Refrigeration and Air Conditioning systems onboard Ships- Vapour Compression systems

Moving heat from a lower temperature to higher temperature requires work to be done, according to second law of thermodynamics and this work can be done in many ways in different systems. The most widely used techniques to move heat from lower temperature to higher temperatures are

1. Vapour Compression systems
2. Vapour absorption systems.
3. Peltier systems
4. Magnetic refrigeration systems

Vapour Compression systems are used onboard because of its high efficiency and co-efficient of performance compared to vapour absorption systems. Vapour absorption cycles are not used now a days and has been phased out towards the beginning of 20th century.

Vapor Compression systems Explained:

Change of state is always associated with a latent heat of phase change and is absorbed from the surroundings. This is the principle behind vapour compression systems. The vapour used is cycled between liquid and gaseous phases. The liquid to gas phase change absorbs heat from the surrounding (the evaporator) and vapour to liquid change needs work to be done, and is supplied by a compressor.

Thus, in a vapour compression system, we must have a compressor which compresses the refrigerant vapor into high pressure vapour, a condenser which cools the sub cooled liquid vapour into liquid phase, a TEV or thermostatic expansion valve or a capillary tube, which regulates the flow of liquid and an evaporator in which the liquid refrigerant absorbs the heat and forms into saturated vapour. The vapour which comes out from the evaporator coils is not really saturated, but superheated, the reason of which is explained below.

The compressor:

Marine refrigeration systems widely use a multi cylinder electric motor driven reciprocating compressors. The advantage of such compressors is that the control of load can be employed using cutting in and cutting out of individual cylinders, which adds to be overall efficiency of the system.

The Air condition compressors crankcase is pressurized

The Air condition compressors crankcase is pressurized because of a bypass connection between compressor suction and the crankcase. This line is given because we cannot afford to lose even a small amount of refrigerant from the system. The piston- liner surface is not prefectly sealed, even if high tech seal rings are used. There is always a little leakage from this interface, as in any other reciprocating
If the crankcase was vented to atmosphere, the refrigerant would escape into atmosphere. This gas which leaks from the interface is collected into the crank case of the compressor and is used back in the next cycle, by connecting crankcase and compressor suction side. Also oil carry over will be there in this arrangement which needs to be coped for.

In latest systems where oil ingress into the system is very much unacceptable, we use teflon or PTFE rings, which sweeps out the scope for piston lubrication. Such systems use a cross-head type piston, and isolates the liner and crankcase.

This is one of the major difference between Air condition compressor and Air compressors. Air compressor crankcase are open to atmosphere , as there is a breather given for the crank-case.

Varying the load on compressors:

The A/C compressor is having more than one unit when load control is required. The multi stage system is used so as to run the compressor at different loads. usually stages are set at 33%,66% and 100% loads. Each unit of compressors put in load according to the load on the system. A solenoid operating valve will keep the suction port depressed always when a unit is not in use. This removes the load on that particular unit. When the particular unit is needed to be on load, and add to the cooling capacity of the system the soleniod valve operates and removes the constraint placed earlier on the suction valve.

A compressor stages are usually setup to cut-in and cut-out based on the L.P or low pressure reading in the compressor suction side. This is explained well below in respective sections.

L.P and H.P sides of a compressor- The distinction -Why ??

The compression discharge line will be always pressurized compared to the suction side, and thus is called High Pressure side. Usually the line till the Thermostatic expansion valve is called H.P side. HP pressure refers to the pressure in this side, and is read by a guage fixed in the compressor discharge.

The compressor suction side from TEV to the suction port is at a Low Pressure, compared to the H.P side and this called L.P evaporator pressure is always referred as L.P pressure, and is of very much importance in the refrigeration system.

**How Temperature of evaporator is controlled in refrigerators.-**

**L.P CUTOUTS**

The pressure in the evaporator is a measure of the evaporator temperature according to the gas laws. The vapor absorbs heat from the evaporator and its pressure rises at a constant temperature, as the phase change is taking place here without any super-heating. When the evaporator pressure or L.P falls to the pressure of the gas at that
particular set temperature, the compressor cuts-out and system is at set-point. When the pressure in the evaporator increases, the compressor cuts in and starts the cycle.

Compressor stages are set at to cut-in at different L.P pressures. If a particular temperature cannot be achieved by a particular no of stages, the L.P pressure increases and at the cutting in point the next stage cuts in.

**Vegetable room at 4 Degrees and Meat room at -18?? Same compressor?? :O**

This is achieved by using back pressure valves in the individual lines from each of these spaces. L.P in each of the evaporator is controlled by this back pressure valve, and thus controls the temperature. Each of the back-pressure valve maintains a particular pressure inside the system, and thus ensures a particular temperature in the system. So, L.P of vegetable room will have a higher value than L.P of meat room. Each of the evaporator is having its own expansion valves.

**Thermo static Expansion valves**

These are flow control devices used in refrigeration systems. The degree of superheat of vapour after the evaporator to the compressor suction side is maintained by the Thermo static Expansion valves. There is an orifice as the main part of the valve, which will open and close based upon demand of the evaporator. This is NOT the device which maintains pressure gradient in the system, and it is the compressor which is doing so.

**How does TEV control degree of superheat?? Why vapour is superheated ??**

A saturated vapour is always appreciated inside the evaporator coils as heat transfer is most efficient during phase change. When superheating happens, lesser amount of energy is absorbed and thus is inefficient. Even though superheating is unfavourable, we always keep a small degree of superheat for the vapour coming into the compressor suction side. This is done in order to avoid entry of any liquid into the compressor, as it may badly affect it.

