

---

# Mike's Guide

---

**A study guide for  
Transport Canada  
3rd Class Marine Engineer  
Written Examination**

**Engineering Knowledge  
General (EK General) Exam**

**January 2014**

---

**Martin's Marine Engineering Page**  
[www.dieselduck.net](http://www.dieselduck.net)

---

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

### Fourteen Topics:

1. Communications
2. Manufacturing Processes
3. Boilers
4. Steering Gear
5. Pumps
6. Firefighting
7. Safe Working Practices
8. Electrical Equipment
9. Propeller Shaft System
10. Rudder
11. Hydraulic Systems
12. Refrigeration
13. Ship Construction
14. Deck Machinery

### Communications (Marine Engineering Principles)

Ability to transmit information relating to machinery components by means of simple drawings by means of simple drawings with supplementary notes and specifications

### Valves:

1. Describe a wedge type gate valve. What might occur if such a valve were screwed down too tightly? Where would you find this type of valve in an engine room? (2008 Exam, Pacific Region Sample)
  - Taylor, p. 127
  - A gate valve, also known as a sluice valve, is a valve that opens by lifting a round or rectangular gate/wedge out of the path of the fluid.
  - When open, there is full unrestricted flow since gate is raised clear of passage. This results in very little friction loss.
  - Should be fully open or closed, not suitable for control of flow.
  - Gate may be parallel or wedge shaped in section fitting against a matched seat.
  - Larger valves may have replaceable seat rings and gate facings.
  - On opening the gate valve, the flow path is enlarged in a highly nonlinear manner with respect to percent of opening. This means that flow rate does not change evenly with stem travel.
  - Also, a partially open gate disk tends to vibrate from the fluid flow. Most of the flow change occurs near shutoff with a relatively high fluid velocity causing disk and seat wear and eventual leakage if used to regulate flow.
  - Spindle is threaded over lower portion and when turned causes the gate to raise or lower. Gate valves are characterized as having either a rising or a non-rising stem.
  - Rising stems provide a visual indication of valve position because the stem is attached to the gate such that the gate and stem rise and lower together as the valve is operated.
  - Non-rising stem valves may have a pointer threaded onto the upper end of the stem to indicate valve position, since the gate travels up or down the stem on the threads without raising or lowering the stem. Non-rising stems are used underground or where vertical space is limited.
  - Bonnets provide leak proof closure for the valve body. Gate valves may have a screw-in, union, or bolted bonnet. Screw-in bonnet is the simplest, offering a durable, pressure-tight seal. Union bonnet is suitable for applications requiring frequent inspection and cleaning. It also gives the body added strength. Bolted bonnet is used for larger valves and higher pressure applications.
  - Gate valves may have flanged ends that are drilled according to pipeline compatible flange dimensional standards.
  - Gate valves are typically constructed from cast iron, ductile iron, cast carbon steel, gun metal, stainless steel, alloy steels, and forged steels.
  - If such a valve was screwed down too tightly, it may become jammed into the seat, possibly causing damage to the sealing properties. It may become deformed. Also it may be very hard to open when required, requiring the use of extra torque such as a wrench.
  - In an engine room, you would find this valve on systems that require full flow or full isolation such as seawater cooling or fuel transfer piping.
2. Sketch and describe a screw down globe valve. (2009 Exam)

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Taylor, p. 125
  - Has somewhat spherical body enclosing valve seat and disc.
  - Flanges provided at each end for connecting to adjacent piping.
  - Internal passages guide the flow through the valve seat.
  - Liquid always designed to come from below so that the upper chamber is not pressurized when valve is closed.
  - Spindle is joined to valve disc for screw lift arrangement. If disc is not attached, the valve is a screw down non-return (SDNR) valve, which will seal off to prevent back flow. Commonly used on overboard and bilge system valves to prevent back flooding. SDNR valve discs must have wings or guides to allow them to be properly aligned when closing.
  - Bonnet is connected to a packing gland to seal around spindle where it leaves body.
  - Upper part of spindle is threaded and passes through a threaded bridge piece.
  - A circular hand wheel is used to turn the spindle, which will open or close the valve depending on direction.
  - Valve disc and seat are machined to be a perfect match and may be flat but are more commonly mitered at an angle.
  - Material for both normally has a very hard stellite coating.
  - Can be fitted where input and output flanges are 90 degrees offset.
3. Describe the construction and action of a reducing valve. State where this valve is used and how it is adjusted. (Diesel Duck)
- Reed's GEK p. 127-128, McGeorge MAM p. 126-129
  - Often used to reduce steam or compressed air pressure.
  - As steam passes through, now work is done since reduction process is throttling. Total heat before is nearly same as after. Temp will be maintained.
  - Materials depend on operating conditions:
    - Body of cast steel or iron.
    - Valve, seat and spindle of steel or bronze.
  - Pressure gauge fitted to outlet side to monitor effectiveness.
  - Relief valve fitted in case valve failure.
  - Downward force = Upward force
  - $P_1$  = higher inlet pressure. Acts in upward direction on main valve (A1) and downward direction on the controlling flexible diaphragm (same area as A1) and the piston beneath it.
  - These two parts are in state of balance.
  - Large spring pushes against spindle tending to open the valve against reduced stem pressure ( $P_2$ ) acting on the area A2 at top of valve.
  - Any decrease in pressure on outlet side ( $P_2$ ) will allow valve to be pushed open by spring.
  - Any increase in pressure ( $P_2$ ) will close it.
    - $P_1 \times A_1 = (P_1 - P_2) \times A_2 + F$
    - $P_1$ ,  $A_1$  and  $A_2$  are constant.
    - $P_2$  will vary with spring pressure  $F$
4. Sketch and describe a quick closing valve as fitted in a fuel line. Why is it fitted? State clearly how it is operated. (CCGC Sample)
- Taylor p. 128, McGeorge MAM, p 129
  - Fuel / oil tank lines have to be fitted with quick closing valves in event of fire.
  - Must be able to be operated remotely.
  - Collapsing of bridge results in the valve closing very quickly under combined effects of gravity and spring pressure.
  - A manually operated wire or hydraulic cylinder can be used to collapse bridge.
  - Should be inspected and exercised regularly to ensure they will work properly in emergency.

### Filtration and Separation:

5. Describe three fluid filters aboard. (2006 Exam)
- Boiler fuel strainer, Reeds Deck p. 108
    - Can be fitted on suction side of pump and after heaters
    - Strainers used to extract particles of grit and dirt that could choke burner nozzles
    - Installed in duplicate with change over valves so that one can be cleaned with the other still in use
    - Pressure gauges on either side of strainer will show indication of dirtiness due to differential
    - Housing contains perforated steel cylinder covered by steel gauze through which fuel is passed. The gauze catches impurities.
6. Sketch and describe a self-cleaning oil filter. Explain the function of magnetic filters. State why centrifugal, magnetic and static filters complement each other in a lube oil system. (Pacific Region Sample, CCGC Sample)
- I will assume self cleaning can be described by looking at the Auto-Klean type:
    - Reed's GEK p. 406, McGeorge MAM p. 136
    - Type of knife-edge filter.
    - Can be cleaned while in operation

