIFIERCLARIFIER

PURIFIERCLARIFIER

① It separates liquids of different densities & solids

It separates only liquids & solids

② It has 1 inlet & 2 outlets (water & clean oil)

It has 1 inlet & 1 outlet (clean oil)

③ Separation disc have distribution holes

Separation disc do not have distribution holes

④ Purifier has Gravity Disc

Clarifier does not have Gravity Disc

⑤ Purifier requires sealing water

Clarifier does not require sealing water

⑥ It has 2 centripetal impellers

It has only 1 centripetal impeller

⑦ Purifier has a line of interface

Clarifier has no line of interface

Q Why top disc does not have neck in clarifier?

- The purpose of having a neck is so that 2 outlets can be provided.

- In clarifier there is only 1 outlet (clean oil) so no need of 2 outlets & hence no need of neck.

PAIBING Disc :-

- These are basically centripetal pumps
- They work exactly opposite to centrifugal pumps
- Unlike in centrifugal pumps, here impeller is stationary & fluid rotates around impeller.
- Unlike in centrifugal pumps, here liquid enters at periphery and leaves at the eye of impeller.
- It converts the KE into PE & extracts the water & oil out

Effect of feed rate :-

- Case ① * If feed rate / throughput is too high, then the purpose of oil remaining inside for longer time for better separation is lost.
- * Also interface will move out, oil will overflow to water side

- Case ② * If feed rate / throughput is too low, then interface will move in, water will get carried over to oil side

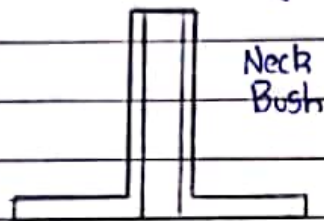
Effect of back pressure :-

- Case ① * If too much back pressure, interface will shift out → overflow

- Case ② * If too less back pressure, interface will shift in → carryover.

Q How to change Purifier into Clarifier :-

- Put ^{separation} gravity discs without holes
- If not available, then put the bottom most separation disc without holes
- Fit the top disc without neck
- Remove gravity disc & fit a neck bush
- Shut the sealing water & remove water pairing disc.



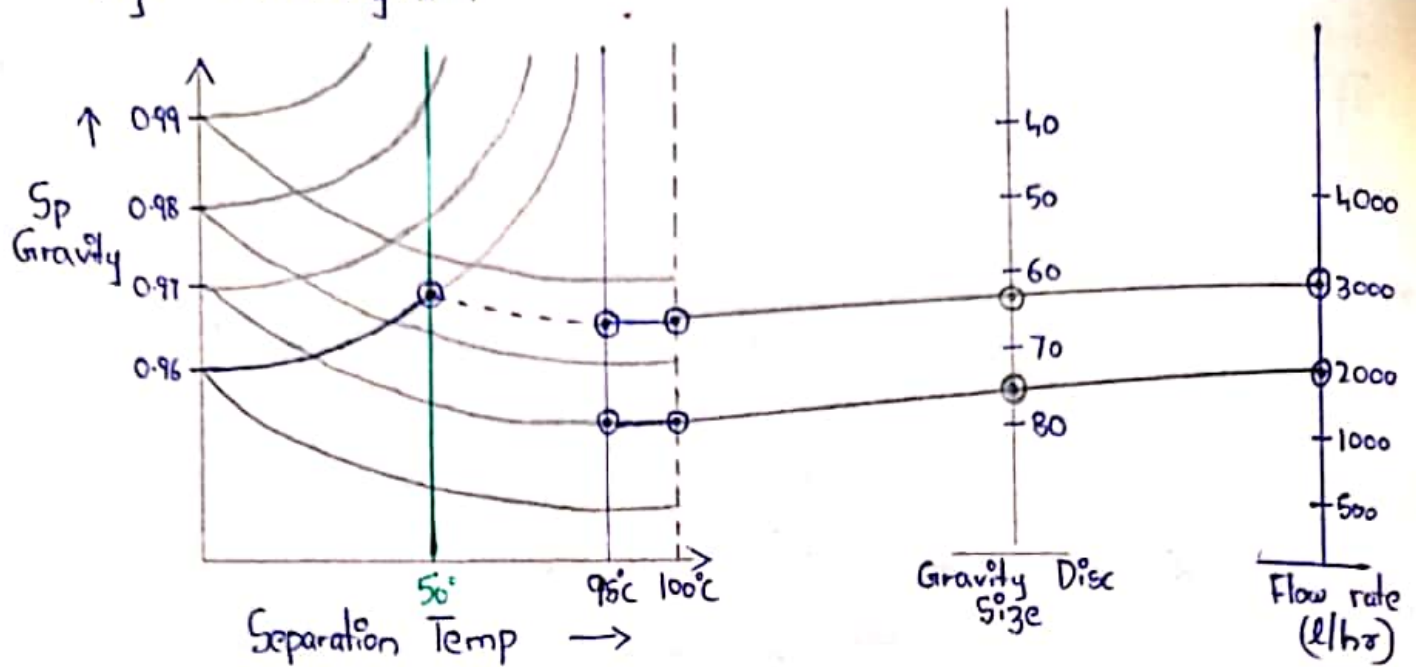
Q How to select correct size Gravity Disc

- When the purifier starts to overflow, espcl after taking new bunker, it is a clear indication that gravity disc is now incorrect.
- Correct size of gravity disc can be obtained by Nomogram

CLYDE

How to decide size of gravity disc

— By nomogram



Flowrate also called throughput

In BDN, we can get fuel ~~either~~ either

@ Sp gravity 15°C

@ Sp gravity 50°C

So at Sp gravity 15°C, follow downward curve

Sp gravity @ 15°C → 0.97

Separation temp → 95°C

Flow rate → 2000 l/hr

So gravity disc of ID 75mm

So at Sp gravity 50°C follow upward curve then downward curve

Sp gravity @ 50°C → 0.96

Separation temp → 95°C

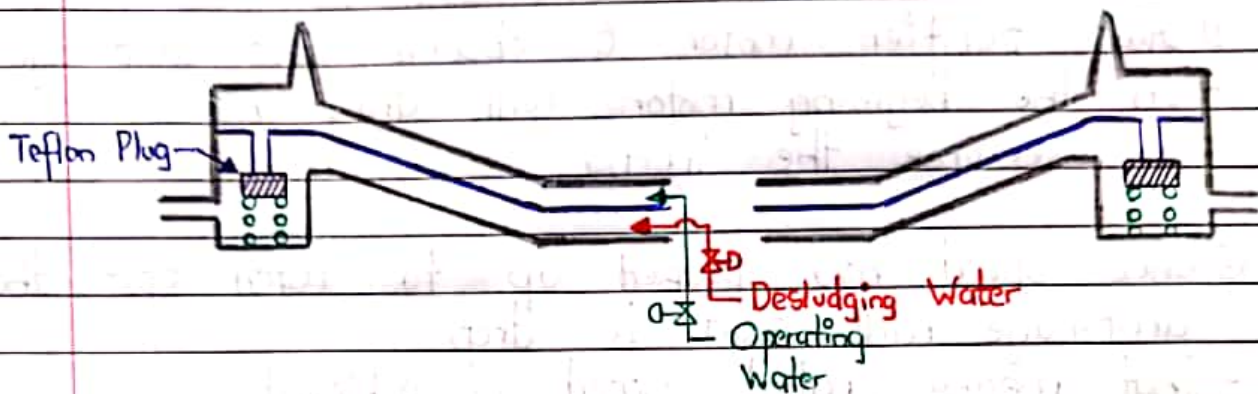
Flow rate → 3000 l/hr

Follow upward curve upto 50°C
Then follow downward curve

So gravity disc of ID 62mm

SLIDING BOWL MECHANISM

- * Desludging water $\rightarrow$ Hydrophore sys (More pr)
- * Operating water $\rightarrow$ Tank (lesser pr)



- * Firstly, operating water is given. Water enters but since teflon plug is closed tight due to spring force, water pr will increase & bowl will be pushed up.
- * When desludging water is given, water acts on teflon plug & pushes it down against spring. This will drain out all water below bowl & bowl will desludge.

CHECK BEFORE STARTING PURIFIER :

- ① Firstly check if brakes are applied or not
- ② Then check oil in gear box
- ③ Check control air of 3 way SV is opened
- ④ Check & open pump inlet vlv
- ⑤ Open heater outlet & inlet valves
- ⑥ Ensure operating water valves are open.
- ⑦ Check if the sludge outlet vlv is kept open.

- Start the heater & pump. let the oil go in recirculation via 3 way valve until operating temperature is achieved.

STARTING PROCEDURE :

- ① Start purifier motor & observe the amperage.
 - In the beginning, motor will draw heavy current to overcome the inertia.
- ② Once speed has picked up to rated rpm, the amperage will start to drop.
 - That means rated speed is achieved.
- ③ Now start sequence will be displayed.
- ④ So first, operating water will be given, & bowl will be lifted up to be closed.
- ⑤ Now sealing water is given & fill bowl until water starts to overflow. & then water is stopped.
- ⑥ Now feed oil inlet is directed from 3 way valve into purifier.
- ⑦ This will form interface & purification will start.
- ⑧ Now once sludge gets accumulated, desludging has to be done.

In Alfa Laval, desludging can be done by

- Total Desludging
- Partial Desludging

Partial Desludging

- Here oil feed is not stopped
- Sealing water is given which is now called (conditioning water). This water will move out & soften the sludge
- Now desludging water (opening water) is given which opens the bowl as it slides down & sludge will be thrown out.
- After this, desludging water is stopped & again operating water is given
- Now as teflon plug is shut, due to water pr. bowl will lift & close bowl
- Again give sealing water & start feed.

This happens for very few seconds.

Total Desludging {Manual Desludging}

- Here oil feed is stopped
- Sealing water is given which is now called (displacement water). This will completely displace all oil from bowl. & fill bowl with water.
- Now desludging water (opening water) is given which opens the bowl as it slides down & sludge will be thrown out
- Remaining procedure is same as above

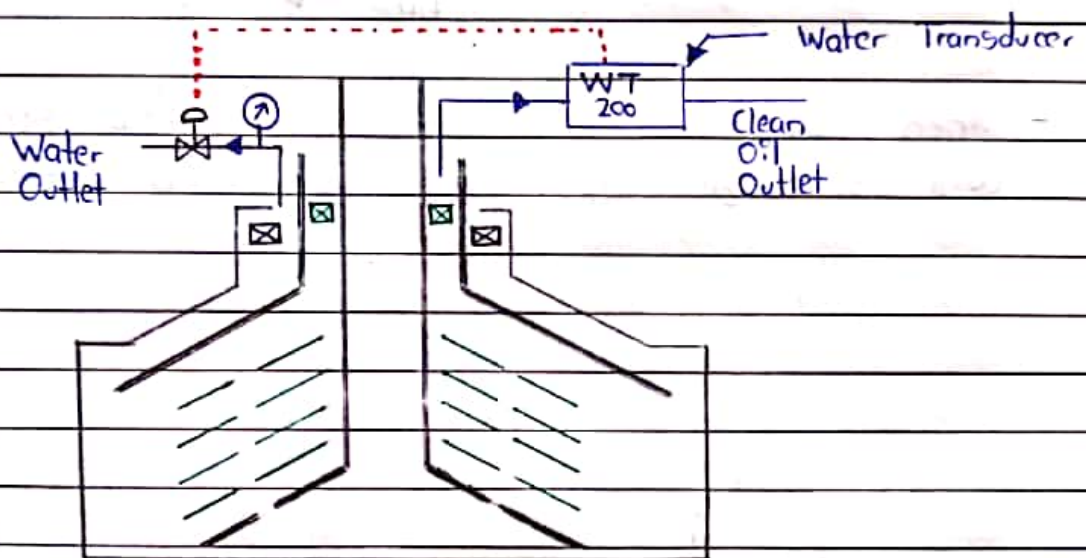
This happens for longer period of time

Q What happens if bowl height changes?

- Bowl ht can change due to wear down of bearings.
- If this happens, purifier won't be able to desludge.
- This is because, operating water & desludging water are being sprayed from a nozzle that is fixed & the holes are in front of it.
- When bowl ht reduces, since the hole is not in front of nozzle, water won't go at all & desludge won't take place.

ALCAP Principle

- Alpha laval clarifier & purifier.
- It mostly works like a clarifier & works also a purifier for a short period.
- This is a completely automated system where partial desludge & total desludge takes place



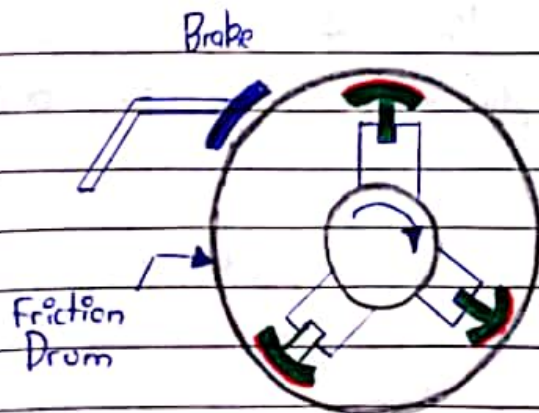
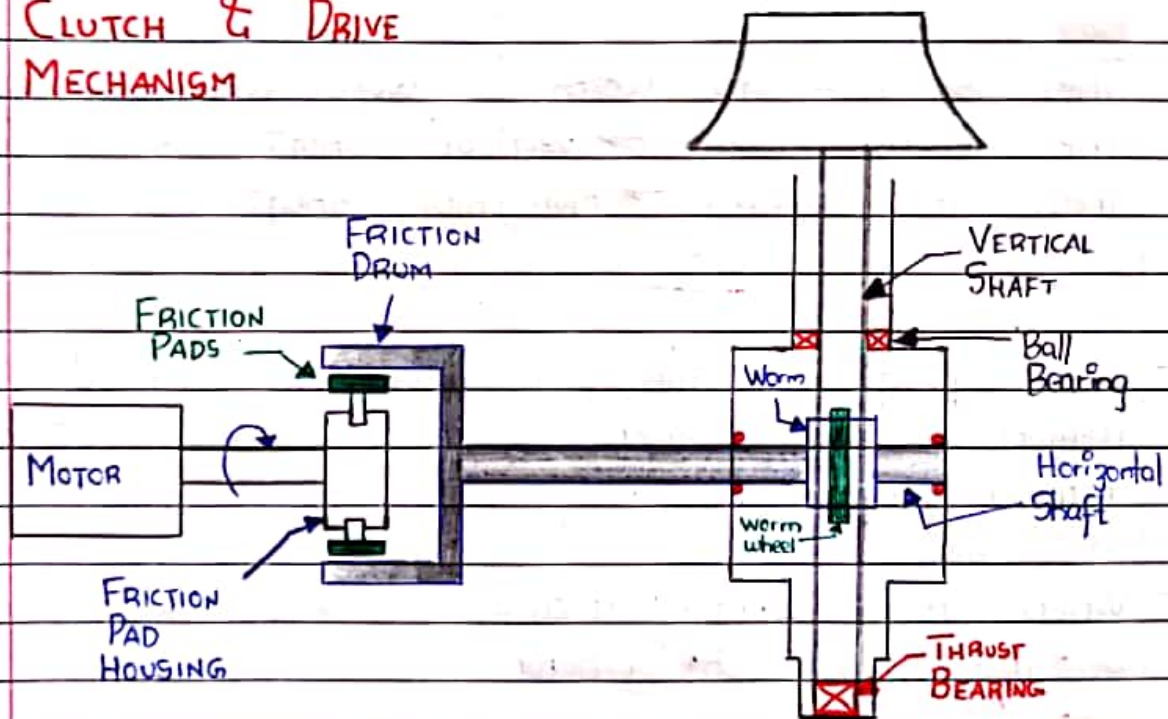
- Water outlet vlv is initially kept shut
- Now as water goes on increasing till it reaches distribution holes, water will get carried over to oil side
- Here water transducer will sense water content in oil.
- This will send a command signal to water outlet SV to remove excess water
- SV will keep open till water transducer stops detecting water content in oil

PURIFIER ALARMS :

- ① Emergency stop due to excess vibrations
- ② Low oil flow
- ③ High/Low oil temperature
- ④ No sludge discharge
- ⑤ No displacement water
- ⑥ Too much water content in oil
- ⑦ Water drain valve capacity insufficient
- ⑧ Power failure

CLYDE

CLUTCH & DRIVE MECHANISM



Friction
Pads with
ferrodo
lining

- * The friction pads will fly out & get clutched with friction drum
- * The friction drum helps to rotate the horizontal shaft.

- Bowl is very heavy & to rotate the bowl from standstill condition & overcome inertia, very high power is required.
- This will result in overloading motor.
- For this reason, there is a clutch provided which will load the motor gradually & overload won't happen.

Q How is purifier RPM high but motor RPM is less

- This is due to worm & worm wheel arrangement. The worm wheel $\rightarrow$ Vertical shaft is smaller than the worm $\rightarrow$ Horizontal shaft.

CRITICAL RPM :-

- When purifier rotates, it has an induced frequency. Similarly every machine has its own natural frequency.
- When these 2 freq match, resonance takes place & heavy vibrations occur.
- This usually happens at time of stopping, hence it is desirable to apply the brake to bypass this critical rpm.
- This is not required when purifier is started as motor drives the purifier & critical speed is passed very fast.

* Top Bearing :-

- Self aligning spring loaded roller bearing
- It takes care of radial thrust.

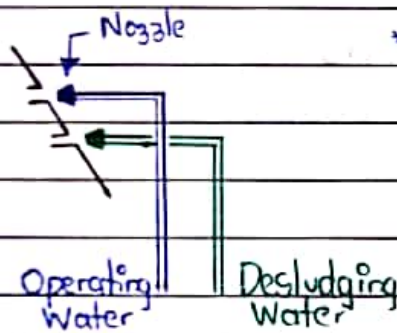
* Bottom Bearing :-

CLYDE

- Thrust bearing $\rightarrow$ Ball bearing
- It takes care of axial thrust

* If the thrust bearing gets worn, the shaft height will change

* By adding shims below bearing or by changing the bearing we can adjust vertical height



* When ht is changed, operating water or desludging water nozzles are not positioned in front of the holes

* So bowl won't be able to close

Q What will happen if motor terminals are interchanged?

- Purifier will rotate but the pairing disc won't work.
- Also if purifier has attached plp, it won't work.

* * HEAT TREATMENT * *

CLYDE

- **STEEL** is an alloy of **IRON** & **CARBON**
- Pure iron is soft & ductile
- Carbon is added to increase strength of iron.

LOW CARBON STEEL :-

- when $0.05 \sim 0.3\%$ carbon is added to Iron, low carbon steel is formed.
- This is also called Mild Steel.

Mild Steel used -

- ↳ wires ↳ rivets
- ↳ sheets ↳ structural members
- ↳ nails
- ↳ chains

MEDIUM CARBON STEEL :-

- when $0.3 \sim 0.5\%$ carbon is added to Iron, medium carbon steel is formed.

Medium Carbon Steel used -

- ↳ con rods ↳ springs
- ↳ crankshafts
- ↳ forging dies

HIGH CARBON STEEL :-

- when $0.5 \sim 1.8\%$ carbon is added to Iron, high carbon steel is formed.

High Carbon Steel used -

- ↳ chisels ↳ springs
- ↳ drill bits ↳ cutting tools
- ↳ dies

CAST IRON :-

- when 1.8 ~ 4% carbon is added to Iron. CI is formed
- It has high compressive strength, good machinability & wear resistance

CLIDE

Uses -

- ↳ Cylinder heads
- ↳ Valves
- ↳ Pump casings
- ↳ Piston rings
- ↳ Pipes

* Metals & alloys are crystalline solids containing randomly oriented crystalline or grains

* Grain size & structure will determine properties of metal

* 3 phases are the principle constituents of Plain Carbon Steel

↳ ferrite	}	Plain Carbon Steel
↳ pearlite		
↳ cementite		

- Ferrite is pure Iron.
It has no % of carbon

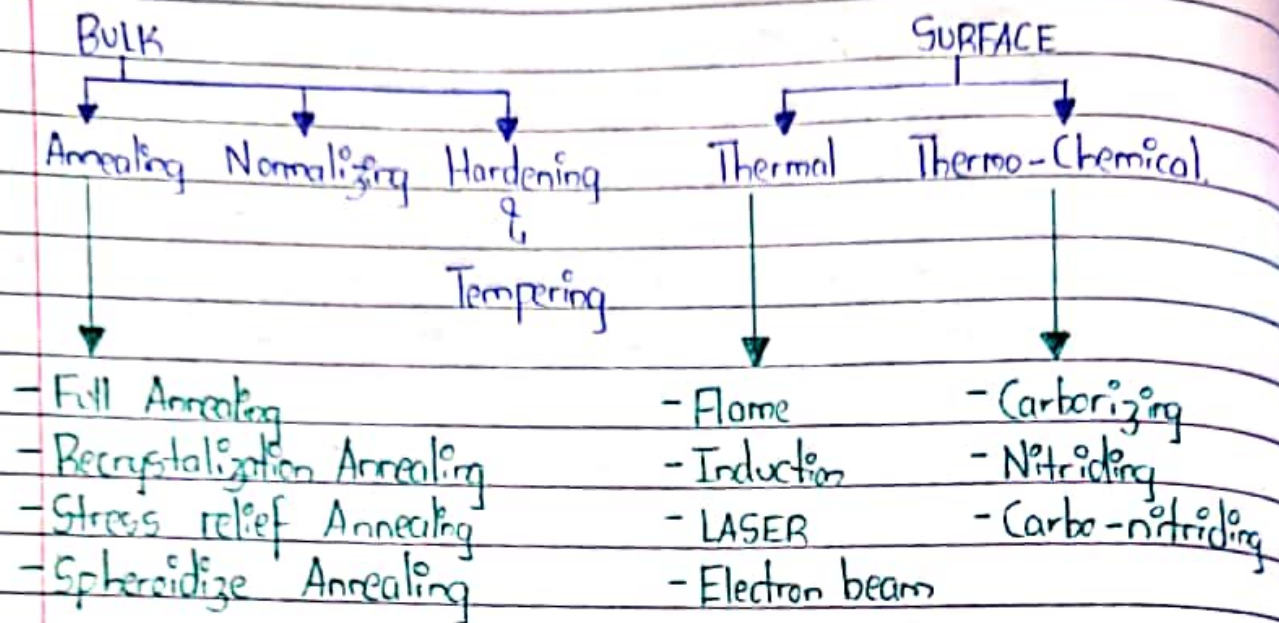
- Once you start adding carbon, you will get Pearlite

- When more carbon is added, you will get Cementite.

* At 0.87%, it completely becomes pearlite

* At 6.67%, it completely becomes cementite

Heat Treatment



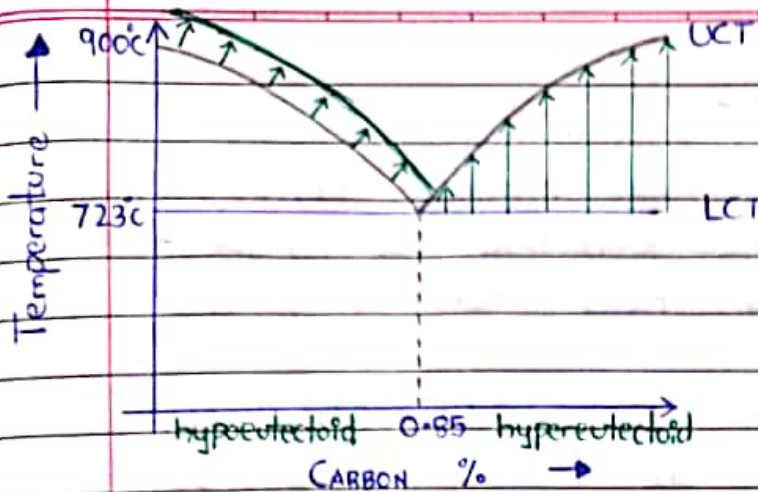
* If carbon % is less than **0.85%**, it is known as hypo-eutectoid steel

* If carbon % is more than **0.85%**, it is known as hyper-eutectoid steel

ANNEALING :

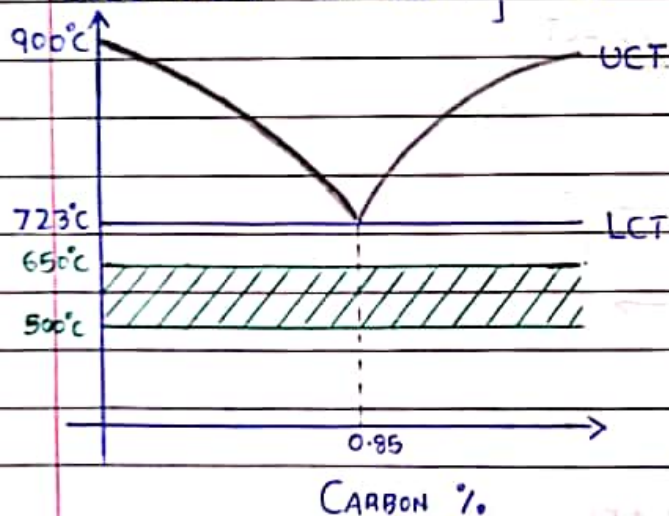
- * It is done for hypo-eutectoid steel in the UCT region & for hyper-eutectoid steel between LCT & UCT
- * Cooling is done slowly so that material will become **SOFT & DUCTILE**
- * Annealing helps to reduce **HARDNESS** & relieve **INTERNAL STRESS**
- * This is also called **Full Annealing**

CLYDE



Process Annealing :

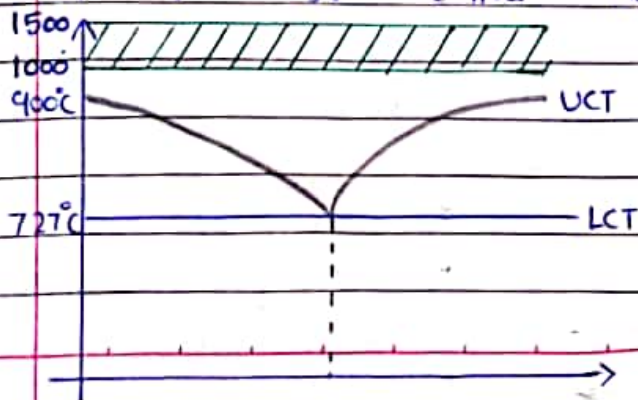
* It is also called intermediate annealing, or subcritical annealing or in-process annealing



* It is done at 500°C to 650°C in the hypo-eutectoid & hyper-eutectoid region

Diffusion Annealing :

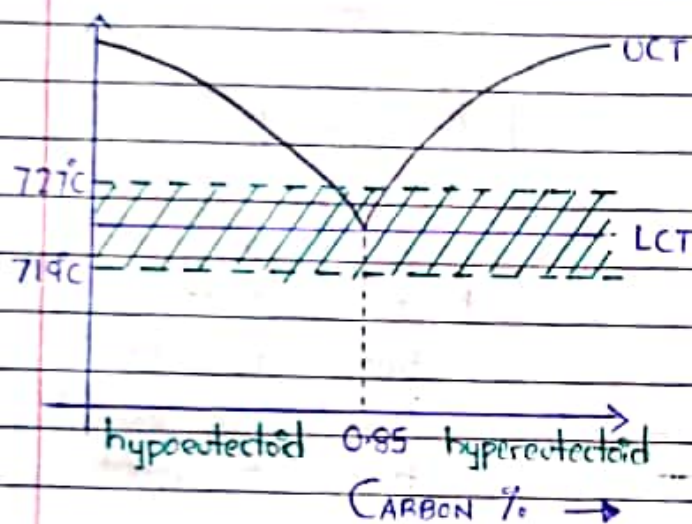
* It is also called homogenizing annealing



* It is done at 1000°C to 1500°C in the hypo-eutectoid & hyper-eutectoid region & hold for 10~20 hrs.

Spheroidise Annealing :

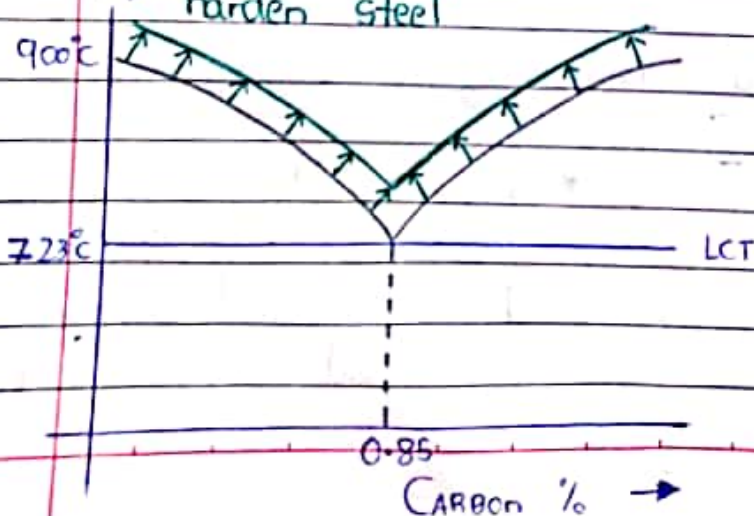
- * Here the material is heated betⁿ 719°C to 727°C in hypo-eutectoid & hyper-eutectoid region & held for **10~20 hrs**
- * This process forms spheroid structure which is soft & ductile & easy to machine.



NORMALIZING :

It is a heat treatment process

- refine grain structure
- reduce segregations in casting or forging
- harden steel



* Steel is heated above UCT in hypo & hyper eutectoid region

* Often used in railway wheels, bars, axels etc.

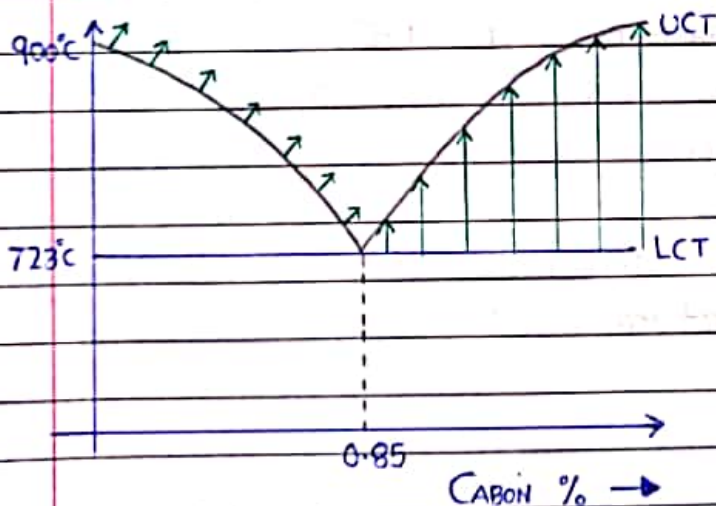
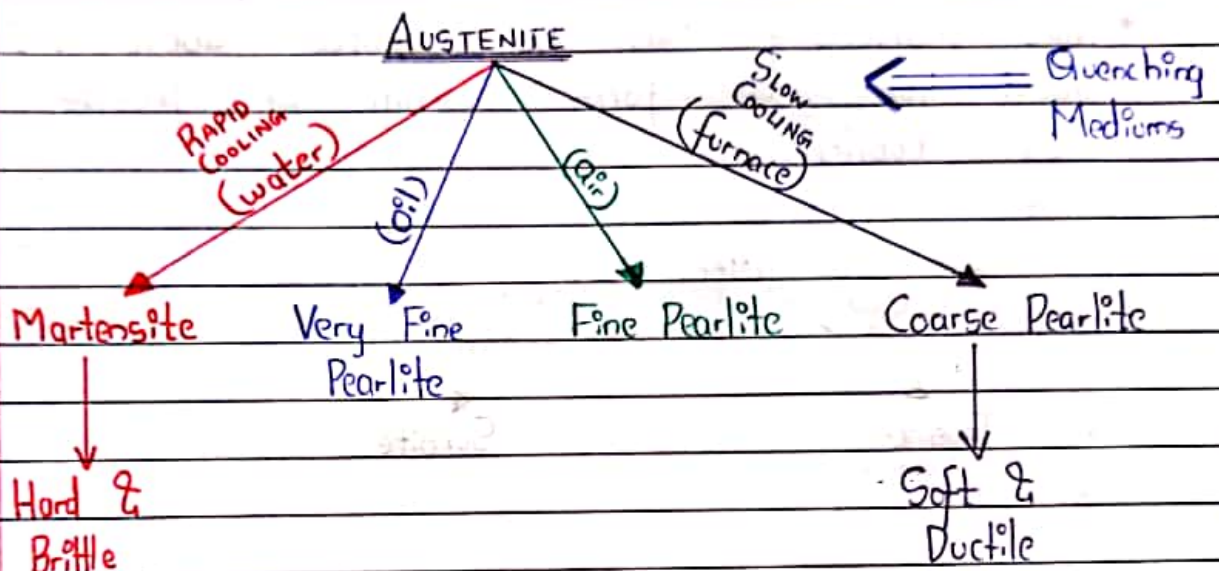
* Cooling is done by air → Moderate Ductility &

HARDENING :

CLYDE

* The hardness of material is increased by heating the metal followed by rapid cooling.

* Rapid Cooling $\rightarrow$ Quenching



* We heat steel above UCT in hypo-eutectoid & betⁿ LCT & UCT in hyper-eutectoid region

* But since rapid cooling is done, stress increases, brittleness increases & toughness reduces.

* Hence Hardening is always followed by Tempering.

Hardness.

TEMPERING :

- * Tempering is done after annealing to regain toughness, ductility & elasticity.
- * The rapid cooling from Austenite gave Martensite
- * New martensite can be heated above 400° or about 400° to form Sorbite or Troosite by slow cooling



HARDNESS : It is measure of resistance to plastic deformation induced by mech indentation or abrasion

TOUGHNESS : Ability of material to absorb energy before fracture.

CASE HARDENING :

CLYDE

- * It is also called Surface Hardening as this process hardens the surface while inner core of metal remains soft.
- * The core remains soft to absorb the stress

Method -

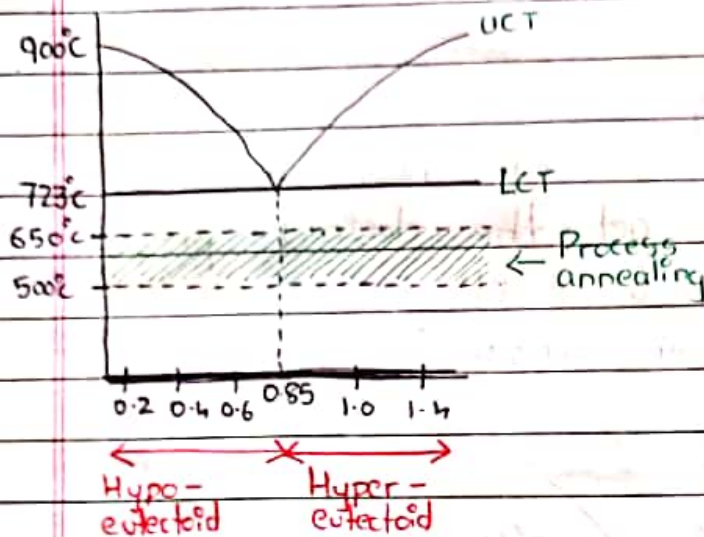
- Component to be case hardened is packed in a box which may be made of fire clay, CI or heat resistant nickel alloy
- Carbon rich material like charred leather, sodium carbonate, barium carbonate or coal is used as packing medium
- This is then heated above 900°C . The surface of component will absorb carbon making the surface hard
- Dept of case depends upon holding time & carbonaceous material.
- 0.8 ~ 3mm case thickness can be obtained
- * This is done for **gears, cams, crankshaft, camshaft**

Homogenize $\rightarrow$ making same

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Process Annealing

- It is also called intermediate annealing, sub-critical annealing, in-process annealing.