TEV's sensing bulb is placed near to the compressor suction where vapour is present in the superheated form inside the L.P tube. The vapour inside evaporator is now superheated and the feeler bulb has saturated vapour inside it. Saturated vapour pressure is always greater than superheated vapour pressure at the same temperature. This pressure difference is directly related to the degree of superheat. Thus TEV operates on this pressure difference as input, and not the pressure inside the feeler bulb as input. When degree of superheat falls below a value, this pressure gradient lowers, and TEV remains closed for a longer period, lowering flow of refrigerant liquid into evaporator coils, and pulls up the degree of superheat.

In large installations an equilizing line is given to balance the feeler bulb pressure in the TEV. This is in order to compensate for the pressure loss in evaporator coils due to friction of the coils. This pressure loss will create an increase in degree of
superheat making the liquid refrigerant vapourizing completely before the end of evaporator coils. The effect is nullified by using a equalizer line.

**Engine room Funnel - Construction, Regulation and Uses of Engine room funnel**

A funnel which forms a part of the engine room, acts as a chimney for the exhaust of engines, boiler steam or engine room gases. It acts as a casing for the uptakes from engine room. It serves the purpose of a normal chimney, and has added modifications for meeting various pollution regulations and safety standards. It clears the exhaust gases off ships deck, and thus keeps in check fouling of ships structure or decks. The funnel houses Main engine exhaust, Generator engine exhausts, Boiler exhausts, and also funnel flaps.

The funnel size and shapes will be largely dependent on the volume of exhaust gases produced by the main propulsion engines and auxiliary engines. Funnel volume is also counted with engine room volume, and therefore should be included in all calculations involving engine room volume, for example calculating volume of CO2 needed for a fixed CO2 system.

The funnel also acts as a casing for the Main engine and auxiliary engine exhaust silencers. Catalytic convertors also finds its place inside the engine room funnel.
**Funnel Flaps Working, Construction and regulations**

Funnel flaps in a ship refers to the movable closures or windows present in the aft head of the funnel (generally). Light weight gases from the engine room escapes to the outer atmosphere through the grills in the funnel or the funnel flap openings.

**Hydraulic or pneumatic arrangements** are provided for closing and opening the funnel flaps. By regulation, the funnel flaps should have provisions to be opened from a remote location. Usually, Fire control stations houses the remote control arrangements for funnel flap operation.

Funnel flaps are to be closed before releasing of CO2 or doing a composite boiler or exhaust gas boiler cleaning by pressurizing the engine room.

Funnel flaps are to be always kept clean and lubricated well. It is a main component of the engine room, a favourite choice of psc inspectors and various other surveyors. A poorly maintained funnel flap will invite bad reports and will pose a serious threat to safety of the engine room.

It is a part of saturday routines to check the remote and local operataion of the funnel flaps, and is usually done by the fourth engineer or third assistant engineer.

**Fire Cabinet or Fire Box- Contents**

Fire box contains the following items

1. Fire hose
2. F-Spanner for opening the hydrant valves
3. Nozzle- Either Standard or Dual purpose; Standard nozzles will produce only jets, whereas dual purpose nozzles will produce both jet as well as Spray depending on the position of the turn key.
4. Hook spanner
5. Instructions pasted on the box
**Difference between purifier and clarifier- GRAVITY DISC**

1. The presence of a gravity disc in the purifier- There is a general misconception that gravity disc generates the interface between oil and water in the purifier. this is not correct. Interface is formed due to the centrifuging action, the lighter oil particles will be in the central portion and the heavier water and sludge particles will move to the outer periphery. Thus, What is gravity disc doing here??? NOTHING! Gravity disc is just giving a surface of separation between oil and water flow. In alfa laval alcap purifiers which are newer models of the renowned manufacturer, There is no gravity disc present. Instead of gravity disc a water in oil detector is used.

2. Clarifier has a sealing ring which seals the water outlet, as water and impurities remain in the until desludging.

3. The conical discs in a clarifier usually don’t have feed holes in them but if they do, then a disc without any holes is fitted at the bottom of the stack.

4. Sealing water is not present in clarifiers for the generation of a seal that prevents the oil to leave through the water outlet at starting. Purifiers and Clarifiers differ only in that clarifiers are not set up to remove water.

**Gangway safety in ships. Things to be checked before using the gangway.**

The accommodation ladder and gangway must:

1. be firmly secured to the bulwark;

2. be properly aligned with the means of access to the vessel;

3. have treads that are at least 600 mm in width and 200 mm in depth, with a permanent non-slip surface;

4. be equipped with two handhold stanchions that are not less than 40 mm in diameter;

5. extend not less than 1.2 m above the top of the bulwark;

6. be fitted at the point of boarding or disembarking the vessel not less than 700 mm and not more than 800 mm apart.

Every accommodation ladder and gangway must:

1. be maintained in a safe condition;

2. be installed in a manner that reduces movement;
3. be suitably rigged and maintained to compensate for the movement of the vessel;

4. be adequately lighted;

5. as far as practicable, be not be more than a 40° angle to the horizontal plane;

6. be provided with a lifebuoy that has an attached line and is strategically placed and ready for immediate use; and

7. have the mechanical, electrical, gearing, hydraulic and pneumatic systems in good working order.

Freeboard explained, and why it is given.

In sailing and boating, freeboard means the distance from the waterline to the upper deck level, measured at the lowest point of sheer where water can enter the boat or ship.

Freeboard defines the reserve buoyancy of a vessel. It is to be there to satisfy the reserve buoyancy regulations by IMO and other conventions. Reserve buoyancy is important for the vessel’s safe operation at sea.