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Particles down to 25 microns
  - Dirty oil passes through series of thin metal discs mounted on a square central spindle.
  - Between discs are thin metal star shaped spacing washers of slightly smaller overall diameter than the discs.
  - Cleaning blades fitted to the spindle and same thickness as washers are between each pair of discs.
  - As oil passes through discs, solid matter of size larger than the space remains on periphery.
  - Filter is cleaned by rotating spindle, which rotates the disc stack and the stationary cleaning blades scrape off the filtered solids, which settle at the bottom of the casing.
  - Periodically the flow through the filter is stopped to drain off particles. They are normally fitted in duplex to allow this.
  - Pressure gauges fitted on either side of filter to monitor pressure differential.
  - Some are fitted with electric motors to turn spindle automatically.
- Magnetic filters:
  - McGeorge MAM p. 137-138,
  - Offer extra protection for engines and gearboxes where ferrous wear particles are likely to be present.
    - Use permanent magnets to attract ferrous particles and prevent them from damaging machinery.
    - Must be periodically cleaned to ensure it does not get clogged with material.
  - Centrifugal, magnetic and static filters complement each other in a lube oil system because they each filter out a different impurity very well – centrifugal gets out water, magnetic gets out ferrous wear particles and static gets out dirt/solids.
7. Sketch and describe an automatic oily water separator. State the routine attention required for satisfactory performance. State how maximum through put is restricted and why this is important. (Pacific Region Sample, CCGC Sample, Camosun College Sample)
- Reed's Deck p. 114-115, McGeorge MAM p. 81-87
  - Oily water separators work on the principle that oil is less dense than water and can be separated because of this gravity differential.
  - Angle surfaces provide areas on which oil can accumulate and form globules, which then float upwards.
  - An oily water separator that can reduce the effluent to 2 ppm oil uses concentric cylindrical oil coalescing cartridges through which the oily water mixture is drawn by a positive displacement pump.
  - The coalesced oil rises to the top of the separator where its accumulation is detected by an oil-water interface probe.
  - When in the normal mode, a controller is constantly monitoring the oil-water interface level and the overboard discharge.
  - In the event of the effluent reaching set limit (5 ppm for Great Lakes), the process is stopped and the alarm given.
  - When the oil-water interface reaches its lower level the controller changes the operation to one of cleaning by back-flushing and oil discharge.
  - The oil-water interface will then rise to the higher level and the separator will be switched back to normal mode.
  - Maintenance includes cleaning the inside of the unit and changing the coalescing filter cartridges when they become clogged or inefficient.
  - By using an oily water separator in suction mode rather than delivery mode, the oil will not be emulsified, thereby making separation easier.
8. What is the purpose of an oily water separator? What precautions would you take when emptying ballast tanks containing some oil or oil tanks containing some water? Why is discharging oil overboard not a good idea?
- Reed's Deck p. 113-116
  - Purpose of an OWS is to separate oil/water mixtures in order to discharge clean water overboard and to deliver oil to compartment that it can be incinerated or sent ashore. This allows cleaner bilges with lower, safer levels.
  - Any time that you are emptying any oil that has any oil content, it must be run through the oily water separator before going overboard.
  - IMO regulations require max 15 ppm in ocean waters, 5 ppm in lakes and coastal waters and 0 ppm oil in Arctic waters. The ship must be underway and not in a harbor.
  - Pollution causes permanent damage to the environment and also can lead to penalties for committing the crime such as fines or loss of engineering certification due to international regulation.
  - Oil emulsions interfere with photosynthesis and the workings of algae and plankton essential to fish life. Also pollute beaches and drinking water sources.
9. With reference to centrifugal separators: (CCGC Sample)
- a. Differentiate purification and clarification
  - b. Explain how both are achieved
  - c. Describe with sketches a self cleaning arrangement

### Systems:

10. List all of the auxiliary systems and machinery in an engine room. (2008 Exam, Camosun College Sample, Pacific Region Sample)
- Ship service generators – provide electrical power to vessel machinery and accommodation.
  - Compressed air system – starting engines, control systems, tools.
  - Fuel system – provide petroleum fuel to engines/boilers.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Ballast system – pump seawater to correct vessel trim/list depending on cargo loading.
  - Bilge system – to empty water out of ship's dry compartments in emergency.
  - Fire main system – to provide seawater to extinguish fires.
  - Domestic water system – to provide hot and cold fresh water to vessel accommodation.
  - Sanitary water system – to provide seawater for sewage purposes.
  - Sewage system – to process and discharge human waste.
11. Using a line diagram, describe a fuel oil storage and handling system. System is to include storage tank, settling tank, day tank and all associated piping, fittings and auxiliaries.

### Instrumentation:

12. Describe the operation and principle of construction of an aneroid barometer. In what units is the instrument graduated? What useful purpose does it serve? What is the normal atmospheric pressure reading at sea level? (TCMS Sample, Pacific Region Sample, Limnos Sample, Limnos Sample)
- Taylor p. 281
  - Uses evacuated corrugated cylinder to detect changes in pressure.
  - Cylinder centre tends to collapse as atmospheric pressure increases.
  - Tends to rise as pressure decreases.
  - A series of linkages transfers movement to a pointer and scale to give reading.
  - Uses to measure slight changes in atmospheric pressure. Atmospheric pressure value is required to find absolute pressure.
  - Atmospheric pressure at sea level is normally 1.02 Bar or 14.7 psi or 30" Hg.
  - An aneroid barometer, invented by the French 19th century engineer and inventor Lucien Vidie, uses a small, flexible metal box called an aneroid cell.
  - This aneroid capsule (cell) is made from an alloy of beryllium and copper.
  - The evacuated capsule (or usually more capsules) is prevented from collapsing by a strong spring.
  - Small changes in external air pressure cause the cell to expand or contract.
  - This expansion and contraction drives mechanical levers such that the tiny movements of the capsule are amplified and displayed on the face of the aneroid barometer.
  - Many models include a manually set needle that is used to mark the current measurement so a change can be seen. In addition, the mechanism is made deliberately "stiff" so that tapping the barometer reveals whether the pressure is rising or falling as the pointer moves
13. Describe a pressure gauge (Bourdon). Where is it fitted and what care and maintenance are required? Give examples of typical pressure readings. How is it protected from steam damage? (Diesel Duck, Pacific Region Sample, Limnos Sample)
- Taylor p. 281, Reeds Deck p. 4, 5
  - Most commonly used type of pressure gauge.
  - Made up of an elliptical section tube formed into a C-shape that is sealed at one end.
  - Tube can be bronze or steel.
  - The sealed in free to move is linked to an arrangement which will move a pointer over a scale.
  - The applied pressure acts within the tube entering the open end, which is fixed in place.
  - Pressure within tube causes it to change in cross section and attempt to straighten out, resulting in movement at the free end.
  - Small movement of sealed end is magnified by linking it to a quadrant meshing with a pinion, which carries a pointer on its shaft.
  - This registers as needle movement on the circular scale.
  - Can be kn/m<sup>2</sup> or Bar or psi, etc.
14. Sketch and describe the construction and operation of: (Diesel Duck, Pacific Region Sample, Limnos Sample)
- a. Barometer
    - Taylor p. 280
    - Mercury barometer is a straight tube type of manometer
    - A glass capillary tube (about 800 mm long) is sealed at one end, filled with mercury and then inverted in a small bath of mercury.
    - Almost vacuum conditions exist above the column of mercury, which is supported by atmospheric pressure acting on the mercury in the container.
    - An absolute reading of atmospheric pressure is thus given.
  - b. Thermometer – at what temp does water boil in C and F. How do you determine is a scale is in C or F?
    - Taylor p. 283
    - Used for temperature measurement readings, normally given in Celsius.
    - Glass tube with bulb at one end filled with either mercury or alcohol depending on range required.
    - An increase in temperature causes the liquid to rise up the narrow glass stem and the reading is taken from a scale on the glass.
    - A high temp mercury thermometer will have the space above the mercury filled with nitrogen under pressure.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Water will boil at 212F and 100C.
15. What is vacuum? Sketch and describe vacuum gauge. (Pacific Region Sample, Limnos Sample)
- Vacuum is defined as negative pressure, which could also be stated as suction.
  - Vacuum is normally measured with a u-tube manometer with one end connected to the atmosphere and one end connected to the source of vacuum (e.g. engine crankcase or steam condenser)
  - Tube is made of glass or plastic.
  - The liquid in the tube is normally dyed water but in the past mercury was used.
  - The vacuum level below atmospheric pressure will be shown using the graduations marked on the u-tube. This distance can then be used to convert to a pressure reading (1" water = .036 psi)
  - The liquid will be higher on the side under vacuum due to suction. The higher the liquid rises, the greater the amount of vacuum.
16. What is the weight of one cubic foot of seawater compared to fresh water? What causes weight difference? What is the average quantity of solids contained in one gallon of seawater? What substances are contained in this solid matter? (Pacific Region Sample)
- Red Book p.246
  - 1025kg to 1000kg
  - More dissolved solids in seawater cause it to be denser, heavier.
  - The average weight of solids in seawater is 3.5% so in a gallon there will be roughly 4.5oz of solids.
  - The different salts contained in seawater are as follows:
    - a. Sodium Chloride: 77.4%
    - b. Magnesium Chloride: 10.5%
    - c. Magnesium Sulphate: 4.5%
    - d. Calcium Sulphate: 3.6%
    - e. Potassium Sulphate: 2.2%
    - f. Calcium Carbonate: .4%
    - g. Siliceous matter: .7%
    - h. Iron and Aluminum Oxide: .7%
17. Sketch and describe any type of pyrometer and explain its working principles. Where are they used in ships? (Pacific Region Sample, Limnos Sample)
- Taylor p. 285, Reed's Deck p. 197
  - A pyrometer is generally considered to be a high temperature measuring thermometer (>500C).
  - Pyro is Greek for fire.
  - They are used for exhaust gas reading and remote readings.
  - In the optical, or disappearing filament, type radiation from the heat source is directed into the unit.
  - The current through a heated filament lamp is adjusted until, when viewed through the telescope, it seems to disappear.
  - The radiation from the lamp and from the heat source is the same at this point.
  - The current through the lamp is a measure of the temperature of the heat source and the ammeter is calibrated in units of temperature.
  - The absorption screen is used to absorb some of the radiant energy from the heat source and thus extend the measuring range of the instrument.
  - The monochromatic filter produces single color, usually red, light to simplify filament radiation matching.
18. Describe a salinometer and explain what it measures. Why may the density of water in the salinometer be higher than the density of water in the boiler or evaporator? (Limnos Sample)
- McGeorge MAM p. 96-98, Taylor p. 295
  - A salinometer measures the salt content in water. This is useful in testing boiler water or product drinking water.
  - An electric salinometer uses a measuring cell to determine concentration of salts. Pure water is considered a non-conductor of electricity, the addition of impurities such as salt increase the conductivity.
  - Conductivity measured in siemens or micro siemens.
  - A unit could use two small cells, each containing a platinum and a gunmetal electrode.
  - The liquid sample passes through the two cells and any current flow as a result of conductance is measured.
  - The insulating plunger varies the water flow in order to correct values to 20C.
  - Since conductivity rises with temperature, a compensating resistor is incorporated in the measuring circuit.
  - A de-gassifier should be fitted upstream of this unit to remove dissolved CO<sub>2</sub> which will cause errors in measurement.
  - A less modern salinometer uses a float in a column of test water. The more salt in the water, the higher the float will sit due to increased buoyancy in denser water.
  - Normally the scale runs from 0 to 4/32.
  - 1/32 = 32000 ppm
19. What instrument measures density of boiler water? What are the unit graduations? (Limnos Sample)