Diffusion Annealing

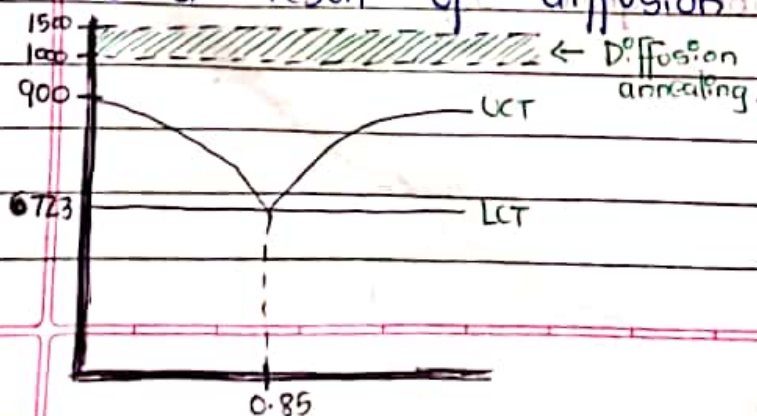
- It is also called homogenizing annealing.
- To remove structural non-uniformity, to reduce brittleness, increase ductility & toughness.

Process

Now steel is heated above UCT ($1000^{\circ}\text{C} \sim 1500^{\circ}\text{C}$) & held at this temp for 10~20 hrs followed by slow cooling.

Result

Segregated zones are eliminated & chemically homogenous steel is formed by this method as a result of diffusion.



Spheroidise Annealing ^{→ Slow cooling}

- It consists of process of heating steel upto temp (727°C) kept at that temp for some time followed by slow cooling.
- At this temp, ferrite will recrystallize & iron carbide will start to form "spheroids"

Ball Structure

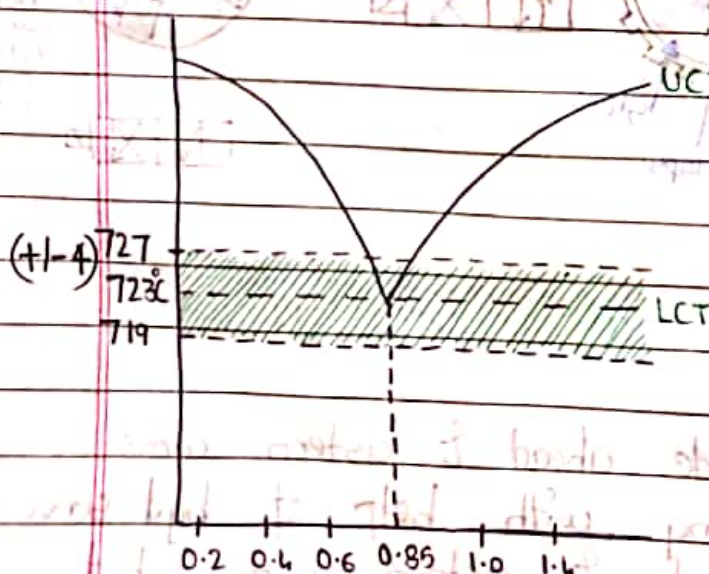
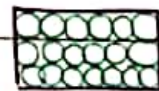
- This change in shape of carbide reduces strength & hardness.
- It forms spheroid structure which is very soft & ductile which is easy to machine & deforming.
- Holding time varies from 15-20 hrs.

Objective :

- * to soften steels
- * to increase ductility
- * to improve machinability
- * to reduce hardness & brittleness



Grain Structure





Normalising



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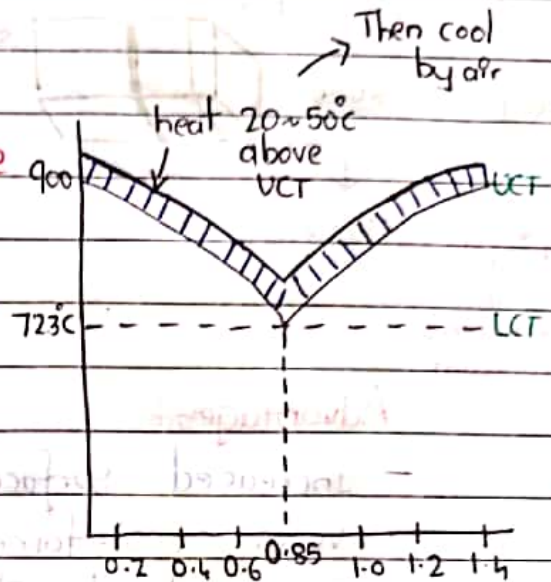
Normalising (Hypo & hyper both)

- It is a heat treatment process
- These characteristics are gained after normalising

- * Tensile strength
- * Machinability
- * Refined grain structure
- * Removed segregation

- Often used in hot rolled steel
ex = railway wheels, bars, axels

- Forged steel



Case Hardening

means
Surface



Core

Gear
Cams
Crankshaft
Camschaft

- It is also called surface hardening because it helps to harden surface while inner core of metal remains soft. This forms the layer of harder metal which is called "case"

- If we need the "surface" to be hardened after finishing of workplace, we use case hardening. → like after milling a gear, we case harden it

- We harden the part which is most subjected to wear (Wear Resistant)

- We do not harden complete part, just the outer part which will be wear resistant

we need the box
as we add hardening
agent

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while the inner part remains soft
so as to absorb stress.

Box

Hardening Agent inside the box

Pack - Carbon steel coated with Al or nickel or Chromium alloy

This box is like a furnace.

Hold Time 6-8 hrs
↓
depending on thickness of hardness we want

SoC ~1000°C
↓
will go to austenite zone

Hardening Agent

- Sodium carbonate
- Barium carbonate
- Coal
 ↳ high carbon %

Advantages:

- Increased surface hardness
- Wear resistance
- Increased tensile strength
- Change in grain structure
- Decreased surface carbon content

Quench by

air



Slow cooling
or else will become brittle.

Gas Carburising

- low carbon steel, mild steel
- to harden the surface
- increased carbon % make surface hard while core remains soft.

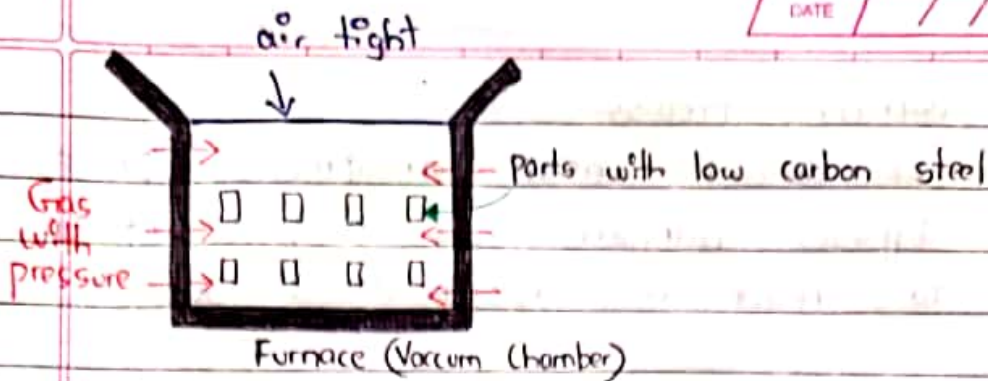


- Uses gases with abundant C

ie methane, ethane, butane



- They combine with O_2 to form CO



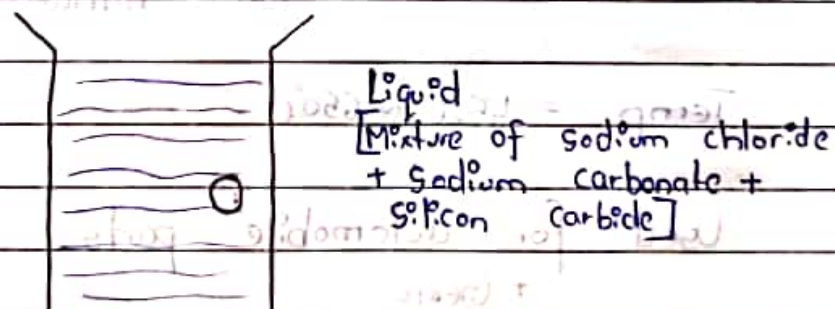
Maintained temp = $900^{\circ}\text{C} \sim 1000^{\circ}\text{C}$ $\rightarrow$ Slow cooling

Advantages :

- Increased surface hardness
- Wear resistance
- Increased tensile strength

Liquid Carburising

- Done for low carbon steel, mild steel
- Here % of carbon is less in the above.



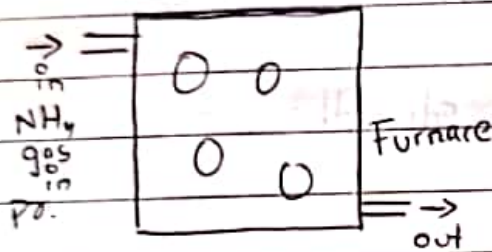
- Temp ($870^{\circ}\text{C} \sim 900^{\circ}\text{C}$) $\rightarrow$ for 0.2~0.3mm surface
parts keep for 35~55 min

Advantages :

- Increased surface hardness
- Wear resistance
- Increased tensile strength
- Increased surface carbon content
- Change in grain structure $\rightarrow$ because we go above LCT

Nitriding Process

- It is a heat treatment process that diffuses nitrogen into surface of a metal to create a case-hardened surface
- It forms a nitride alloy (Nickel, Chromium)
- The hardened surface is harder than carburized surface.



Ammonia = $\text{NH}_3 \rightarrow \text{Nitrogen} + \text{Hydrogen}$

↓
Binds with surface to form nitride alloy

Temp = $450^\circ\text{C} \sim 650^\circ\text{C}$

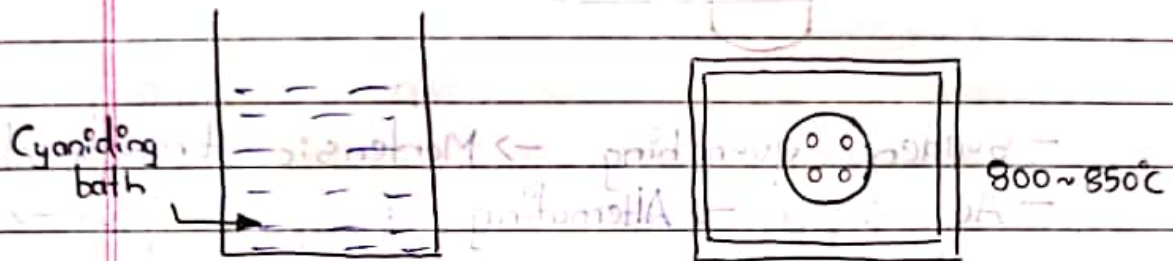
Used for automobile parts

- * Gears
- * Crank shaft
- * Cam shaft
- * Valves
- * Cam follower
- * Fuel pump actuators

Due to air tight chamber (limited O_2 which prevents explosion)

Cyaniding Process

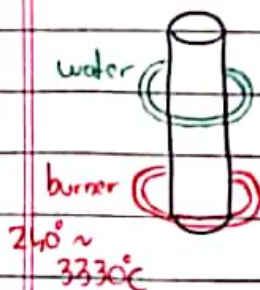
- Done for low carbon steel, medium carbon steel or alloy
- Cyaniding bath = Solution Cyanide + Sodium Chloride + Sodium Carbonate.



- Automobile parts → Gears, Cams

Flame Hardening

- Done for med carbon steel
- O₂ acetylene flame natural gas flame to create high temp.

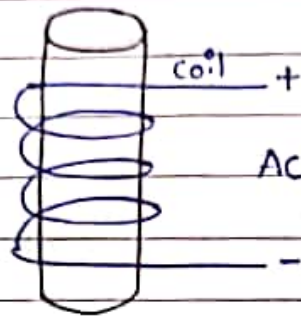


Heat the wkpiece with oxy-acetylene flame & quench it v quickly

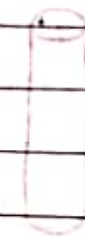
- Used in piston rings.

Induction Hardening

- done for low carbon steel & alloy steel.



- sudden quenching $\rightarrow$ Martensitic transformation
- AC supply $\rightarrow$ Alternating magnetic flux $\rightarrow$ eddy current.
- Coil & material do not touch.



** OILY WATER SEPARATOR **

- * OWS is one of the critical machinery equipments as per MARPOL ANNEX 1 for ship of 400 GT & above

Marpol Annex 1

- Regulation 15

CONTROL OF DISCHARGE OF OIL.

- Ship is proceeding enroute
- Oily mixture is processed through oil filtering equipment
- Oil content of effluent without dilution does not exceed 15 ppm.
- Oil mixture does not originate from cargo plp room bilges on oil tankers
- Oil mixture in case of oil tanker is not mixed with cargo oil residues

* No discharge at all in Arctic & Antarctic waters

* Ship can discharge in special area also provided automatic stop for 15 ppm is provided.

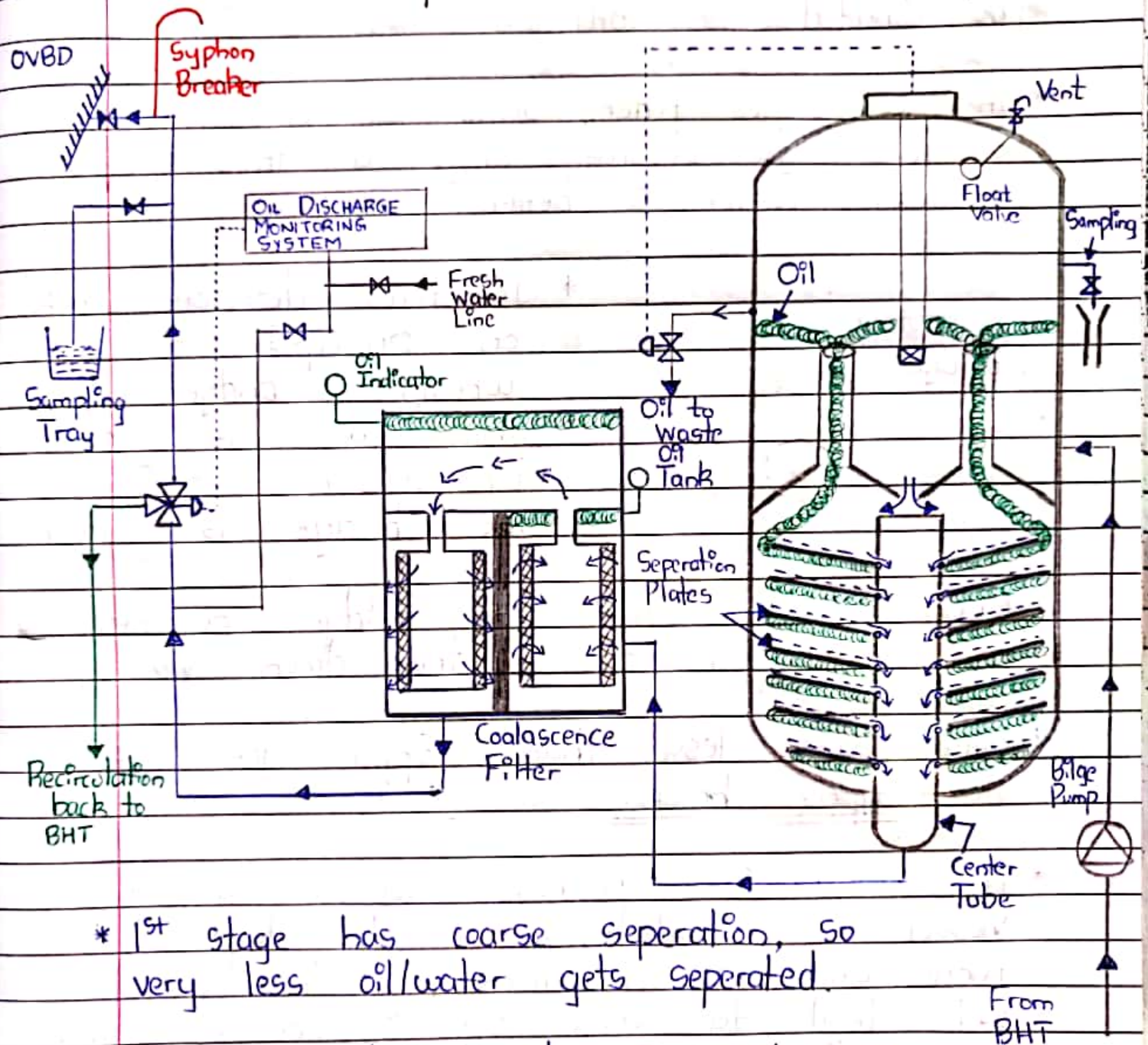
* OWS can be operated only under authority of Chief Engineer & Captain.

* Once OWS has started, date, time, duration, vessels position must be recorded.

CLYDE

- * The entire setup consists of 2 separation units
- * 1st Stage separation takes place in primary chamber
- * 2nd Stage separation takes place in secondary chamber which has coalescence filler
- * Here in OWS, separation takes place under principle of Stokes law
$$= \frac{\pi D^3 (P_w - P_o) g}{6}$$
- * The greater the difference between oil & water densities, the better will be the separation.
- * Firstly, completely fill OWS with sea water.
- * The 1st stage separation consists of separation plates
- * The water/oil from separation plates comes inside center tube through fine holes in tube once OWS starts taking from BHT
- * Bilge p/p → Reciprocating Pump
- * Oil gets stuck to separating plates while the water being heavy enters center tube
- * Oil being light tends to float on top & gets collected. Once the oil touches the interface detector, the drain valve is opened

- * Interface detector works on principle of capacitance as dielectric of water & oil are different.



- * 1st stage has coarse separation, so very less oil/water gets separated.

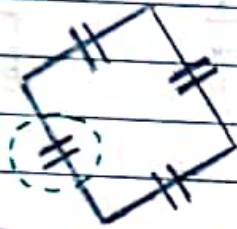
- * Now in 2nd stage, due to coalescence filter, fine separation of oil/water takes place

- * After coalescence filter, the sample is given to **Oil Discharge Monitoring Sys.** where 15 ppm is checked.

* If ppm becomes more than 15ppm, 3 way vlv will shut, & discharge will be directed to BHT

* In coalescence filter, small oil droplets accumulate & tend to become large & thus separation becomes faster & better.

Wheatstone Bridge



* Interface detectors works on principle of wheatstone bridge

* When water is detected by sensing capacitor, the bridge is **balanced**.

* Once oil is sensed, the bridge becomes **unbalanced** & opens the drain vlv.

* Bilge water less than 15ppm goes OVBD via Syphon breaker

* It is provided because suppose initially vessel is loaded, so outside draft is more. Once vessel discharges, the vessel will tend to come up & chances are that entire OWS can get drained to sea.

MAINTENANCE :

CLYDE

- * Drain the OWS and clean separation plates
 - * Inspect the primary chamber for any damage or corrosion.
 - * Clean coalescence filter regularly.
-
- Fresh water is passed to ODM sys to check O setting.
 - To check span setting, a chemical solution is provided which can give you span setting.
 - * There is also a sampling line & a tray provided incase we want to check operation of 3 way vlv in case ppm exceeds 15.

FRESH WATER GENERATOR

* There are 3 methods with which FW can be produced

↳ Low pressure evaporator

↳ Flash evaporator

↳ Reverse osmosis

* Normally water boils @ 100°C

but if pressure is reduced, the water will start to boil at a lower temp.

* As pr decreases, BP also decreases

* FWG are of 2 types

↳ Shell & tube type

↳ Plate type

* FWG consists of 2 main parts

① EVAPORATOR :

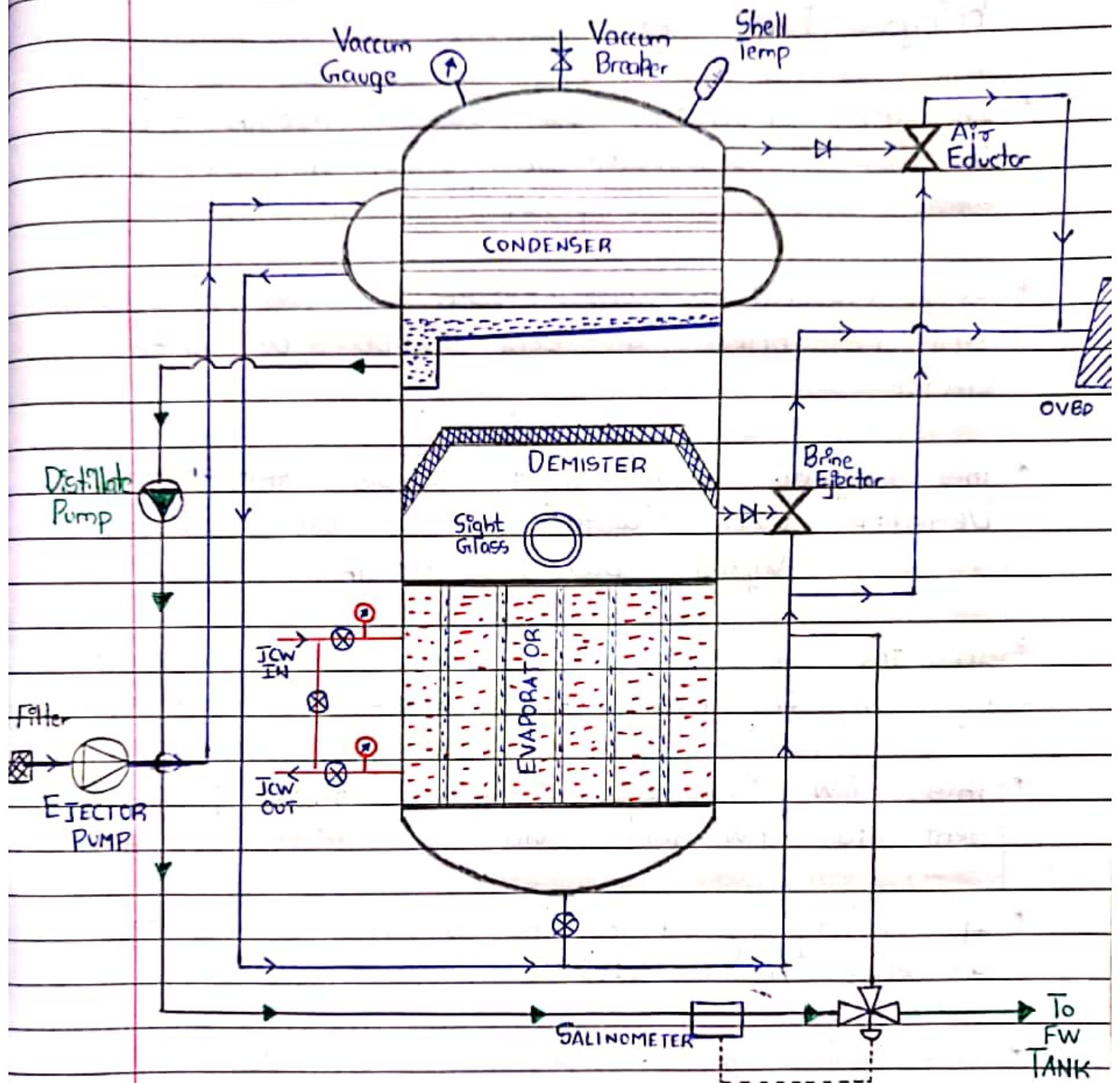
where SW is boiled

② CONDENSER :

where vapour is condensed.

- If driving fluid is liquid.
it is EJECTOR

- If driving fluid is air.
it is EDUCTOR



* The ~~ejector~~ EJECTOR PUMP is started & water is sent to ejector & eductor.

* Here venturi-effect takes place due to the convergent-divergent nozzle & vacuum is created.

- * This draws all air from FWG shell & brings FWG into vacuum.
- * In the evaporator, SW passes through tubes & **JCW** passes through shell. This heats up water & gets evaporated.
- * 20% evaporation will happen & remaining 80% will be brine & sent OVBD by brine ejector.
- * This vapour being light passes through **DEMISTER** where water droplets are removed & only vapour passes through.
- * In the condenser, this vapour is condensed by SW & thus **FRESH WATER** is collected.
- * This FW is removed by distillate pump & sent to FW tank via **salinometer & 3 way vlv**.
- * If salinity is high, the 3 way vlv actuates & sends water OVBD.
- * **Once boiling starts, vapour slightly reduces the vacuum.** Once condensation begins, vacuum starts becoming normal.
- * **AIR EJECTOR** is required to work continuously as dissolved gases from SW will accumulate in shell.

* FWG shell should not go above 60°C as internally a plastic coating exists

* Initially, we get good vacuum, but as soon as we open JCW, vacuum drops means condenser tubes are choked & cleaning is required as condensation is not taking place

Q How to know if evaporator tubes are holed?

- Close SW inlet
- Start JCW in & out.
- Observe sight glass
- If water can be seen in sight glass that means tubes are holed & JCW has entered tubes

* Suppose we have good vacuum but water production reduced, shell temp also low.

So check JCW in & out temps

Drop should be atleast 15°C .

If not means evaporator tubes are choked & cleaning is required.

SALINITY HIGH REASONS

CLYDE

- demister fouled / holed
- Salinometer faulty
- rapid bubbling in cold country.

- * In cold countries, vacuum comes nearly to 100% & production will increase considerably.
- This is because the condensation is too high.
- So plant production will increase but at same time, high salinity alarm will also start.
- Adjust & break some vacuum can be done to avoid this

VAPTREAT - Unitor

AMEROVAL - Drew Chemicals

- * These chemicals are added to evaporator to prevent scale formation

Q Why generally FWG is located in 2nd platform instead of bottom platform

- The main reason is backpressure
- Due to backpr when the draft is more, vacuum won't be able to be developed.

Q Loss of vacuum ? Reasons

- Ejector plp filter choked
- Ejector plp efficiency has dropped
- Eductor nozzle enlarged or choked
- Backpr due to more draft
- Leak of air near sight glass
- Vacuum breaker not closed properly.
- Condenser tubes leaking

PROCEDURE TO START FWG

- ① Firstly ensure ejector plp suction, discharge & OVBD vlv are kept open
- ② Start ejector plp, pr should be approx 3bar & now observe vaccum gauge.
- ③ Vaccum will slowly drop but wait till it drops to 95%
- ④ Now open SW outlet & inlet valve
- ⑤ Open ICW outlet & inlet & throttle bypass

CLYDE

* * Air Compressor * *

PURPOSE OF AIR :-

- To start engine $\rightarrow$ 30 bar
- Control air $\rightarrow$ 7 bar
- Service air (cleaning, chipping) $\rightarrow$ 7 bar

SOLAS requirement

- * There should be min 2 air compressors onboard
- * Each compressor must be capable to fill each air bottle in 1 hr from atm pressure to 30 bar.

- * Similarly there must also be min 2 air bottles

- * Air bottle capable to provide

$\rightarrow$ sufficient air for 6 kicks

$\rightarrow$ sufficient air for 12 kicks

6 AHEAD

6 ASTERN

- * It should be alternating (Ahead... Astern... Ahead)

In IC engines, we carry out adiabatic compression because at end of cycle we need sufficient amt of heat to self ignite fuel.

- * But in Air Compressor, as the piston moves, it converts
RECIPROCATING ENERGY $\rightarrow$ PRESSURE ENERGY

- * The heat generated during this process, is the Heat Of Compression.

- When piston reciprocates, all heat generated is carried away via cyl walls
- So temp @ start of compression = temp @ end of compression
- This is called "Isothermal Compression"

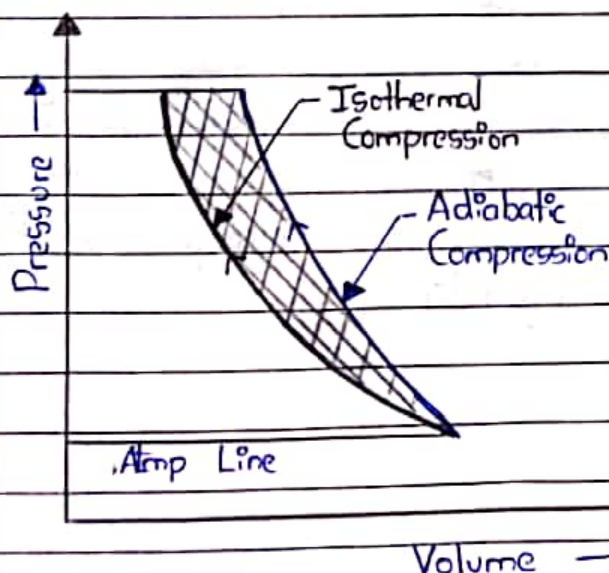
$$PV = C$$

CLYDE

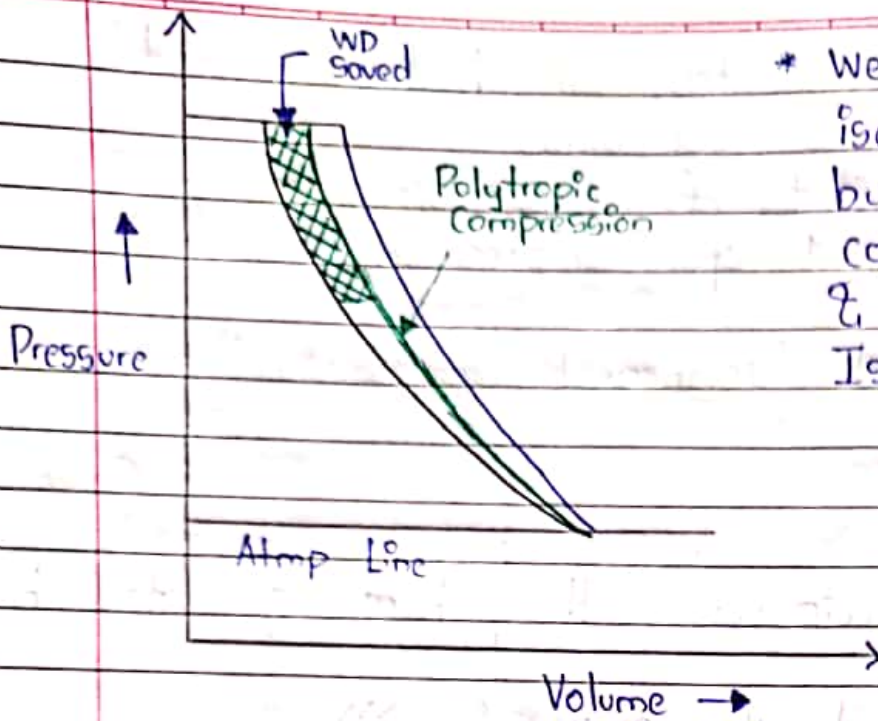
- When piston reciprocates, the heat generated but none of heat is removed
- So temp @ end of compression >>> temp @ start of compression
- This is called "Adiabatic Compression"

$$PV^\gamma = C$$

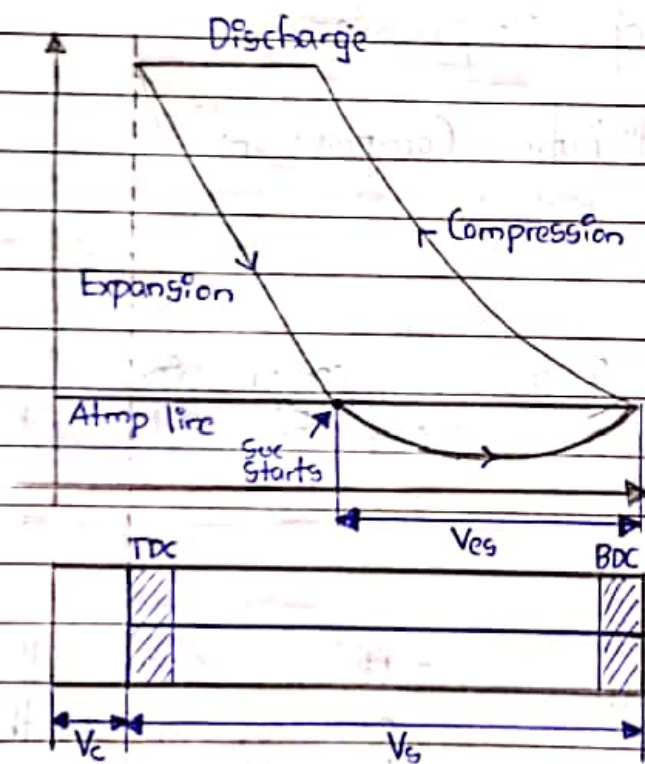
- * On ship neither isothermal compression is possible nor adiabatic compression can be achieved.
- * So we carry out POLYTROPIC COMPRESSION



- If we see both process, in Isothermal less amount of work is done



* We cannot do isothermal compression, but we can cool air betⁿ stages & come near Isothermal



- When piston is at TDC, some air will be trapped above piston

- When piston moves from TDC $\rightarrow$ BDC, the air above piston will expand

- When p_r in cyl becomes lesser than atmp p_r , then only

fresh air can enter cylinder

Volumetric Efficiency :

$$= \frac{\text{Effective suction volume}}{\text{Swept volume}}$$

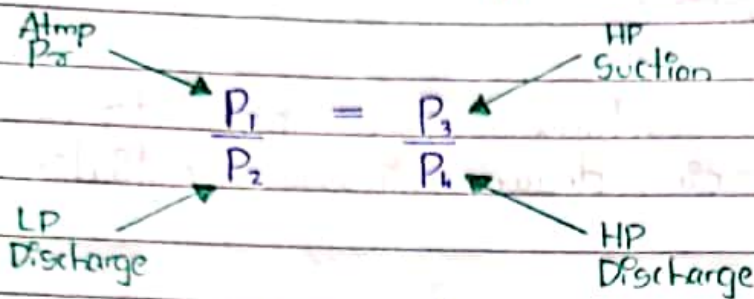
* Effective suction volume can be defined as actual vol of air drawn inside cylinder

Q Why can't we compress air from atm pr to 30 bar in 1 stage itself?

- Firstly effective suction vol will be very less & hence vol eff also will be less.
- 30 bar air compression in 1 stage, will cause v high rise in temp damaging & reducing life of valves, piston, piston rings etc.
- Oil will get carbonized
- Large engine components will be required
- Torque & balancing problems
- More power required by motor

* Hence 2 or 3 stage compressor is used instead of single stage.

Q Just by looking at compressor 1st stage, how can you determine if compressor working fine?