Sufficient freeboard is required at all times to prevent the vessel being swamped and overwhelmed. For ocean-going vessels, it is important to note that those structures above the waterline that are not watertight will not contribute to the reserve buoyancy of the vessel. Again, this makes sense – an open wheelhouse, or a cabin with the doors left open will not offer much protection if the vessel begins to ship water over the side.

Another factor affecting the freeboard to take into account is the trim of the vessel. Trim is defined as the difference between the draft forward and the draft aft. Draft is the depth of the hull below the water. If the aft draft is greater, the vessel is described as being trimmed by the stern, if the forward draft is greater, she is trimmed by the bow.
Length between perpendiculars and its Significance

**Length between perpendiculars**, often abbreviated as p/p, p.p., pp, LPP, LBP or **Length BPP** is a term describing the length of a ship. LBP refers to the length of a vessel along the waterline from the forward surface of the stem, or main bow perpendicular member, to the after surface of the sternpost, or main stern perpendicular member. When there is no sternpost, the centerline axis of the rudder stock is used as the aft end of the length between perpendiculars.

Measuring to the stern post or rudder stock was believed to give a reasonable idea of the ship’s carrying capacity, as it excluded the small, often unusable volume contained in her overhanging ends. On some types of vessels this is, for all practical purposes, a waterline measurement. In a ship with raked stems, naturally that length changes as the draught of the ship changes, therefore it is measured from a defined loaded condition.

The significance lies in the fact that this length gives the length of the waterline of the vessel, in loaded condition, a very crucial parameter.
Annex 1 discharge criteria outside special area and inside special area for marine vessels

**Inside special areas or outside special areas within 50 nm**

ANY DISCHARGE IS PROHIBITED with the exception of clean or segregated ballast

**Outside Special areas:**

ANY DISCHARGE IS PROHIBITED, with the exception of clean or segregated ballast, or except when:

1. the tanker is proceeding en route, and

2. the instantaneous rate of discharge of oil does not exceed 30 litres/nm, and

3. the total quantity of oil discharged into the sea - does not exceed - for tankers delivered on or before 31 December 1979 - 1/15,000 of the total quantity of the particular cargo of which the residue formed a part - and - for tankers delivered after 31 December 1979 – 1/30,000 of the total quantity of the particular cargo of which the residue formed a part, and

4. the tanker has in operation an oil discharge monitoring and control system and a slop tank arrangement as required by regulations 29 and 31, respectively

**Cylinder Head - Cylinder head mountings, Function and Combustion chamber shape.**

Cylinder head or cylinder cover houses various fixtures called cylinder head mountings. They are positioned and designed very carefully, as they are subjected to very high combustion pressures, and temperatures. Cylinder head mountings and functions are explained below in a brief sense.

Functions of cylinder head:

1. Forms a part of the combustion space- Cylinder head covers the top part of liner thus providing a space for combustion to take place. The shape of the cylinder head will greatly influence the combustion space shape, and thus characteristics and peak pressures developed in the engine. The efficiency of swirl and injection also depends on the Shape of this space. the three main Combustion chamber designs are Hemispherical pent roof, Bath tub and Wedge.
2. Cylinder head mountings- It houses various running parts like Exhaust/inlet valves, Fuel injectors, Relief valve, Air starting valve, Rocker arm, indicator cock, cooling water and fuel connections etc.

How to test emergency generator??
how would you take it on load??

For emergency standby generators (required by life-safety code), critical loads supported by the generator system typically include emergency lighting, fire alarm systems, fire pumps, and elevators. Life-safety generators are also sometimes used to additionally support optional loads, such as data centers; however, in this case the life-safety loads take precedence over the optional loads.

1. Fuel tank fuel supply levels piping, hoses and connectors; operating fuel pressure; and for any obstructions to tank vents and overflow piping.

2. Oil (check for proper oil level and oil operating pressure; lube oil heater) • Engine oil level can be checked with the unit stopped or running on many engines; otherwise, it should be checked with the unit stopped

3. Cooling system (check coolant level, water pump(s), jacket water heater, belts, hoses, fan)

4. Exhaust system (check drain condensate trap and for possible leakage)

5. Battery system [look for possible corrosion; check specific gravity, electrolyte level (a level between 1250 and 1275 is acceptable) and battery charger]

6. Electrical (conduct a general inspection of wiring and connections; check circuit
breakers/fuses)

7. Prime Mover/Generator (Check for debris, foreign objects, loose or broken fittings; check guards and components; look for any unusual condition of vibration, leakage, noise, temperature or deterioration

NOTE: This is not an all-inclusive list. The equipment manufacturer may have additional maintenance requirements that will likely include monthly, quarterly, semi-annual and annual inspections and checks.

Monthly testing

1. Emergency generators can be exercised monthly with the available load and exercised annually with supplemental loads at 25 percent of nameplate rating for 30 minutes, followed by 50 percent of nameplate rating for 30 minutes, followed by 75 percent of nameplate rating for 60 minutes, for a total of 2 continuous hours.

2. Load tests must include complete cold starts

Test and Overhaul of Fuel Injection Valves of marine engines-
Why diesel oil testing is usually done first??

This article discusses the testing and the overhaul of fuel injectors of marine engines, the testing of the needle and guide condition of the fuel valve, and the procedure to overhaul and inspect the injectors taken out of the marine diesel engines.

Fuel Valve Checks

The fuel valves taken out from the engine must be checked for function and performance. Even in engines which are stopped on heavy fuel oil in ports the fuel injector taken out must be immediately tested with diesel oil before they get cold as this will flush and clean the components. It must be noted that if the fuel valves taken out are tested after they have cooled, will show bad performance even if they were performing satisfactorily in service.