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- A hydrometer is used to measure density of a liquid.
  - It is measured as a ratio to the density of water which can be considered as 1.0 (1000kg/m<sup>3</sup>)
20. How is the air pressure in the combustion system of a boiler measured? Describe a suitable measuring instrument. (Limnos Sample)
- This pressure would be similar to charge air – roughly 15-25 psi so I would describe a Bourdon tube pressure gauge.

### Manufacturing Processes

Knowledge of the methods of manufacture of the various machinery components and the effects of various treatments on the physical properties of the materials commonly used

#### Steel

21. With reference to steel, what is meant by the following terms and describe how these processes are carried out: (Limnos Sample)
- Taylor p. 332
    - a. Annealing – The steel is heated to around 850-900C and is cooled slowly, either in the furnace or in an insulated space. Softer, more ductile steel than normalized steel is produced.
    - b. Tempering – This process follows the quenching of steel and involves reheating to some temperature up to about 680C. The higher the tempering temperature, the lower the tensile properties of the steel. Once tempered, the steel is rapidly cooled by quenching.
    - c. Case hardening – The steel is heated to 850-900C and then is rapidly cooled by quenching in oil or water. The hardest possible condition for the particular steel is thus produced and the tensile strength is increased.
22. Describe briefly the methods for detecting cracks in shafting. How may cracks be repaired in large castings? (Limnos Sample)

#### Fuel/Oil Properties

23. What is calorific value? What is it measured in? How is it found? What is the calorific value of diesel fuel? (2006 Exam)
- Calorific value is defined as the heating value gained from the complete combustion of a unit mass of fuel.
  - It is measured in mega or kilojoules of energy per kilogram of material.
  - The calorific value of diesel is 45MJ/kg.
  - Calorific value is found using a bomb calorimeter under very closely controlled conditions.
  - It consists of a strong cylindrical stainless steel bomb in which combustion of the fuel takes place.
  - The bomb has a lid that is screwed to the body of the bomb to make a perfect gas tight seal. The lid has two stainless steel electrodes and an oxygen inlet valve. To one of the electrodes a small ring is attached on which a stainless steel crucible is supported.
  - The bomb is placed in a copper calorimeter surrounded by air and water jacket (which prevents heat loss due to radiation).
  - An electrically operated stirrer and a Beckmann's thermometer (which measures to a fraction of a degree) is placed in the water jacket to maintain uniform distribution of heat and measure the increase in temperature respectively.
  - A small amount of fuel is fired by electric charge under conditions of pressurized oxygen.
  - The temperature rise of the apparatus and coolant is measured and this change in temperature reflects potency of fuel involved.
  - There exists a Higher CV, which includes heat in water vapor formed when combustion products condense and are reusable. Lower CV does not reflect this.
24. Define and describe how they are obtained and units that they are measured in: (Diesel Duck, Camosun College Sample, Pacific Region Sample)
- a. Viscosity
    - Taylor p. 293-295, McGeorge p. 51-52
    - Viscosity is a fluids resistance to flow. Measured in centistokes.
    - Viscosity control of fuels is essential if correct atomization and combustion is to take place.
    - It is controlled by heat. Heat is added to reduce viscosity.
    - It is measured with a viscosity sensor. A small constant speed gear pump forces a fixed quantity of oil through a capillary tube.
    - The liquid flow in the capillary is such that the difference in pressure readings taken before and after the capillary.
    - This difference relates to a level of viscosity through a differential pressure gauge.
    - Onboard test can also include dropping a metal ball through a tube of sample at 80C and timing this to calculate the kinematic viscosity.
    - Can be a Redwood, Saybolt or Engler flow instrument.
  - b. Specific Gravity
    - McGeorge GEK p. 51, Taylor p. 150
    - Ratio of a substance's density to that of a reference substance (normally water for liquids).
    - Expressed as a ratio (e.g. 1.025) and measured at a fixed temperature.
    - Measured with hydrometer.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Required for bunker calculations and choosing the purifier gravity disc.
- c. Flash Point. What is minimum for aboard ship?
  - Reed's GEK p. 55-57
  - Flash point is the lowest temperature at which oil will give off a flammable vapor.
  - As flashpoint is indicative of fire and explosion risk for storage and transport, it is an important property of the oil.
  - The minimum flash point on diesel vessels is 140F/60C – some places 66C. This is to prevent flammable vapors from forming in the storage tanks under atmospheric conditions.
  - Test determines the temperature at which fuel will give off sufficient vapors to ignite when a flame is applied.
  - Involves using the Pensky Marten Closed Flashpoint test apparatus.
  - The flame element is depressed through a port just above oil surface at a timed sequence as the oil is heated.
  - A blue flame appears just before flashpoint and the temperature is recorded when the vapors flash off.
  - 22C and below – Dangerous – gasoline, benzene
  - 22 – 66C - Medium Risk – kerosene and vaporizing oils
  - 66C and higher – Safe for marine fuel
- d. Closed Flash Point.
  - Reed's GEK p. 55
  - The closed-cup method prevents vapors from escaping and therefore usually results in a flash point that is a few degrees lower than in an open cup.
- e. Fire Point
  - Reed's GEK p. 62
  - Temperature at which the volatile vapors given off from a heated oil sample are ignitable by flame application will burn CONTINUOUSLY.

Also give the flash points and specific gravity for:

- f. Diesel – 85C, .87
- g. Kerosene – 50C, .74
- h. Gasoline – -17C, .72
- i. Bunker C –100C, .95
- j. Lube Oil – 230C, .8

### Boilers

Constructional details and management of auxiliary boilers, including firing arrangements and boiler mountings, boiler water testing and treatment.