Now LP discharge & HP suction is same
So $P_2 = P_3$

CLUE

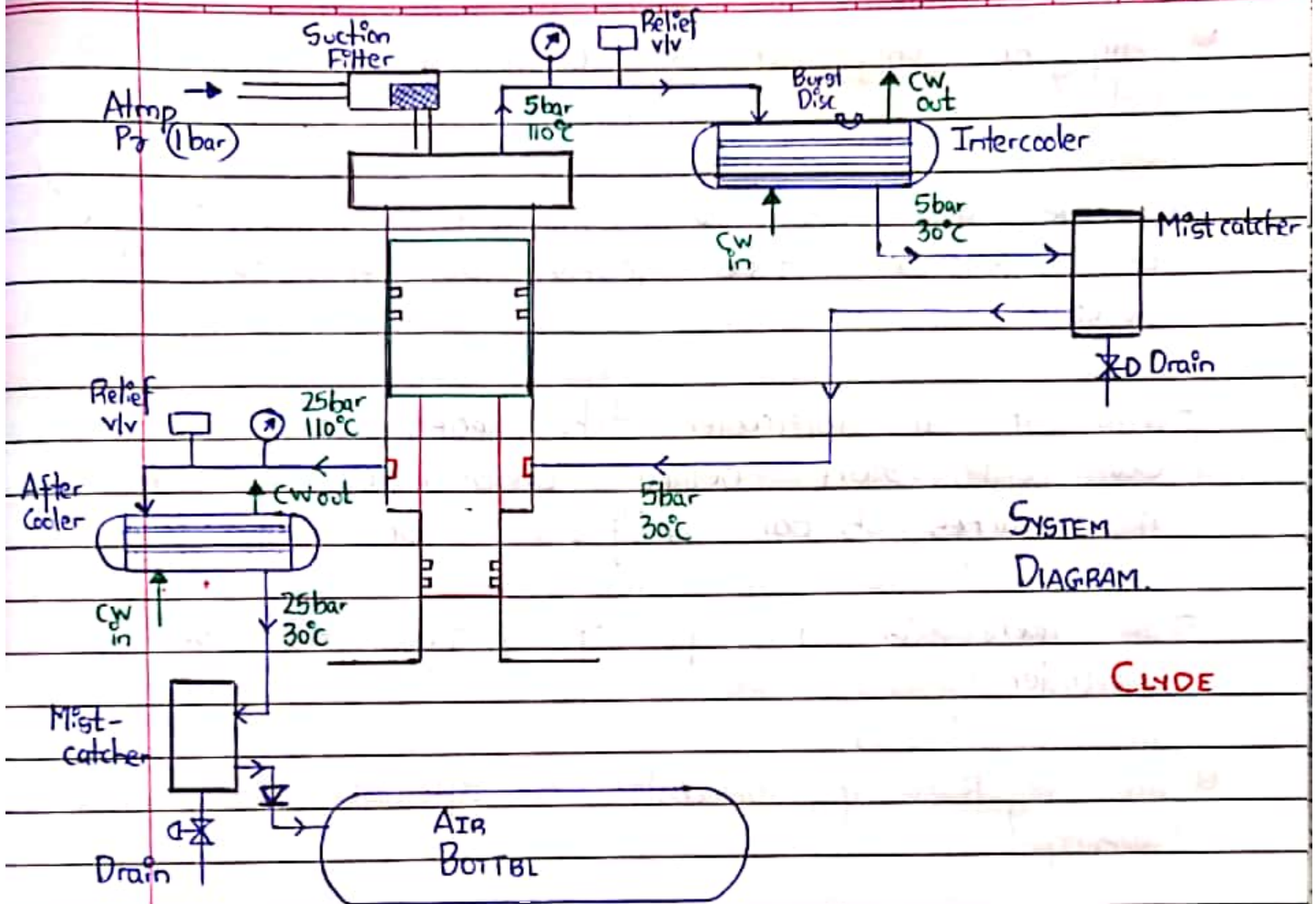
$$\frac{1 \text{ bar}}{5 \text{ bar}} = \frac{5 \text{ bar}}{P_4}$$

$$\therefore P_4 = 25 \text{ bar}$$

- IF HP discharge shows 25bar means compressor works fine
- You can also check time req to fill air bottle as per sea trial

COMPRESSOR TYPES

- ↳ Tandem type (LP & HP piston on 1 unit)
- ↳ Multithrow type (LP & HP piston separate)



a In intercooler & aftercooler, why air passes through tubes

- If air passes through shell, expansion will take place & compression will be lost.

SAFETIES :

- ① Relief Valve → Set at 10% above working pr.
- ② LO low pr trip
- ③ Bursting disc → Provided on LP cooler
- ④ High air temp trip → @ 93°C
- ⑤ Fusible plug
- ⑥ Motor overload trip

Q Why BD only on LP cooler & why not HP cooler?

- Suppose you put BD on both coolers, & now LP intercooler tube leaks, so LP BD will burst
- Now if HP intercooler tube leaks, the same CW will start getting pressurized & when it reaches 5 bar itself, LP BD will burst
- So there is no pt of putting BD for aftercooler

Q How to know if intercooler or aftercooler tube is leaking?

- Stop compressor
- Open CW in & out
- Now manually open drain of mist catcher
- If continuously water comes means tubes are leak.

BURSTING Disc is made of COPPER & it is not advisable from safety point of view to make bursting disc on ship

Q How to check which tube is leaking?

- Remove the 2 ends cover
- Connect hyd plp to shell
- If water starts coming from a particular tube, means that tube is leaking

PURPOSE OF NR Valve :

- When compressor is stopped, unloader vlv's are open.
- So we don't want air from bottle to drain
- Also if 2 compressors are running, interference should not ^{take place}
- * New compressor, main bearings & HP piston & liner LO is sent by a pump
- * For some compressors, an oil box is provided on top to provide drop by drop lubrication to  LP piston & liner
- * Otherwise a line from pump is provided by a line to the LP side
- * In compressor, oil must have ANTI-OXIDANT Properties otherwise yellowish colour laquer formation will form CLYDE

Reasons for long running of compressor?

- Air leak as vlv is kept open
- Unloader kept open
- Vol eff of compressor dropped
- Suction filter choked
- Leaky suc/discharge valves
- Piston rings worn
- More clearance volume
- Faulty pressure switch
- Air bottle drain left open

PURPOSE OF UNLOADER :

- To reduce the starting torque and to prevent the motor from overloading.

Bumping Clearance -

- * If BC is 0, then piston will go & bump/bang against cyl head & damage the components.
- * If BC is too high, then volumetric eff of the compressor will be very less.

Q How to measure BC ?

LEAD BALL METHOD

- * Remove the cyl head
- * Remove the valve
- * Make a ball of lead wire
- * Box back cyl head & valves
- * Turn flywheel till piston reaches TDC
- * Now remove ball & measure thickness

If BC allowed is 2mm
make ball of = $2 \times \text{Max BC allowed}$
= $2 \times 2 = 4\text{mm}$

BC should be 5% of total stroke

- DIAL GAUGE METHOD

- * Remove bottom end bolts
- * Remove bottom half of con rod big end
- * Fit the dial gauge to upper keep & magnetic block to crankcase
- * Now with throwbar, lift up piston till it touches TDC
- * Dial gauge reading will give you BC.

- DEPTH GAUGE METHOD

- * In some compressors, no need to remove cyl head & valves
- * There is a provision to directly insert depth gauge

$$BC = \text{Value} - \text{thickness of cyl} - \text{thickness gasket}$$

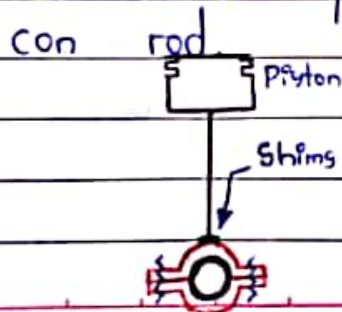
Q How does BC change?

- due to wear down of bearings
 - ↳ main bearing
 - ↳ bottom end bearing
 - ↳ gudgeon pin bearing
- cyl head thicker gasket

CLYDE

Q How to rectify?

- change / renew bearings
- add shims if it is a marine palm type



- * But by adding shims, LP BC will decrease but HP BC will increase

* So this is not right method

Q In what conditions will LP relief vlv lift?

- ① Cooler tubes badly choked & hence RV may lift
- ② HP suc vlv leaking travelling back when HP piston comes down
- ③ HP delivery vlv leaking.

Q In what conditions will HP relief vlv lift?

In case NR vlv does not hold, pr from air bottle can make HP relief vlv lift.

* Put hand on suc filter

Turn flywheel

As piston moves down, hand will feel suction
means LP delivery vlv is OK.

* Keep turning flywheel

Let piston come up

Suc vlv will close & you'll stop feeling suc on hand

means LP suction vlv is OK.

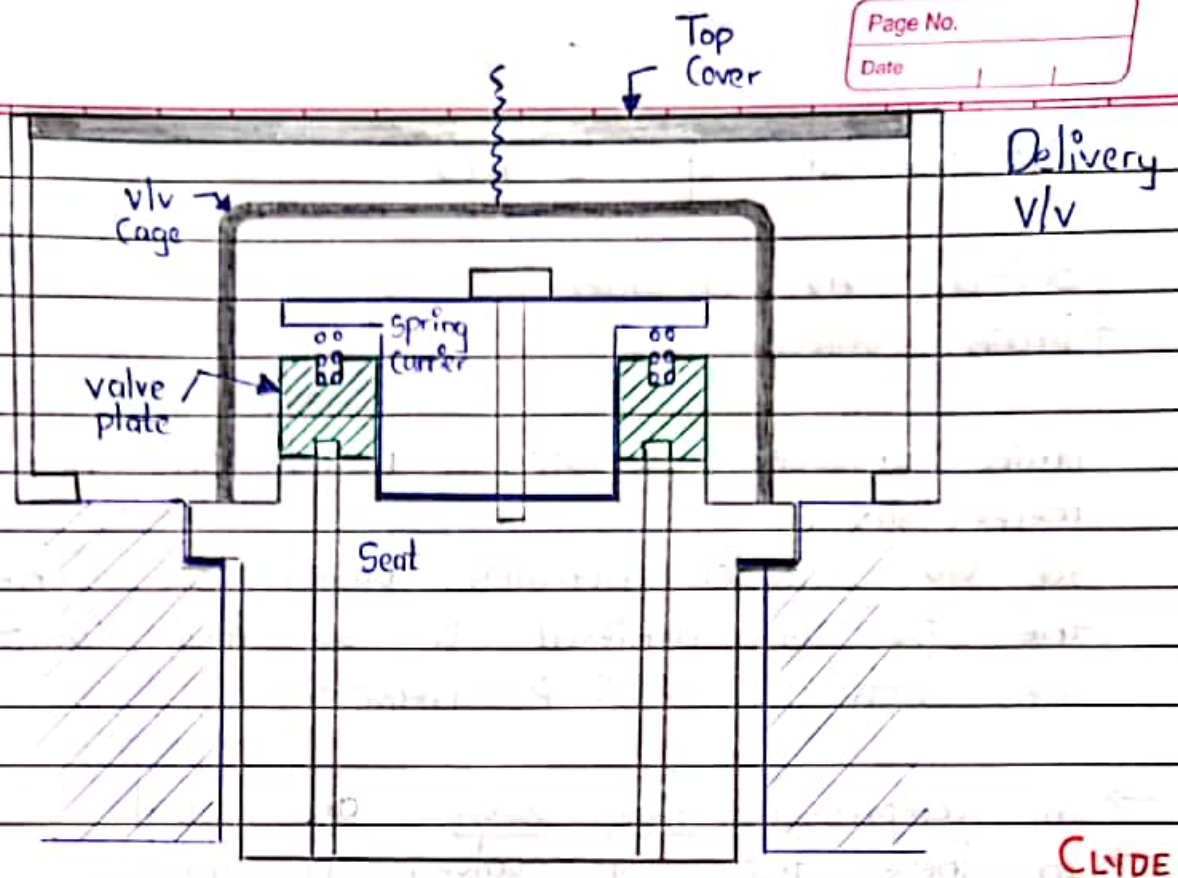
* Remove NR vlv

Air from air bottle will come back

Piston to be at TDC

Remove HP suc vlv & check if air is coming

means HP delivery vlv is OK



vlv plates made up of nickel-cr steel
vlv seat made up of carbon steel

- * Firstly cover on top has to be removed by loosening nut
- * Clean carbon in valve pocket
- * Remove vlv cage
- * Now use a puller to take out vlv assembly
- Clean vlv & vlv seat with brush
- Wash with diesel
- Check condition of vlv plates if cracked
- Lap vlv plate & seat properly on surface plate
- Check vlv thickness
- Check condition of spring or spring plate

HP valves are smaller than LP valves

Unloaders are of 2 TYPES

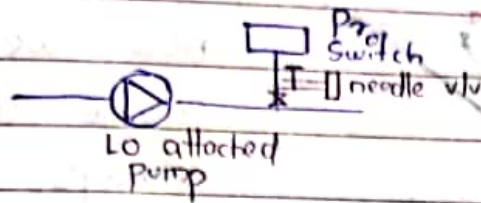
- Suction vlv unloader
- Drain unloader

Drain unloader actuates based on timer mechanism

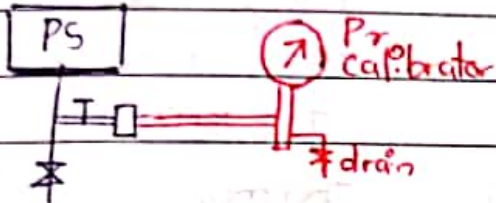
Suc vlv unloader actuates based on when the pr is achieved & so that compressor does not START / STOP frequently

- In compressor, Plate Valves are used
- In these type of valves no throttling takes place
- If throttling happens, pr will drop
- These vlv are lightweight, so no inertia

① Low Lo' pr trip.

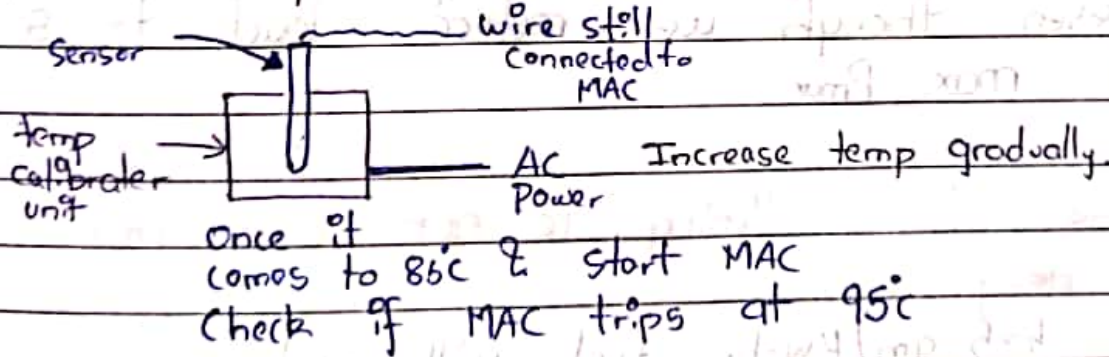


- * Isolate Pr switch from line
- * now attach hand held pr calibrator
- * pressurize to 5 bar
- * Start MAC
- * now slowly drain pr from pr calibrator
- * At 1 pt, MAC will trip.



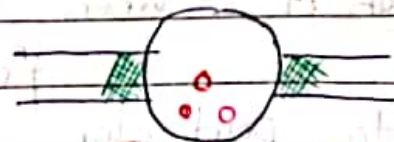
At that pr, you'll get Lo low pr trip
It usually trips at 2 bar
wk pr about 4 bar.

② High air temp trip = 93°C (Alarm & Trip)



Once it comes to 86°C & start MAC
Check if MAC trips at 95°C

- * In some designs, there is ICW high temp alarm (optional)
- * Or ICW no flow alarm



If flow good, balls continuously move in sight glass.

* * REFRIGERATION * *

Q Works on which cycle?

- It works on vapour compression cycle as we do to work by the compressor

2ND
LAW
OF
THERMO-
DYNAMICS

- But why to do work by the compressor?

- As we know, heat travels from body at higher temp to a body at lower temp

- But if we need heat transfer from lower temp to higher temp → Work needs to be done

- This work is done by Compressor.

* SATURATION TEMP

- means boiling temp at the corresponding pressure
like water boils @ 100°C at atm pressure
water boils @ 60°C at lower pressure

- Saturation temp is the temp for a corresponding saturation pr at which a liquid boils to its vapour phase.

- This temp depends on the pr of system
- So if the sys remains at const pr during phase change, it would remain at const. saturation temp.

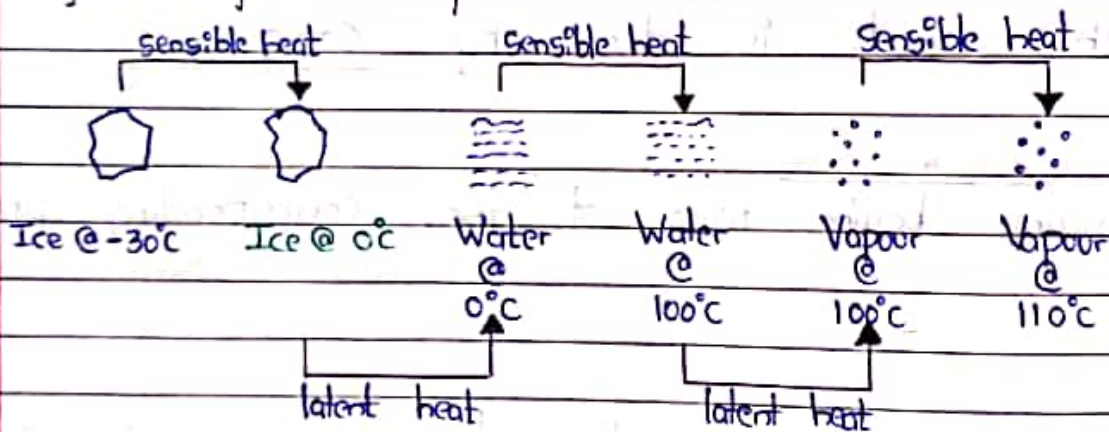
LATENT HEAT :-

- It is the heat added or removed from a body that causes a change in phase from solid to liquid & liquid to vapour without any change in temp.

- * SOLID $\rightarrow$ LIQUID latent heat of fusion
- * LIQUID $\rightarrow$ VAPOUR latent heat of vapourization or evaporation

SENSIBLE HEAT :-

- It is the heat added or removed from a body that causes a change in temp without any change in phase.



ENTHALPY :-

- It is the total heat content of system.
- It includes internal energy & product of pressure & volume.

ENTROPY :-

- It is the measure of randomness of a system.
- Suppose sys is not organized, so some part of energy will be utilized to organize this randomness.
- Entropy is the wastage of energy as no useful output comes from it.
- But this is necessary to bring the sys in order.

For ex : Frictional losses is entropy in engine

CRITICAL TEMPERATURE :-

- The max temp at which no matter how much pressure you apply, the substance cannot be liquified.

CO_2 has critical temp 31°C at 73 atm pr
After this temp, CO_2 cannot be liquified.

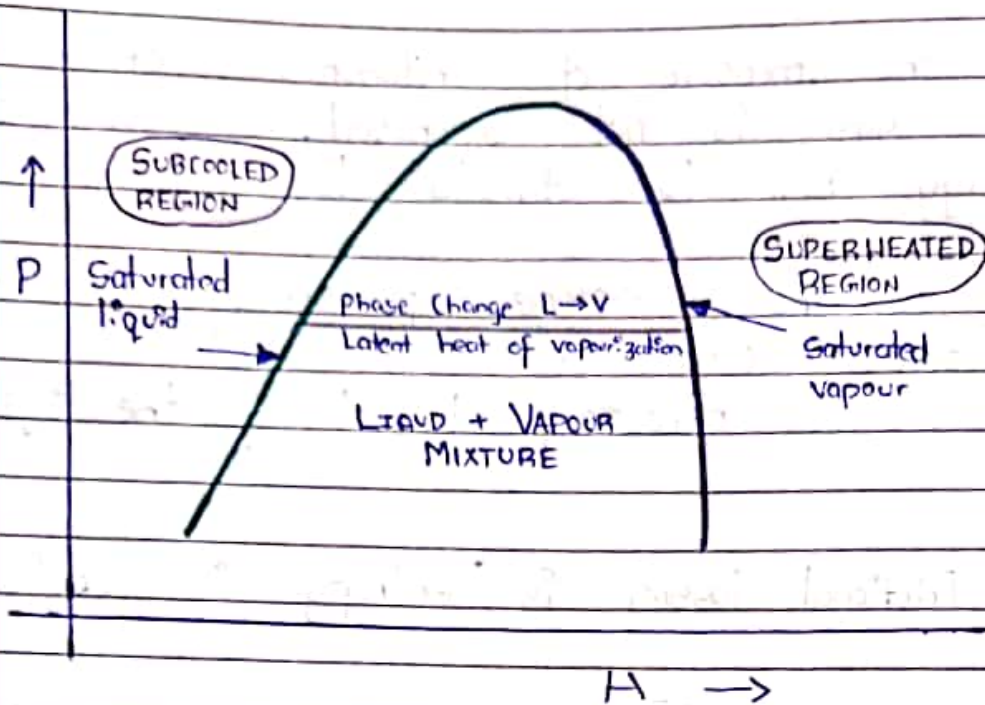
CRITICAL PRESSURE :-

- It is the pr that must be applied in order to liquify substance at its critical temp.

31°C is critical temp } for CO_2
73 atm pr is critical pr }

P-H Diagram

Basics



OZONE DEPLETING POTENTIAL :-

- ODP of chem compound or gas is the relative amt of degradation it can cause to ozone layer

GLOBAL WARMING POTENTIAL :-

- GWP is measure of how much a given mass of gas contributes to global warming
- It is a scale that measure amt of heat trapped by green house gas to amt of heat trapped by mass of CO_2

* when liq evaporates, it takes latent heat from surrounding & cool surrounding

- example - spirit

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Refrigeration.

CLIDE

* Works on 2nd law of thermodynamics

Heat trans high temp
↓
low temp

work needs to be done

* Heat transfer normally occurs from high temp to low temp ← no need of external aid

* But if you need heat trans. from low temp to high temp → **wk needs to be done**

* when pr drops, B.P also drop

* when there is change of phase, it absorbs the latent heat of evaporation

① Env friendly → low global warming & low ozone depleting potential

② Should have high critical temp

ex - freon

but CO₂ critical temp 31°C after which it cannot be converted to liq

(m³/kg) ③ Low specific volume $\frac{\text{vol of fluid}}{\text{mass of fluid}} = \frac{V}{P \times V} = \frac{1}{P}$

④ High critical temp

⑤ low critical pr

⑥ Non-toxic, non-corrosive, non flammable

⑦ Easily separable from oil

⑧ It should have high latent heat of evaporation.

Miscible with oil

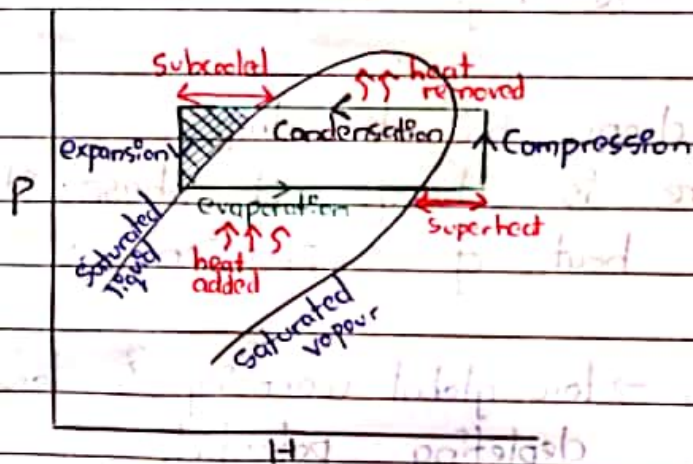
F-11 } CFC ← Banned
 F-12 } chloro
 } fluoro carbon

F-22 HCFC
 hydro chloro
 fluoro carbon ← Using

HFC-123 ← Using

HFC-134A

HC-29 ← Upcoming



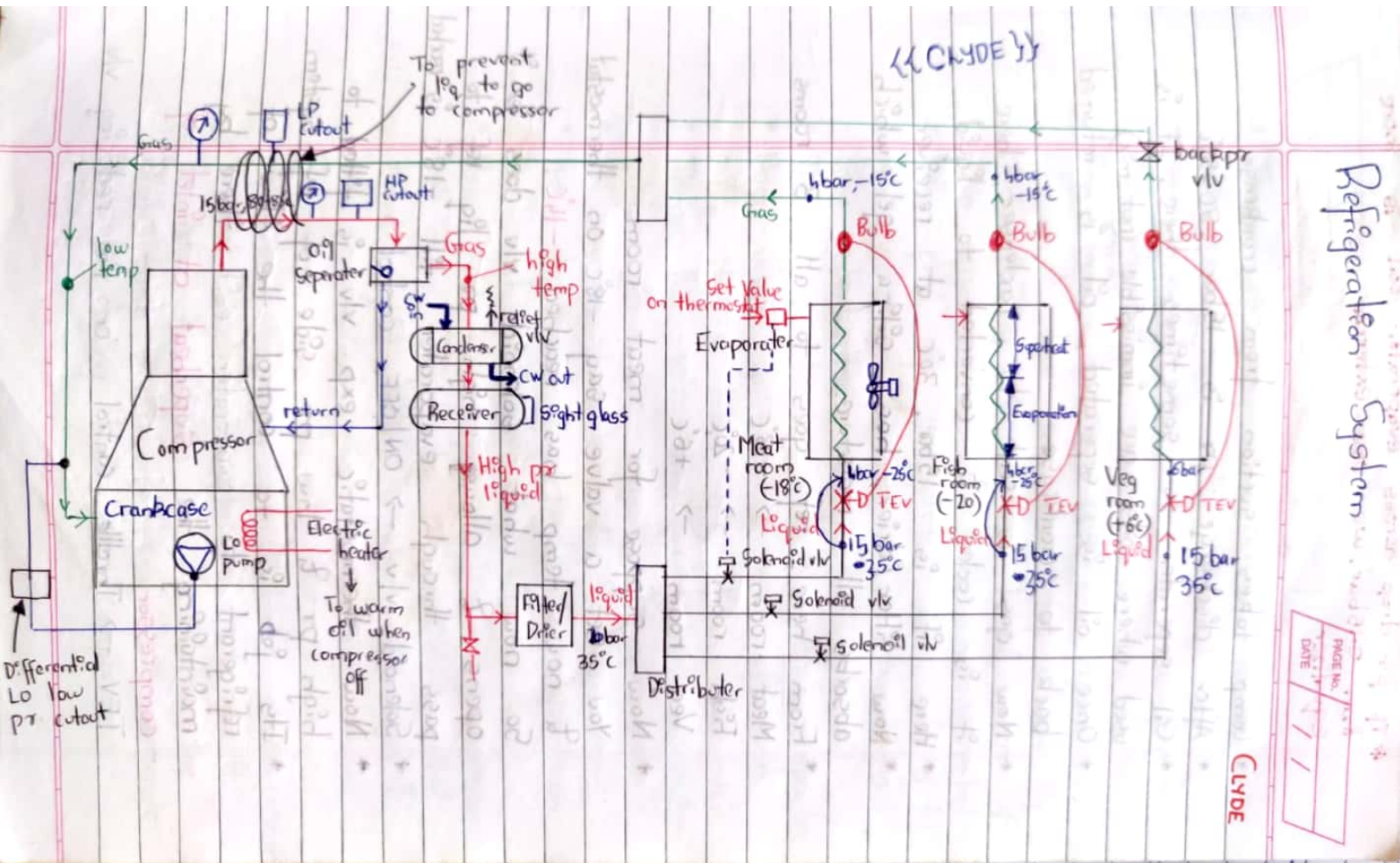
If Subcooling is less, ref eff is less

Throttle
condenser
water
outlet vlv

If Subcooling is more, Flashing effect will be
 0 & lq will return back & frosting on compressor

Subcooling happend in condenser.

Refrigeration System



* If pr drop across evaporator coil is more than 0.15 bar, we use external equalizer

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- * Comp. takes suction from crankcase
- * After discharge, pr is 15 bar, $80 \sim 85^\circ\text{C}$
- * Oil separator is sometimes there. It is used where oils are immiscible (not mix)
- * Once oil is separated, oil is returned back to crankcase
- * Now gas is sent to condenser, here it is cooled & converted to liquid
- * Here it is 15 bar, 30°C at receiver
- * Now filter/drier has silica gel which absorbs all moisture
- * From here, ref goes to all 3 rooms
 - Meat room $\rightarrow -18^\circ\text{C}$
 - Fish room $\rightarrow -20^\circ\text{C}$
 - Veg room $\rightarrow +6^\circ\text{C}$
- * Now suppose for meat room
You set a valve say -18°C on thermostat & now temp has reached -14°C .
So now what solenoid vlv does is, it opens & allows high pr liq ref to pass through evaporator till -18°C is reached
- * Solenoid vlv $\rightarrow$ ON/OFF control
- * Now thermostatic exp vlv is fitted to high pr & low pr side of ref system
- * Its job is to control the flow of refrigerant to evaporator coil there by maintaining the superheat at inlet of compressor
- TEV $\rightarrow$ Throttle control or Pr reducing vlv

- temp drop
- * There is pr drop, across ~~evaporator~~ TEV
 - * So at outlet of TEV is low pr liq refrigerant.
 - * Now this liq ref passes evaporator coils at low pr due to which liq starts boiling, it takes latent heat of evap from room & room gets cooled.
 - * Now part of evaporator coil will act as evaporator & other part will act as superheater
 - * The gas absorbs latent heat & evaporates
 - * Now when gas comes out of evap. coils, it is hbar, -15°C from hbar, -25°C
 - * There is 10°C drop at the evaporator which is the degree of superheat
 - * It acts as both evaporator & superheater
 - * The degree of superheat will depend on how much liq given by exp. vlv
 - * Now cold gas goes back to compressor, but there might be a possibility that some liquid still remains with gas & can go to compressor & damage
 - * So what we do is, the suction pipe to compressor & discharge of compressor is tied together & lagging put on it
 - * So now if liquid comes back, the high temp ~~to~~ discharge line will evaporate the liq coming back to compressor.

Now in air compressor
air comes on top of piston
but in ref compressor
air comes in crank case why?

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Because liq. may return & if goes on
top of piston, it will cause damage.

Now $\frac{\text{heat removed from evaporator}}{\text{heat equivalent of WK done on compressor}} = \text{COP}$

- More the COP
- More betⁿ is the refrigerant effect

example

Suppose tanker carries 10,000 lt diesel
& engine consumes 200 lt of fuel

$$\frac{10,000}{200} = \text{COP}$$

Safety ①

TEV will maintain some degree of
superheat & not allow liq to go to
compressor.

Safety ②

Suc & dis line of compressor joined
together

Safety ③

If liq comes back into crankcase, it
will evaporate & crankcase has a
heater

Safety ④

Safety header spring v. which will entirely
lift in case liquid is tried to
be compressed

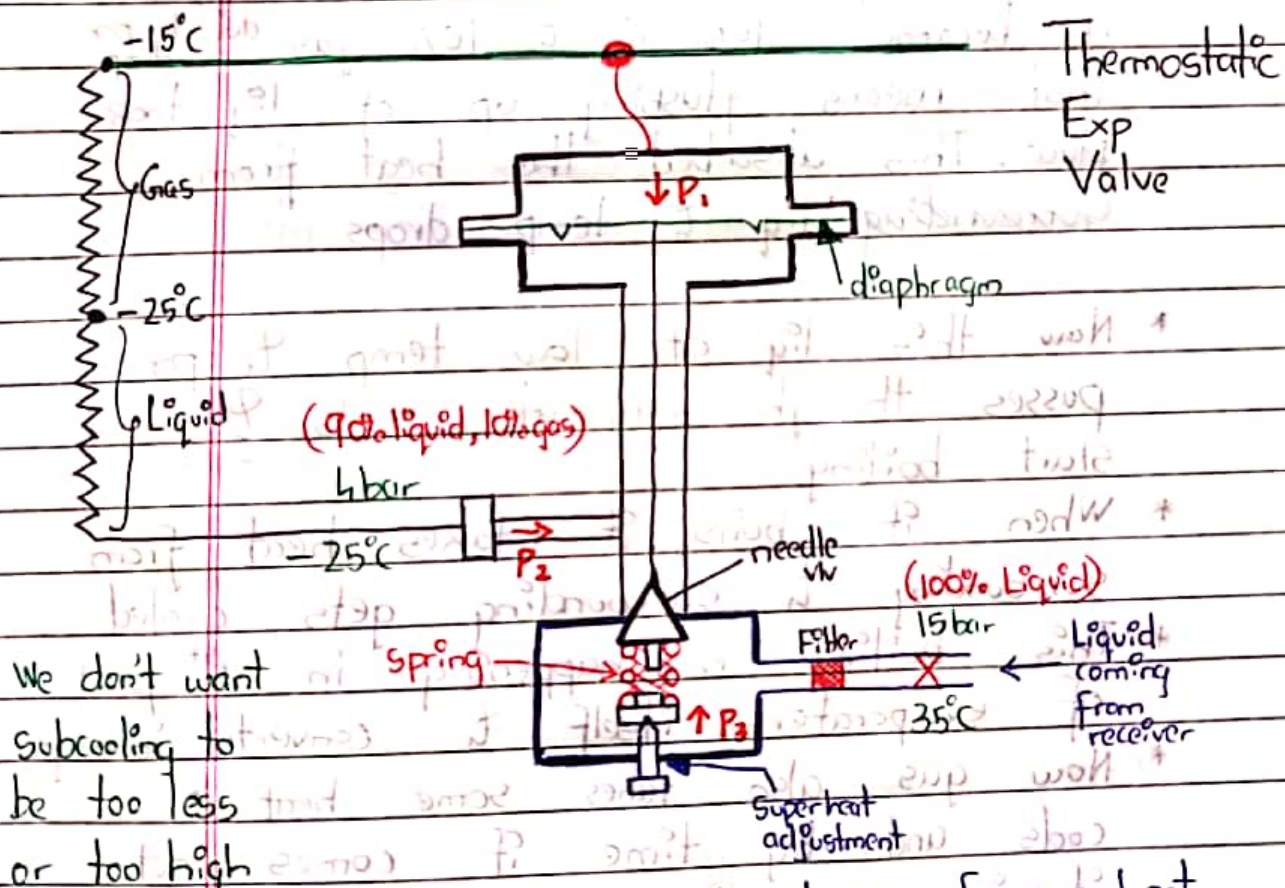
* Crankcase heater starts when compressor is off & stops when compressor starts → to keep warm

Safety ⑥

Compressor are driven by belt & not directly coupled. Now due to liq compression, heavy torque is produced & this will cause the belt to slip.