In the majority of cases the fuel injectors have a good spray profile but they open up at a less pressure. The pressure adjustment can be done without opening up the valve and should be done so. The engine manufacturers also instruct that unless the fuel injector valve has a major problem like holes choked or valve dripping, they should not be opened up. The valve should be cleaned from the outside, pressure checked, pressure adjusted and tagged.
Inspection and Repairs
In the case where the fuel injector valve is not performing as required and has some defect, then it needs to be opened up and overhauled. The assembly and the disassembly have to be done as per the instructions given by the engine manufacturer. However, below is a general guide about what you will most likely have to do.

After the fuel valve has been disassembled then the following checks have to be done:

1. The needle guide should be immersed in clean diesel oil and the needle taken out and checked for free movement. In the case of any resistance which may be due to the presence of carbon or fuel sludge the needle may be put in and pulled out in succession many times while keeping it submerged in diesel oil. It is important to do this in a container full of clean diesel oil so the contaminants can be flushed away.

2. After the needle guide has been cleaned, the needle should be taken almost out and then let it fall in with its own weight. A free and smooth movement with small jerks as the clearance is making way for the oil to come out is an indication that the clearances are all right and the needle guide is in good condition. It must be noted that the needle should fall fully into the seat.

3. On the other hand if the needle falls fully in one go, then the clearances have increased and the fuel will leak past the spindle and less fuel will go in the cylinder. The needle must be inspected for any wear marks if this happens. The needle guide can be used but must be changed soon.

4. If the needle does not go down and gets struck then it must be thoroughly cleaned again. If still there is no improvement then the needle might have become bent. Check the needle for any signs of overheating.

5. The push rod end should be checked for any abnormal wear.

6. The seating between the nozzle body and the valve body if damaged can be repaired by lapping with fine lapping paste. It must be noted that the lapping paste should be thoroughly flushed away with clean diesel oil and thereafter blown dry with compressed air.

7. Check the nozzle spring for breakage, poor seating and other defects. Change if required.

8. Check the leak off pipes, shims, packing etc for the condition. If the fuel valve is water cooled, the cooling pockets should be cleaned with compressed air.

• Tests and Adjustments
1. After the parts are cleaned and inspected the fuel valve is assembled as per the manufacturer’s instructions and thereafter tested for function and performance.

2. The assembled fuel valve is installed on the test stand and after purging the pipe line the manual handle is operated in quick succession. The nozzle should start discharging with a sharp crackling noise at the set pressure. The pressure at which the injector is supposed to fire depends upon the manufacturer’s engine design but normally is between 250 to 350 kg/cm² with an allowance of plus or minus 10 kg/cm².
3. In case the lifting pressure is not correct, it can be adjusted by the adjusting screw.

4. The spray characteristics should be satisfactory and as per the manufacturers advice.

5. All the holes of the injector should be firing and can be checked by a torch light or a filter paper can be folded as a cone and then the injector tested. The holes on the filter paper will show the number of holes firing. In this procedure you must be careful as the high pressure spray can enter the skin and is toxic for us.

6. The spray angle should be as stated by the manufacturer. The atomization of the fuel should take place and solid spray should not come out.

7. Clean diesel oil should be used for the testing purpose.

8. In the case that the fuel valve is dripping the needle guide should be taken out and repaired.

- **Caution**

The needle and the guide is always a pair and should not be interchanged with another one. Cleanliness is the most important factor in making fuel valves. A clean fuel valve lasts a longer time. The fuel under pressure can enter the skin and the blood stream and is toxic for humans. Take care that you stay away from the spray. The fine mist can catch fire and is inflammable. Do not smoke or use naked lights where the fuel injectors are being tested.

**Working of Electro magnetic brakes - Fail safe arrangement for Engine room cranes.**

![Image of brake system](image)

Basiclly, a lever which is connected to the arm which carries the brake shoes are pulled in when the circuit is deenergized, it releases only when the circuit is energized and the drum will become free to move. Explained operation is given below. This is a fail safe arrangement as a power failure wil ensure the brakes tightened on to the drum, The Shoes are of cast iron and other components are of fabricated steel. The lever is hinged on the main arm, which is connected to the side arm through a tie rod, and is stressed by a pre-loaded compression spring. The compression of the spring can be adjusted to set the braking torque to desired value. The brake liner of selected quality material is riveted to the shoes by aluminum rivets. A.C. solenoid with laminated magnetic sheet steel houses a copper magnetizing coil which is impregnated with
Class F materials. The plunger which is connected to the lever, is drawn in to the coil, when it is energized with AC source. This loads the spring and releases the brake shoes from the brake drum. When the supply is cut off, the plunger is pulled out of the coil, and spring force clamps the brake shoes on the brake drum and the brake is applied.

Usually this kind of brakes are used in E/R cranes, motors and other heavy rotating machineries which needed to be stopped instantly, and needs to hold load.

**Under voltage and over current trips**

The Under Voltage trip stops you putting a generator that is not generating full voltage onto the board.

Checking of the trips:

I would always check the makers Instruction Manual for the specific breaker before trying to do anything.

As this is a procedure that is usually carried out for the Classification Society Special Survey of Electrical Equipment, and will usually be carried out by a specialist electrical contractor, often the licensed service agent for the Breaker Manufacturer. It would usually be carried out as part of the 5 yearly Special Survey during a drydock when the vessel would be on shore power.

No testing would normally be carried out with the Alternator running yet alone on load. The Breaker would have to be electrically isolated from the Generators and the Main Bus Bars to test it. So it would usually be "Racked out" of the Board.