Gauge Glasses:

25. Sketch and describe a boiler water gauge glass suitable for a small boiler. (2010 Exam)
  - Reed's Deck p. 34, Flanagan p. 70, Taylor p. 86
  - Must be two methods of ascertaining boiler water level and two sets are often fitted. Often these are at opposite ends of boiler due to motion of ship affecting readings.
  - Must be clearly seen by operator.
  - Water gauge is a glass tube (up to 17 bar) or plates gripped in steam tight glands with water and steam shut off cocks attached to side of boiler allowing operator to see water level inside.
  - Tube type consists of 2 gun metal bodies with a glass inserted between them. The glass is held in place and sealed by gland nuts tightened into soft tapered packing rings.
  - Steam cock is fitted in steam space, water cock is in water space, and gauge positioned so glass is half full at boiler working level.
  - If water level falls too far, there is danger of top rows of tubes being exposed to steam and becoming overheated and become damaged or fail.
  - If water rises too high, there is danger of water being carried out of boiler with steam, (priming), possibly resulting in damage to system from water hammer.
  - For small boilers and on drums of water tube boilers, the gauge is fitted directly on the shell.
  - This simple arrangement has only 3 cocks – steam (normally open), water (normally open) and a drain (normally closed).
  - There is a ball stop valve fitted to water cock that will plug opening in case glass tube breaks. This will stop water from escaping and flashing off due to pressure differential that will cause injury to personnel.
  - Valve handles lie vertically downward when in open position so that vibration or accidentally knocking into them will not cause them to open inadvertently.
26. Describe how and when you would prove a water gauge glass for a small boiler. What would you do if you discovered that there was no water showing the glass? (2010 Exam, Diesel Duck, Camosun College Sample, Pacific Region Sample)



# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Reed's Deck p. 35, Flanagan p. 73
  - Should be blown through at regular intervals, at least once a watch, or whenever the level is unknown.
  - This prevents accumulation of foreign matter which may choke steam or water passages and lead to a false reading.
  - To prove simple glass (without hollow column):
    - a. Close steam and water cocks, open drain. Nothing should blow out if cocks are not leaking.
    - b. Open water cock briefly to check that water passage is clear. Water/steam should blow out of drain.
    - c. Open steam cock briefly to check that steam passage is clear. Steam should blow out of drain.
    - d. Close drain and open water cock. Water should gradually rise up glass.
    - e. Open steam cock and water level should fall to that within boiler.
  - If the glass has a hollow column, it must also be cross blown to prove it is clear.
  - If water fills glass, then boiler is overfilled and it is unsafe to put feed water in. Feed supply should be reduced or stopped to prevent damage from priming.
  - If water does not show in glass, then water is below safe level and it may be unsafe to put feed water into boiler.
  - Reduce boiler load and rate of firing and as long as the water is covering the combustion chamber, increase feed water by using the standby feed pump and auxiliary feed check.
  - If water is not covering combustion chamber then cut boiler out of service completely.
  - Shut off the fuel and if overheating is suspected, operate the easing gear on boiler to release boiler pressure.
  - When the boiler has cooled down it should be examined and only returned to service when inspector is satisfied with condition.
  - A plate guard is fitted around gauge glass to protect personnel in case it breaks while proving it.
27. How would you go about replacing a tubular type gauge glass? (2008 Exam)
- Reed's GEK, p. 104
  - Care must be taken to ensure glass tube is of proper length.
  - Too long and a blockage of the steam connection may occur due to accumulation of deposits around the top of the glass.
  - Too short and it may not be fully inserted into the packing. The packing may work its way over the open end of the tube causing a breakage.
  - Care must be taken to not scratch glass.
  - Always install new gaskets.
  - Tighten nuts again after glass and casing have warmed up.

### Feed Water System:

28. What does density refer to when discussing boiler and feed water? How is it measured? Why is it essential to have low-density boiler water? (2008, 2011 Exam)
- Reed's Deck, p.46, Taylor p. 96
  - It is essential to have low density sea water to:
  - Prevent scale formation that can accumulate on surfaces causing interference with heat exchange and a reduction in flow. This may lead to failure due to overheating.
  - Water and steam pathways could become blocked due to excessive solids in fluids causing sludge deposits.
  - Also high density water may be more acidic or corrosive due to presence of harmful salts, causing damage to steel components.
  - An excess of alkaline salts together with operational stresses can create a condition known as caustic cracking of metal that may lead to serious failure.
  - High density water may also cause foaming which leads to priming (carryover of water in steam leaving boiler) that can damage system components, especially propulsion machinery.
  - High density water has a high level of dissolved solids
  - Factors affecting density of feed water include:
    - a. Contamination with seawater. Can enter feed through a leaking condenser or priming of an evaporator.
    - b. Presence of metal salts in water known as hardness of water. Some are decomposed by heat and can cause scale and are known as temporary hardness. Some are not decomposed and are known as permanent hardness.
  - Density is tested using a sample from a boiler test cock (referred to as salinometer cock). A hydrometer or salinometer is placed in sample and the total dissolved solids level (normally in parts per million) is checked. If high, then there should be an investigation as to source of contamination into system.
29. What can affect the density of boiler water? How can you ensure you have low-density boiler water?
- Chemicals such as lime and soda ash can be added to feed water to deal with temporary hardness salts. This lowers the hardness.
  - The boiler water can also be blown down out of boiler using scum and bottom blow downs and newer, higher purity feed water can replace it.
  - Saltwater ingress should be prevented by fixing leaks immediately.
  - Corroding components should be replaced to reduce metallic solutes due to oxidation.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