Safety ⑥

Compressor has no flywheel



We don't want subcooling to be too less or too high

- * TEV → maintains const. degree of superheat at outlet of evap coil
- * TEV → flow control device
- * Also called **flow control vlv**
- * Liquid enters & leaves. At needle vlv
- * Throttling takes place → causes pr drop
- * At needle vlv 15 bar → 4 bar & liquid is flashed up.
- * 100% liq → 90% liq & 10% gas

Because of throttling

Pr drops

Because of pr drop

10% of liq $\rightarrow$ into gas

It takes heat from remaining liq & temp drop

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- * Now when 10% of liq is converted to gas, it will absorb latent heat of evaporation

When liq enters, it is at 35°C but at outlet it is -25°C ? How?

- because first it was 100% liq, then it became 90% liq & 10% gas due to pr drop. That means flashing up of liq took place. This absorbed the heat from surrounding liq & temp drops.

- * Now this liq at low temp & pr passes through evaporator coils & start boiling

- * When it boils, it takes heat from surrounding & surrounding gets cooled.

- * This boiling is happening in 1st part of evaporator itself & converts into gas

- * Now gas also takes some heat & cools and by time it comes out it is -15°C from -25°C

- * So 10° superheat

- * Now gas going back, its temp is sensed by a bulb having same liq ref in it

- * When it senses, gas/liq inside the bulb & capillary will expand/contract & exert pr P_1

P_1 = Gas expanding in capillary

P_2 = Evap pressure

P_3 = Superheat adjustment

When P_1 & P_2 is equal, vlv is set
But since we adjust P_3

$$P_1 = P_2 + P_3$$

P_2 & P_3 tries to close vlv

Now P_1 also needs to increase

If only temp increases, then P_1 can act equally down & that is superheat. (temp rise)

* This is called internal equalizer.

* The more you increase P_3 more you will require P_1 (superheat)

Example

Now if we have taken new ^{with evap region} provision, it will absorb heat & also act as superheat, but superheat will be very high. P_1 will increase & vlv will open. & provision will cool rapidly.

In domestic refrigeration & AC, -
thermostatic control - vlv not used,
capillary tube is used.

close receiver outlet
And start comp
to test LP cutout

LP Cutout $\leftarrow$ Auto reset

- * Provided so comp. not to go to vacuum & it will draw air.
- * It will cut out comp. at about 1 bar
- * Freq. start & stop of comp. on LP cutout is called **Short Cycling**.

cut out 1 bar
cut in 1.2 bar
example

Reasons

- LP cut out difference too low
- Compressor vlv's leaking
- Low charge (can see from receiver)
- Filter/Drier choked
- Leaky solenoid valves
- Moisture in system (blocking exp vlv)

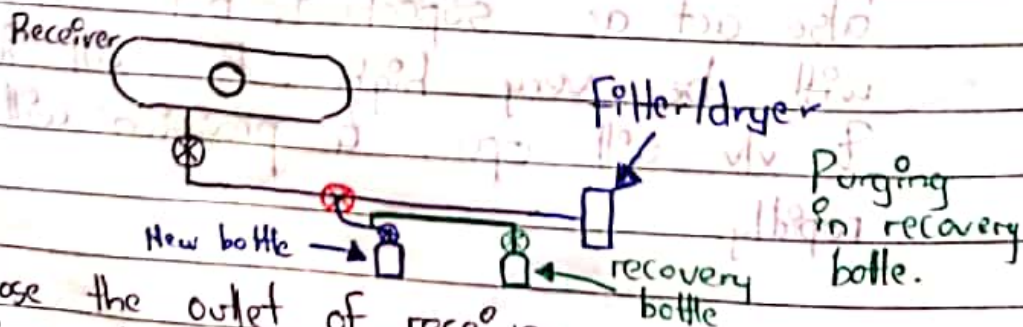
Charge to be done from HP side

Charging

* before charging, check where all the refrigerant has gone $\rightarrow$ Leakage

If using freon 22, no venting to atm
Do it in receiving bottle

Maintain a log of ref charged



- Close the outlet of receiver
- Pump down all refrigerant in receiver by run comp
- Receiver level $\rightarrow$ check
- Always charge from HP side & not LP side

- * Halide lamps
 - * Soap solution
 - * Ultrasonic leak detection
- To find leaks

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Close discharge vlv of receiver

Put new recharge bottle

Connect recovery bottle

Open vlvs of new bottle & recovery bottle

This is for purging.

Now close recovery bottle vlv

Open discharge vlv of receiver.

{ Difference betⁿ Lopr & suction pr }

Differential LO LP Cutout

- * To protect comp against loss of LO pr
- * We want discharge pr above suction pr (gas ref coming back to crankcase)
- * It measures diff in pr betⁿ suction to crankcase & pump discharge
- * This pump is a LO pump supplying oil to bearings.
- * LO pump pr can be low due to no LO, filter of pump choked etc

Stop cooling water to condenser to test HP cutout

HP Cutout ← Manual reset

- * Provided to protect system from high pr

Reasons

- Condenser cooling not proper as tubes may be choked
- HP cutout may not be properly adjusted
- Air in system
- Overcharging

Silica gel colour changes to blue when it absorbs moisture.

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HP Cutout $\leftarrow$ Manual reset

* To protect compressor & system against high pr

- In condenser cooling not proper as tubes may be choked (relief vlv will lift if pr increases)
- HP cutout may not be properly adjusted
- Air in system
- Overcharging

* Now air if there in system $\rightarrow$

Along with air moisture also goes

How to detect & How to remove?

- HP cutout

- condenser will become hot

- discharge pr will be high (as air is non-condensable)

* Air can go in by charging the gas, charging the oil or maintenance receiver

- Shut ~~valve~~ vlv of compressor

- Pump down all the refrigerant

- Ref will be collected in receiver till LP cutout

Measure temp of saturated liq. ref.

Now corresponding to temp, check the pr.

- Purge out air from condenser

* Compound pr gauge on discharge & su side

* Compound pr gauge shows pr & corresponding saturation temp.

* Receiver has a temp indicator. (saturation temp)

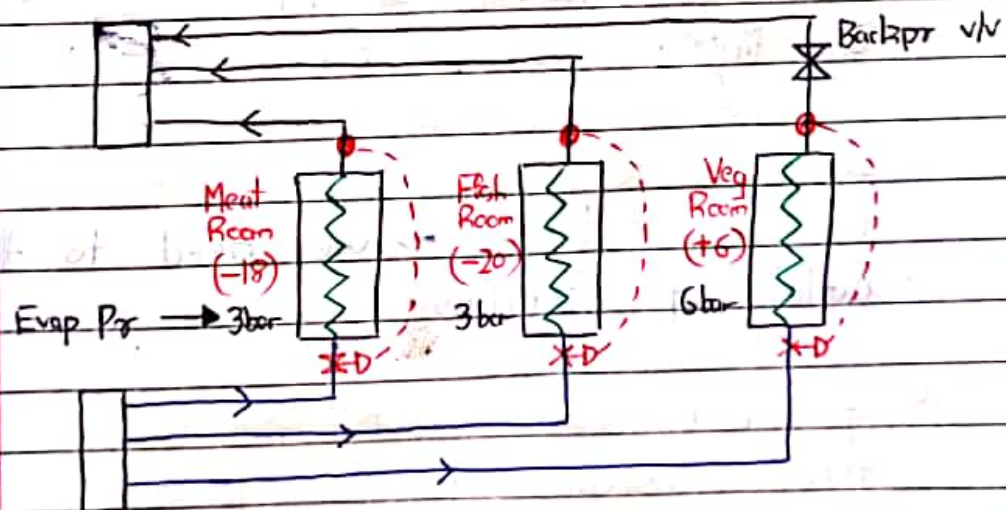
* Mixture is sys can cause icing on exp vlv & can cause LP Cutout $\rightarrow$ removed by filter/dryer

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How veg room maintained at $+6^{\circ}\text{C}$ & other rooms maintained very cold?

- low pr. higher rate of evaporation & faster will be the cooling
- Now meat & fish are dead but fruits & veggies are not dead, they breathe
- They will die if kept at or below 0°C
- So we want v. less cooling for them & we do that by increasing the pr
- We have a back pr control vlv
- Instead of maintaining 3 bar like other rooms, here we maintain 6 bar
- Evaporation pr = 6 bar $\rightarrow$ Veg room

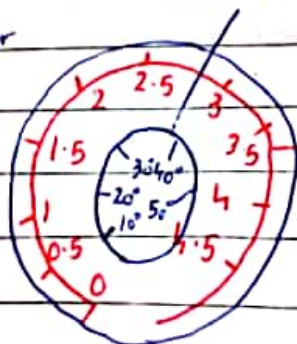


Sat. Temperature

(Suppose temp indicator shows 30°)

So corresponding pr is 2 bar

But compound pr gauge shows 3 bar



* Compound Pr Gauge

Pressure

Frosting on suc of compressor?

- Evaporation not taking in evaporator tube & hence liq. ref comes back & cools the compressor.

- So evaporation is taking place here instead of evaporator.

This can happen due to many reasons

① Evaporator tubes are frosted (ice formation) & hence evaporation cannot take place there.

② Expansion vlv not properly adjusted, due to which superheat is too low & liquid comes back to compressor

③ In case of cold countries $\rightarrow$ subcooling is very high $\rightarrow$ we need to throttle outlet of condenser

④ If bulb comes out, it senses atm temp instead of line temp. So it will send large amt of ref & cause frosting.

⑤ If oil in evaporator coil then evap won't happen as oil will act as insulator

⑥ Air circulating fan tripped

In that case, oil in crankcase will decrease

This may happen if oil separator not working properly.

How to remove the oil?

pumping the ref into receiver

- close receiver outlet
- run compressor
- vacuum will start to develop on sur of compressor & LP cutout will happen $\rightarrow$ bypass
- It will suck all oil from system & come in compressor sump.
- Better to do defrosting first as oil will become thin & easy to remove

How to charge oil in compressor?

- By plp $\rightarrow$ No need to make vacuum
- By making vacuum in sump of comp.

① On crankcase, 1 charging connection is there put a funnel & put the oil in it but

To check
ref gas
leaks

Holide lamp

Electronic detector $\rightarrow$ sends pulses

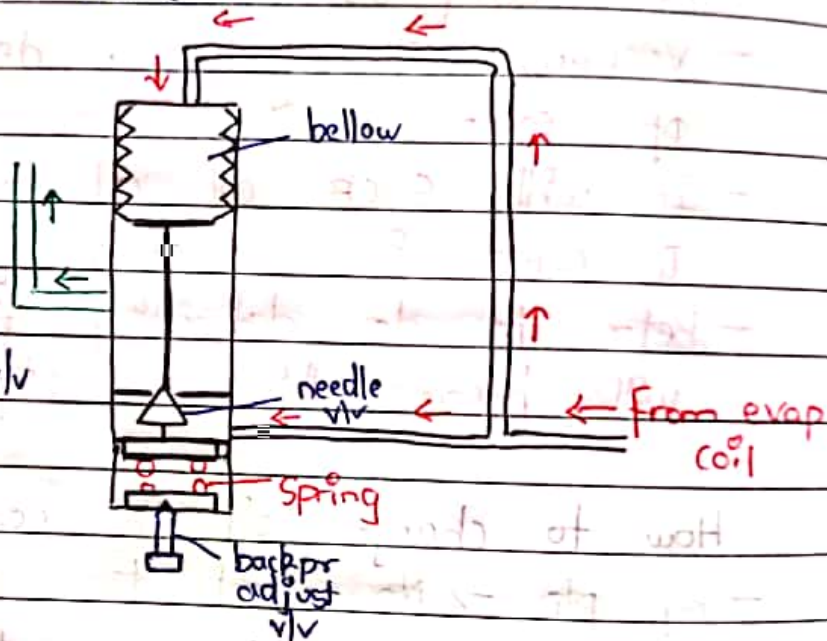
Exact leaks will be pinpointed by soap solⁿ

- keep the vlv closed.
- ② Now shut the discharge vlv of compressor receiver
 - ③ Comp will now go to vacuun
 - ④ Now open & up charging vlv very slowly.

CLYDE

Back-pr valve

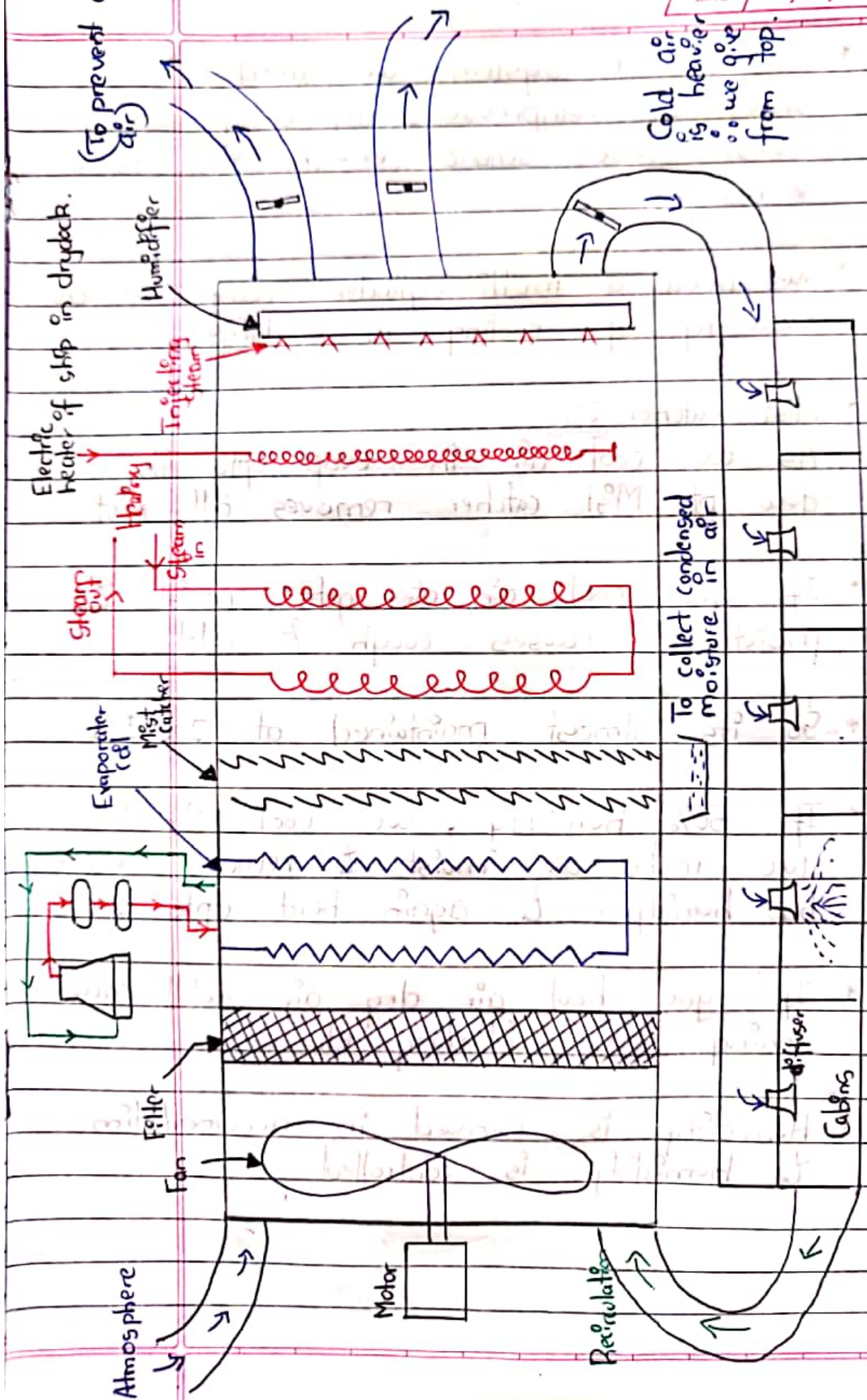
Spring will
try to shut vlv
& gas pr
tries to open vlv



* Due to backpr vlv, rate of evap will be low (6 bar) other rooms (3 bar)

**** Air Condition System ****

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Rate of heat transfer to
melt 1 ton of ice at 0°C
with 24 hrs = 1 ton

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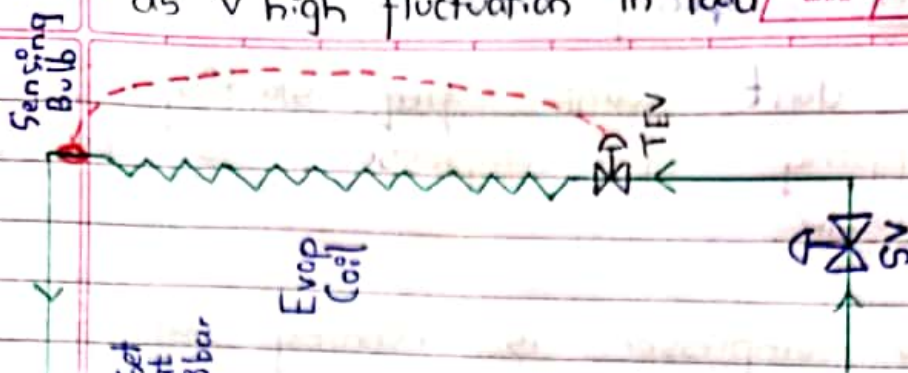
- * Now in AC system, we need to select a compressor, depending on worst case scenario. (ex - travelling to a v hot region)
- * We need a multi cylinder compressor as capacity of cooling is v large
- * Mist catcher :-
As we cool air in evap upto its dew pt. Mist catcher removes all mist
- * If you cool air, air gets moist & moistness causes cough & cold.
- * So its almost maintained at $20^{\circ}\text{C} \pm 1$
- * If 50% humidity, we cool air to 10°C make air moist & remove moisture by humidifier & again heat upto 20°C
- * If you heat air, dry air will cause itching, nose bleeding etc.
- * Humidity is sensed in accommodation & humidity is controlled.

CLYDE

Unloader

↳ Capacity Control
as v high fluctuation in load

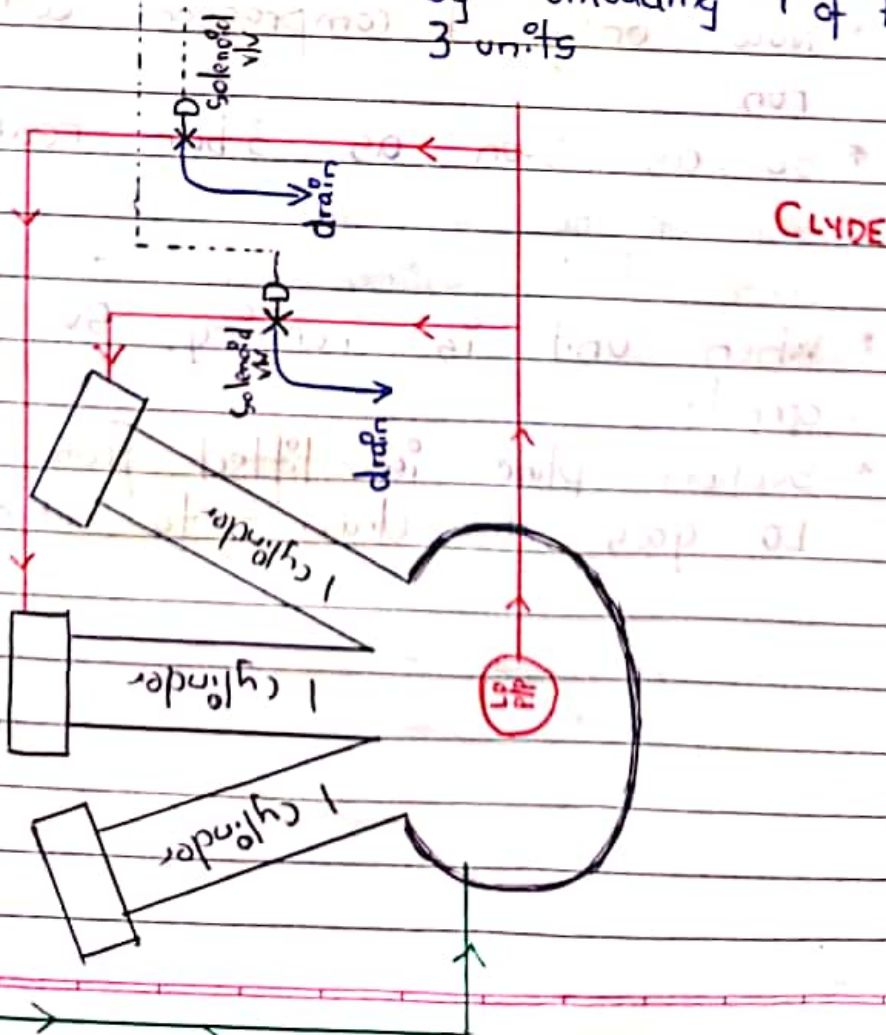
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* When outside temp drops & cooling is too much then exp vlv will start closing to maintain superheat. This will cause drop in suc pr

* So suc pr is an indication of load on compressor

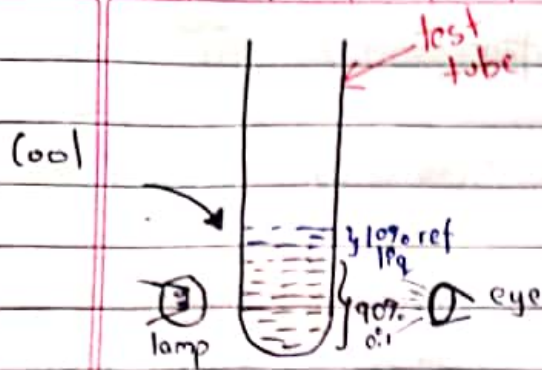
* Hence capacity is controlled by unloading 1 of the 3 units



Unloader → Capacity Control

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- * We don't want freq starting & stopping of compressor. So we use Unloader.
- * Now compressor is running at full load (100%) all 3 units
- * Now when temp. reduces, exp vlv starts closing to maintain degree of superheat & less liq ref will go to evap coil.
- * Now if pr comes to 3 bar, 1st unit will cut off
- * If room further cooled, pr comes to 2 bar, 2nd unit will also cut off
- * Now only 1 compressor will be run
- * So as soon as 3 bar reaches, SV will operate & drain the LO to unit thus cutting it out.
- * When unit is running, SV will not operate.
- * Suction plate is lifted from vlv & LO goes to drain → to cut out 1 unit



* 90% oil + 10% ref liq
& shake

* Now ref liq will evap
& cooling starts

* At 1 pt light won't be
able to be seen due to
wax formation

Low flock pt } 2 imp thing
Low pour pt } abt oil

The min temp before which wax will
start coming out of oil is called
Flock Pt.

The min temp after which fluid won't
flow is called **Pour Pt**

Copper Plating

- Problem associated in ref system
- At hot surfaces, copper will get coated
- Cu comes from compressor & evap. tubes
- Cu coating happens on liner wall, piston rings etc
- Reason on Cu coating is oil deterioration or comp. run too hot or air in system
- Causes blow past in compressor.

Safety Header Spring Valve

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* Critical pr of a substance is pr required to liquefy a gas at its critical temp.

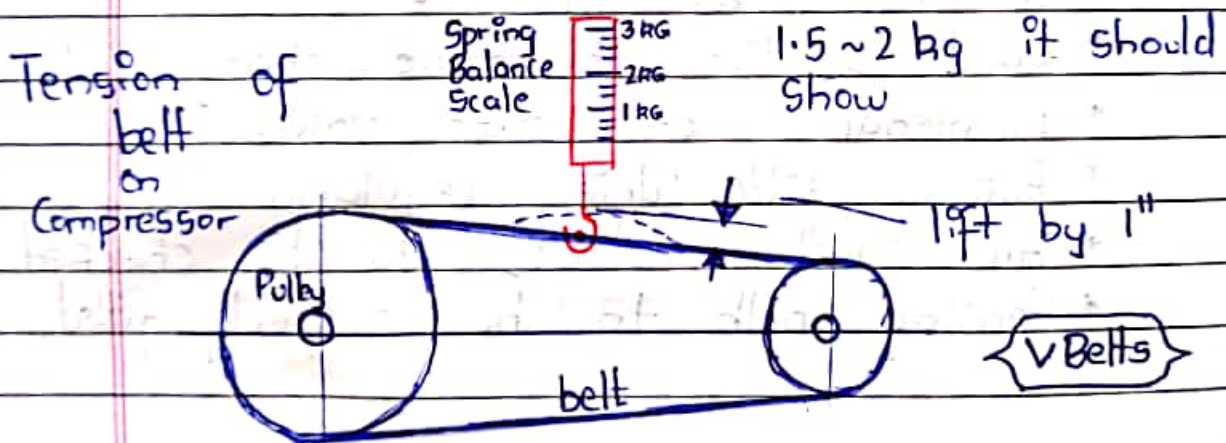
* Copper Coating - Copper from coils (condenser) & get coated over piston rings & liner.

Reasons :-

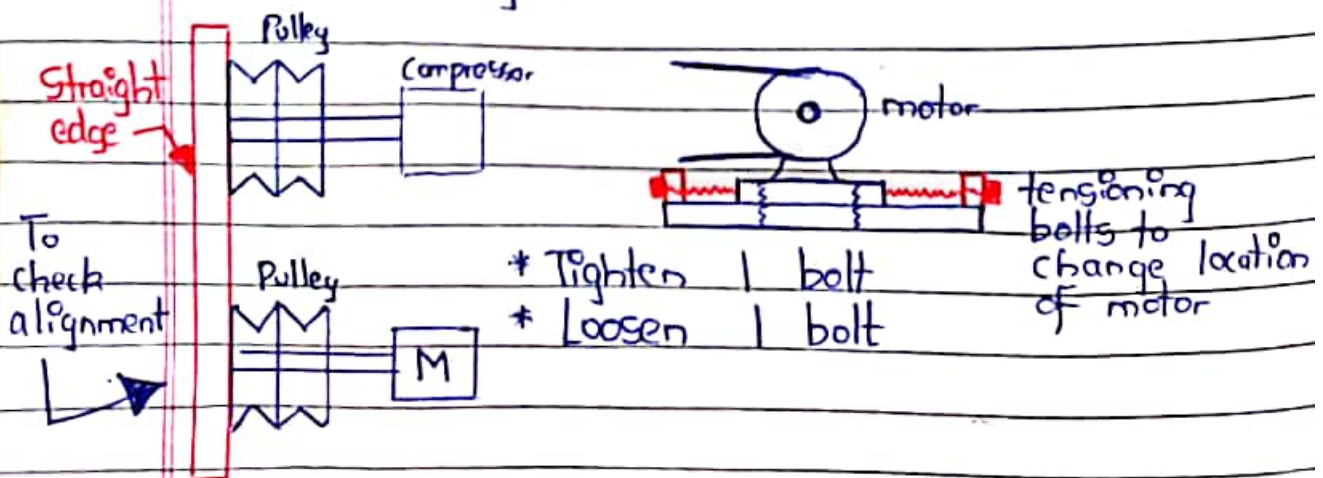
* Air in sys

* Comp. run too hot

* Oil has deteriorated



Q How to adjust tension?



Steering Gear

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CLYDE

Hyd Safeties

- ① low level & low low level alarm for hyd oil tank.
- ② Relief valve
- ③ Manual bypass valve
- ④ High LO temp alarm
- Mech stopper

Electrical Safeties

- ① Limit switches upto 35° & mech stoppers upto 37°
- ② Electric motor overload alarm
- ③ Power failure alarm
- ④ Phase failure alarm
- ⑤ High temp alarm $\rightarrow$ winding
- ⑥ Short circuit trip.
- ⑦ Alarm @ 200% of rotor current

Main Steering System

- ① Steering sys capable to turn rudder 35° P to 35° S
- ② Steering sys capable to turn rudder from 35° on 1 side to 30° on other side is not more than 29° at max draft & max full ahead speed.

- If this can be achieved by 1 pump then that p/p to have 100% capacity
- If this can be achieved by 2 pumps then each p/p to have 50-50% capacity

Aux Steering System

- ① Steering sys capable to turn rudder 15° on 1 side to 15° on other in not more than 60sec at max draft & half full speed or 7 knots whichever is greater

CLYDE

- Every oil tanker, chem tanker, gas carrier of 10,000 GT & above &
- Every other ship of 70,000 GT & above

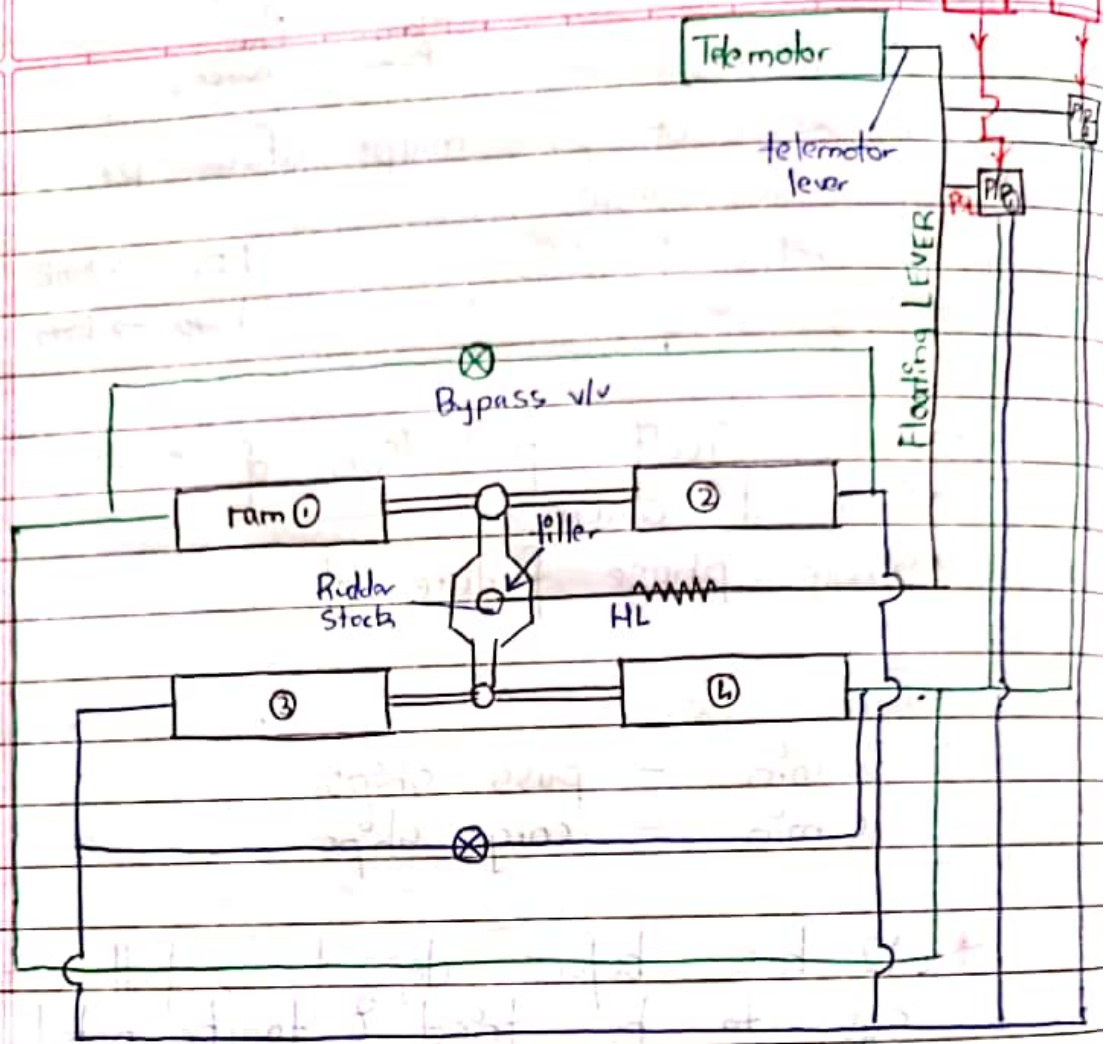
the main steering gear shall comprise of 2 or more identical power.

If main steering sys has ~~identical~~ identical units then no need of aux steering sys.

- * In passenger ship, each steering unit to have 100% redundancy

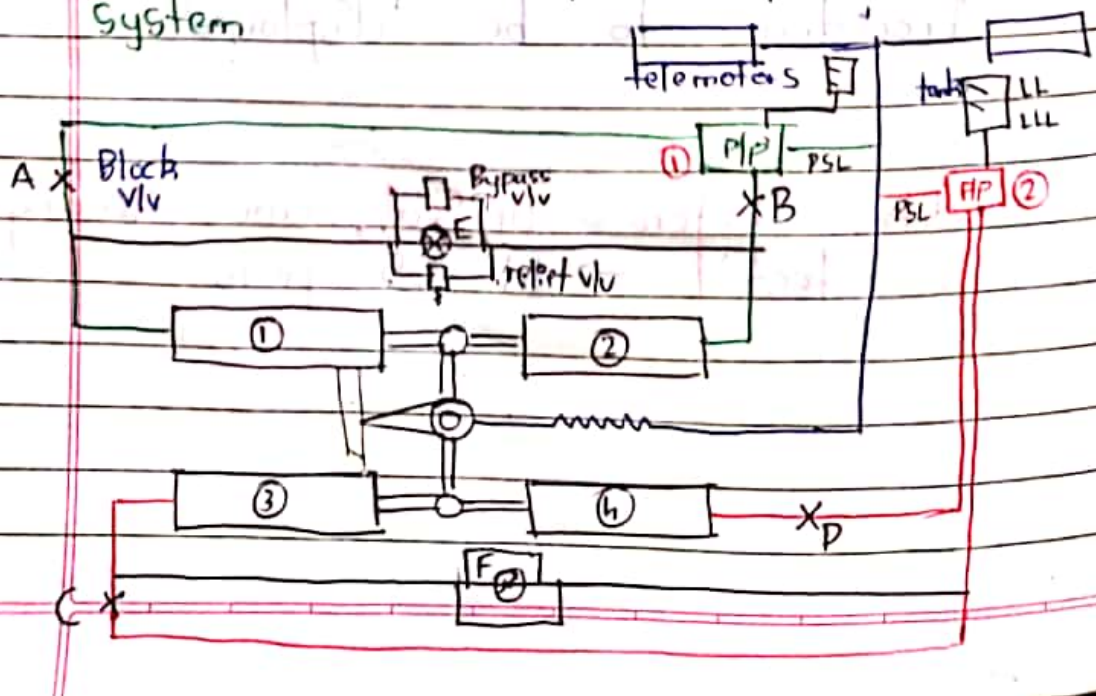
- * In cargo ship, each steering unit to have 50% redundancy

- * Design pr for piping & steering gear components should be by 1-25 times max working pr.
- * Eme steering operation to be available from steering flat only
- * There should be a gyrorepeater to indicate vessels heading.
- * Dedicated communication sys from wheelhouse to steering flat.
- * Procedures for eme steering to be displayed in steering flat.
- * Eme steering sys should come into operation within 45 sec of power failure.
- * Eme power to be available for
 - 30 min passenger ships
 - 10 min cargo ships
- * Once in 3 months, eme steering should be tested
- * All crew should be capable to change from normal steering to eme steering
- * 24hrs prior arrival in US ports, eme steering to be tried out.
- * 12hrs prior departure, full steering sys to be tried out & noted in logbook.