Old Breakers have simple electro mechanical trips for overload and undervoltage, and can only be tested by current injection. This involves connected the low voltage, high current windings of a transformer across the breaker, the output current, delivered at only a few Volts, is adjusted until the breaker trips.

More Modern breakers have sophisticated Electronic devices to trip the breaker in addition to the electro mechanical system and sometimes these can be tested by adjusting the set points for undervoltage and over current to the actual operating conditions and thus causing the breaker to trip. However, these devices are often not accepted by Class or Statutory Surveyors who require the Electro Mechanical system to be working. Testing the trips by changing the set points is only acceptable if you can prove that the calibration of the sensors is correct at the normal trip point.
NPSHA Explained

NPSHA

The dreaded term NPSHA means Net Positive Suction Head Available. It’s a term that most people find difficult to relate to in part because they have no idea what value it should have. Before we discuss values and the exact definition of NPSHA, let’s get an intuitive understanding of NPSHA. NPSHA is a measure that corresponds to the level of pressure at the pump suction. The higher the pressure, the higher the NPSHA and the better the pump will operate. Normally we measure pressure with a gauge that is calibrated in psig (pound per square inch gauge) or kPa in the metric system. This pressure scale is set at zero when there is no pressure or the pressure is equal to atmospheric pressure. The atmospheric pressure at sea level as measured on an absolute scale such as psia (pounds per square inch absolute) is 14.7 psia. In the absolute scale, pressure starts at zero which is the lowest possible pressure and means that there is no molecules of matter in the environment that can create pressure such as in outer space. It then can have any value corresponding to a high pressure environment.

The term head in NPSHA has been well explained in the pump tutorial, the head component that we are most interested in here is the static head or the level of fluid above the pump suction. Head is measured in feet in North America and in meters just about everywhere else. The value of NPSHA will vary between the lowest value of 0 feet, up to the value of the local atmospheric pressure head 34 feet plus the suction static head minus a small quantity which we will get to shortly. 34 feet is the value of atmospheric pressure at sea level expressed in terms of pressure head. If your tank has 10 feet of suction head, the NPSHA may be 34 + 10 = 44 feet which is ample. One should start to worry when the value of NPSHA falls below 20 feet.

How can the value of NPSHA drop below 34 feet? This is possible if there is allot of friction or plugging which increases friction in the suction line. Sometimes these two occur together, when the level is low in the suction tank due to physical constraints or poor level control or other reasons, this decreases the overall NPSHA and a further decrease occurs due to friction.

How will you know if the NPSHA is adequate? The manufacturer tests the pump under various suction head conditions and provides a requirement or NPSHR for each flow condition on the characteristic curve of the pump. It is then a matter of checking this value against the NPSH available and making sure that the NPSHA is higher.

Why do you have to worry about atmospheric pressure, after all atmospheric pressure is everywhere, how could the operation of the pump be influenced by its value? Because atmospheric pressure depends on the elevation, the pressure varies significantly depending on the elevation above sea level. Atmospheric pressure gets added to the pressure provided by the static head and if you are at a
high elevation atmospheric pressure will be less and therefore the suction pressure will be less.

OK, so let's say that the suction tank is pressurized with a nitrogen blanket on top of the liquid surface at 100 psig for example, do you still have to account for the atmospheric pressure?

Yes, you do. When you pressurize the tank you start pressurizing from some level, that level is the local atmospheric pressure. If your local atmospheric pressure is 10 psia and you add 100 psia of nitrogen pressure than your total on top of the liquid is

110 psia.

Figure 1

To measure suction pressure two units are typically used, the psia or pounds per square inch absolute or the inch of mercury. Pressure gauges can be purchased that have scales with either one of these two units in North America.

The following figure shows how these two scales can be used.
Most pumps can operate with a suction pressure that is below atmospheric pressure. A pressure that is below atmospheric pressure is referred to as a vacuum. That is why a value of 20 feet for NPSHA can be quite acceptable. This is also how it is possible for a normal centrifugal pump to lift fluid from an elevation that is below the suction. For more information on low pressure at the pump suction see the pump tutorial.
A pump that operates in this fashion will require a foot valve to keep the liquid in the suction pipe to avoid having to re-prime the pump when it is stopped.

We can calculate or we can measure NPSHA, let’s start with measuring NPSHA. The main measurement we need is the pressure close to the pump suction. But first a digression on what the pressure measurement we take will mean. What happens to the flow and pressure within the pump past the point of measurement.

The next figure shows that the pressure drops considerably as the fluid enters the eye of the pump. This happens for two main reasons: the velocity as the fluid approaches the eye increases which decreases pressure also friction and turbulence further decreases pressure. The pressure can be low enough that the liquid will start to boil at this low pressure. **What do you mean the liquid will boil at low pressure?**
Figure 4

There are two ways to boil a liquid. One way is to increase the temperature while keeping the pressure constant until the temperature is high enough to produce vapor bubbles. In the next figure this is what happens if you take one point in the liquid phase and you move horizontally (that is at constant pressure) by increasing the temperature. Eventually you hit the vaporization line of the particular fluid and the fluid starts to boil or produce vapor bubbles. We do the same thing every day when we boil water in a pot.

The other way to boil a liquid is to lower the pressure. If you keep the temperature constant and lower the pressure the liquid will also boil. In the next figure this is what happens if you take one point in the liquid phase and you move vertically (that is at constant temperature) by decreasing the pressure. Again you hit the vaporization line of the particular fluid and the fluid starts to boil or produce vapor bubbles.
Figure 5

If the pot were covered and you had a source of vacuum (see next figure) by lowering the pressure in the pot you would be able to make the water boil at a lower temperature. When the pressure is 7.5 psia or \((14.7 - 7.5 = 7.2)\) or 7.2 psi less than the atmospheric pressure the water will boil at a temperature of 180 °F and when the pressure is 1.5 psia the water will boil at 120 °F. This is what happens at the pump suction when the pressure is low enough to make the fluid boil or vaporize.