30. What is the cause and effect of scaling? How do you prevent it? What are the allowable limits of scale build up? (2008 Exam, Pacific Region Sample)
- Scale in a boiler forms an insulating layer on the water side of the heating surfaces.
  - This insulating layer resists the transfer of heat from the fire and hot combustion gases to the water and thus heats up the metal surfaces.
  - If the layer of scale is sufficiently thick and resists transfer of heat sufficiently, the metal will overheat, become weak and possibly rupture.
  - This could lead to boiler failure and injury or death to personnel nearby.
  - When a steam bubble is formed on a heating surface, all the salts in the bubble will flow to the hottest part, which is the heating surface metal.
  - Since slightly soluble salts become insoluble at high temperatures, scale will be formed at the base of the bubble.
  - When the bubble leaves the heating surface, a ring of scales is left. These rings interlace and scale is formed.
  - Calcium sulphate is usually the most serious of scale forming salts.
  - Scale is prevented by ensuring the boiler has low density feed-water.
  - Saltwater ingress must be kept to an absolute minimum. Leaks must be repaired.
  - Scale is also prevented from forming by adding to the water a soluble chemical such as sodium carbonate which will react with the scale forming calcium sulphate and form a harmless sludge which can bottom blown out of boiler.
  - Scum and bottom blow downs must be regular.
  - Boiler should also be opened up and scale cleaned from surfaces with a cleaning (mildly acidic) solution.
31. Describe corrosion in a boiler. (Pacific Region Sample)
- Red Book, Flanagan p. 111
  - Corrosion on the water side of boilers may occur in the following ways:
  - Chemical/acid attack – Normally occurs in superheaters due to the high metal temperatures involved. Can result in pitting or cracking in tube bores or in scaling and flaking on the gas side of tubes. Alkalinity must be maintained (ph 10-12) and proper water flow must be maintained in superheater.
  - Galvanic action – A form of corrosion in which the metal is eaten away by the galvanic action of non-homogenous parts of the iron and steel. Boiler water may act as electrolyte. When an externally applied electrical current flows between two poles, ions leave the positive pole and move towards the negative pole. Corrosion then occurs at the positive. Zinc plates are fitted to boilers to be acted upon before the boiler shell thus protecting the steel. Alkalinity must be maintained (ph 10-12).
  - Oxidation – Dissolved oxygen attacks boiler steel at saturation temperatures and pressures. The rapidity of attack increases rapidly with temperature. Best controlled by preventing introduction of air to the feed water and removing the dissolved gases by heating and use of deaerators.
  - Feed water must be kept pure as possible.
  - Should also be tested and treated chemically to neutralize acid forming salts and remove traces of oxygen that escape the deaerator.
32. Describe the operation of a surface condenser and explain how it functions. What are the indications of incorrect cooling water circulation? Name all the valves and fittings on the circulating water system between the shipside suction and the overboard discharge. (2008 Exam, TCMS Sample)
- McGeorge MAM p. 18, Taylor p. 103, Reed's Deck p. 56
  - A surface condenser is a vessel in which steam is transformed from vapor into liquid so that it may enter the boiler to start the heating cycle again.
  - Amount of cooling should limit under cooling of condensate, which would lessen efficiency of system. Steam sometimes used to heat condensate back up to proper temperature.
  - Condenser should also allow removal of gases and vapor from condensing steam.
  - The steam enters at an upper level, passes over tubes through which cold seawater passes through and then falls to the bottom where it is removed by a pump or by gravity.
  - Construction is similar to other tubular heat exchangers. Propulsion systems condensers quite large.
  - Some smaller units have u-tubes so that the cooling water gets two passes across steam and also to allow expansion and contraction at free end.
  - Cooling water for straight tube units enters at bottom and circulates in one or two passes.
  - A water box is fitted at the fixed end(s) of shell.
  - Tube plates made up of brass are sandwiched between flanges of water boxes. If soft packing is used, these tube plates are drilled, counter bored and tapped.
  - Tubes may be cupro-nickel or aluminum brass.
  - May be expanded in at one end and soft packing at other or soft packing on both ends.
  - If expanded at both ends, a shell expansion joint must be fitted.
  - Tubes are prevented from sagging with steel baffle plates along length.
  - A baffle plate at entrance to steam space deflects steam away from damaging tubes directly.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Access doors fitted on water box end covers and shell bottom for repair or inspection.
  - Anodes fitted to prevent corrosion by galvanic action.
  - Defective tubes can be plugged temporarily.
  - Condenser kept at vacuum to draw steam from the working part of system (turbine, etc.)
  - Indications of incorrect cooling circulation would be:
    - a. Hot or cool spots in system. If areas of system are not receiving proper flow, they may overheat. If receiving too much cooling, there may be an excess of condensation and the system may lose efficiency.
  - The fittings on the cooling water circuit are:
    - a. High and low sea side suction intakes
    - b. High and low sea suction valves
    - c. Duplex strainers
    - d. Circulating water pump (main and standby with isolation valves)
    - e. Condenser with isolation valves
    - f. Overboard valve
33. Why is feed water heated before entering a boiler? What are the dangers involved in pumping cold feed into a steaming boiler? What arrangements are used to heat feed water? (TCMS Sample)
- Feed water is heated before entering a steaming boiler for the following reasons:
    - a. To improve plant efficiency. The boiler will not have to work as hard to create steam if the water entering it is at a higher temperature.
    - b. To reduce thermal stress. Cold water entering a steaming boiler could contact hot surfaces and cause thermal shock. This could cause rapid contraction of steel, which can lead to cracks. This may cause the boiler to burst, which could cause serious injury or death to engine room personnel.
  - There are two main types of feed water heaters:
    - a. Surface feed heater: uses steam as the heating medium.
      - i. Used to be direct contact heater but not used in modern installations.
      - ii. Fit between feed pump and boiler.
      - iii. May be two stages, heating steam from auxiliary exhaust line or live steam bled off.
      - iv. Consists of shell and tube heat exchanger.
      - v. Feed water moves inside a few nests of tubes.
      - vi. Steam enters top, passes around tubes and out bottom as condensate.
      - vii. Leaves as water since it has given latent heat to the feed water through the tubes.
      - viii. Steam may be bled off exhaust line or live steam.
    - b. Economizer: uses exhaust gas as heating medium.
      - i. Water leaves normal feed heaters and passes through tubes in boiler exhaust uptake.
      - ii. Water enters at top and moves downwards to the hottest part of the economizer and then to steam drum.
34. Sketch and describe the feed system between the condenser or hot well to the boiler. (2009 Exam)
- The heating equipment that the condensate will pass through consists of:
    - Inter/after and gland exhausters condensers of the air ejector units
    - Drains cooler
    - De-aerating feed heater and its vent condenser
    - High pressure feed heater and/or economizer
35. Describe briefly the construction and action of a feed water regulator. (Camosun College Sample)
- Reed's Deck p. 33-34, Flanagan p. 68, Taylor p. 310-311
  - A feed water regulator is a controller that automatically maintains the correct water level.
  - Essential for water tube boilers with high evaporative rates and small reserve of water since the level is critical.
  - If level is too low, damage may occur from overheating.
  - If too high, damage may occur due to priming and carryover of water and dissolved solids into superheaters, steam lines, etc.
  - Frees up E/R personnel from operating the feed check valve.
  - Maintains steadier steaming conditions and reduces water shortage and priming.
  - Fit in feed line, before the main feed check. Can be attached directly to boiler shell or mounted to an external chamber with balance connections to the steam drum or boiler shell.
  - In most cases they use a float or thermal means of operation and thus must have a direct connection to the steam/water space on boiler.
  - Works opposite to conventional thinking and low rated boilers:
  - During maneuvering, an increase in steam flow out of boiler occurs due to the opening of the steam supply valve. This leads to a reduction in boiler pressure, however the water level in boiler rises due to "swell" effect. Swell occurs due to the lower pressure causing steam to

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

flash off and create bubbles and the level to rise. The regulator opens the feed valve to increase feed water flow in order to meet the increased steam demand.

- When steam demand is reduced by closing in on the steam supply valve, the boiler pressure increases. Boiler fuel supply is reduced and the water level will fall due to the "shrink" effect. The regulator closes in on the feed valve to decrease feed water flow.
- This is to prevent priming, water hammer and damage from occurring if the steam demand were to suddenly increase and cause "swell".
- Shrink and swell problems are removed by a second measurement element besides drum water level, which is steam flow.
- A third element water flow is added to avoid problems if feed water pressure were to vary.
- The water level will gradually return to its desired value and a balanced boiler throughput exists.

36. How can oil enter feed-water and what are the consequences? What precautions are required to prevent this? (Pacific Region Sample)

- Reed's Deck p. 47
- Oil can enter feed-water on modern boilers through steam heated fuel systems such as heating coils in oil tanks. If a tube leaks, the oil could enter the condensate system and then the boiler.
- An independent drains tank is normally fitted to check for oil contamination and dump the tank to prevent contamination of the main feed system.
- Oil could also be seen in the boiler gauge glass.
- As oil adheres to heating surfaces of boilers, heat transfer will be affected negatively. This could lead to overheating and possible failure.
- Oil also can cause foaming and priming.

Construction:

37. How are stays affixed on a scotch marine boiler? Why are flat surfaces stayed? What types of stays are in a scotch marine boiler? (2008, 2009 Exam, Pacific Region Sample)

- Reed's GEK p. 116, Flanagan p. 4, 8
- Stays are fitted to flat plates in boilers to counteract bending forces that try to bend plate into shape of arc, where equilibrium is achieved.
- When force is applied to curved plate, internal forces are set up to enable plate to withstand the force without distortion.
- Bursting stress is resolved into perpendicular components, one of which opposes the force.
- Hemispherical surfaces are preferred but sometimes flat surfaces are unavoidable.
- Stays are strengthening members attached to each flat piece.
- There are four methods of affixing stays:
  - a. Screwed with nuts
  - b. Screwed and riveted over
  - c. Plain welded
  - d. Screwed and welded over
- Types of stays in scotch boiler:
  - a. Large steam space stays (longitudinal) - support upper flat surfaces in steam space
  - b. Girder stays (transverse)- used on top of combustion chamber to transmit bending stresses from top plate to vertical tube plate and back plate of chamber.
  - c. Stay tubes and combustion chamber stays (longitudinal) – support mid section of the back plate, tube plates and combustion chamber
  - d. Through stays (transverse) – support lower section of end plates

38. Describe smoke and water tubes and show how they are fitted to a boiler. (2008 Exam)

- Smoke tubes are either plain tubes or stay tubes.
- Plain tubes are expanded into the tube plates at both ends and they are about 6.5 to 7.5cm.
- The front end is often swelled out for easier tube removal.
- The stay tubes plates must be supported which are screwed and then expanded into both tube plates. They are normally thicker at ends.
- Front is secured with nut or welded, back is welded.
- Proportion of stay tubes to plain tubes is 1:3.
- Water tubes can be attached to drums and headers by expanding or by welding.
- In most cases, the generating, screen and water wall tubes are expanded into plain seats and then bell mouthed.
- The tube ends must be cleaned and then carefully drifted or roller expanded into the tube plate.
- The must project out of the hole by at least 6mm. The bell mouth must have taper of 1mm per 25mm of outside diameter plus 1.5mm.
- With larger tubes like down-comers, it is usual to use grooved seats. The tube material flows into the grooves during the expansion process to form a tighter seal.
- Super-heater tubes facing temps of over 450C are often attached by welding.