For tankers, gas carries of 1000 GRT & above.

2 independent & separate power activating system



100% redundancy

In case of failure of 1
Sys, the other Sys can give

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100% / Power

2 Independent systems

Each delivering 100% capacity.

Both systems cannot be active together.

P/P ① Run

A B open, E closed

plp ② off

C D closed, F open

In case of leak

LL displayed

Once LLL displayed

Computer auto stop

plp ①, closes A B & opens

E

Also starts plp ②

with ① ② open F closed.

Single failure criteria with 100% redundancy.

So chances of rudder failure is impossible.

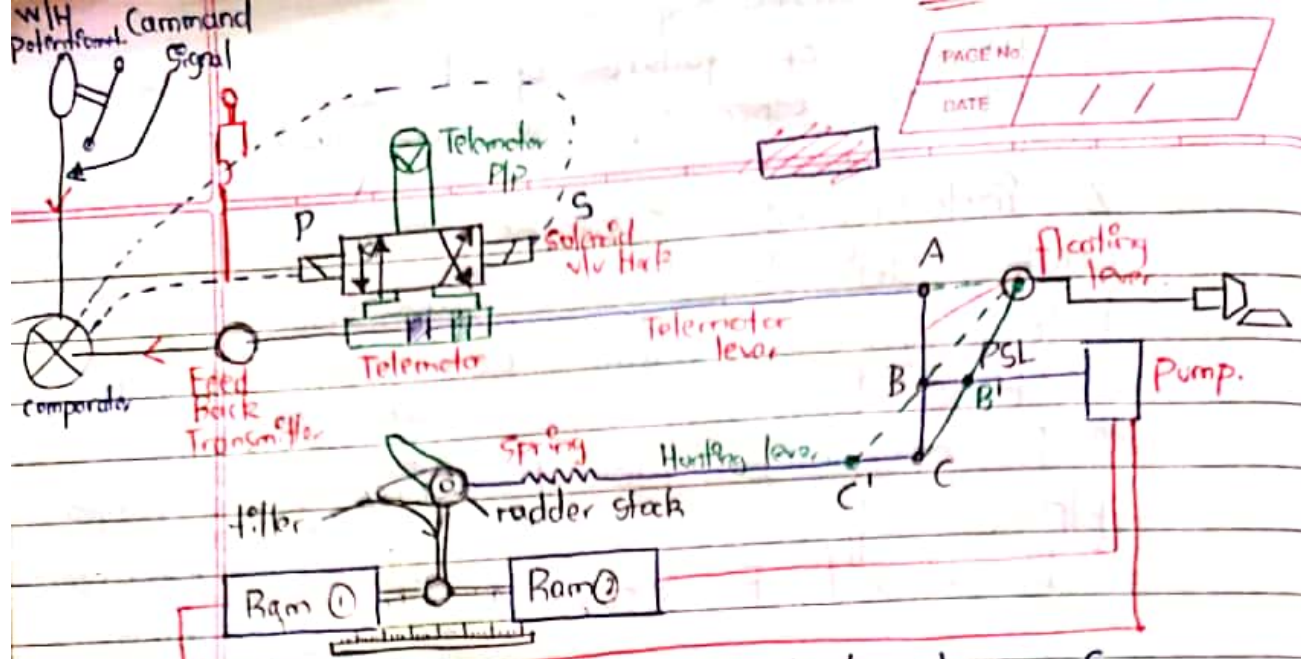
In 50% redundancy, 2 identical units. When they operate together, they give 100% capacity.

A B C D X Y all open

E & F shut

This is single failure criteria with 50% redundancy.

- Each plp will have header tank
- Tank will have low & low low level alarm
- Mech handplp / electric plp needed to transfer oil from storage tk to header tk
- Isolation vlv / Block vlv are used at the time of maintenance & rudder remains in position



- Spring in hunting lever protects lever from stresses.

Telemotor transmitter

Angle given (10°) but comparator also receives actual angle (0°)

Now solenoid vlv activates & gives oil. This moves telemotor

Also feedback transmitter

Hunting Gear is a error control mechanism. It consists of telemotor lever, floating lever, PSL & hunting lever.

Now if Combination of telemotor lever, hunting lever, floating lever & p/p stroke lever but rudder is called **Hunting Gear** doesn't move.

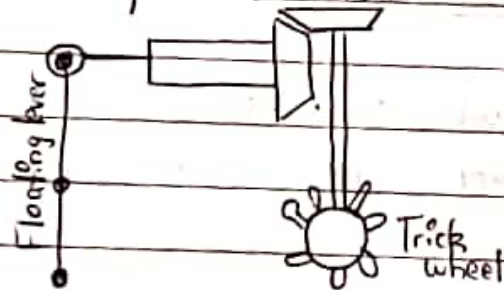
Hence In emergency, steering, we operate solenoid vlv manually when transmission fails to be done by

op solenoid valves

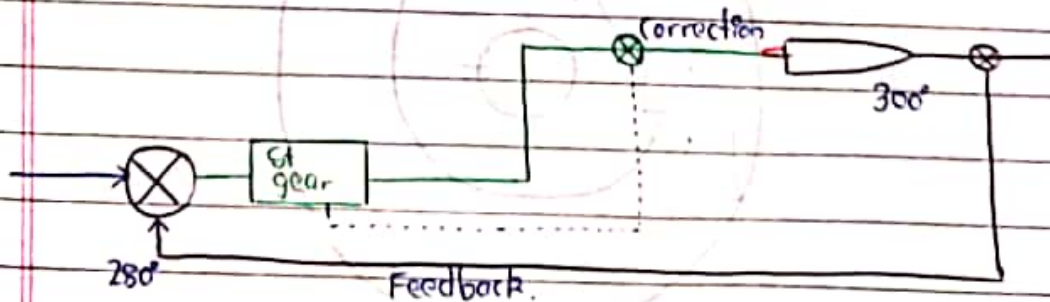
If feedback transmitter fails, we need to switch to non-follow up steering.

In non-follow up, there is no auto feedback. We ourselves are the feedback. When we give 15° on spring loaded lever & leave it, rudder goes to 15° & stops. If you want midship, again turn spring loaded lever in opp direction.

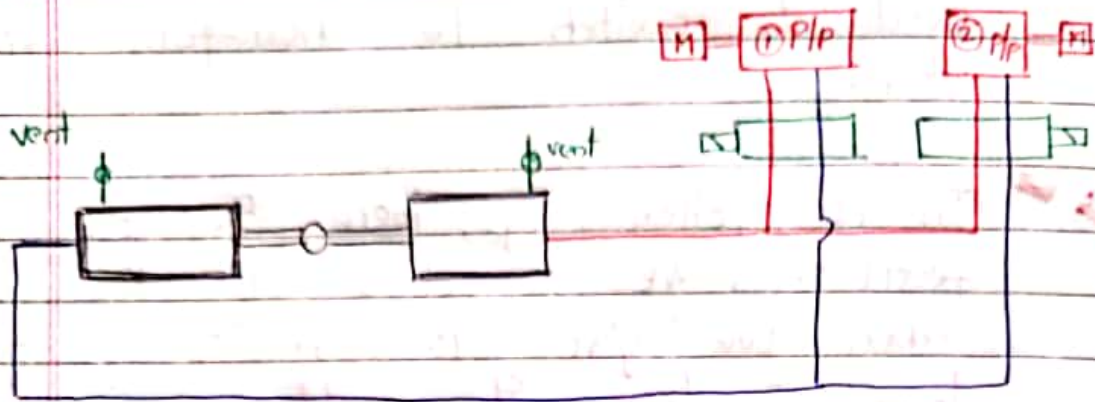
Now if telemotor fails.



In follow up, there is an automatic feedback.



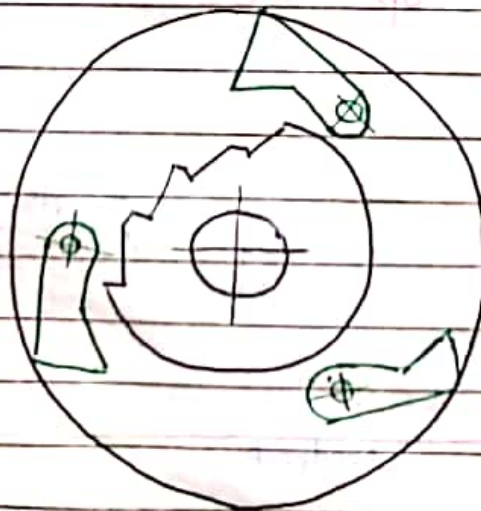
Suppose course is put to 300° (set course)
Actual course is 280°
So due to 2° difference, correction will be applied



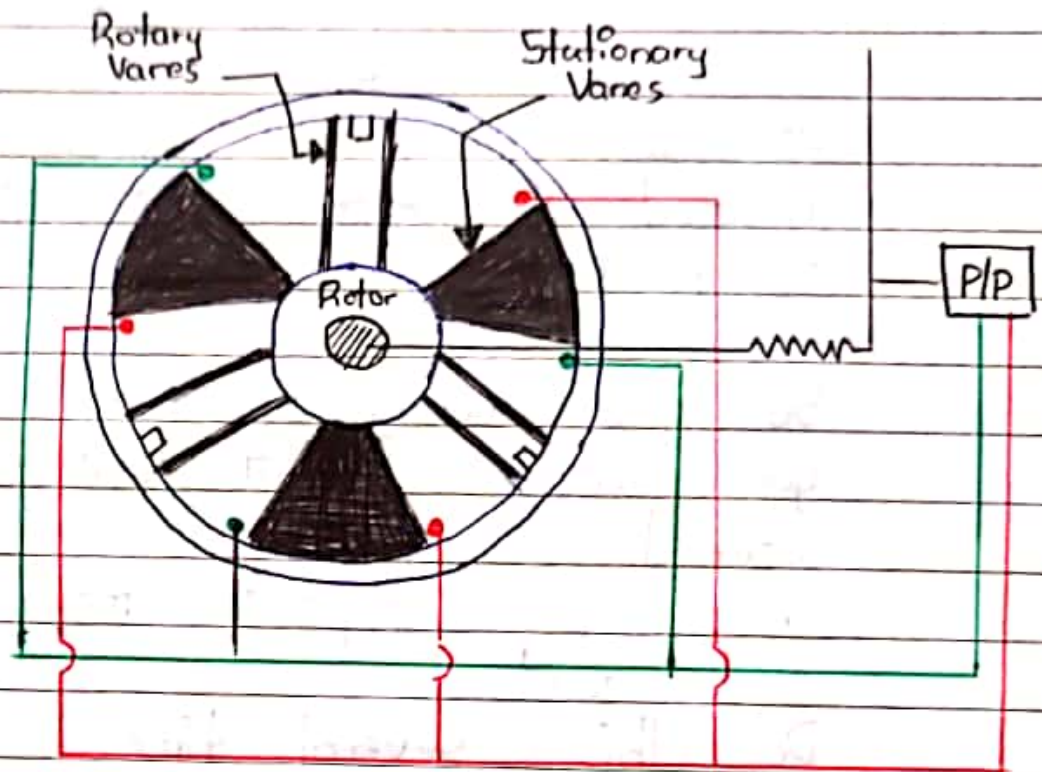
Motoring effect

To avoid this, Solenoid operated block vlv is used to minimize motoring effect

Also a pawl & ratchet arrangement can be used betⁿ motor & plp coupling.



Rotary Vane Pump. - Compact steering



Sealing strips are CI or brass

SLOW MOVEMENT OF RUDDER. REASONS

- ① Pump worn out, capacity reduced
- ② Bypass vlv leaking
- ③ Relief vlv leaking
- ④ Leakages across ram
- ⑤ leakages betⁿ vanes
- ⑥ Air in system.

Air
In
Sys →

Sluggish movement
followed by jerk movement.
Also noise will be there

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DATE	/ /

If air in system, jerking will be there.



Air gets compressed & when pr released, air expands & gives jerk to fluid.

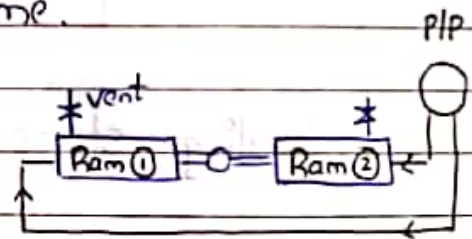
So give movement, the fluid which goes in ram, that vent to be opened.

Then give opposite movement, open that vent.

Do this several time.

Air can come

- empty header tk
- maintenance of plp
- filter not prepurged.



Rotating cone fixed to rudder stock.

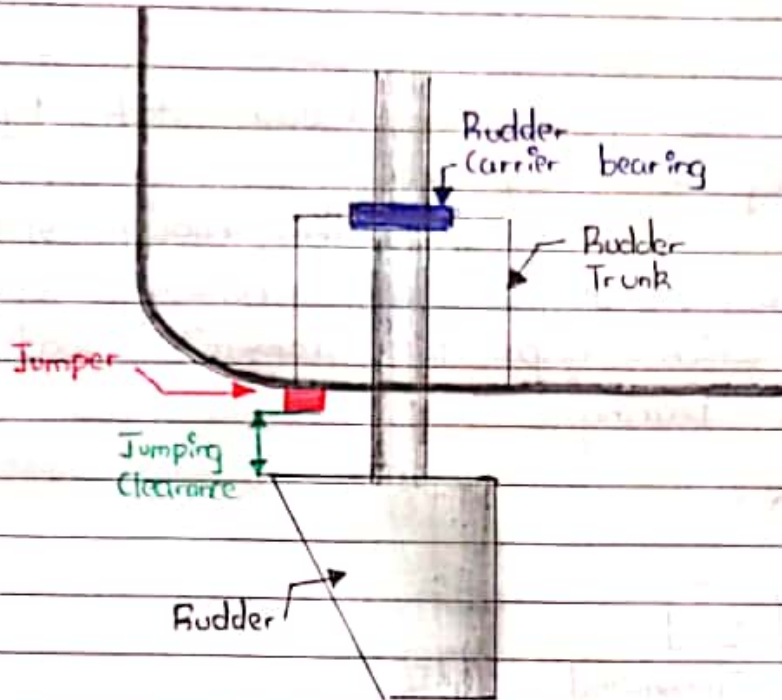
Fixed cone fitted on steering platform

Rotating cones rotates with rudder stock.
Brass strips (bearing)

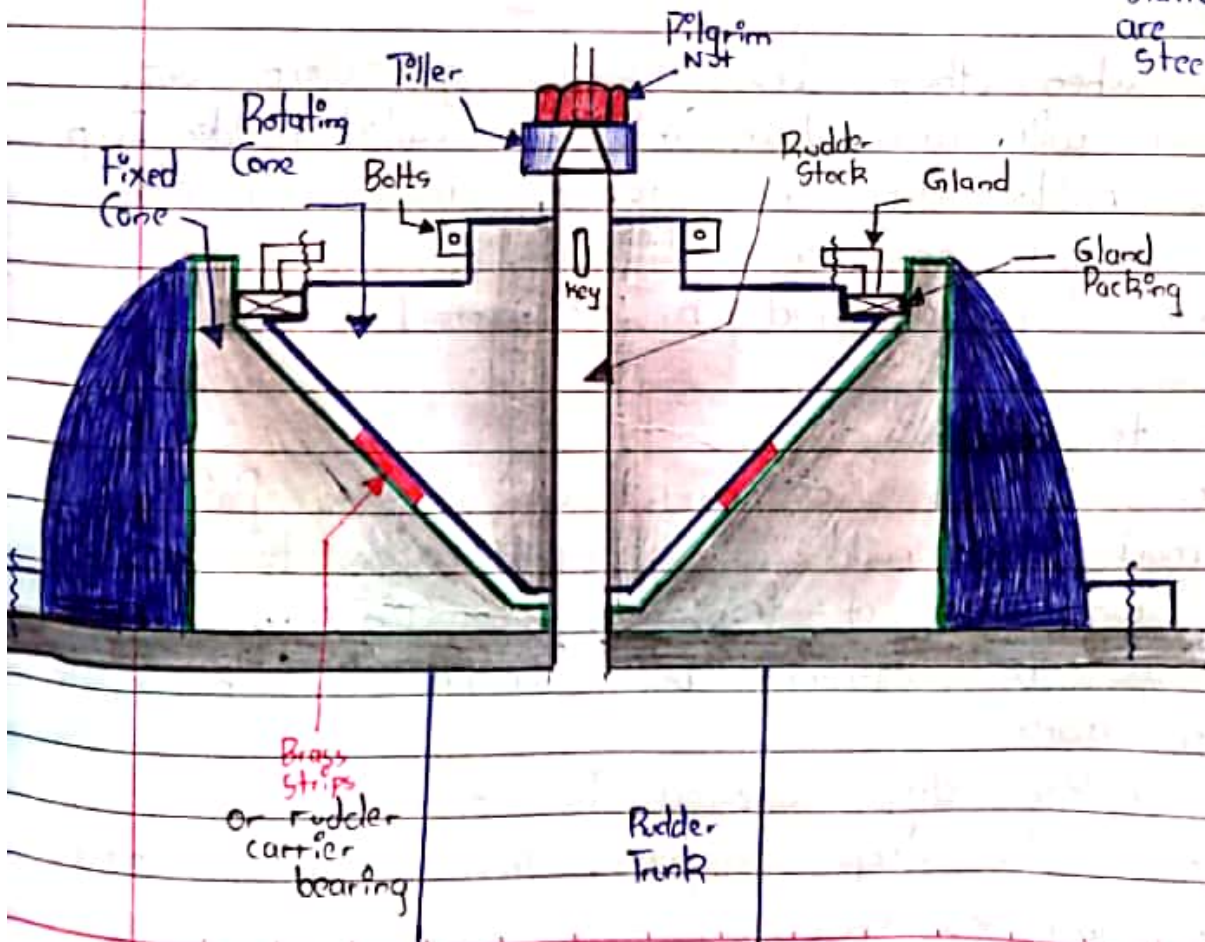
Both cones are in 2 halves.

A greasing pt provided to give grease

*** RUDDER ***

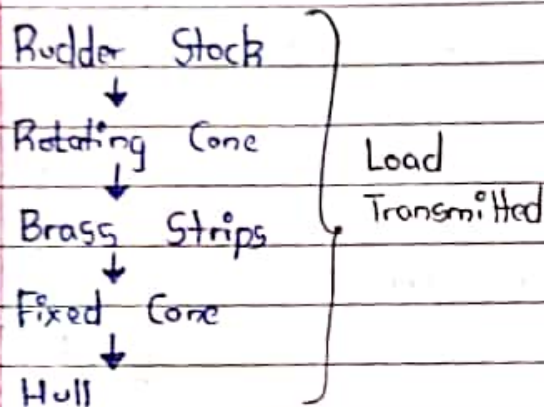


* Tiller connected to rudder stock via pilgrim nut.



Moving Cone & Stationary Cone are made of steel.

- * Rudder carrier bearing consists of 2 parts
 - ① Fixed cone
 - ② Rotating cone
- * Rotating cone is fixed over rudder stock by means of key & locking bolts.
- * Rotating cone rotates along with rudder stock
- * There are brass strips betⁿ rotating cone & fixed cone which help to transmit load & also act as bearing



- * Now when these brass strips get worn out, rudder will come down. This is called Rudder Drop
- * This rudder drop has to be measured either at drydock, or port or sea
- * Rudder drop measured by → Trammel Gauge

How to measure?

- * There will be a mark on steering flat & 1 mark on rudder stock. (Take rudder to midship)
- * Now with help of trammel gauge (pin gauge), you can see the difference betⁿ original mark & recent mark
- * Max rudder drop allowed is 3mm
- * When rudder drop happens, the jumping clearance also increases.

* Movement of rams is transmitted to rudderstock via crosshead.

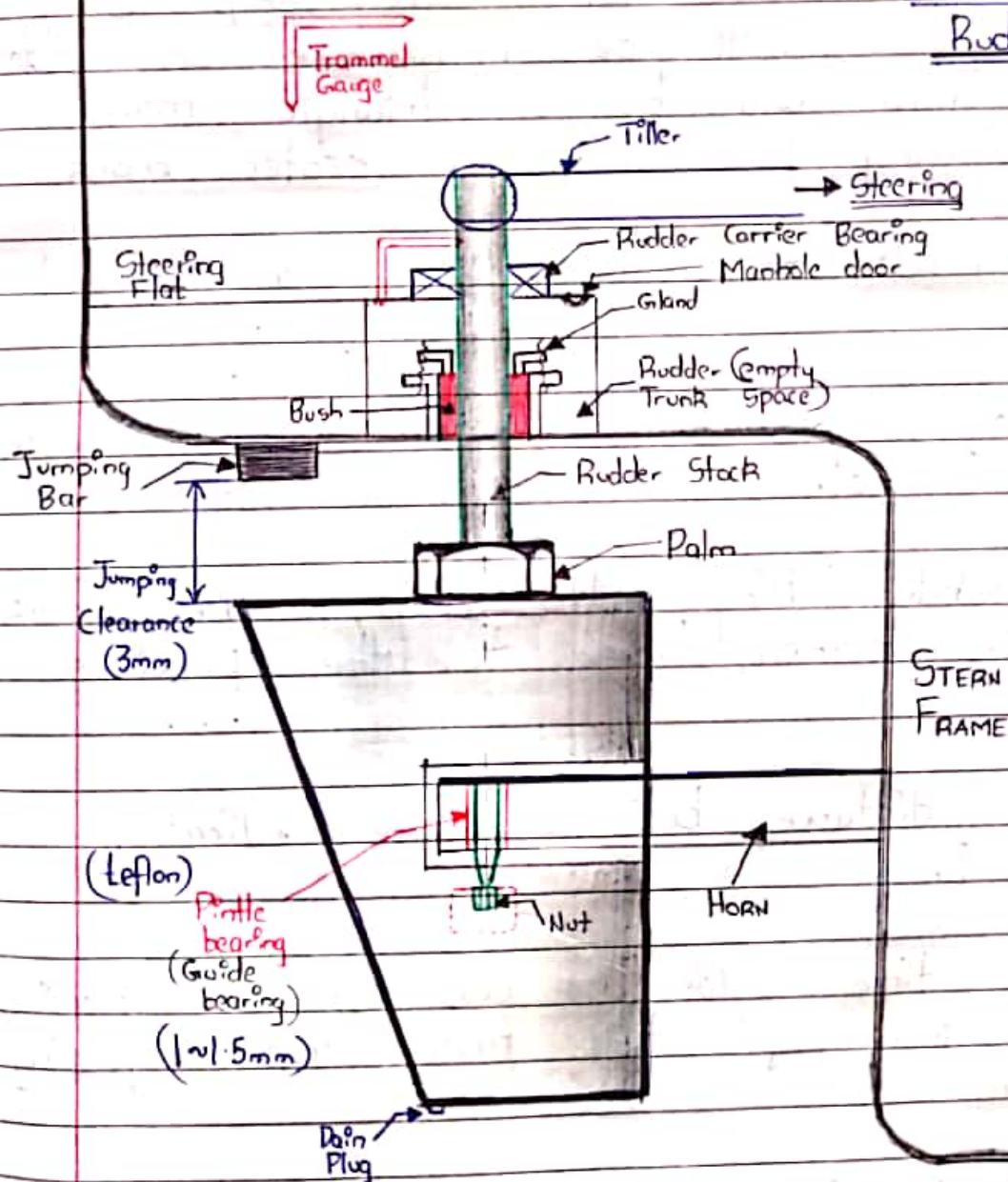
* Rudder should not drop more than the rudder drop allowance @ crosshead.

* If this happens, entire weight will come on rams & rams will bend

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Semi-balanced Rudder



* If rudder carrier bearing wears down, RUDDER DROP will happen

* Rudder drop should not be more than rudder drop allowance @ crosshead.

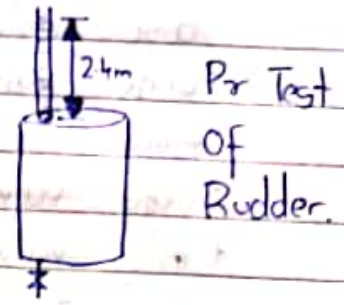
Rudder stock & rudder post are both same

CLYDE

- * Jumping bar is placed on hull at stern.
- * In cross-head, jumping allowance is provided at top & max rudder drop allowance is provided at bottom.
- * Rudder drop to be taken when ship is floating. There will be 1 marking on rudder stock. There will be a triangle mark on steering flat with a center mark.
- * Take rudder to midship. Now with trammel gauge
- * Coincide 1 end of trammel gauge to centre of Δ & other end to rudder stock.
- * Now while taking rudder drop, a new mark will be obtained, lower to the previous mark.
- * Measure distance betⁿ 2 marks indicating
RUDDER DROP
- * If last time rudder drop was taken in floating condition, then again take rudder drop in floating condition.
- * Pintle bearing is only a guide bearing.
- * To take pintle bearing clearance, remove the closing plate & with feeler gauge check clearance.

- * In drydock, open the drain plug of rudder & check if water comes
- * Nothing should come out otherwise rudder might be holed.

→ Inside of rudder is painted by float coat

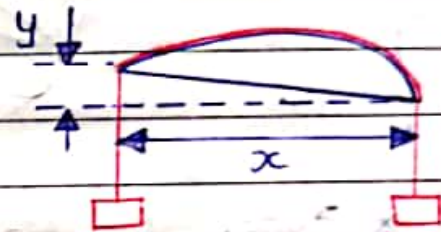
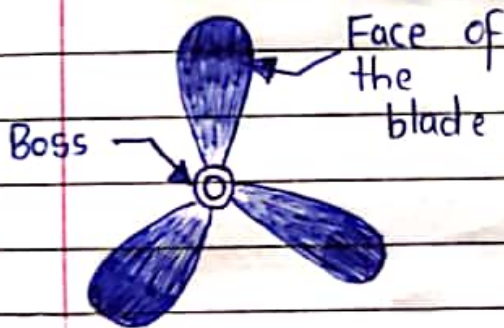


*** PROPELLER ***

PITCH :- The axial movement created due to 1 complete revolution of propeller is called pitch.

{{CLYDE}}

* Given in (m/rev)

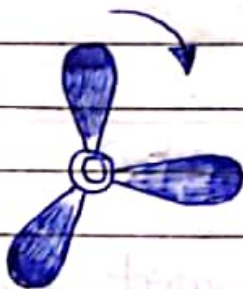


$$\frac{y}{x} = \tan \theta$$

$$\text{Pitch} = 2\pi r \tan \theta$$

Ships speed given in **Knots**

1 Knot = 1.852 Km/hr



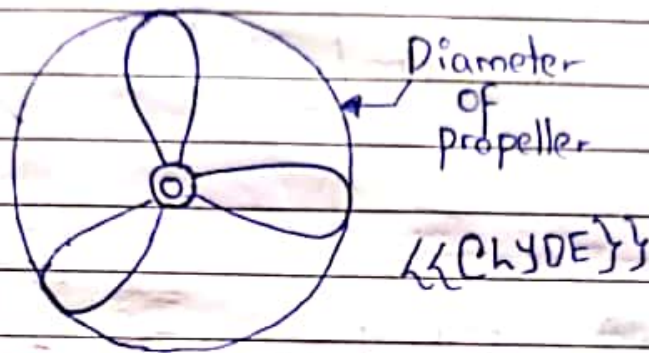
Right Hand Propeller



Left Hand Propeller

* Normally right hand propeller is widely used

* Propeller Diameter :- The diameter of circle where the propeller blades rotate is called propeller dia



* TYPES OF PROPELLER

① Fixed Pitch Propeller

- Here blades can be directly casted to boss or can be detached to the boss

② Controllable Pitch Propeller

* Now Theoretical Speed = $\frac{\text{Pitch} \times \text{rpm} \times 60}{1.852}$

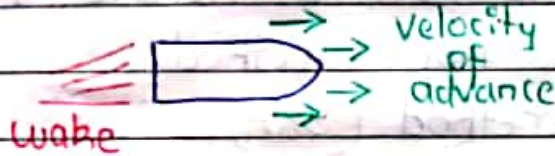
* It is given by (V_T)

* It is the speed calculated theoretically

* But ship cannot move by theoretical speed due to some slip

* So ship moves with actual speed denoted by (V)

Th's $\frac{V_T - V}{V_T} \times 100 = \text{Apparant Slip}$



So basically ship moves ahead by (V_{otw})

Now $\frac{V_T - V_a}{V_T} \times 100 = \text{Real Slip}$ Real Slip involves wake force.

* But we are only concerned about apparant slip not real slip

* MATERIAL OF PROPELLER

«CLYDE»

- Brass → Used earlier
- Mg Bronze
- Ni-Al Bronze → Currently used

* Earlier keyed propeller was used

* But due to excessive stress concentration there was more possibility of propeller shearing off.

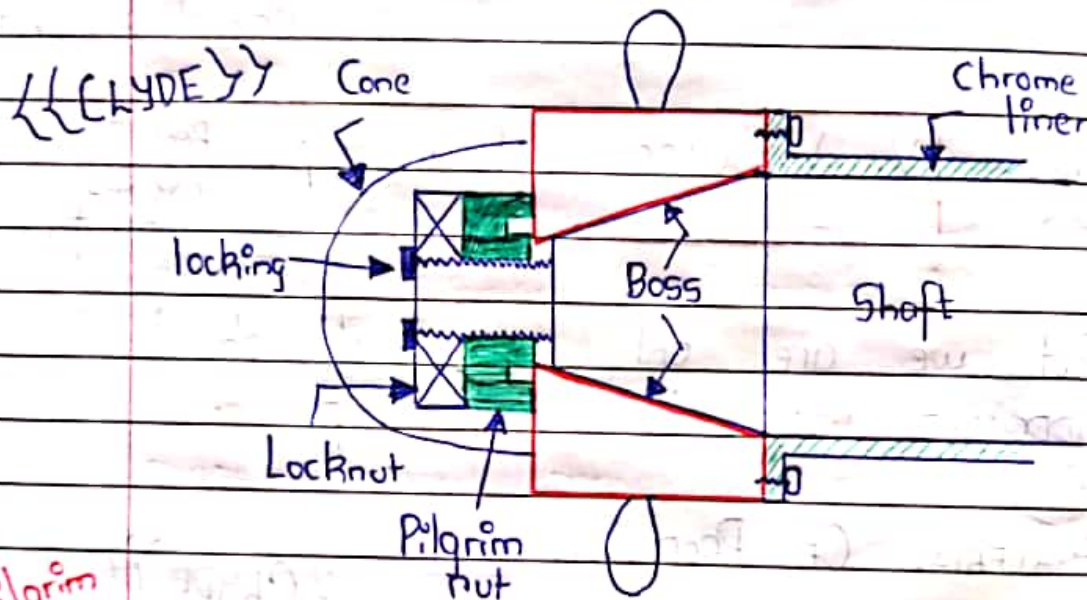
* If engine is running & propeller is lost → Engine will trip on overspeed

* we use Keyless propeller these days

METHODS TO FIT & REMOVE PROPELLER

↳ Pilgrim nut method

↳ Wet method (SKF)



Pilgrim
Nut
Method

Removal Of Propeller (Key or Keyless)

- First take propeller drop
- Take no 1 unit to TDC
- Take out the cone
- Take out bolt connecting chrome line to propeller boss & push it in.
- Remove locking and use special spanner & remove locknut.
- Also remove pilgrim nut & put it back in opposite direction.
- Pilgrim nut has inbuilt hyd-jack

Withdrawing
Plate

Loading
ring

Hyd
Jack

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Shaft

{{ CHYDE }}

- After this connect loading ring & withdrawing plate
- Now pump the hyd jack, this will push out loading ring ultimately pushing withdrawing plate
- This will pull out propeller

After removal

- Check condition of shaft for crack
- Check bedding (contact) betⁿ propeller & shaft → use **persian blue**
- Clean contact surfaces before fitting

Fitting Of Propeller

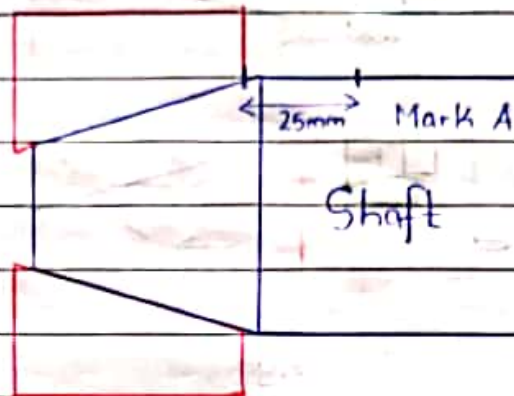
- Insert propeller over shaft
- Fit back the pilgrim nut & loading ring
- Use hyd jack, first only give initial pressure

*Value of push-up always given wrt temp.

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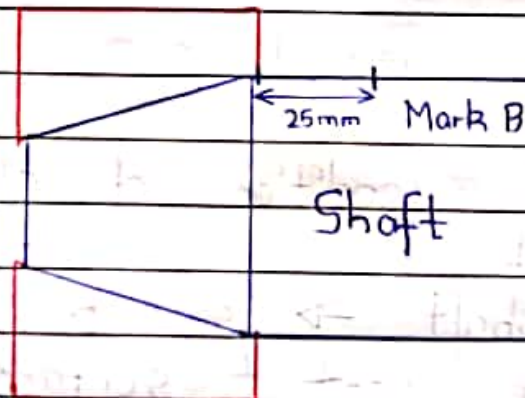
Date

{ CLYDE }



- Now measure 25mm from the current propeller position. as mark (A)

- Now apply full hyd press such that propeller now moves in



- Now again measure 25mm from current position and give mark B

- $B - A$ = Pushup of propeller. This reference value will be given in manual.

Wet Method

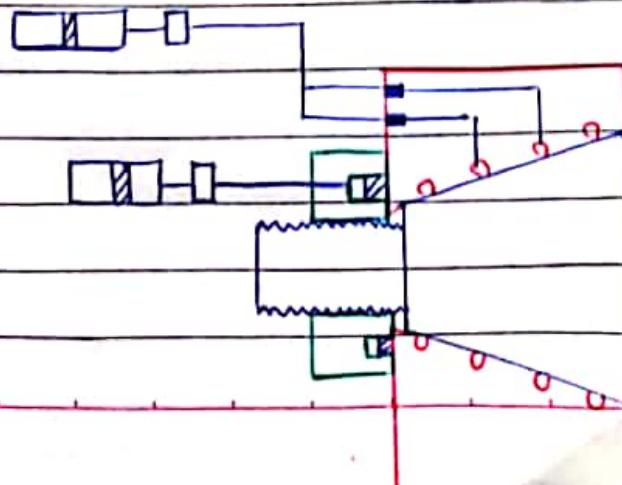
Removal Of Propeller (Keyless)

Hyd Jack

HYDE

- * On the propeller boss, there are grooves
- * Remove chrome liner, & locknut
- * Loosen pilgrim nut
- * There will be 2 hyd connections with boss along with snap coupling
- * Now connect hyd plp to coupling & start pumping oil till oil starts to come out from sides of taper betⁿ shaft & propeller
- * Due to its own wt, propeller will be able to slide down from shaft.