Check out this video ![image](https://via.placeholder.com/150) of how you can boil water at room temperature using low pressure.

It is not unusual for industrial processes to operate at temperatures that are close or higher than 120 F. Therefore if the temperature is high and the pressure drops as the fluid enters the pump, it will be easier to produce cavitation because the pressure drop produced by the pump will have to be smaller to match a higher vapor pressure. If cavitation is occurring or suspected, there are two possible solutions: to increase the pressure at the pump inlet or decrease the fluid temperature.
Figure 6

The pressure at which the liquid vaporizes is known as the vapor pressure and is always specified for a given temperature. If the temperature changes, the vapor pressure changes.

See the pump glossary for vapor pressure values of different liquids.

Why is vapor pressure an issue? If the pressure in the pump eye drops below the vapor pressure, cavitation will occur. Cavitation begins as the formation of vapor bubbles at the impeller eye due to low pressure. The bubbles form at the position of lowest pressure at the pump inlet (see Figure 4), which is just prior to the fluid being acted upon by the impeller vanes, they are then rapidly compressed. The compression of the vapor bubbles produces a small shock wave that impacts the impeller surface and pits away at the metal creating over time large eroded areas and subsequent failure.

The sound of cavitation is very characteristic and resembles the sound of gravel in a concrete mixer. You can hear characteristic noise of cavitation. Go to this link to see a photo of an impeller damaged by cavitation.

The formula for NPSHA based on a pressure measurement at the pump suction is:

\[
NPSH_{avail} \ (ft \ fluid \ absol.) = 2.31 \left( \frac{p_{atm} \ (psi)}{SG} + \frac{v^2 \ (ft/ \ s)^2}{2g \ (ft/ \ s^2)} + z_{atm} \ (ft) + 2.31 \left( \frac{p_{av} \ (psi)}{SG} - p_{a} \ (psi) \right) \right)
\]

[1]
$p_{GS}$: pressure in psig at the pump suction (this pressure can be negative)
$z_{GS}$: is the difference between the gauge height and the pump suction, this is necessary to
correct for an erroneous reading due to the gauge height.
$v_S$: the velocity of the liquid at the suction in ft/s
$p_A$: atmospheric pressure in the local environment
$p_{va}$: vapor pressure of the liquid at the operating temperature.
$SG$: specific gravity of the liquid.
If we are designing a system then it is not possible to measure the pump suction pressure and
therefore we have to calculate it.

The pressure head at the pump suction is given by:

$$H_S(\text{ft fluid}) = -H_F - \frac{v^2}{2g} + z$$  \[2\]

where

$H_S$: pressure head corresponding to the pressure measurement $p_{GS}$
$z$: the height between the free surface of the suction tank and the pump suction centerline.
$H_F$: the friction head loss in the suction line.

$H_S$ is related to $p_{GS}$ by the static head relationship seen in the pump tutorial.

$$H_S(\text{ft fluid}) = \frac{2.31}{SG} \times p_{as} (\text{psia})$$ \[3\]

If we replace the value of $p_{GS}$ in equation [3] into equation [1] and considering that there is no
correction for pressure gauge height required the term $z_{GS}$ disappears, we then obtain:

$$NPSH_{\text{avail}}(\text{ft fluid absol.}) = -H_F(\text{ft}) + z(\text{ft}) + 2.31 \frac{(p_a (\text{psia}) - p_{va} (\text{psia}))}{SG}$$ \[4\]
Therefore to calculate NPSHA, we use equation[1] when we have an existing system and we can measure the pressure at the pump suction. And we use equation [4] when we are designing a pump system.

Let’s try an example. The pump system used in the pump tutorial is a good start. We will use equation [4] to calculate the NPSHA. The value of z which is the suction static head is 15 feet. In the pump tutorial we calculated the friction loss in the suction to be 3.1 feet. The velocity head or term vs^2/2g is often quite small, of the order of 1 foot or less and this is no exception so we will therefore neglect it. The atmospheric pressure is 14.7 psia. The vapor pressure for water at 60F is 0.5 psia. Values for vapor pressure of other fluids at various temperatures is available in the pump glossary. The specific gravity of water is 1.0.
The value of NPSHA is

\[ NPSH_{\text{avail}} (\text{ft fluid absol.}) = -3.1 - 15 + 2.31 \left( \frac{(14.7 - 0.5)}{1.0} \right) = 14.7 \]

then: This value is a bit on the low side and I would normally check the pump curves to ensure that I have sufficient NPSHA at the required flow rate. However in this case, we know we are using a jet pump which is specifically designed for this type of application so I wouldn’t worry about it.

**HRC Fuse (High Rupturing Capacity Fuse) and its Types**

This type of fuse contains a fuse wire in it, which carries the short circuit current safely for a given time period. During this period, if fault is removed, then it does not blow off otherwise it will melt and remove the circuit from electrical supply hence, the circuit remains safe.

The common material, which is used to make an HRC fuse is glass, but this is not always the case. Other chemical compounds are also used in HRC fuse manufacturing and construction based on different factors. Its external enclosure is made fully airtight in order to avoid the effect of atmosphere on the fuse materials. The major objection on HRC fuse is low and uncertain breaking capacity of semi-enclosed fuse.

The fuse inside is filled with silica based powder, which helps in quenching the arc produced during fusing. Ceramic will help in isolating the fuse from outside atmosphere.