39. Describe a fuel burner. What are the pressure and temperatures associated? (2008 Exam)

- Flanagan p. 93-94
- A pressure jet oil burner forms a simple robust unit, widely used in marine boilers.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Basic assembly consists of:
    - Steel tube or barrel
    - Swirl and orifice plates
    - Cap nut
  - Complete unit is clamped onto a burner carrier attached to the boiler casing which:
    - Holds burner in correct position relative to the furnace
    - Permits supply of fuel through an oil tight connection.
  - Some type of safety device must be fitted in order to prevent the oil from being turned on when the burner is not in place.
  - The oil is supplied to the burner under pressure and as it passes through the burner performs two basic operations:
    - Imparts rotational energy to the oil as it passes through angled holes in the swirl plate.
    - Atomization as the rotating fuel is forced under pressure through a small hole in the orifice plate that causes the oil to break up into fine droplets.
  - As a result, a hollow rotating cone of fine particles of oil exits the burner tip.
  - The throughput is controlled by:
    - Varying oil supply pressure
    - Changing diameter of orifice
  - The ratio of maximum to minimum throughput is known as turn down ratio:
    - Square root of ratio of max to min oil pressures
  - Minimum supply pressure: 700kN/m<sup>2</sup>
  - Maximum supply pressure: 7000kN/m<sup>2</sup>
  - Burners must be kept clean and care should be taken not to scratch finely machined orifice and swirl plates.
  - Orifice/swirl plates should be replaced when worn out – can be checked with gauge.
  - Burners not in use should be removed; otherwise the heat from the furnace will cause remaining oil in barrel to carbonize.
40. Describe an oil burner for a boiler. How would you clean the burner? What care and attention must be paid during reassembly? (2011 Exam)
41. Explain the difference between fire/smoke tube and water tube boiler. (Camosun College Sample)
- Reed's Deck p. 23
  - In a fire/smoke tube boiler, the hot gases from the furnace pass through the tubes while the water is on the outside.
  - In a water tube boiler, the water flows inside the tubes while the hot gases pass around the outside. They generally produce large quantities of high-pressure, superheated steam for use in steam turbine machinery.
  - With the demand for higher efficiencies, steam temperatures have steadily increased and so has pressure.
  - A boiler forms a more efficient heat exchanger if it consists of a large number of small diameter tubes rather than a small number of larger tubes that is found in a fire/smoke tube boiler.
42. How is a manhole fitted to a boiler? What inspection of the door and joint should be made to ensure a good fit? (Camosun College Sample)
- Manhole requires a gasket:
    - Clean the manhole plate and boiler seat thoroughly.
    - Smear a new gasket on one side with white lead and place this side on the manhole plate. This burns the gasket to the plate allowing easier removal.
    - Smear the exposed side of the gasket with a graphite and oil mixture. This will allow this side to break away easily from boiler when removing.
  - Place the plate in the boiler and lift it into position.
  - Secure dogs to tighten nuts, being sure to allow an even space between the edge of the manhole and the shoulder on the manhole plate (i.e. – center the plate)
  - When steam has been raised on boiler, tighten nuts again.
  - Always use the manhole wrench for this job and never use a pipe or longer wrench to increase torque.
43. Describe the procedure if you found that a boiler tube burst while you were on watch at sea? What temporary repair could be made? (Camosun College Sample)
- If a boiler tube burst while on watch, the boiler must be immediately secured and the Chief called.
  - The fires must be stopped. Oil and air registers closed off.
  - Secure steam stops.
  - Speed up blowers to force the escaping steam up the stack if there is any danger to personnel.
  - Continue feeding the boiler until the furnace temperature drops so that the exposed surfaces will not become overheated.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Open air vent when pressure reaches 5 psi. Allow boiler to cool gradually.
  - A leaky tube can be plugged by two tapered plugs connected by a threaded rod.
  - The plug for the combustion chamber end has a threaded hole through it for the rod.
  - The plug for the front end has a hole through it just big enough for the rod to pass through it.
  - The combustion chamber end plug is screwed on then hammered in to the end of the tube.
  - The front plug is fitted over the rod and then a washer and nut is tightened to secure it in place.
44. Describe a packaged auxiliary boiler suitable for use aboard a motor driven ship. Explain what safety devices are fitted. Using a line diagram, explain how the boiler is made to be automatic in operation. (CCGC Sample)
- Flanagan p. 18-19
  - The term package boiler refers to self-contained units mounted on a single bedplate and comprising:
    - Steam generating section
    - Feed water system and pump
    - Fuel oil system and pump.
    - Forced draught fan.
    - Suitable control equipment
  - Steam generating section can be of tank or water tube design using natural or forced water circulation.
  - Basic arrangement consists of a horizontal cylindrical shell of welded construction that contains one or two cylindrical water-cooled furnaces.
  - Furnaces are attached to the front tube plate and at the rear end to a hemispherical combustion chamber that is pressed out from a single plate.
  - Hot gases from the furnace having passed through the combustion chamber then enter the first pass of smoke tubes, which conduct them to a front chamber.
  - From here they are directed through a second set of smoke tubes to a smoke bob formed at the rear of the boiler.
  - The gases then leave the boiler through a suitable uptake.
  - General layout is similar to that of a Scotch boiler and a number of internal stays are required to support the flat tube plates and other flat surfaces.
  - About one third of tubes are stay tubes.
  - Internal access is provided by means of a top manhole in the shell and by a lower manhole cut in the front end plate.
  - Inspection doors at the rear of the boiler give access to the smoke box and combustion chamber.
  - At the forward end of the boiler is a wind-box formed by an extension of the boiler shell beyond the front tube plate.
  - A forced draught fan mounted within this space draws air from the back of the boiler so that it is preheated before it enters the furnace. A control damper is used to regulate air flow.
  - Automatic controls are provided to regulate the fuel and air supplies in response to changes in steam demand while maintaining the boiler water level.
  - The controls are configured to give a correct sequence to the different operations to be carried out safely.
  - Safety devices will shut the boiler down automatically with a loss of water, combustion air pressure, or flame failure.
  - An alarm system will also show high steam pressure or water level, low fuel pressure or high uptake temperatures, etc.
  - Devices must be manually reset before boiler can be started to ensure safety.