Hyd Jack

Fitting Of Propeller

- Pump both hyd jacks.
- Once push-up is achieved & oil starts to come from sides, stop the top hyd plp
- Make sure bottom hyd plp is still holding pressure
- Now pilgrim nut will go in & put lock nut also

CLIDE

* * Stern Tube * * - Oil lubricator type

- * Stern tube → CI
- * Fwd & aft bearing → White metal bearing
- * Lip seal → Nitride rubber.

→ There are 3 lip seals in the aft & 2 lip seals in the fwd.

→ The lip seals are tightly pressed against the chrome liner with help of garter spring.

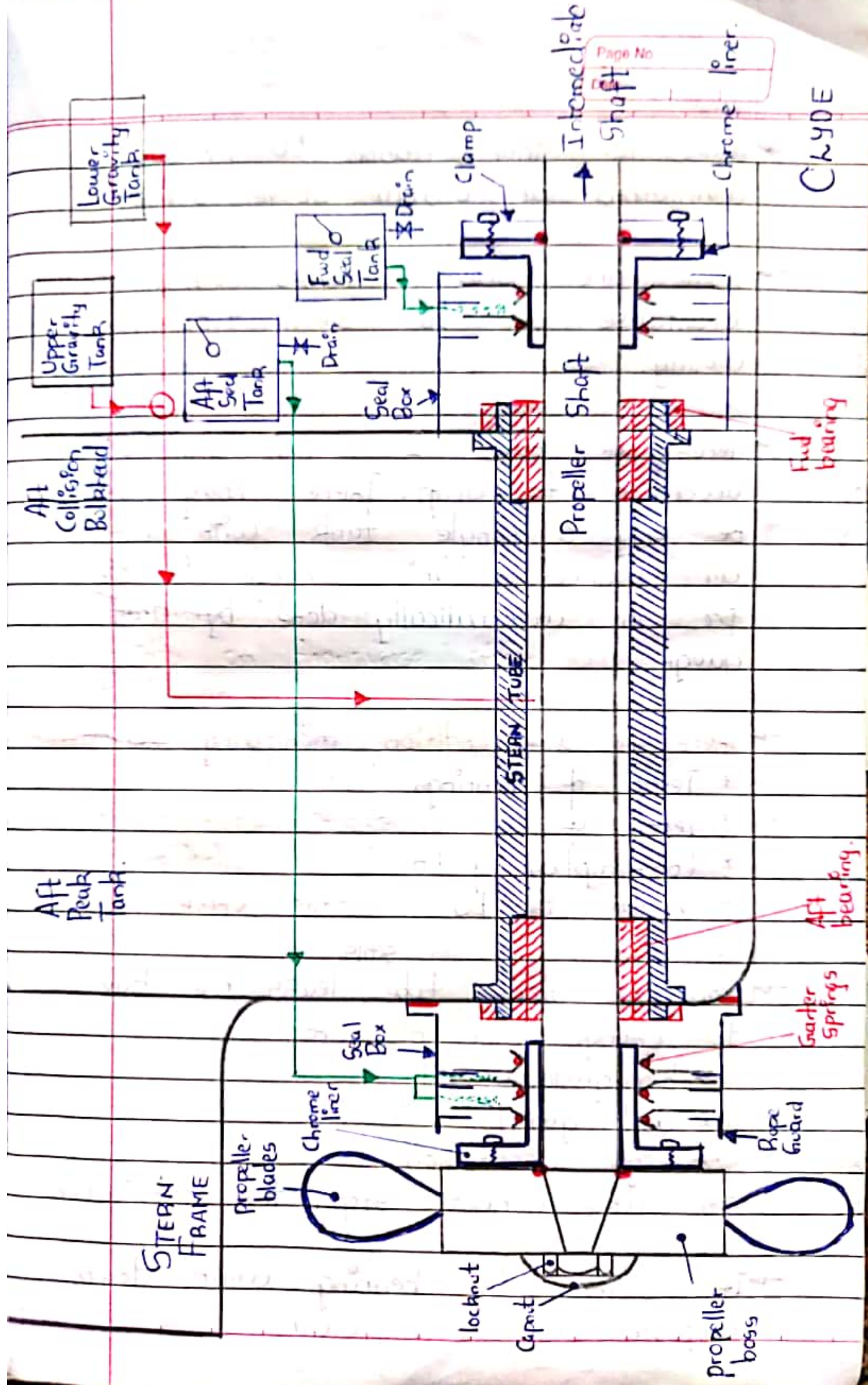
→ As propeller rotates, the chrome liner also rotates.

→ Lip seal cannot be directly mounted on propeller shaft as after prolonged hrs, it may erode the material on shaft. {grooving}

→ Hence to protect it, a chrome liner is fitted. Chrome liner is fitted by slide fit.

→ Now from fwd & aft tank LO is sent in betⁿ the lip seals to cool the seals.

→ Also in the aft, the seals should be such that water should not be able to enter.



→ Hence for that reason, LO pr is maintained at 0.3 bar above SW pr.

→ There are gravity tanks which send crankcase oil to stern tube for cooling.

→ Here we have 2 tanks, upper & lower according to draft. There may also be only a single tank with compressed air connection. This change in air pr is automatically done by draft gauge.

→ There is a condition monitoring sys where

- * Temp of bearings
- * Temp of LO
- * Consumption of LO
- * Water in LO

are checked.

→ Now if stern tube seals leaks, we have to change over oil to

- ↳ biodegradable oil
- ↳ seal guard
- ↳ high viscous oil

as we cannot stop the lubrication

→ If stern tube bearing wears down, propeller drop will occur.

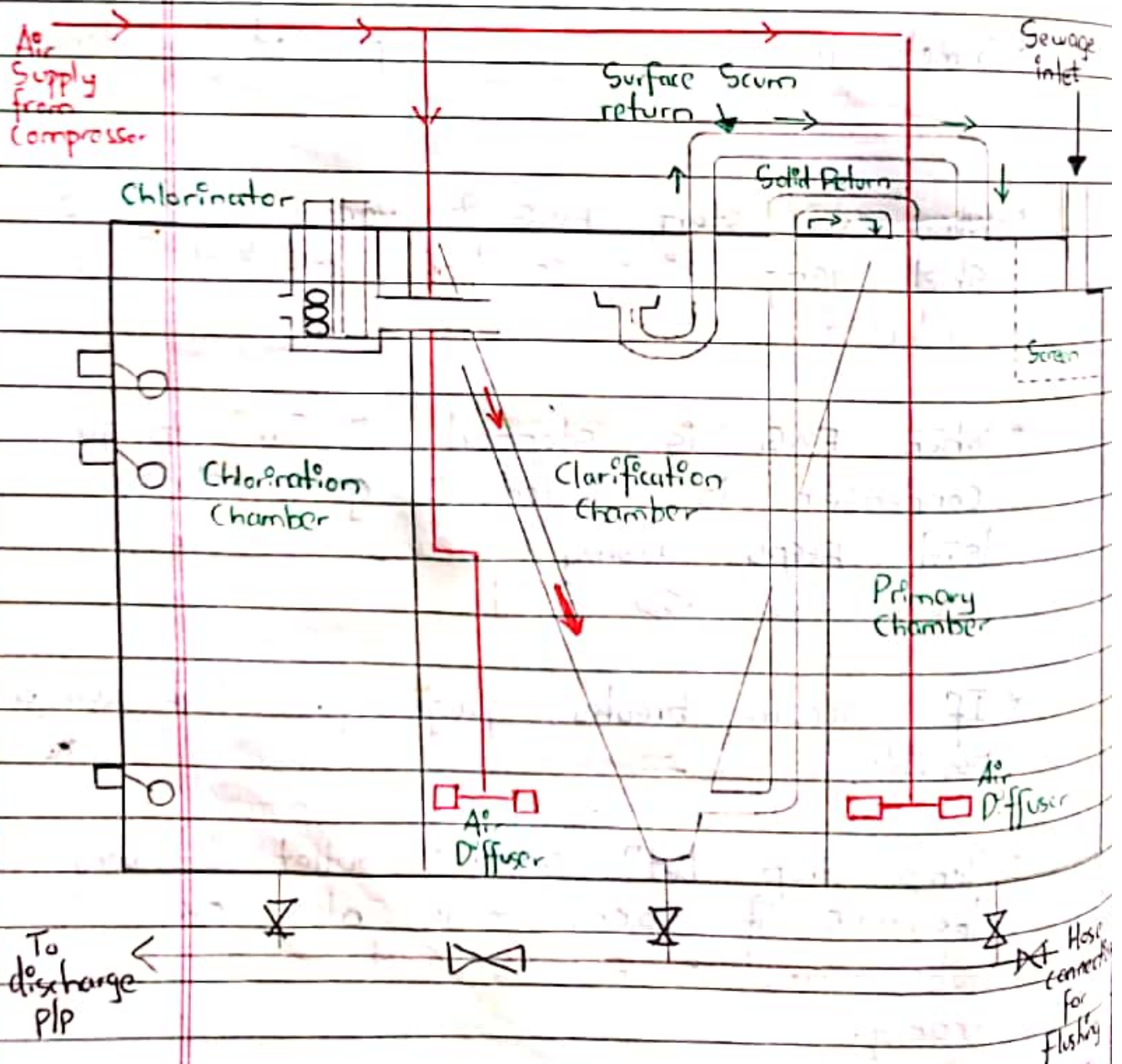
** Sewage Treatment Plant **

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Regulation :-

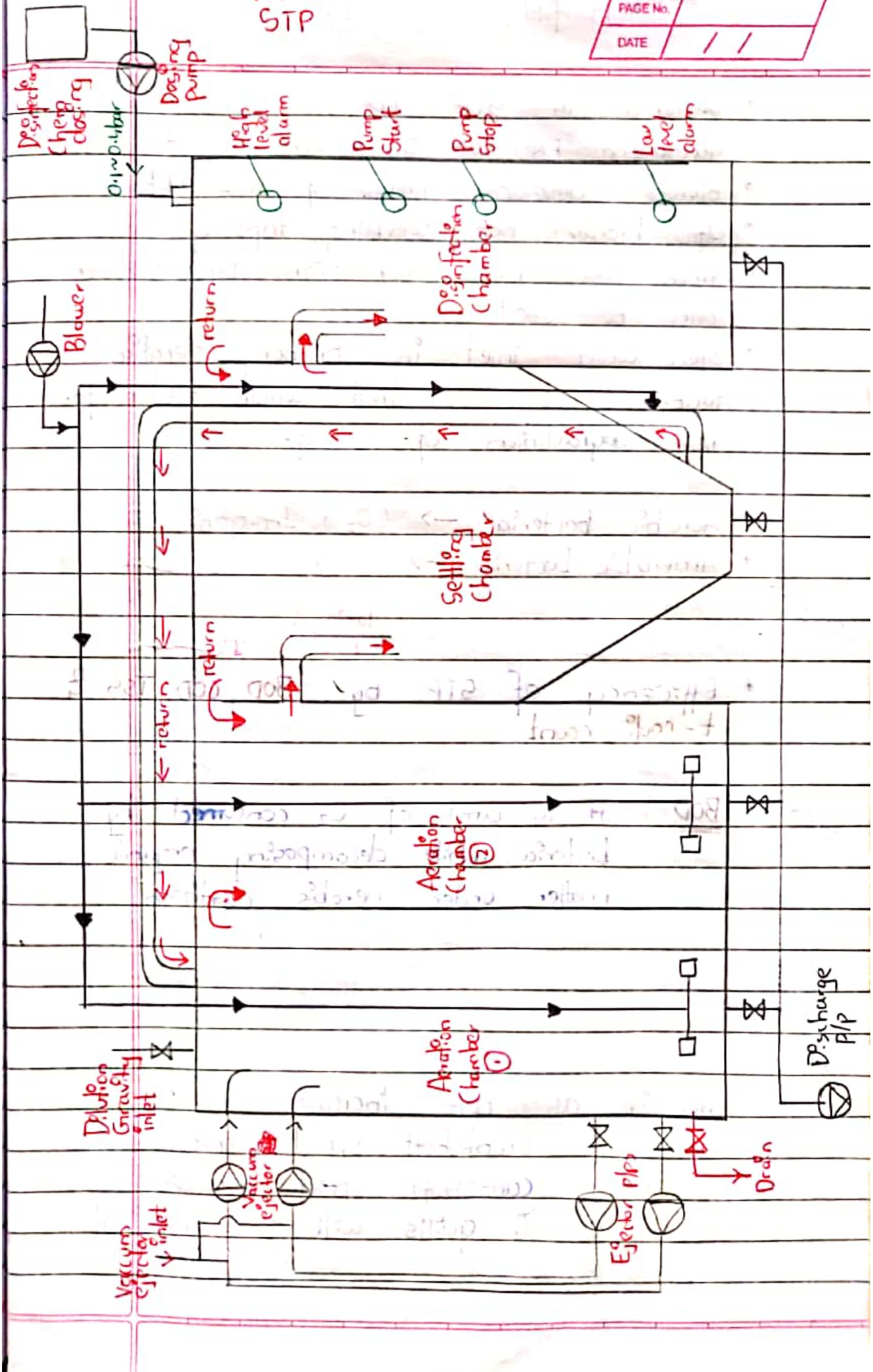
Reg II Annex IV

- * 3Nm ~ 12Nm → Comminuted & disinfected Sewage
- * >12Nm → Non comminuted & disinfected Sewage
- * Sewage discharge when
 - ship is enroute
 - ship speed not less than 4 knots
- * Effluent shall not produce visible floating solids nor discoloration.



Biological Vacuum STP

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Toilet $\rightarrow$ Main Manifold $\rightarrow$ Filter $\rightarrow$ Ejector P/p

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- * Bacteria is GTP comes from gamazene FN 700 & human excreta.
- * Blower develops press of $0.2 \sim 0.4 \text{ bar}$
- * If blower not working, tapping line from air bottle (7bar) with press reducer can be used
- * Grey water inlet in primary aeration tank is to use that waste water for betⁿ degradation of sewage.

* Aerobic bacteria $\rightarrow \text{CO}_2 + \text{Inorganic waste}$

* Anaerobic bacteria $\rightarrow \text{CH}_4 + \text{H}_2\text{S} + \text{NH}_3 + \text{Black water}$

25mg/lit

Toxic &
Explosive gas

- * Efficiency of STP by BOD, COD, TSS & t-coul^o count.

Biochem

BOD :- It is amt of O_2 consumed by bacteria while decomposing organic matter under aerobic condition.

Normally as rpm increases
crankshaft speed increases
camshaft speed increases
& quills will give more oil

Valves are used to control flow in pipelines

① Gate valve

- * It basically consists of a gate or a vlv disc which regulates flow of fluid
- * Gate valve can give either full flow or no flow
- * Gate valve cannot be used for throttling
- * This valve when open, gives a full bore flow without change in direction

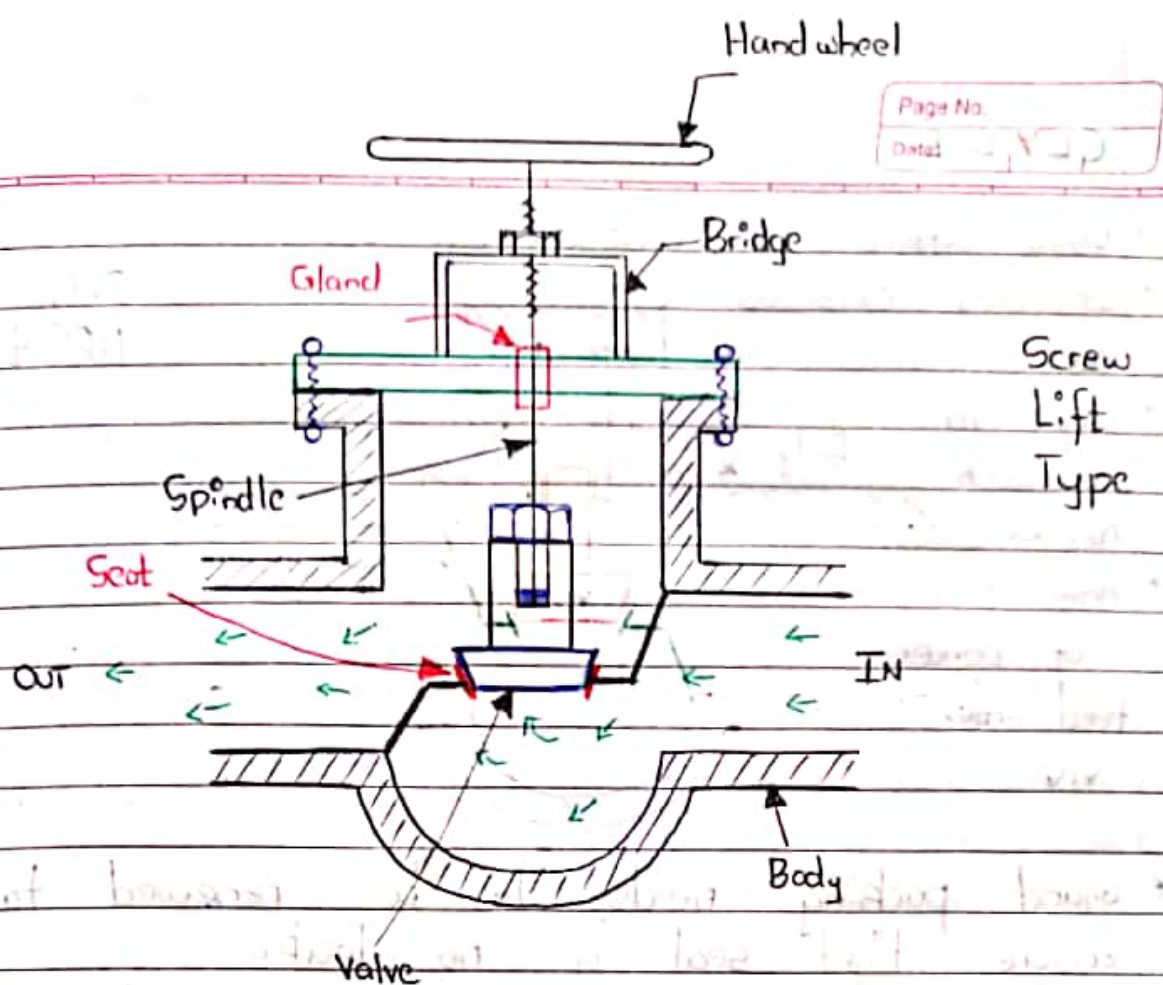
- The handwheel is attached to gate with a spindle
- The screwed spindle works in a nut & lifts vlv to open or close
- The gate opens/closes against the seat

- * Gate vlv can be used where bidirectional flow re
- * Gate → brass
- * Body → CI

② Globe valve

- ↳ Screw lift type
- ↳ Screw down non return type
- ↳ Only non-return type

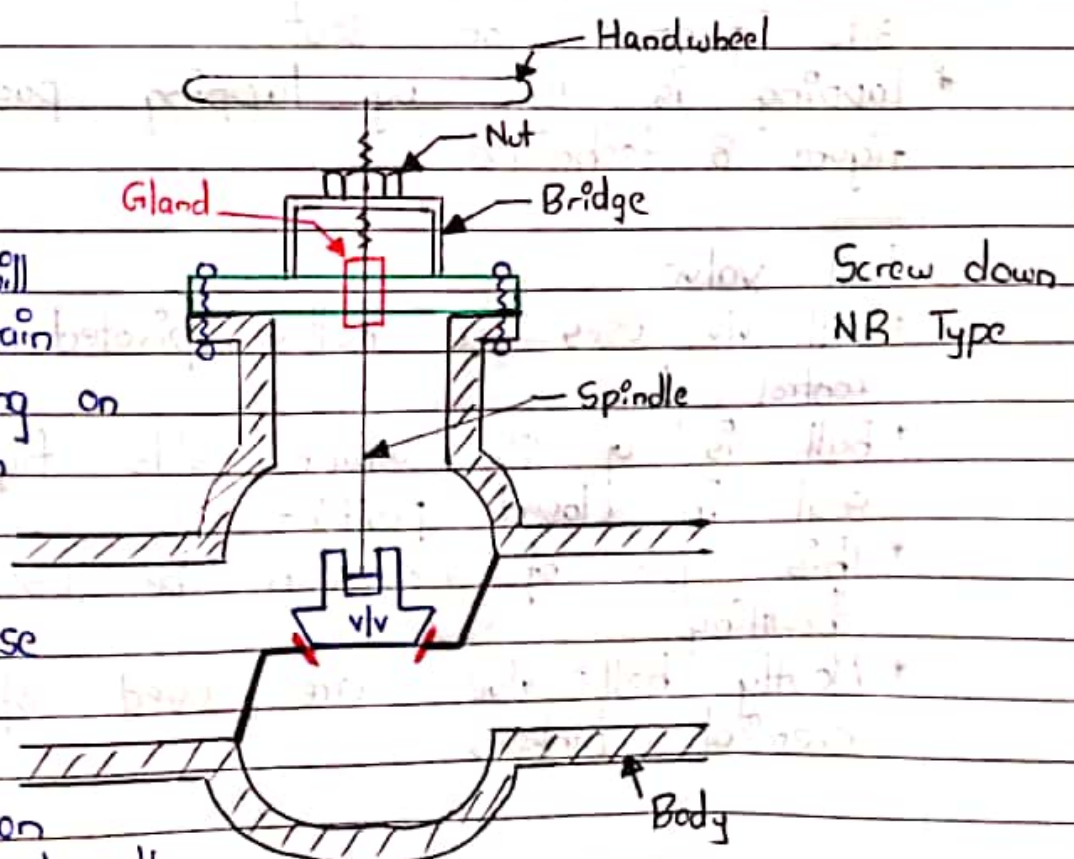
- * In screw lift type, the handwheel is connected to vlv with spindle & nut
- * This vlv can be used to control flow, but it cannot act as non-return
- * Here due to change in direction, there will be pressure drop



* This type is unidirectional

* Here vlv will lift a certain ht depending on how much handwheel is opened

* When reverse flow takes place, vlv will sit on seat & not allow to flow back



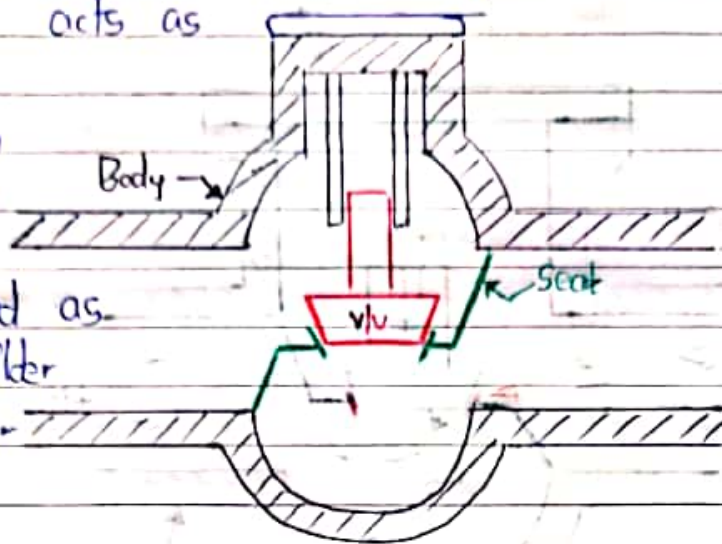
CLYDE

* Used where no control required

* It only acts as NR

* Used in IG deck NR vlv

* Also used as 1 of boiler feed water vlv



Only NR type

* Gland packing needs to be renewed to ensure tight seal & no leaks

* Continuous opening & closing of globe vlv can damage vlv seat.

* Lapping needs to be done to ensure vlv sits properly on seat

* Lapping is done by lapping paste using figure 8 technique.

③ Ball valve

* Ball vlv uses a hollow, pivoted ball to control flow

* Ball is of SS, which sits tight on teflon seat in closed position.

* This type of vlv can be used for throttling.

* Mostly ball vlv are used often on chemical tankers

*** BOILER ***

CLUDE

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If steam from boiler used for main propulsion
→ Main Boiler

If steam from boiler used for other applications
→ Aux Boiler

>60 bar high pr boiler
20 bar low pr boiler

Rate of evaporation
10,000 kg/hr

Boiler Rating.

- ① Smoke tube - low pr → Thermal eff low
- ② Water tube - high pr → Thermal eff high

Boiler rating 20bar, 1 ton/hr

Smoke Tube

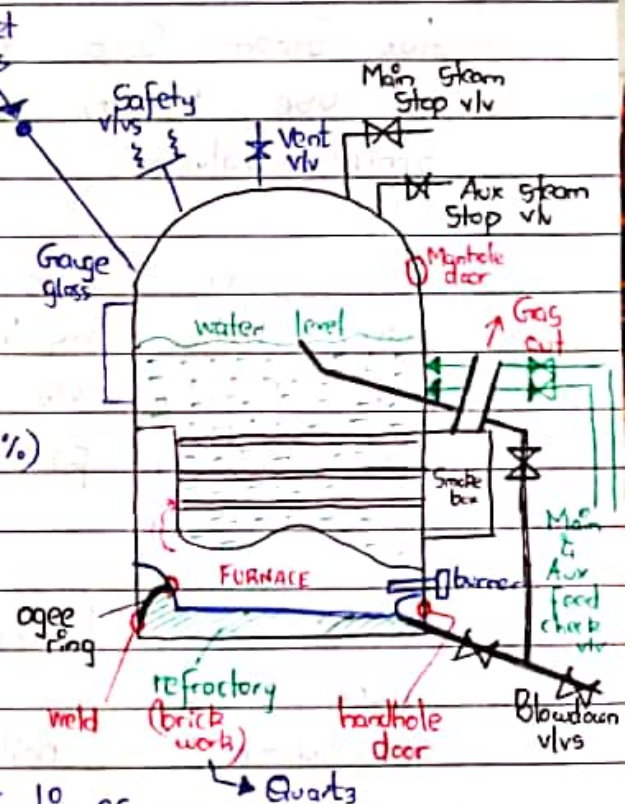
Here gas → tubes
water is around the tubes

Connects furnace to shell
of boiler - Ogee Ring

Boiler : low carbon steel ($C < 0.2\%$)

Higher carbon, metal might
become v hard & might
crack

0.7% Mg → for ductility



Boiler drum pr tested to 1.5 times
working pr

Design pr & working pr both are different
parameters

Under no circumstances, working pr should not go
above design pr.

Swelling

- When sudden steam demand, pr in boiler reduces.
- This causes foaming / priming to take place
- Indicator will sense water level is high & not supply water to boiler.

Shrinkage

- When sudden steam demand drops, pr in boiler starts to rise & this pr will act over water
- Indicator will sense water level is low & supply water to boiler.

Here 3 element control is used

- ↳ water level indicator
- ↳ water inlet transmitter
- ↳ steam outlet transmitter

Tubes → Steel

- | | | |
|--------------------|------------------|-------------------------|
| - Generating tubes | * Plain tubes | } based on construction |
| - Stay tubes | * Sinuflow tubes | |

- Screen tubes (protect generating tubes from direct heat)
- Generating tubes (which actually generate steam)
- Return tubes
- Water wall tubes (connected betⁿ 2 headers)

* Steam has more latent heat than water hence water vlv opened first, glass gets warmed up & then steam vlv opened

11 - Boiler Mountings

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① Vent vlv

Remove air / accumulated gas from system

If air remains inside, it can cause corrosion
ex - Iron oxide

Also for boiler to not go under vacuum

Suppose boiler is under vacuum, & has manhole
it may collapse or damage due to it

② Main Steam Stop vlv

To control steam flow to turbines

Big valves $\rightarrow$ Slow opening type

If 2 boilers run in parallel, then SDNR

③ Aux Steam Stop vlv

To use steam only for aux machineries

Small valve

④ Safety Vlv (2 in nos)

Protect boiler against overpressurizing

Both safety vlv lift pr not more than 3%
of working pr

⑤ Gauge Glass

2 in no, 1 in port & other std

There should be 2 means to detect level
of water in boiler (it could be remote gauge glass)

⑥ Handhole door

All mud gets accumulated at bottom near

O-gee ring & can be cleaned from handhole

⑦ Main & Aux Feed Check vlv

To feed water into boiler

There are NON RETURN vlvs

(Ex: 13) Refractory → to protect boiler from radiant heat
→ stores heat ene when boiler stopped.

moulded like brick
plastic like cement

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③ Bottom Blowdown vlv

To remove accumulated sludge or the mud from boiler

④ Scum Blowdown vlv

To remove floating impurities like froath, oil

⑤ Galinometer vlv

Also called sampling vlv to check condition of water

⑥ Manhole Door

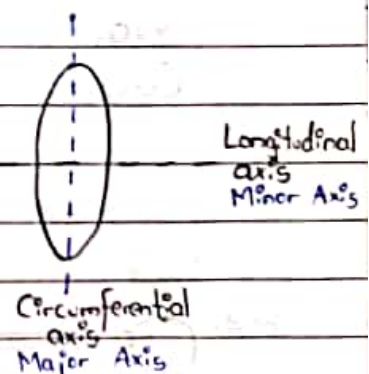
Manhole door always elliptical

To be fit from inside & elliptical cls is only shape which can be fit from inside & achieve Positive Closing.

Longitudinal stress are greater
Circumferential stress are lesser

Internal Mountings

When the hole is cut, the material becomes weak. Hence to compensate for weakness, a compensatory ring is welded



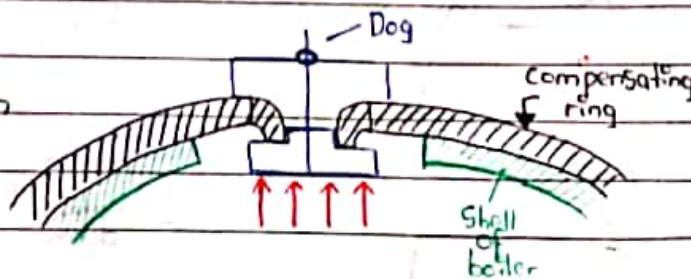
* Scum Blowdown

funnel

* Demister

* Water rings

distribution



* Operating pr can never go above design pr

* Design pr can be above operating pr

Shell thickness $(t) = \frac{Pd}{2S}$ → d.a. of tubes
 Pressure → Tensile Strength

Refractory

Brick work is basically refractory made up of quartz

- use to store heat when boiler is stopped
- acts as shield to protect shell from radiant heat of furnace

Moulded refractory (plastic refractory)

Brick refractory

Advantages

It is simple, low pr boiler

Simple to operate & maintain

Steam storage capacity more

Dis-Adv

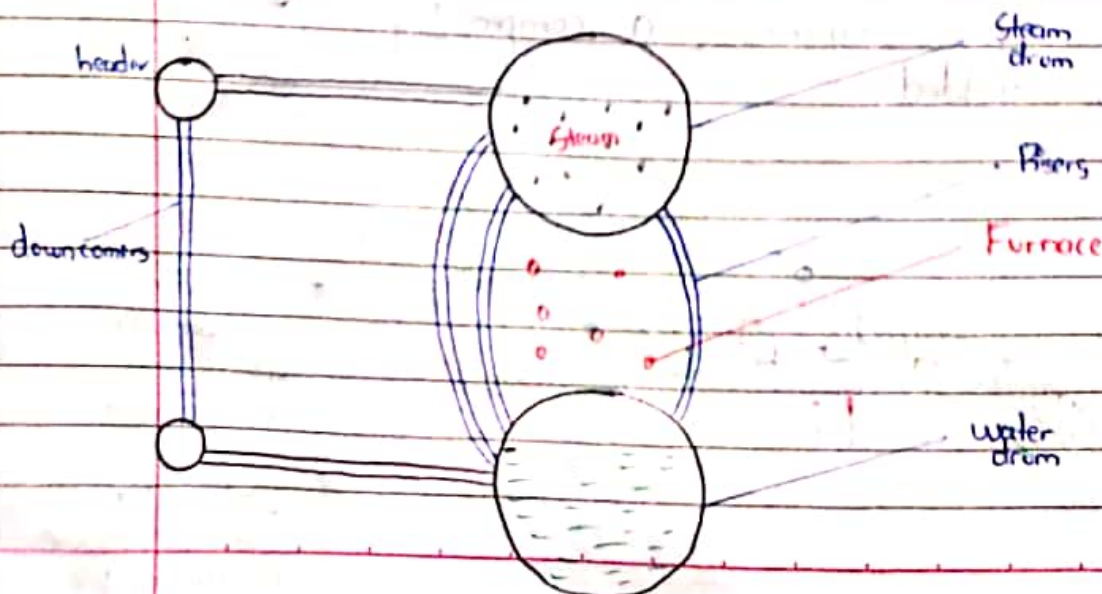
Cannot be used for high pr boilers

Has low evap pr.

Higher warm up time

Water Tube Boiler (D type boiler)

Consists of 2 drums joined by tubes



Warm up time

8hrs - Water tube boiler

12hrs - Smoke tube boiler

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Riser

Risers or of seamless tubes or
Heated water $\rightarrow$ steam rises in these tubes

Wall tubes are membrane tubes
Thicker tubes (stay tubes) which gives support
In these tube, water converted to steam flows
All other tubes than stay tubes are called
generating tubes

Advantages

Rate of evap higher

Compact boiler

Boiler efficiency high (thermal efficiency)

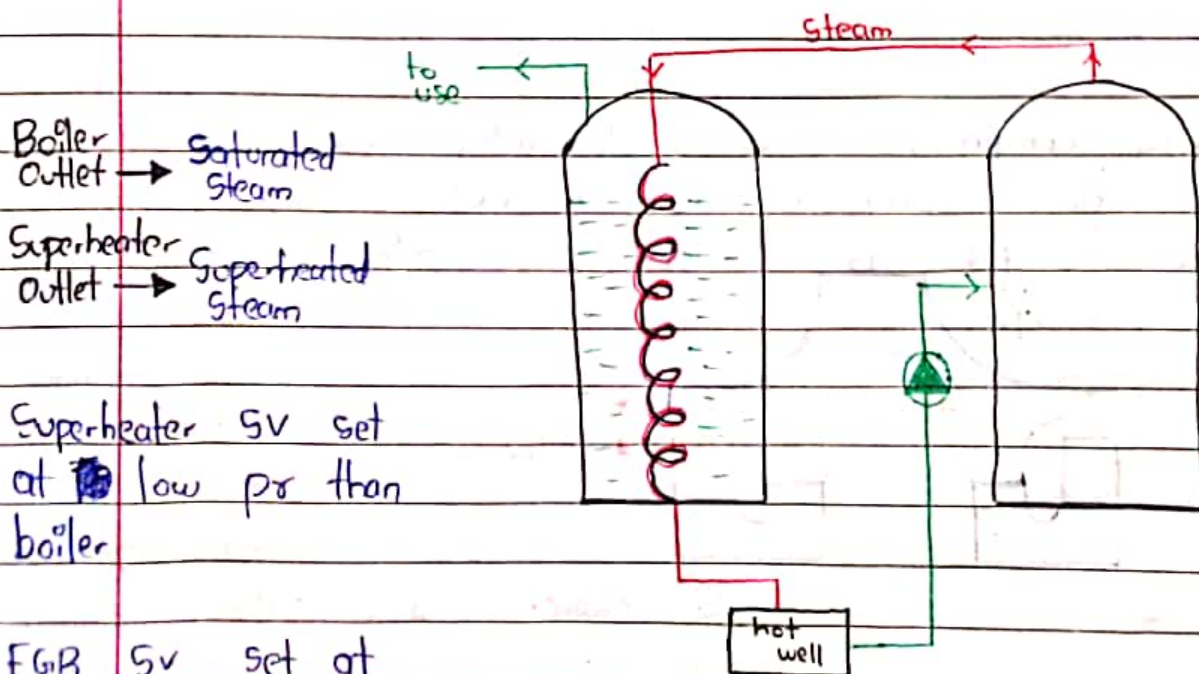
Can provide high steam demand (continuous operation)

Warming up time is lesser compared to smoke tube

Dis-Adv

Requires v good quality of water treatment.