Application of H.R.C fuses:

- Used for protection of Transformers, Motors and automobile, etc.
- It is also used in motor stators
- Backup protection
Surge limit of a turbocharger

Surging in a turbocharge happens when a reversal of gas flow through the turbocharger compressor happens. When an engine cannot use up all the air delivered by the turbo compressor, the pressure inside the scavange reciever increases rapidly. This air will be blown back through the turbo compressor through the diffuser ring. It can cause imbalance of the rotor shaft and vibrations in the system which is not at all good for the plant.

Turbocharger characteristic curve is a plot between pressure ratio and air flow through the turbo compressor. This curve is defined for each RPM of the turbocharger and shows how the turbocharger will behave under such RPMs. Turbocharger will have different efficiencies under different pressure ratios for same RPM.

As the effciency of the turbocharger increases for the same RPM, the turbocharger reaches more and more near to the surge point. Surge point is a praticular pressure ratio at which a turbocharger will surge under a particular RPM.lets say a T/C starts surging at a pressure ratio of 2.0 for an RPM of 15000. The surge point for 15000 RPM can be said as 2.0 bar under this condition. Above 2.0 pressure ratios, the T/C mass is defintiley going to surge, be it 2.1 or 200 for 15000 RPM.
If u draw a line connecting all the pressure ratios or surge points for all the T/C RPMs possible, u get what u call the SURGE LINE. See the image below for more clarity.

Please comment below for more discussion.

How charge air coolers of marine engines works

Charge air coolers or scavenge air coolers are used to cool down the charge air, usually after supercharger or turbocharger compressor in diesel engines. In marine engines, the charge air temperature after the T/C compressor can rise upto 145-160 deg Celsius.

The increase in temperature of air is not at all a good thing for the efficiency of the plant, as efficiency increases proportionally with charge air density. Thus, this air needs to be cooled to the lowest possible temperatures, to increase the density of the air, and thus the efficiency of the plant.

The volume of air handled is so huge that the LT system of the ship (central fresh water system) cannot handle the heat transfer. A LT system which can cool the charge air supplied to ME needs huge plate coolers, which are not worth it. So, a conventional tube type cooler with sea water as cooling medium is used for this purpose. And please note that the lowest charge air temp here possible is also sea water temperature, which is always less than the LT temperatures.
Direct cooling using sea water onboard ships is used only in Main Charge Air coolers for Scavenging due to this.

Sea water is very corrosive and is not usually used for cooling other engine parts directly.

**Boiler water treatment- What ph level to maintain??**

Boiler water should be always alkaline, as acidic medium accelerates corrosion. Only in a alkaline environment, steel will stay as steel in contact with water. Steel and water in touch is like petrol and matchbox together. Always they have huge affinity to each other. Acidic environment just lights the fire and ur boiler inside will start rusting, giving dark brown water when u take samples for tests.

Boiler water should be treated to a ph level of 9.5-11.5 as UNITOR, a big player in boiler treatment chemical market, recommends.

Alkalinity is normally maintained by adding sodium hydroxide, branded by different chemical companies in different names. UNITOR brands it as autotreat, VECOM brands it as BOILER TREAT, and so on...

Sodium hydroxide provides a highly alkaline environment in the boiler. This is about the only environment where water and steel get along well. Heat magnifies the normally corrosive effect water has on steel, since it speeds up chemical reactions. Maintaining the correct alkalinity range minimizes this highly corrosive effect of water. Alkalinity also plays a critical part in various chemical reactions in the boiler. Frequently, most of boiler water alkalinity comes from the addition of sodium hydroxide in the chemical program. Some of the alkalinity comes from naturally occurring alkalinity found in raw water supplies. If it is present naturally, it contributes to the required alkalinity in the boiler and decreases the amount of sodium hydroxide needed.
Jerk type fuel pumps having injection timings retarded—Why?

Fuel pumps plungers are machined to very fine tolerances, as is the matched barrel in which it reciprocates. This means that a plunger from one fuel pump cannot be used into another barell from a different fuel pump, of same make and model.

Wear due to erosion (due to high pressure fuel as it spills) takes place on the top edge of the plunger and the edge of the helices and spill ports. This, together with the wear in the plunger and barrel, will lead to the injection timing becoming retarded, for which adjustment may have to be made.

Labyrinth seal fitted on the back surface of a compressor wheel of a turbocharger:

A labyrinth arrangement is fitted to the back of the compressor impeller to restrict the leakage of air to the gas side. It also prevents the oil being drawn into the compressor. Labyrinth seals use high rotational speed of the shaft to its advantage.

Labyrinth seals or glands are fitted to the shaft and casing to prevent the leakage of exhaust gas into the turbine end bearing, or to prevent oil being drawn into the compressor. To assist in the sealing effect, air from the compressor volute casing is led into a space within the gland. A vent to atmosphere at the end of the labyrinth
gives a guide to the efficiency of the turbine end gland. Discoloring of the oil on a rotor fitted with a roller bearing will also indicate a failure in the turbine end gland.

**How centrifugal compressors handle air, where centriful pumps do not**

Centrifugal pumps and compressors operates on the same principle of converting kinetic energy of the rotating impeller to pressure energy of the fluid it handles. The fluid particles are thrown out from the tip of the impeller with huge kinetic energies, which is coverted to pressure energy by the special volute design of the casing. Both cent. pumps and compressors operates on same principle but have a different clearence levels, and impeller dimensions.