Double evaporation boiler



EGB SV set at high pr than boiler $\rightarrow$ because water from EGB has to go back to boiler

Foaming / Priming with steam causes carryover of

— CARRY OVER

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Plane tubes

Stay tubes

Swirlflow tubes or sinuflow tubes → used in smoke tube boilers

Thimble tubes (increased surface area)

To increase surface area,

finned tubes

studded tubes

Boiler Internal Mountings

- ① Demister (we get dry saturated steam)
- ② Scum blowdown collection funnel
- ③ Water distribution pipe → for smoke tube

(3%
above
working
ps)

SAFETY Vlv - Min 2 safety valves to be there

Excess pr to be relieved & protect boiler

Spring loaded

- ordinary

- high lift

- improved high lift

Spring compression will determine vlv lift

but here problem is accumulation of pr.

Acc of pr is dis-adv of spring loaded safety vlv

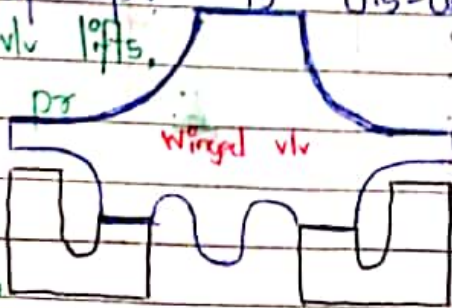
Once vlv lifts,

Spring pr

force

also

increases



↓

Lip

clearance

lip clearance

helps to

increase lift

Lip clearance also takes care

of expansion

Lip clearance helps vlv to sit on seat

$$C \times A \times P = 9.81 \times H \times L$$

Formula to govern area of safety vlv

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H = total heating surface of boiler (m^2)

E = rate of evap (kg/cm^2)

A = aggregate area of safety vlv through which steam can pass

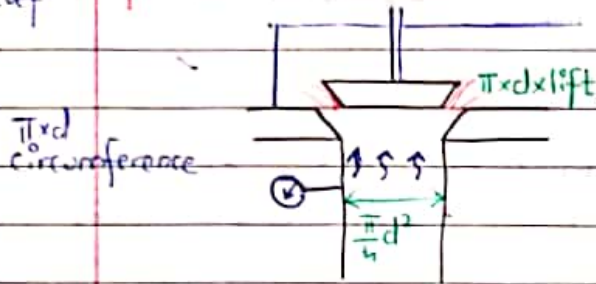
$P = \frac{\pi \times d^2}{4}$ should be equal to $\pi \times d \times \text{lift}$

working
pr in
(MN/ m^2)

Hence lift should be atleast $d/4$

C = constant
discharge
coef

But $d/4$ is difficult to get due to spring force



If area ie $\frac{\pi d^2}{4}$ is more

than area of lift, pr won't be released & pr will rise in boiler eventhough

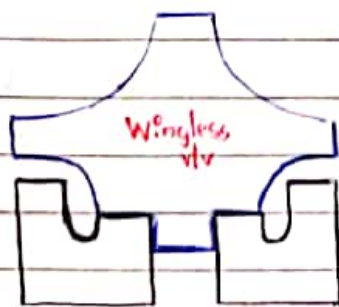
safety vlv has lifted.

Hence $\frac{\pi d^2}{4} = \pi \times d \times \text{lift}$

$\left\{ \begin{array}{l} \text{lift} = \frac{d}{4} \end{array} \right\}$ valve should have a lift of min $d/4$

But this is difficult as when vlv lifts, spring gets further compressed & now spring force tries to close vlv ← This is major drawback.

* Min bore of safety vlv should not be less than 38mm



Lip clearance can be checked by lead ball

If lip clearance is too less, the steam goes out & gives throttling effect & chattering can be observed

Suppose wk pr = 10 bar

lifting pr not to be more than 10.3 bar

SV not to be more than 3% above working pr

* When sv lifts, spring gets compressed, & for valve to lift further it requires more pressure which is actually called

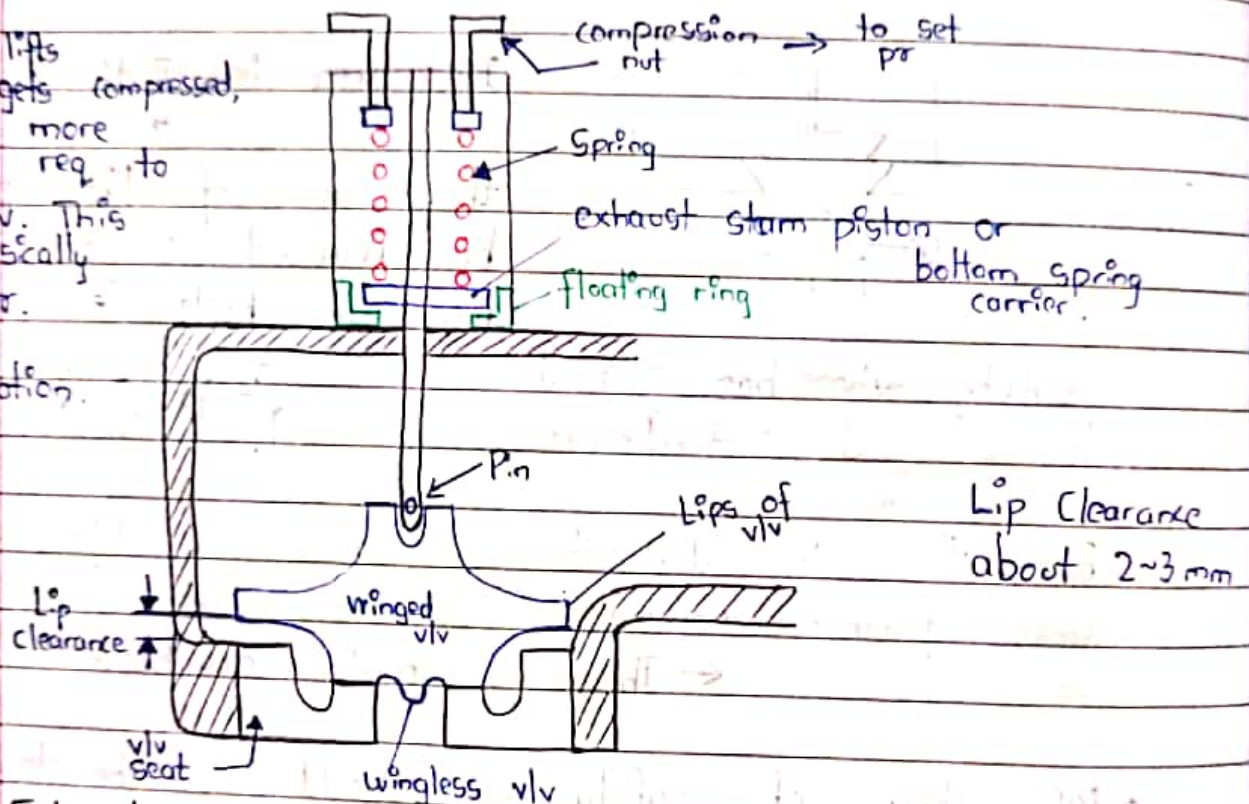
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Accumulation of Pr

* When boiler fires & sv lifted if you continue firing, boiler pr will go on increasing even though steam is going from sv. This is called accumulation of pr

As vlv lifts spring gets compressed, & now more pr is req. to lift vlv. This is basically back pr. called Accumulation of Pr



Exhaust steam piston is addition to ordinary safety vlv

Now lift is $D/16$

Springs having square cls area to improve the lift

Ordinary Safety vlv : $(d/24)$

- * Wingless vlv not there (winged vlv)
- * Square spring
- * No floating vlv
- * No exhaust steam piston

Betⁿ lifting & sitting pr of vlv is called

If vlv has lip then no need of blowdown ring.

Blowdown ring decides sitting pressure.

Blowdown of safety vlv

Waste steam pipe should be sufficient large enough & not give backpr.

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High Lift Safety vlv : $(d/12)$

- * Winged vlv
- * Square spring
- * No floating ring
- * But it has exhaust steam piston

D/L will be obtained only by Easing Gear.

Improved High Lift Safety vlv : $(d/12 \text{ to } d/8)$

- * Wingless vlv
- * Square spring
- * Floating ring
- * Exhaust steam piston

(Vlv & vlv seat made of Monel metal)

Easing Gear

- to lift safety vlv in case of emergency

More the lift, accumulation of pr will be reduced.

We do improvising in safety vlv lift, to avoid accumulation of pr.

All vlv will have a min lift of $d/4$

Now there should be a drain provided at outlet of safety vlv.

This is to drain any condensate or rain water.

This drain should have min dia **20mm**

This drain should not have any valve.

In full bore safety vlv, there will be 0 accumulation of pr.

Lift pr has to be adjusted on pilot vlv
Pilot vlv will lift & allow steam to pass through main vlv.

Dif betⁿ lifting pr & sitting pr
is called Blowdown of safety vlv
It can be adjusted by blowdown ring
threaded to vlv seat.

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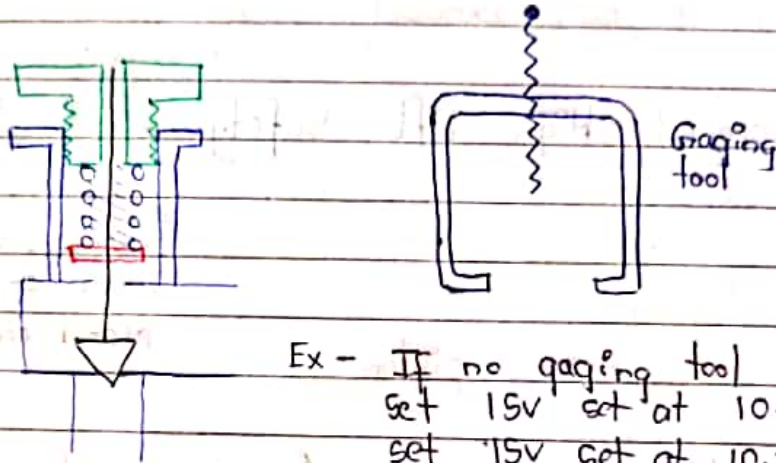
Date

Setting of safety vlv

Firstly bypass HP cutout

To be set not more than 3% of working pr.

* both valves
set at
3% above
work pr



Take sufficient water in boiler

Use well calibrated in pr gauge

Gaging tool used on 1 safety vlv, now set other vlv
Now start raising pr till 10.3 bar if working
pr is 10 bar.

Adjust compression nut, till safety vlv lifts.

Stop boiler to see when safety vlv sits.

If no gaging tool, set 1 safety vlv at higher
pr then other with lower pr.

Put ring betⁿ safety vlv body & compression
nut → to lock the safety vlv setting.

Now fit easing gear & tryout.

* Measure gap betⁿ compression nut & valve &
put a split collar to lock sv setting.

- * 7 min smoke tube boiler
- * 15 min water tube boiler

After SV has lifted

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Acc of pr test → Done when SV are new

- Take sufficient water, stop feed plp
- Shut steam stop vlv
- Fire boiler max firing.
means rate of evap should be max
- Now steam pr rises & safety vlv lifts
- Note pr & time
- Now keep firing even after both safety vlvs lifted
- Now pr in boiler should not increase more than 10% of working pr with both vlvs lifted
- If water level has dropped considerably, then acc of pr test can be stopped.
- Done to check the lift of safety vlv & that no pr should accumulate in boiler
- Done only initially when the safety vlv are new & just fitted

Easing Gear

- only easing gear can give dlh lift
- * Used to check proper functioning of all parts & no leakage
- * If particle stuck betⁿ valve & seat & steam leaks, use easing gear & flush away particle.
- * If incase leak on boiler shell & we need to release all steam, we use easing gear.

Easing
Gear.

- Due to some reason, small steam leak betⁿ vlv & vlv seat, so by EGB particle will blow away
- Removal of steam if some problem with boiler
- check no leakage of components

Why EGB is set at higher pr than boiler?

Now boiler is at normal working pr. of Suppose 10 bar.

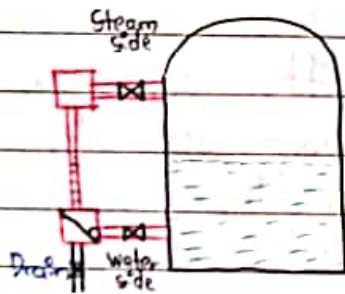
If EGB has to send water back to boiler, it should be definitely above 10 bar.

If water pr is lesser than 10 bar, feed water won't be able to enter boiler itself.

Hence EGB safety vlv set at higher pr than boiler.

Gauge Glass

- to check water level in boiler



Tubular Gauge Glass
Plate type gauge Glass
↳ made of borosilicate

First shut steam & water vlv

Open drain

Now gauge glass becomes empty

Open water side & check water side clear

Shut water side

Open steam side & check steam side clear

Shut steam side

Now close drain, open water side then steam side

Open water vlv first, because water contains less amt of heat, gauge glass warms up then open steam side

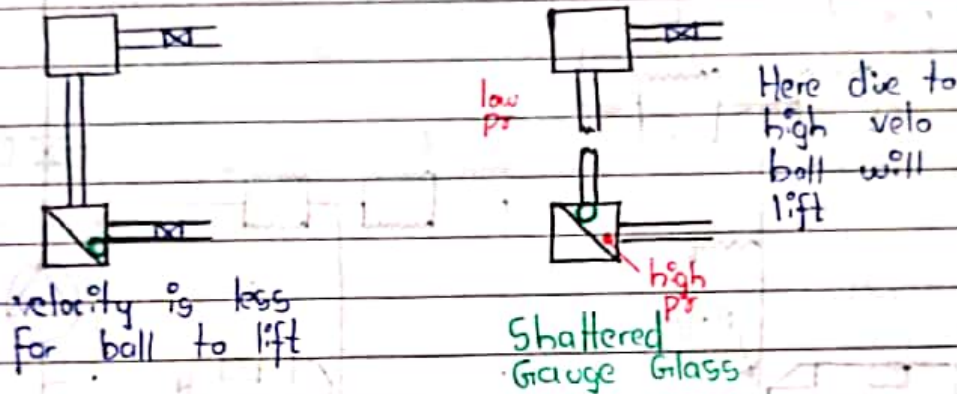
Also steam has higher rate of evap.

Gauge Glass Safety

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- ① Plate type gauge glass, only cracks but does not shatter
- ② Water, Steam valves open vertically downwards
- ③ Hollow steel ball in water side to protect person from hot water falling on operator



- * Now-a-days reflex type gauge glass are used
- * A mica strip is also provided to protect gauge glass

Q What if you find less or no level of water in gauge glass

- Always take in consideration worst case scenario

Stop boiler

Stop steam stop vlv

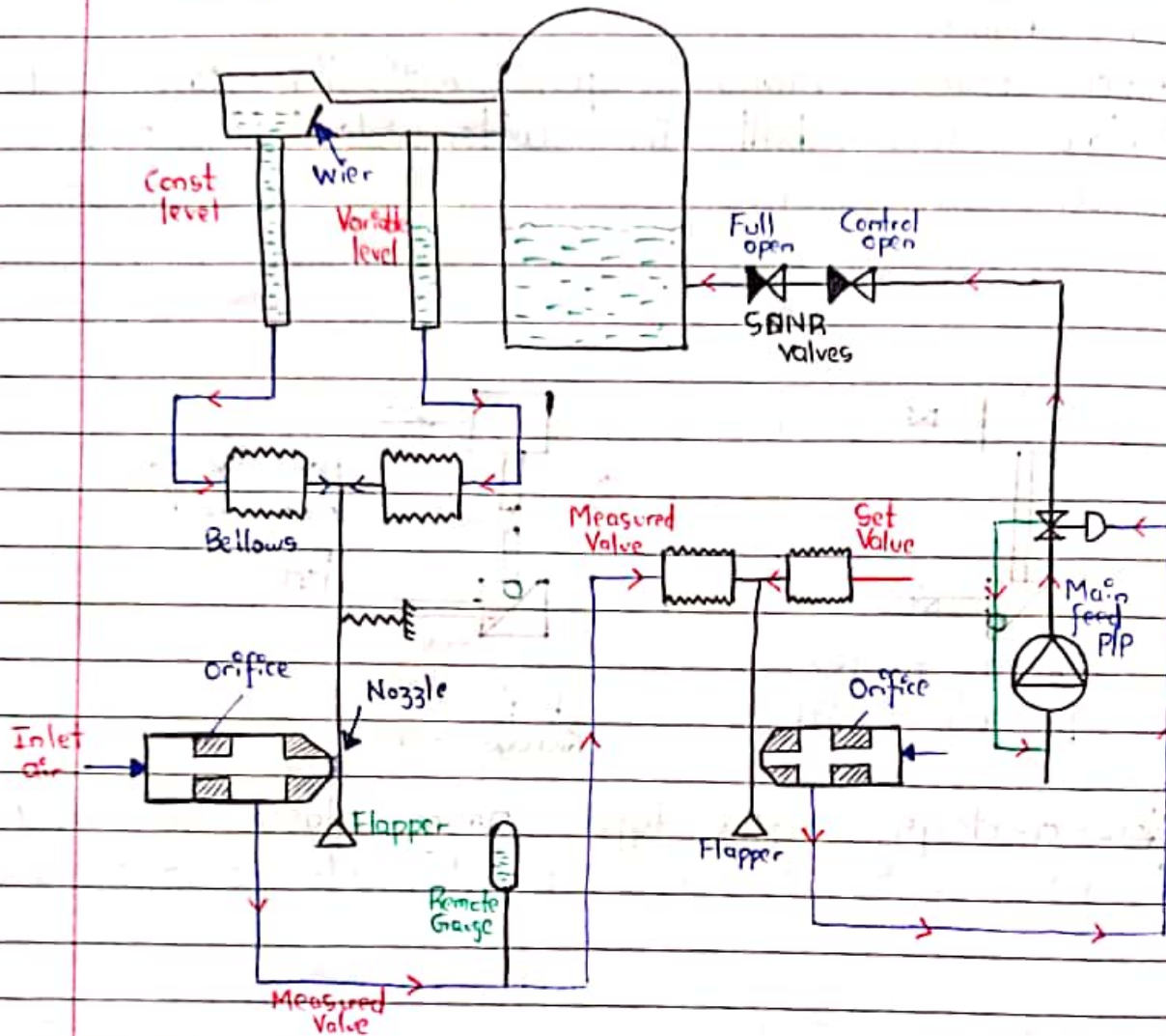
Now do gauge glass blowthrough

If water is really not there

Do not take water now or you'll cause crack

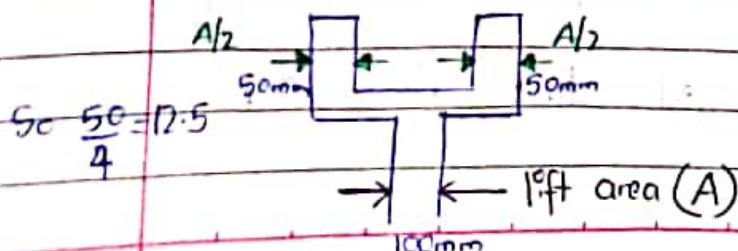
Investigate the low level of water if plp has lost suction etc.

After boiler has cooled down, now take water in boiler



- * Here plp is continuously ON
- * In ON/OFF control, plp cuts in & cuts off.
- * The remote gauge is in ECR & from there we can check level of water in boiler.

Why
SV on
game
chest



Carryover of water with steam is called Carryover

If this happens:

- corrosion, erosion & scale formation of steam plant machinery.
- also if there is a superheater, salts in water will deposit in the superheater tubes & finally tubes will choke.

BOILER ALARMS

Low level alarm

low low level alarm

High level alarm

High high level alarm

Low steam pr alarm

High steam pr alarm

Low feed water pr alarm

Low FO pr alarm

low FO temp alarm

low combustion air pr alarm

Flame failure alarm

Difference betⁿ SV & RV

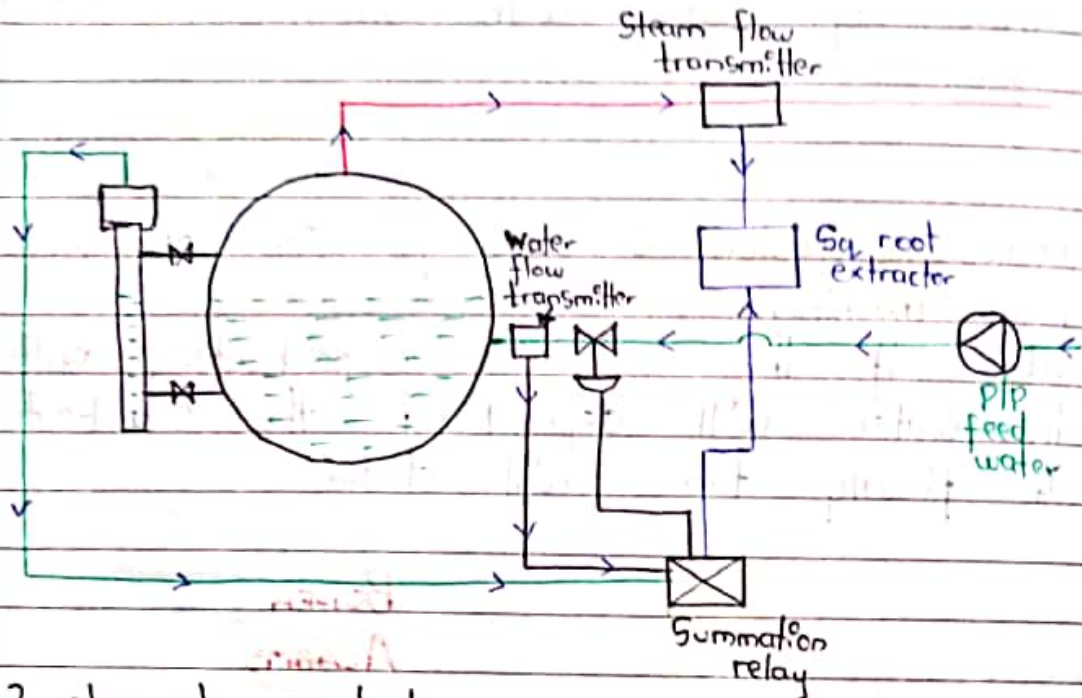
- ① SV → releases pr to atmosphere
RV → releases pr back to suction line
- ② SV → utilized for gas/steam
RV → utilized for compressible liq
- ③ SV → used where continuous pr is generated
RV → not used where continuous pr is generated
- ④ SV → fitted only vertically
RV → fitted anyhow

Black Smoke $\rightarrow$ Unburnt HC
 * Bad quality fuel
 * Air quantity poor
 * Air fuel ratio not proper
 * Check fuel pressure & temp.

* Faulty burner

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$\rightarrow$ 2 element control

Checking water level & also steam flow

$\rightarrow$ 3 element control

Checking water flow, steam flow & also water level

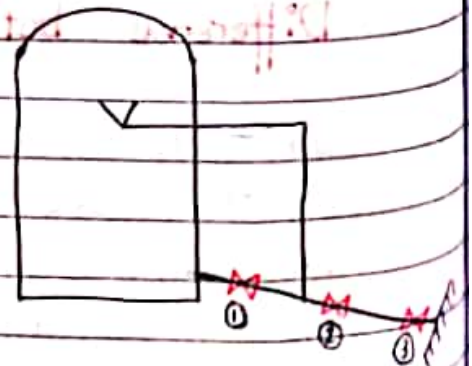
With 3 element control, problems like Swelling & Shrinkage can be avoided.

Boiler blowdown

① Open overboard valve fully ③
 Open ① fully & now
 control valve ②

② Now over a period of time,
 this valve will need to be
 repaired.

③ If no ① valve will be throttled & damage takes
 place & blowdown cannot happen until boiler stops



Panting Of Boiler - In & out movement of casing of br happens due to pr variations in furnace. This could be irregular load on boiler or any obstruction in exh gases & also back fire.

- ④ If no ③ vlv will be damaged, then ship will have to be going to drydock
- ⑤ Normally vlv ③ undergoes max damage & has to be renewed everytime at drydock.

Cross Blowdown of Gauge Glass

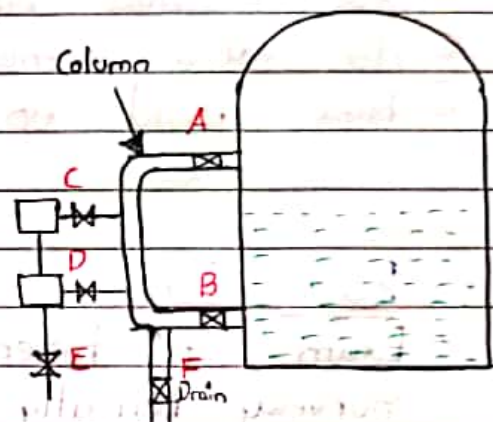
For high pr boilers, the gauge glass is mounted on a column to protect it from cracking.

- ① First, close A, B, C, D & open E & F

- ② Once line is clear.

- ③ Close A, F, D & open B, C, E let water flow from steam side

- ④ Close B, F, C & open A, D, E let steam flow from water side



Water Leak in tubes

- First of all feed water consumption will increase rapidly
- White smoke in exhaust
- Boiler water level in gauge glass difficult to maintain

Corrective Action

- ① Stop boiler firing
- ② Go inside furnace but after post purging.
- ③ Now you'll see water coming out with jet from holed tube
- ④ Put steel plugs & plug tube.

Hyd Pr Test Of Boiler

- ① If any tubes or plate of boiler has been changed then hyd pr test of boiler needs to be done
- ② Hyd pr test is normally done at 1.5 times ^{design} working pr of boiler.
- ③ Open vent
- ④ Blank safety vlv
- ⑤ Use a hyd plp & fill water in boiler
- ⑥ As water comes, close vent.
- ⑦ Now 'build up pr 1.5 times design pr

Boiler Survey

- Exam of boiler by competent authority
- Survey normally conducted by class. society
- After 1st 8 yrs every 2 years survey is done
- Within 5 yrs, atleast 2 surveys to be carried
- Between 2 yrs gap should not be more than 3 yrs.

- ① Firstly, change over boiler & ME, to D.O. as no steam available
- ② Stop boiler firing
- ③ Stop steam outlet & feed water plp.
- ④ Start blowdown & slowly reduce pr Gradual Blowdown
- ⑤ When pr comes to 1 bar, open vent.
- ⑥ Now if still water remains, blowdown water in tank provided
- ⑦ Now check pr gauge is 0
- ⑧ Finally, boiler depressurized.

- ⑨ Now open the top manhole door & now open bottom manhole door.
- ⑩ Because already inside boiler high temp gases might still be there. On opening bottom door
- ⑪ Now dismantle all mounting & put a tag mark.
- ⑫ All vlv & vlv seat need to be inspected vlv bodies to be checked for erosion.
- ⑬ Put spindles on lathe to check trueness.

Safety
vlv
checks

Disconnect safety vlv from easing gear
Open compression nut
Check vlv & seat
Check spring (jump ability)
Check vlv casing drain

- ⑭ Go to water side & check for pitting, corrosion
- ⑮ Check buckling, bending of tubes
- ⑯ Check scale formation of tubes by using stroboscope
- ⑰ Check demister, funnel for blowdown.
- ⑱ Check holes on distribution ring.
- ⑲ Check corrosion, erosion & scale formation of steam plant machinery.
- ⑳ Now call the surveyor.
- ㉑ Box back all the valves

COLD START OF BOILER

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- ① Keep vent vlv open
- ② Make sure blowdown vlv closed
- ③ Now take water by opening feed water vlv
- ④ Take 1/4th water level in boiler

⑤ Warming Up.

This is done by raising temp gradually. But first carry out ~~pos~~ purging.

- ⑥ Now slowly raise pr 1 bar at time
- ⑦ Till steam comes from vent
- ⑧ Don't close vent until steam doesn't come out of vent with force.
- ⑨ Close vent
- ⑩ Now check for water, steam, gas leakages
- ⑪ Call Surveyor to set safety vlv.
- ⑫ Tryout all alarms & trips

- * low level alarm
- * low low level alarm & trip
- * High level alarm
- * Steam high pr alarm
- * Steam high high pr alarm & trip
- * Flame failure alarm & trip
- * Fuel oil low pr alarm
- * Fuel oil low temp alarm.

Checks on safety valve

Check jumping of spring

Check the D/L length at 3 places

Check trueness of spindle on lathe

Check if drain of safety vlv is clear.

Check lip clearance

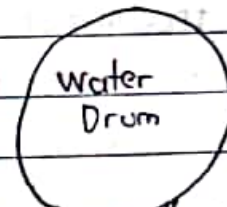
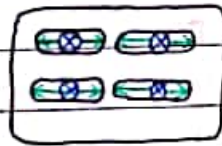
Ensure split collet in place after setting safety vlv.

Boiler Drum Expansion

With heat drums expand

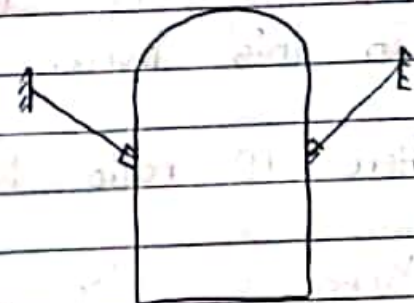
Hence sliding feet are provided

This is at back of boiler



Sliding foot

In



Sliding stays

Flame to be bright orange
No smoke from funnels

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BURNERS

- To spray oil in comb. space
- Burner will do fuel atomization & penetration
- It will also control flow depending on load

PRESSURE JET BURNER cannot be used for fluctuating load.

- * Oil from booster plp
- * Goes to orifice plate & swirl plate
- * Swirl plate has tangential holes

As oil comes in, it forms a rotating cone
This rotating cone is formed by tangential entry

- First rotational energy to oil is imparted by angled holes in swirl plate.
Here throughput can be maintained in 2 ways
- by varying oil supply pr
 - by changing dia of hole in orifice plate

Here we can only increase throughput by increasing pressure

$$\frac{\text{Max throughput}}{\text{Min throughput}} = \text{Turndown ratio}$$

More turndown ratio, more preferred burner.

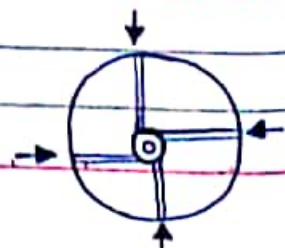
Depending on load, we vary turndown ratio

In this burner, TD ratio = $\frac{\text{max throughput} \rightarrow \text{max pr}}{\text{min throughput} \rightarrow \text{min pr}}$

Here TD ratio is normally 3.5 to 4

When oil finally is forced under pressure through a small hole in orifice plate which causes jet to break into fine droplets. → This is called atomization.

Swirl plate → tangential holes



If less TD ratio, oil won't fire & can cause blowback

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ROTATING CUP BURNER

Spray of oil is formed by rotating cup. This mechanical cup rotates with help of motor & belt.

Here atomization & penetration does not depend on pr of fuel, it depends on rotation of cup.

In this burner TD ratio = max +

Here fuel is controlled at lower loads with help of Fuel Control vlv.

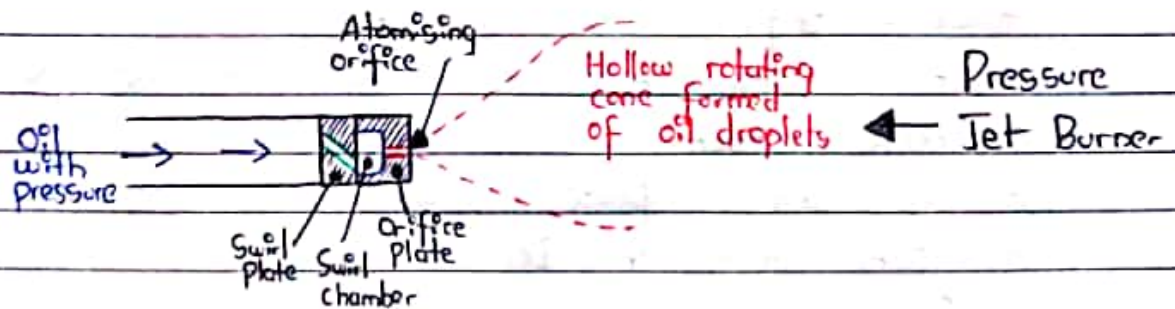
Also primary air surrounds rotating cup.

Primary air $\rightarrow$ mixes with fuel.

Secondary air $\rightarrow$ supports combustion.

There is a fan mounted on same shaft on which the cup rotates $\rightarrow$ Own FD fan.

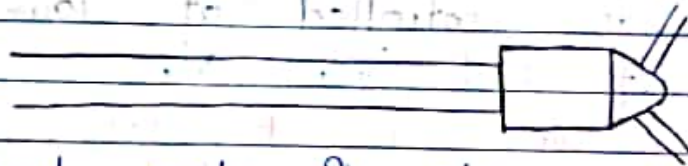
Here TD ratio is normally 10.



- * Bowl rotates at speed of 2000 ~ 7000 rpm
- * Flame produced by rotating cup burner tends to be longer.
- * Here no need of high oil pr, just sufficient pr is needed to overcome frictional losses.

Y-JET BURNER

- * Steam assisted or air assisted burner
- * It consists of an oil supply vlv which sends oil to tip of burner.
- * It also has a steam supply vlv which passes through center of oil path & forces the oil jet out.
- * Here turndown ratio is 12~15



- * Oil through center & steam around it.
- * Used only for tankers

Burner Maintenance

- Check orifice hole if choked
- Check spray holes & check with Go - NoGo gauge
- Check tangential channels if choked
- Lap orifice plate over swirl plate
- Clean all with DO
- Tighten cap nut with req torque

Casing of boiler moves in & out $\rightarrow$ Panting

This takes place due to uneven
pr when burner is already in op.

This can be due to fluctuation of load in boiler
dripping of fuel.

Check orifice holes with go & no-go gauge

Ensure tangential holes are clear in swirl plate

The swirl area in burner should be clear

Lap swirl plate & body

Backfire Of Boiler.

Repeated unsuccessful firing of boiler

In manual firing, if you have bypassed pre-purging or still gases are present in boiler.

This causes backfire.

This can also happen if using HFO burner for diesel.

Hence automatic prepurging is required.