The performance of a centrifugal pump will be largely dependend upon the wear ring clearence. Wear ring clearence is the clearence between the impeller and the casing at the inlet side of the pump. If this clearence is high, the fluid inside the casing will be pumped back to the suction eye, reducing pump efficency. For a normal centrifugal pump handling liquids, this clearance is relatively higher. For a centrifugal compressor, the wear ring clearence will be extremely small. This will allow handling of fluids of very low densities i.e, air.

A large impeller can create very high angular velocities at the impeller tips, which traslates into high pressure energy of the fluid handled. The Auxilliary blowers for main engines and T/C blowers are centrifugal with large imepeller diamters because of this reason. Large rotational speeds also increases the rate of energy transfer to the fluid handled, which also results in handling of light fluids.

**Why nimonic coating is provided on valve stem of exhaust valves of marine engines??**

The purpose of Nimonic coating in exhaust valve of modern marine engines is to prevent hot corrosion of the valve stems, increase valve life and to minimize the effect of valve burning.

Modern marine engines, operaing on HFO with a bore greater than 300mm, the one propelling my current vessel is MAN B&W 6G50ME, operates with a relatively high exhaust tempertaures of 350-400 deg celsius. Under this temperature the uncoated valve stems may give up ther strength, leading to overall reduction in valve life. Also under high temperatures the valves stems are subjected to hot corrosion. Nimonic have a very high temperature stability and resists hot corrosion.
Full nemonic coated valves are also available from engine manufacturers, which will increase overall lifetime of the valve, but increase the cost marginally.

Valve seats are usually treated with a harder alloy compound, stellite.

MAN B&W are now introducing DURA SPINDLE valves with W seats to still increase the overall life, with a promised run time of 20000 hours.

**Purpose of an economiser on board a ship**

An economiser, as the name suggests increases the overall economy of the main propulsion plant. The heat from burning fuel in main engine is mostly used to move the piston and thereby create the main propulsion onboard. Some of this heat energy cannot be used in the process, as the process is never isothermal. This heat energy is used to produce steam onboard, using economisers.

The process is simple. The unused heat from the main engine exhaust is transferred to water in the economiser, which produces the necessary steam for the propulsion plant. When economiser is absent, this heat energy need to be provided by burning extra fuel in boilers, which costs $$$$. So economiser in the end, increases the overall heat efficiency or the ECONOMY of the propulsion plant.
**Why a diffuser is given in the atomizer of a pressure jet boiler**

A diffuser is a Round plate with a circular hole in the middle, and a number of radial grooves, which is placed in front of a jet atomizer of a boiler.

The function of diffuser or as normally called, swirler plate is to mix the air and fuel properly. There are radial cuts in the diffuser plate which will create a vortex flow of the air. Atomizer is directed into the middle hole of the diffuser. When the Combustion fan directs air into the diffuser, it creates a vortex flow. The atomizer nozzle directs the fuel into this vortex, which gets evenly mixed with the air. The flame stability is greatly related to the cleanliness of the diffuser plate.

When the diffuser plate becomes dirty, mostly due to carbon and fuel particles sticking to it, the radial cuts in the plate are blocked. In this condition, the air supply to the boiler burner becomes low, and Boiler starts tripping at high loads. The air-fuel ratio cannot be maintained under a dirty diffuser condition. This further creates more carbon accumulation which may eventually fully block the diffuser swirler action, and failing the boiler even at low loads. This is a major reason why a boiler fires reasonably good under low load and trips under high loads, mainly above 70%. This is my personal experience onboard my vessel, where my boiler was tripping at 70%+ loads. Inspection of diffuser revealed considerable carbon accumulation. Once cleared boiler was firing normally under all loads.

To prevent the blockage of diffuser plate, always keep good fuel-air ratios.

A small carbon accumulation can accelerate the spoiling of the plate.

Keep ur diffuser plates clean and have a happy boiler my sailor friends:) happy sailing.
How to Blow down a boiler

Boiler blow down is one of most important routine jobs done on a main or aux boiler onboard a ship. I have a AALBORG MISSION OC- 2000 Kg/hr steam composite boiler and ALBORG MISSION OC- 20000 Kg/hr aux boiler onboard the vessel i am currently onboard. The boilers are being blown down regularly, when the water tests show an increased chlorine level, when conductivity increases, or when the boiler water colour changes to reddish brown.

Blow down is needed to remove the sediments which get accumulated in the water ring on the boiler or when chlorine levels increase due to bad quality feed water (when fresh water generator salinty is high).

PROCESURE TO BLOW DOWN:

1. Keep boiler firing (this way you will have a better circulation of water inside the boiler)
2. Normally 2 valves are given on boiler side and 2 valves on the sea side for blowdown purpose. The idea behind giving two valves for blowdown in each of the places is that, The valves attached to the ships hull and the boiler body are very difficult to overhaul, when ship is sailing or in port. These valves can be overhauled when ship is in dock only(by adjusting list or blowing down entire boiler you can do this, but you know how hard it is :P). So normally dont play around with these valves and dont keep them throttled(throttling a steam valve or a high pressure line valve causes wire drawing effect which destroys valve seats and it starts leaking). Now, you need to control flow rate for blowing down, and how do u achieve that?? Throttle the valve which is not attached to the boiler body or the ships hull!! This is why 2 valves are given.
3. Open the valve attached to the ships hull and the boiler body fully first.
4. Open the sea side valve.
5. Throttle the flow rate using the second valve given after the valve attached to boiler body.
6. When water level reaches the normal level on gauge glass, close the throttled valve first(see which valve is throttled from point no.5)
7. Close other valves.
8. Finish the blowdown.

This is my practise.. if u guys have any new ideas or suggestion please dont forget to leave them in comments. Happy sailing :)}