Also if flap is open too much, & burner not able to fire, the fuel will accumulate in boiler & suddenly this fuel can ignite.

This is also a main reason for backfire.

NEVER stand in front of burner as if backfire happens, you may die.

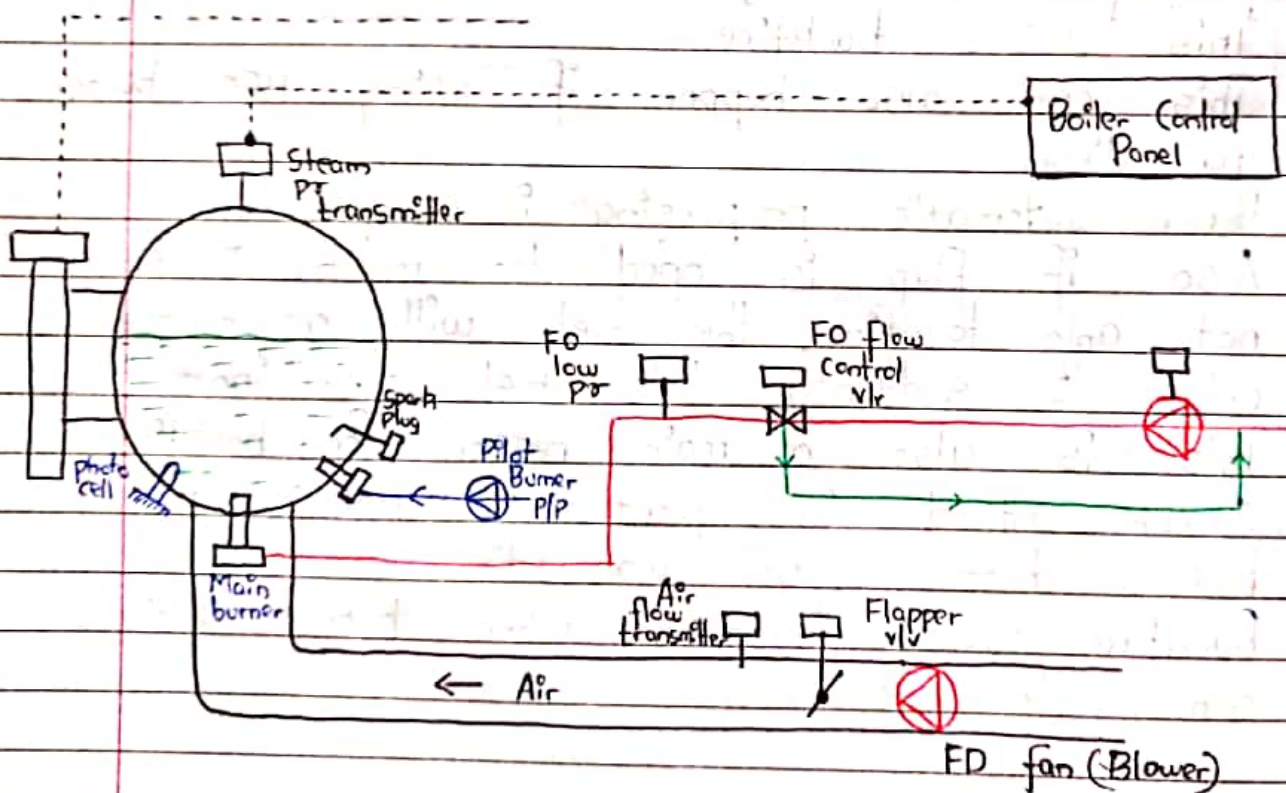
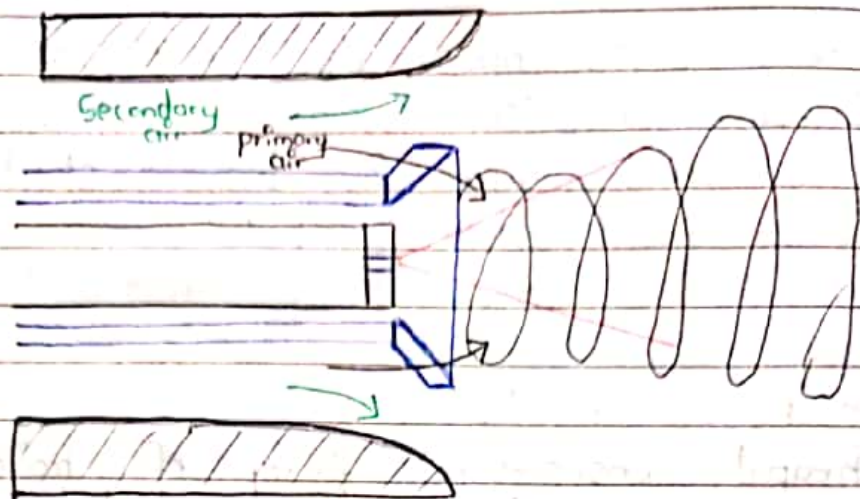
Backfire usually happens when burner initially comes into operation.

Maintain proper air/fuel ratio

Carry out burner maintenance

Check flame through the flame eye

It should be bright orange flame.



Now boiler is stopped & auto mode
 FO booster plp run but in recirculation mode
 When boiler pr drops, a start signal will
 be given to B.C.P.

Now immediately water level will be checked
 A prepurging sequence will start.

Max no. of tubes you can
plug is 20%

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Now the spark plug (25,000v) step-up transformer will give spark.

Pilot burner plp starts & fuel given to pilot burner.

Once flame is established, signal is given to 3 way vlv & it will stop recirculation.

Now fuel will be sent to main burner.

Once it ignites, both burners will run for about 4~5 seconds & photocell checks this.

Now signal goes to cutoff pilot burner plp & pilot burner cutoff.

Incinerator

↳ ID fan
furnace under vacuum

Boiler

↳ FD fan
furnace under pr

Flame failure alarm

Put light on photocell, now connect the 2 terminals with multimeter. Once light falls, multimeter measures conductivity, if not conductivity will be lost → Procedure to test photocell

Low air pr alarm

Low fuel oil pr alarm

Low water level alarm

Low low water level alarm

When load
increases

- air increases
then fuel increases

When load
reduces

- fuel reduces
then air reduces

No spark - spark plug problem

Check proper connections

Check if transformer not working

Check dist of electrodes

Air might be too much

M Pilot burner not firing - check pilot burner

Check filter

Check pilot burner plp

Photo cell not working

Main burner not firing - check main burner

Check filter

Check main burner plp

Check op. of 3 way vlv

WATER / STEAM HAMMER EFFECT

Steam in line gets condensed

Water is now collected in line

Now if main steam vlv opened

HP steam comes in contact with water (LP)

Now as this happens vacuum develops & draws more steam

This causes water to recoil & water starts hammering

This happens due to accumulation of water
∴ always keep drain open until steam comes out

Also use the warming up line to avoid water hammer

STEAM TRAP

Steam consists of

Specific heat

Superheat

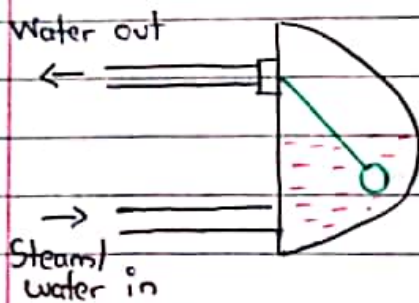
Latent heat of evaporation

We want to trap the steam until it converts into water

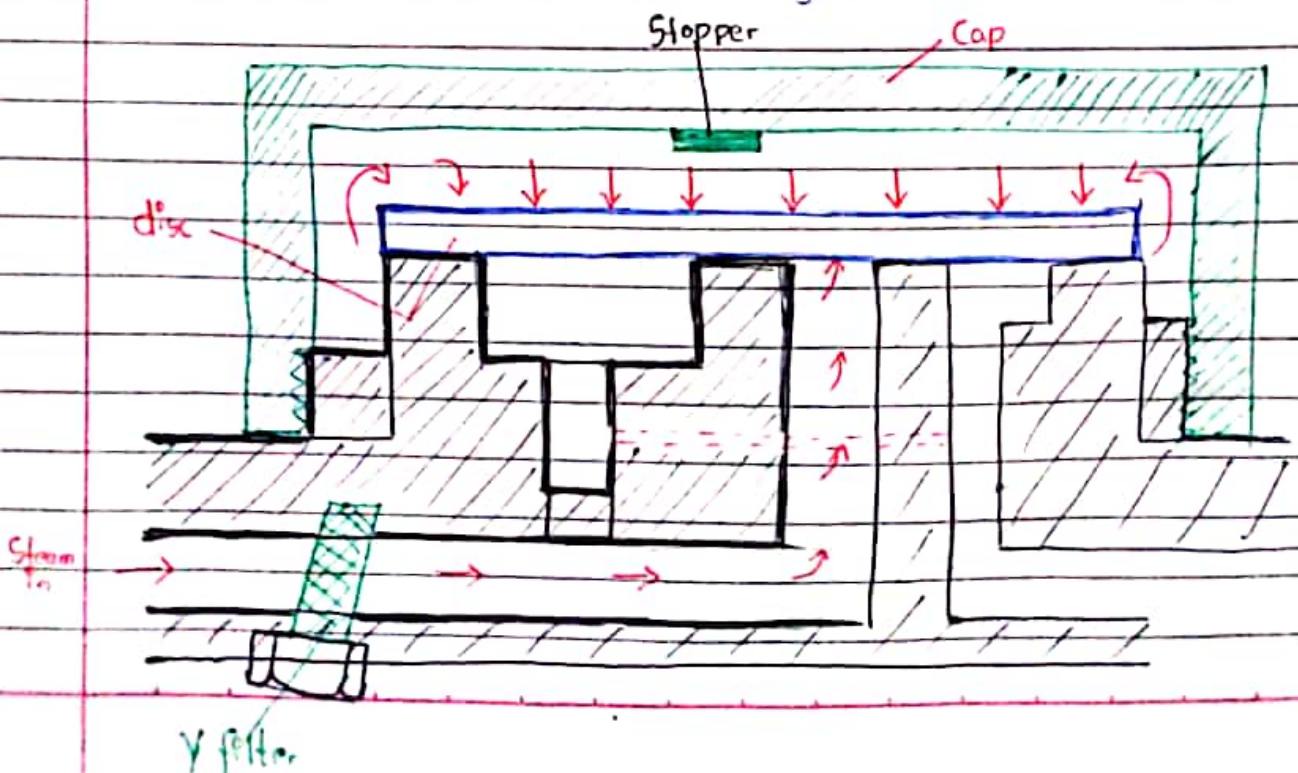
① Bucket steam trap (float type)

② Thermostatic steam trap

③ Thermodynamic steam trap



- * Here water/steam enters, the float is down.
- * It closes the outlet now
- * Once that steam condenses, the float rises due to water level
- * Once the limit has reached, the float opens outlet vlv & all water goes out



BOILER WATER TREATMENT

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Corrosion
by
 O_2

Efficiency of boiler & life of boiler depends on Quality of water in boiler

Main corrosion - oxidation corrosion

- due to dissolved O_2 in water
- air not vented



Iron Oxide (hematite) red powder or rust

Further oxidation

$\rightarrow Fe_3O_4$ (magnetite) black powder

Hence avoid entry of O_2

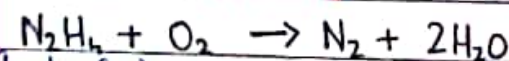
Mechanical Method $\rightarrow$ for removal of O_2

- maintain temp as high as possible $> 60^\circ$
- remove all air from vent at time of warming up
- use mechanical deaerators
- keep hotwell closed
- try to use vacuum condensers instead of atm condenser

Chemical Method

Add

HYDRAZINE



(hydrazine)

Oxygen
scavenger

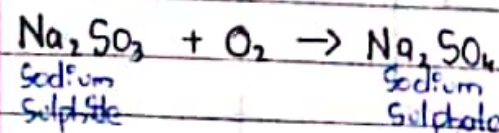
* Hydrazine does not increase dissolved solids

OR

* But hydrazine is cancer causing
excess hydrazine can form ammonia causing
ammonia corrosion

Add

SODIUM
SULPHIDE



Sodium
Sulphite

Sodium
Sulphate

- * Helps in reducing caustic embrittlement
- * Increases dissolved solids

Corrosion due to high alkalinity

If water is very alkaline, material of boiler becomes brittle

This is called **CAUSTIC EMBRITTLEMENT**

This normally happens due to too much Sodium hydroxide (NaOH) in water

Corrosion due to hydrogen ions

All acids have hydrogen ions.

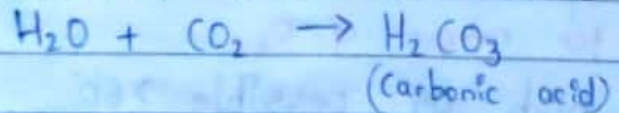
They are very light

If it gets trapped in metal like welds

This hydrogen reacts with carbon & this together causes **Hydrogen Cracking**

Corrosion by CO₂

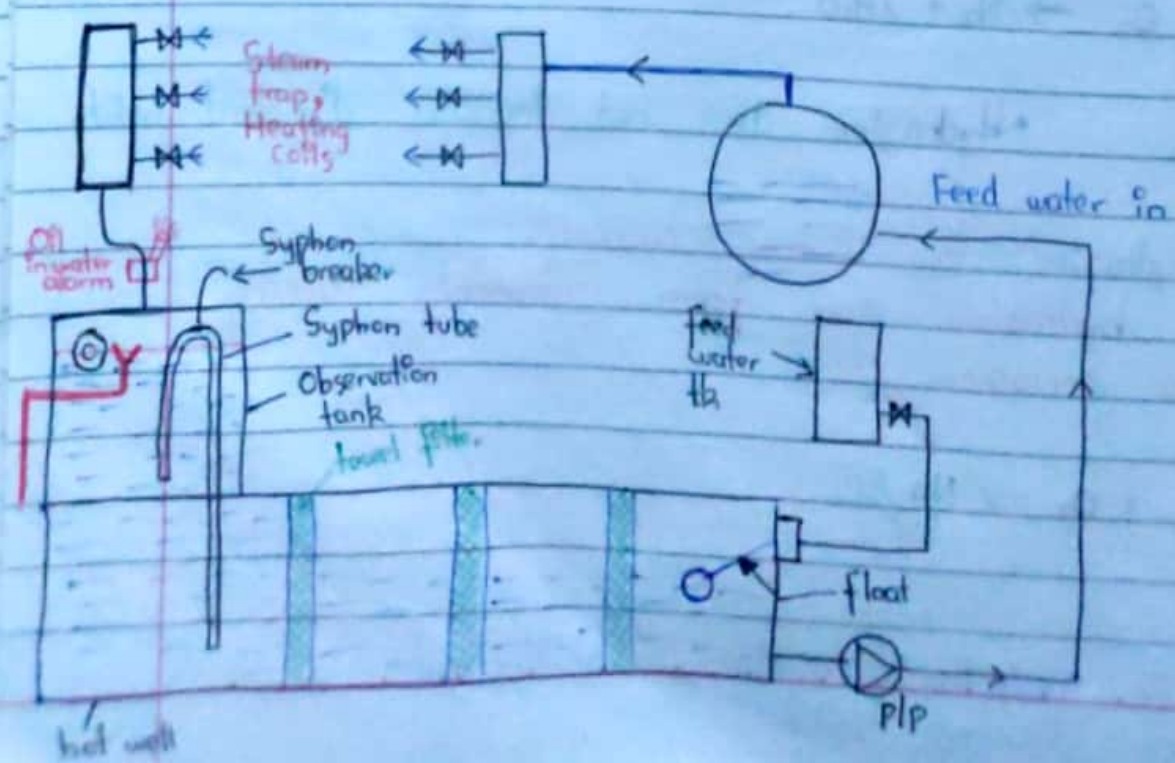
Corrosion due to CO₂



Hence CO₂ presence causes **Acid Corrosion**

To counteract, we use Calcium hydroxide Ca(OH)₂ or Sodium hydroxide NaOH

Oil in boiler can cause corrosion



log of reciprocal of hyd ions conc
= PH

Power of hydrogen

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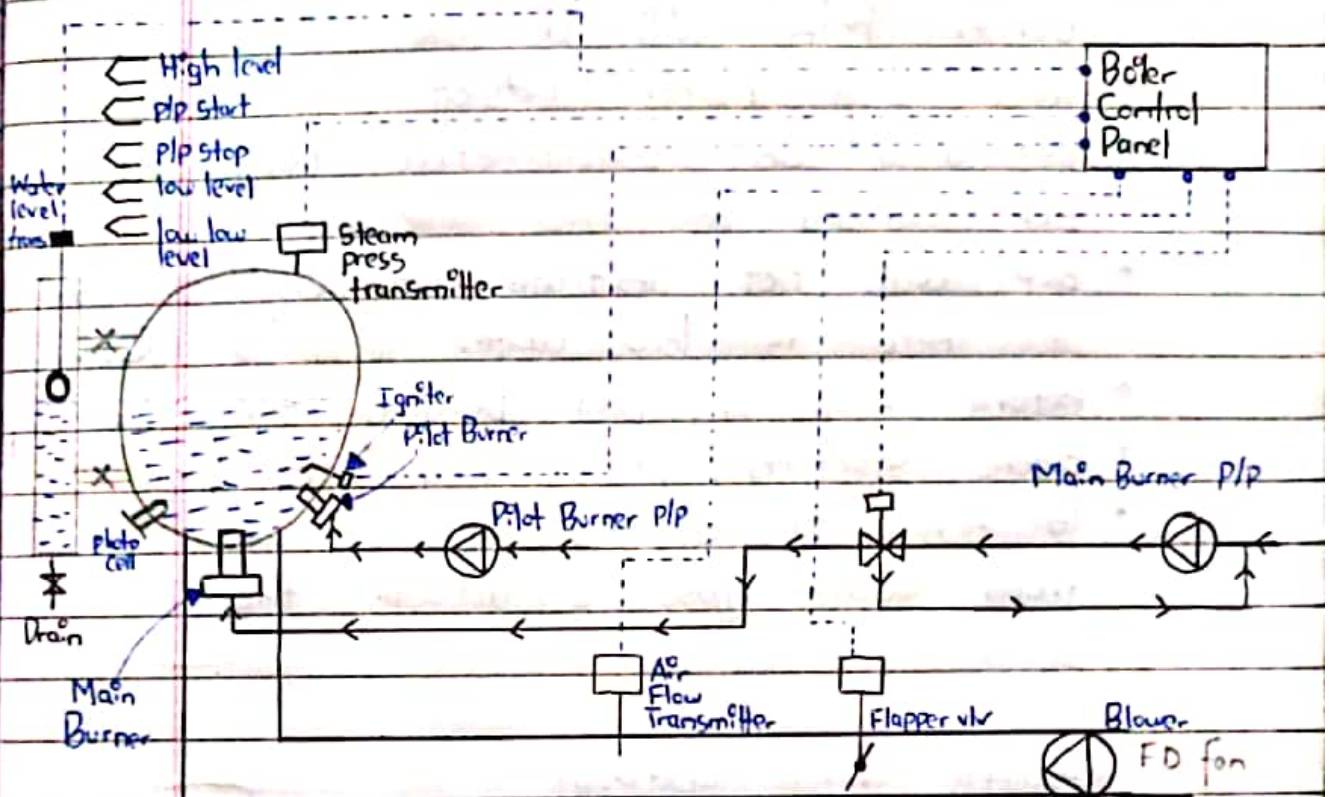
- * All water comes to obs tank & might have oil in it.
- * Firstly oil can be detected by oil in water alarm.
- * Syphon tube prevents oil to go to hotwell. Syphon tube only takes suction at bottom.
- * Even if oil goes in hotwell, towel filter will absorb this oil & not allow oil to go to boiler.
- * Oil can come in hot well, if any oil leak from heaters.

Also you can observe oil from gauge glass & also sight glass of hot well.

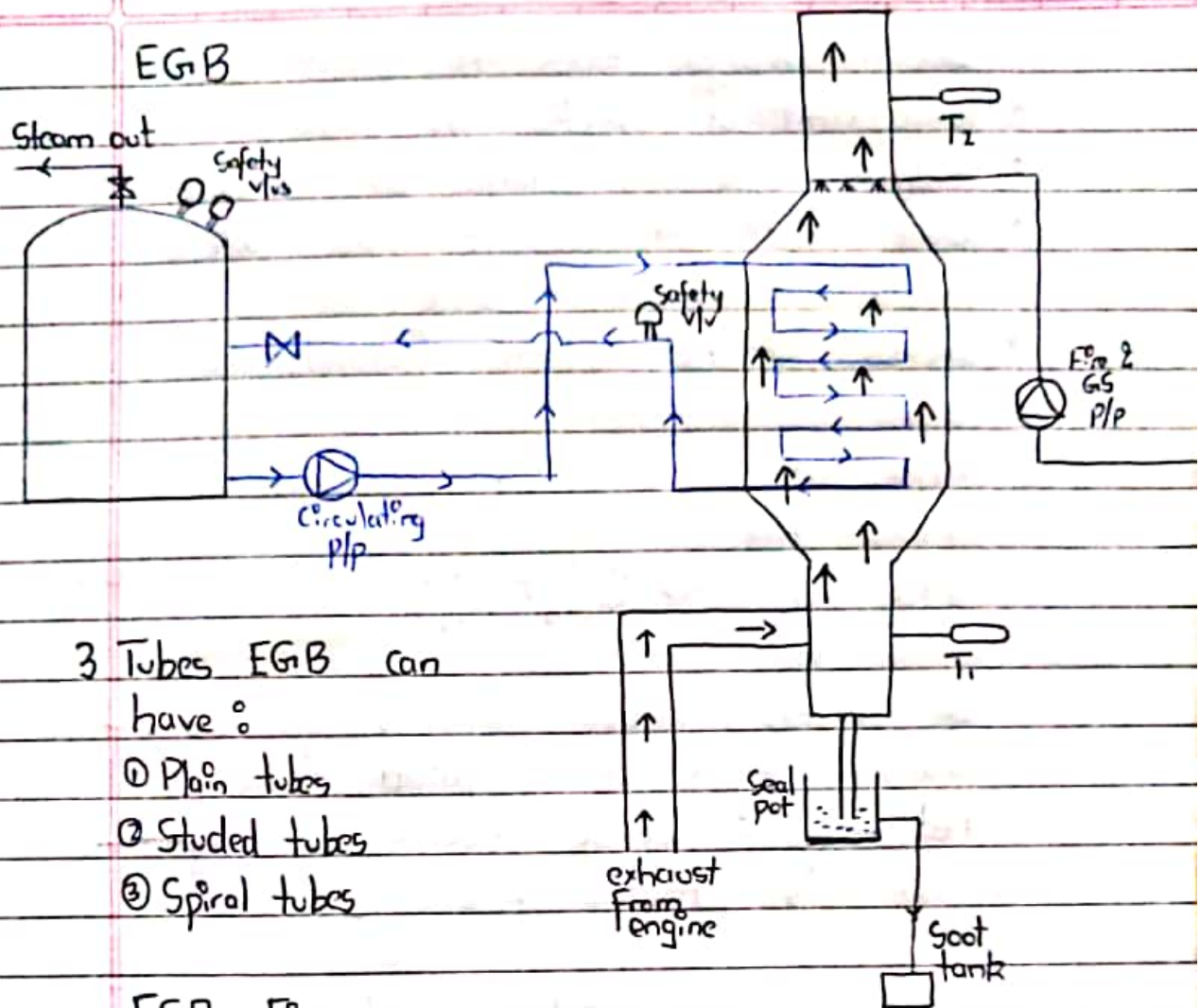
Carryout scum blowdown & not bottom blowdown or else oil will spread on walls on boiler.

Oil will first come to obs tank & then hotwell.

START / STOP Sequence Of Btr



- * When the press is low, the steam pressure transmitter sends signal to Boiler Control Panel (BCP)
- * BCP initiates starting sequence.
Start sequence will not initiate if btr level is low low.
- * The FD fan starts supplying air
- * The BCP controls flapper vlv which decides the amt of air to be sent.
- * Now the igniter will actuate. & pilot burner will send fuel.
- * Once the flame is sensed by photocell, the signal is sent to BCP
- * This BCP will now send signal to 3 way solenoid vlv & actuate main burner p/p



3 Tubes EGB can have :

- ① Plain tubes
- ② Studded tubes
- ③ Spiral tubes

EGB Fire

- * Due to ME exhaust gases, there will be carbon deposits on tube.
- * Now if carbon in dry condition is safe as its ignition temp is 1000°C
- * But if carbon is wet condition, due to unburnt LO/FO espcl when manoeuvring, then its ignition temp drops to 200°C & catches fire immediately.

Reasons for deposits

- * Not proper combustion
- * Manoeuvring long time
- * Incorrect LO feed setting
- * Injector dripping
- * Leaky exhaust vlv

Indication of EGB fire

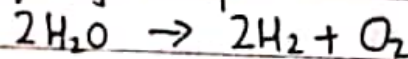
- * large amt of sparks in exhaust
- * Sudden rise in steam pr. in boiler
- * Outlet side exhaust of EGB ~~will~~ will be higher than inlet side.
- * Excess smoke from funnel.

Type of fires

- Minor fire
- Major fire → Hydrogen Fire
Metal Fire

- If excess carbon deposits on tube, heat transfer will be impaired, tube will become red hot & cause source of ignition
- This is metal fire

Now if waterwash is done, this will cause hydrogen fire



Action In Case Of EGB fires

- ① Do not carry out soot blow
- ② Do not lower load on engine (as soot will become more wet)
- ③ Inform bridge & stop ME immediately
- ④ Stop boiler
- ⑤ Put canvas cover on the blower side (so that no more air goes to support combustion)
- ⑥ Some ships have fixed fire fighting system to fight EGB fires.
- ⑦ Do not stop boiler circulating plp
- ⑧ Skirt the GS & fire plp for water nozzle cooling
- ⑨ Start Boundary cooling.

- ① SOLAS req for air compressor & air bottles?
- ② What is swept vol & clearance vol?
- ③ What happens if $V_c = 0$ & $V_c = \text{maximum}$?
- ④ What do you mean by vol eff of compressor?
- ⑤ What are types of compressors?
- ⑥ Why we cannot do single stage compression?
- ⑦ Why we carry out multi-stage compression?
- ⑧ Just by observing the compressor, how can you determine compressor working normal?
- ⑨ Reasons for increase in V_c ? & how to know?
- ⑩ Reasons for decrease in vol eff?
- ⑪ Draw entire circuit diagram, & show safeties on sys?
- ⑫ What if compressor motor terminals are interchanged?
- ⑬ Adv of intercooler & after cooler?
- ⑭ Procedure to start air compressor manually?
- ⑮ What is loc of fusible plug & at what temp it fuses?

- ①⑥ How to check if vlv are leaking or ok?
- ①⑦ When will 2nd stage relief vlv lift?
- ①⑧ What is bumping clearance? How to check? What is normal value?
- ①⑨ How to adjust the BC?
- ②⑦ What will you do if burst disc of compressor bursts during manduvring?
- ②① Difference betⁿ air compressor cycle & ref cycle?
- ②② How to test Lo low ~~temp~~^{pr} trip?
- ②③ How to test high air temp trip?

Purifier :

- ① Why is a purifier required onboard?
- ② Where does 1st stage of separation take place **IMP Q's**
- ③ Principle of working of purifier?
- ④ Factors affecting separation?
- ⑤ Where is the interface to be maintained?
- ⑥ How to decide size of gravity disc?
- ⑦ What is pairing disc?
- ⑧ Difference betⁿ purifier & clarifier?
- ⑨ How to change purifier to clarifier?
- ⑩ Why do we need plates in purifier?
- ⑪ Explain friction pad assembly?
- ⑫ Purpose of applying brake?
- ⑬ Reasons for purifier vibrating?
- ⑭ Explain sliding bowl assembly?
- ⑮ Explain starting of purifier?
- ⑯ Explain stopping of purifier?
- ⑰ Explain partial & total discharge?
- ⑱ Purifier not desludging reasons?
- ⑲ Purifier overflow reasons?
- ⑳ Purifier vibrating reasons?
- ㉑ Reasons of purifier ht change & actions?
- ㉒ What will happen if purifier rotates in ^{opp direction?}

Refrigeration Q's

* Flock pt
* Pour pt
* COP

- ① Principle of ref sys?
- ② Properties of refrigerant?
- ③ Which refrigerant used on ship?
- ④ Safeties of refrigeration system?
- ⑤ Where the check level of refrigerant in the system?
- ⑥ Function of TEV?
- ⑦ Why ref & AC compressors are belt driven?
- ⑧ What is purpose of crankcase heater?
- ⑨ Purpose of differential LO pr cutout?
- ⑩ Reasons for LP cutout?
- ⑪ What is short cycling?
- ⑫ Reasons for HP cutout?
- ⑬ How to check leak in refrigerant sys?
- ⑭ How to charge LO in system?
- ⑮ Why defrost necessary before LO charging?
- ⑯ How to charge refrigerant in system?
- ⑰ How to detect air/moisture in system?
- ⑱ How to remove air/moisture from system?
- ⑲ How to test LP, HP cutout?
- ⑳ Purpose of compound pr gauge & location?
- ㉑ Reasons for icing on suction of comp.
- ㉒ How veg room maintained at high temp.

Boiler Q's

IMP Q's

- ① What are types of boiler?
- ② What are boiler mountings?
- ③ Why are manhole doors elliptical in shape?
- ④ Purpose, types & material of refractory?
- ⑤ What are boiler internal mountings?
- ⑥ What is swelling & shrinkage of boiler?
- ⑦ How does foaming / priming take place?
- ⑧ Explain boiler 3 element control?
- ⑨ Reasons & effects of carry over?
- ⑩ Difference betⁿ water tube & smoke tube boiler?
- ⑪ Safeties of gauge glass?
- ⑫ Procedure of gauge glass blowthrough?
- ⑬ Why water side to be opened first?
- ⑭ What is accumulation of pressure?
- ⑮ Types of safety vlvs & their lift?
- ⑯ What should be min bore of sv?
- ⑰ What should be min lift of sv & how to achieve it?
- ⑱ Parts of sv
- ⑲ What do you mean by blowdown of sv?
- ⑳ You are on watch, suddenly blr water low level alarm comes? blr Actions?

- ②① Explain procedure to set SV onboard?
- ②② What is gaging tool? What to do if no gaging tool onboard.
- ②③ Procedure to carry out accumulation of pressure test?
- ②④ In what conditions, acc of pr test to not be carried out.
- ②⑤ Procedure to perform boiler survey?
- ②⑥ Function of easing gear?
- ②⑦ Procedure for cold starting of boiler?
- ②⑧ What is warming up time for water & smoke tube boiler?
- ②⑨ Explain modulating control & ON/OFF control?
- ③① Reason & procedure for hyd pr test of boiler?
- ③② Reasons for not being able to maintain water level in boiler?
- ③③ Explain fuel oil sys of boiler?
- ③④ Explain term backfire & precautions?
- ③⑤ Why prepurging & postpurging both required?
- ③⑥ Explain diff types of boiler burners?
- ③⑦ How will you know burner is working fine?
- ③⑧ Causes for freq alarm of boiler flame failure?

- ③⑨ How to test photocell is working or not?
- ④⑦ Why EGB sv set at higher pr than boiler sv?
- ④① Reasons of EGB fire?
- ④② Actions in case of EGB fire?
- ④③ Explain the boiler water treatment procedures?
- ④④ what are 2 types of fire in EGB
- ④⑤ How to know EGB fire.
- ④⑥ Tubes in boiler
- ④⑦ How will you know no water inside boiler.
- ④⑧ Why 2 gauge glass req. → Redundancy
- ④⑨ what is panting of boiler
- ⑤② what is layup of boiler
 - ① Close steam
 - ② Fill up completely full of water
 - ③ Add heaters
- ⑤① where is boiler sample taken from
- ⑤③ Difference betⁿ blr & incinerator.

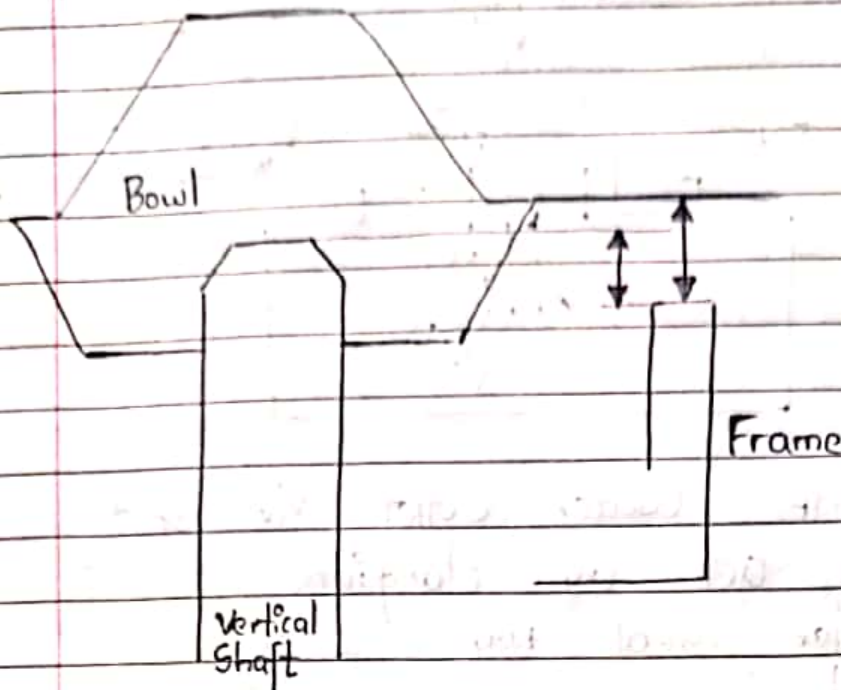
FWG

- ① What are the types of FWG & which one is used onboard?
- ② What is reason of loss of vacuum in FWG?
- ③ What is reason for high salinity?
- ④ Why vacuum drops initially & come back to normal?
- ⑤ What is use of air ejector once vacuum is produced?
- ⑥ Why shell temp should not go above 60°C ? What will happen?
- ⑦ What happens if condenser tubes leaking? How will you come to know?
- ⑧ How to know evaporator tubes are leaking?

- If vacuum decreases & shell temp increases means condenser tubes leaking.

- ⑨ Good vacuum but production is less?
Reasons $\rightarrow$ check Jcw in/out
- ⑩ Shell temp increases, vacuum dropped?
Reasons $\rightarrow$ condenser tubes choked.
- ⑪ If demister fouled, how to know?
- ⑫ In cold countries, after a while we get high salinity alarm? why?
- ⑬ How to reduce salinity in cold countries?
- ⑭ What chem treatment is done to reduce scale formation?

How to measure bowl height → **PURIFIER**



Bowl ht to be checked before & after assembly of bowl

Use vernier or scale to measure

Bowl
ht
Shaft
ht

Frame & bowl nut

Top of vertical shaft & frame

ex $40.4 \pm 0.5\text{mm}$

- Put straight edge on top of shaft
- Then measure ht from frame to shaft