### Mountings:

45. Describe how a boiler safety valve works. (2006 Exam, Diesel Duck)
- Boiler safety valves are designed to prevent boiler from being over pressurized and are therefore the most important fitting.
  - They are mounted high up in steam space and normally two are fitted due to regulations for protection. They may be fitted to same chest.
  - Mounted as close as possible to steam space, no valves are permitted between.
  - Each must be capable of releasing all excess pressure without allowing more than 10% more than operating level. Set at no more than 3% above working.
  - Spring loaded valves are used since they work when vessel is inclined in any direction.
  - Must lift at least 1/4 of valve diameter in order to provide full steam flow.
  - Normally valve is held closed by helical spring pressure.
  - With excessive pressure, steam pushes against valve face which forces valve to lift and steam to escape.
  - Steam will go through waste pipe up through funnel to avoid personnel.
  - The spring pressure increases as the valve opens but this is counteracted by the shape of the lid, which has a lip arrangement giving it more surface area to act on when opened.
  - A manually operated easing gear allows valve to be opened manually during emergency or inspection.
  - Springs and valves must be fitted within lockable casings that prevent tampering after inspection by TCMS.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Must be built with corrosion resistant materials;
    - Bronze or stainless/monel - valve, seat, stem, locknut
    - Cast steel - casing
  - A High Lift safety valve is an improved design that allows a faster release of over pressure steam.
  - A piston is fitted to the spindle at upper part of waste steam space of valve chest.
  - The piston is a larger diameter than valve and works in side a loose ring within a guide plate.
  - The guide plate centers the spindle and has open ports to allow steam to piston.
  - This steam lifts the piston upwards, opening safety valve to release steam quickly.
46. What are scum and blow down valves? How are they used? What is scumming? How is scum formed? (2006, 2008 Exams)
- Scum valves are positioned just below normal water level.
  - Their function is to get rid of foreign matter/oil that collects on surface of boiler water by blowing it out when the valve is opened periodically.
  - They are fitted with an internal pipe leading to a scum pan near the surface.
  - The outside of the valve is connected to boiler blow down line.
  - Blow down valves are positioned at the bottom of the boiler.
  - Their function is to get rid of foreign matter/sludge that collects and sinks to the bottom of the boiler water when the valve is opened periodically.
  - Can also be opened to drain cool boiler for inspection or maintenance.
  - The valves may be arranged two in a row so that the first valve can be open fully and the second cracked to blow down. This protects seat of first valve to reduce risk of leakage.
  - The outside of the valve(s) is also fitted to the blow down pipe that is connected to a ship side valve to get rid of this waste steam/water.
  - Scumming is the process of opening scum valve to get rid of top layer of water to protect gauge glass from choking with impurities and to promote steam generation with boiler water with higher purity.
  - Scum is formed when boiler water picks up particles, insoluble substances/oils that are less dense than the water.
  - Chemicals are also used to coagulate insoluble sediments to make them easier to get rid of by scumming.
47. Name all the fittings on a donkey boiler, where they are placed and their function. How would you blow down the boiler in preparation for entering and cleaning? (Diesel Duck)
- Flanagan p. 67-70
  - Various fittings and valves are required for the proper working of a boiler.
  - Those attached directly to the pressure parts of a boiler are referred to as boiler mountings:
    - Safety Valves – fitted to protect boiler from overpressure.
    - Main Stop Valve – Enables boiler to be isolated from steam line or other boilers. (SDNR)
    - Auxiliary Stop Valves – Enables boiler to be isolated from auxiliary steam lines. (SDNR)
    - Feed Check Valves – Fitted to give final control of feed water into boiler. (SDNR)
    - Feed Water Regulator – Fitted to control the flow of water into the boiler and maintain the level at a desired value.
    - Water Level Indicators – Fitted to show water level in drum. Must be two fitted as per regulations.
    - Low Water Alarms – Fitted to indicate risk of damage possible due to low water level.
    - Blow Down Valves – Fitted to lower density of boiler water or drain it completely for inspection or maintenance. Consist of two valves in series that will discharge through a blow down pipe over the ship side.
    - Scum Valves – Fitted with shallow pan near normal water level to enable discharge of surface impurities.
    - Air Vents – Fitted to release air when raising steam or when filling the boiler.
    - Salinometer Valves – Fitted to enable sampling of boiler water. Normally has a cooling coil to prevent flash off.
    - Pressure Gauge – Allows operator to check current pressure inside boiler.
    - Thermometer – Allows operator to check water and steam temperatures.
48. Sketch and describe easing gear. What is its purpose and how does it work? (2009 Exam)
49. Describe a double acting steam pump that can be used to supply a boiler with feed water. (2011 Exam)

### Inspection:

50. You are handed over a watch of an online boiler, what would you do to ensure that the boiler is working safely? (2009 Exam)
- Flanagan p. 113
  - Watchkeeper must familiarize himself with the plant of which he is in charge.
  - Must be aware of individual equipment operating control signals, flow rates, temperatures and load conditions and regularly check for deviations from the norm.
  - Emergency conditions normally precipitate with some prior clues so one should be alert and take corrective action before problems escalate.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Blow down gauge glass to ensure it is reading correctly.
  - Ensure that boiler safety shut down devices are tested, operable and maintained.
  - Alarm and automatic controls are within manufacturers recommended limits.
  - Checklists should be followed and any issues logged and communicated to others, especially watch relieving you.
  - Check quality of feed water and investigate any sources of contamination.
  - Check for leaks and fix if possible. Isolate the system first and wait for cooling. Leaks will hurt plant efficiency and lead to excess feed adding which leads to more impurities in water.
  - Be alert for fire risks and keep tank tops, drip trays, etc clean and free of oils.
  - Store combustibles away from heat sources and fix oil leaks.
  - Be familiar with firefighting systems and equipment. Ensure you are familiar with quick closing valves and remote steam shut off valves in case the engine room has to be abandoned.
51. What is the procedure for entering a boiler for inspection while another boiler is online? (2009 Exam)
- Flanagan p. 106
  - The most important part of this inspection will be safety of personnel.
  - The running boiler must be totally isolated from the one to be inspected and all interconnecting valves must be tagged and locked out.
  - The boiler to be inspected must be cooled down and drained/vented with no vacuum.
  - Top manhole can be opened up. Slacken nuts but do not remove them until joint is broken in case of any pressure or vacuum built up. Manhole can then be removed. Opening should be roped off for safety.
  - Bottom manhole can then be opened up with nuts first slackened and a water level checked. Any existing water should be then pumped out prior to entry.
  - Bottom hole is opened second since hot vapor may then escape through top door and scald someone due to the draft created.
  - Allow the boiler to ventilate and do not allow flames or naked lights nearby in case there is explosive vapors in or around boiler.
  - Use a gas sniffer to check for proper oxygen content in air and treat the boiler as a confined space prior to entry.
52. A boiler has been opened up for inspection and is to be brought back online. Describe the procedure you would follow before lighting up and raising steam. (2011 Exam)

### Steering Gear

Construction, arrangement, and working of steering gears and telemotors

53. Describe fully the operation of the electric hydraulic steering gear. Describe the action of the hunting gear (how it returns the rudder to amidships). What provisions are made to absorb the shock of heavy seas striking the rudder? (2008 Exam, Diesel Duck, Camosun College Sample, Pacific Region Sample, Limnos Sample)
- Reed's Deck p. 138, 141 (sketch), McGeorge GEK p. 124, Taylor p. 219, Reed's GEK p.189
  - Most popular type of steering gear.
  - Purpose is to transmit steering commands from wheelhouse to move the rudder.
  - Hydraulic part of system includes a telemotor that provides a fluid link between the wheelhouse transmitter and the steering compartment receiver.
  - This receiver moves a control rod that is attached to the hunting lever, which forms a mechanical link to the pump control rod and the tiller.
  - Simple type of hydraulic system also consists of two hydraulic rams, one situated on each (port and starboard) side of tiller.
  - These are linked at their outer end (middle) to the tiller arm by a crosshead and swivel block.
  - Other ends of rams work inside their own hydraulic cylinders and pipes connect these cylinders to a hydraulic pump.
  - Hydraulic oil (or special mineral oil) is used as the medium.
  - Function of pump is to draw oil from one cylinder to the other at high pressure.
  - This action causes one ram to move out and the other ram moves back into its cylinder.
  - Pump is rotary displacement driven by a constant speed electric motor. This is where the electric part of the name comes in.
  - Pump is normally variable displacement that is controlled by a moveable plate or ring inside the pump. When in mid position, no oil is drawn in or discharged. When plate moves, oil will travel one way. When plate moves in opposite way, oil will be delivered the opposite way. The plate is actuated by the pump control rod that is attached at its outer end to the hunting gear.
  - Hunting gear is an arrangement of levers that is designed to return the pump to a neutral (no oil delivery) position after the tiller has been set to its desired position.
  - Pump control is moved by the telemotor through this floating lever, the other end of which is connected to the tiller by a safety spring.
  - The pump is only required to deliver oil when the steering wheel is moved. The wheel movement pumps oil to the receiver which cause pump displacement, then ram movement, which results in tiller movement.



# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- When the tiller has moved through the angle corresponding to the wheel position, it will remain there until the wheel/telemotor is moved again.
- In a ram type steering gear, a protective bypass system is fitted, complete with spring loaded shock (relief) valves which open due to excess pressure in event of a heavy sea forcing rudder over.
- This transfers shock from tiller to rams by bypassing some oil from one side of system (i.e. cylinder) to the other, permitting the rams to move and abnormal stress on the rudder stock is avoided
- A spring loaded return linkage on tiller (hunting gear) will prevent damage to the control gear during a shock movement.
- In moving over, the pump is actuated by the hunting gear and the steering gear will return the rudder to its original position once the heavy sea has passed.
- In some systems, the quadrant is connected to the tiller with two heavy shock absorbing helical buffer springs. When the quadrant is moved by the steering gear, it pulls the tiller through one of the springs. This allows spring compression, thereby absorbing shock loading, in the event of heavy seas.

54. Describe a Hele Shaw pump and how it operates. (Camosun College Sample, CCGC Sample, Limnos Sample)

- Known as a radial cylinder pump.
- Constant speed, variable delivery.
- Normally driven by electric motor in the same direction.
- Pump unit can rotate in neutral, not deliver any oil.
- Within casing, shaft drives cylinder body which rotates around central valve/tube arrangement
- Shaft is supported on either end by roller bearings.
- Cylinder body connected to central valve by ports that lead to connections at outer casing for supply/delivery of oil.
- A number of pistons (normally 7 or 9) fit in radial cylinders and are fastened to slippers by a gudgeon pin.
- Slippers fit into a track in the floating cylinder ring
- Floating ring rotates can move side to side since ball bearings are housed in guide blocks.
- Two spindles connect floating ring to steering control shaft.
- When floating ring is concentric with central valve arrangement, there is no piston movement therefore no oil is pumped.
- If floating ring is pulled to right, then a relative reciprocating motion occurs in cylinders.
- As per drawing, the upper right piston moves outward and draws in oil at this stage. As it rotates the lower cylinder has less volume available for oil and pushes it through discharge port on bottom of valve arrangement.
- When pulled to the left, the opposite occurs. The lower cylinder would draw in oil due to suction of the void created. This excess oil would then be pumped out of top discharge port as the upper cylinders have less room for oil and the pistons pump it out.
- This oil pumping action forces the rams connected to tiller to move, thereby controlling rudder angle.

55. Describe the arrangements made to allow a hydraulic steering gear to be operated by hand. (Camosun College Sample)

- Taylor, p. 216
- The receiver cylinder has a control spindle connected to it by a pin.
- This control spindle operates the slipper ring or swash plate of the variable delivery pump.
- If the changeover pin is removed from the cylinder and inserted in the local hand wheel drive, then manual control of the steering gear is possible.

### Telemotors

56. Why is it important to exclude air from telemotor systems and the ram cylinders of steering gears? What methods are employed to rid these systems of air? (2011 Exam, TCMS Sample, Diesel Duck, Camosun College Sample, Pacific Region Sample, Limnos Sample)

- Air is dangerous in any hydraulic system and must be carefully avoided, especially in telemotor systems.
- Air is compressible unlike fluid and therefore will cause inconsistent operation and a time lag between bridge steering wheel movement and actual steering gear response.
- Large quantities of air will cause unacceptable sluggishness and faulty steering. This could lead to collision, grounding, pollution and loss of life.
- Evidence of air entrained in oil can be exhibited by jerky system operation and a jumpy pressure gauge needle.
- If air has entered system due to a fault or maintenance, charging the system may be required to get rid of it.
- A charging system involves a charge tank that is to be filled with clean oil and to be kept topped up during the bleeding process.
- The steering wheel is put to mid position and the bypass valve and charging valves are opened.
- The hand pump is operated to push oil throughout system.
- A spring loaded check valve prevents oil back flow when charging and not allowing air into main section of system.
- During pumping, air cocks are opened to purge air and closed when a clean stream of oil escapes.
- The oil is circulated until oil returned to tank spurts oil to action of hand pump indicating there is no air in system that would cushion oil flow.
- To charge cylinders of oil and ensure no air is present in them, they are filled with oil through filling holes until all air has been displaced.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Then the purge valves are opened on cylinders and pumps and the stop valves and bypass valves.
  - The system can then be barred over to force oil through system.
  - When all air is expelled, the charging tank will no longer lower in oil level.
  - The system valves can then be set to working position and the pump started.
  - Steering can be brought slowly back and forth hard over to hard over to expel any remaining air.
57. Describe the construction and operation of a telemotor. How is the system checked for leakage? What is the fluid used in a hydraulic steering gear or telemotor? Why is this fluid used instead of water? (Diesel Duck, Camosun College Sample)
- McGeorge MAM p. 125, Reed's Deck p. 135
  - Telemotor on many vessels has become the standby steering mechanism, used when automatic steering fails.
  - Consists of a hydraulic system with a transmitter on bridge and a receiver connected to a variable delivery pump through the hunting gear.
  - Transmitter and receiver connected by solid drawn copper pipes.
  - Liquid displaced in the transmitter by wheel action causes a corresponding displacement in the receiver and pump control.
  - Transmitter consists of a cylinder with a pedestal base, which contains a piston operated by a rack and pinion from the steering wheel.
  - The make up header tank operates automatically through spring loaded relief valve and make up valves.
  - Excess pressure in telemotor system cause oil to be released through the relief valve to the make up tank. Loss of oil is made up through the lightly loaded make up valve.
  - The two valves are connected to the cylinder by a normally open shut off valve and the bypass, which connects both sides of the pressure system when the piston is in mid position.
  - There is also a manual bypass.
  - The make up tank must be kept topped up.
  - The receiver in steering gear compartment often has a cylinder and ram arrangement that is connected by crosshead to tiller and spring loaded to center the rudder.
  - Movement of the receiver is set by stops to correspond with maximum rudder angle.
  - System is checked for air or oil leakage by investigating fittings and connections from bridge to steering gear while under operational pressure. Any leaks found will have to be fixed as soon as practical or else steering performance will be compromised.
  - The fluid normally used in modern installations is hydraulic oil or a mineral oil of low viscosity and pour point. Oil provides a corrosion free alternative to water and its properties can be modified through manufacturing. Oil is also not susceptible to freezing or boiling under normal conditions. Oil also has good lubricating qualities.

### Pumps

Constructional details and principles of action of pumps, general requirements for pumping systems.

### Bilge System:

58. With the aid of a simple line sketch and briefly describe a bilge pumping system for use in the machinery spaces and holds of a cargo ship. Include a description of the type of valves used and the locations of strainers. (2011 Exam, Diesel Duck, Camosun College Sample, Pacific Region Sample, Limnos Sample)
- The purpose of a bilge system is to clear water from the ship's normally dry compartments in the event of an emergency.
  - Under normal conditions bilge water must be processed through the oily water separator to ensure a 0-15 PPM oil level depending on geographical area.
  - International ship building regulations require adequate sizes of piping and pumps to be used in certain spaces in order to ensure the system will operate with proper capacity to rid water.
  - The system uses manifolds and valves and a bilge main pipe to draw from affected compartments and pump overboard.
  - Pumps are normally centrifugal, self-priming units.
  - If extra pumping action were required, the bilge ejection system could be employed. This uses the E/R's largest pumps to eject bilge water. On many ships, this is connected to the main engine seawater cooling pumps.
59. Describe a typical bilge system. Sketch a typical bilge well, complete with suction pipe, valve and mud box. What type of valve is used as a bilge suction valve? Why is it so constructed? (2008 Exam, TCMS Sample)
- Mud boxes are fitted on the suction side of the bilge pump and strainers to the end of each compartment bilge suction pipe in order to strain out debris that may clog piping. The mud boxes must be able to be readily cleaned.
  - Screw down non-return valves must be used in a bilge system to prevent back flooding of any compartments in case that section of bilge piping became pressurized. Flow will only exit the well towards the pump suction and then onwards out the shipside discharge.
60. What is bilge injection? Where is it placed and how is it used? What materials are used? Type of valve? (Diesel Duck, Pacific Region Sample, Limnos Sample)
- Taylor p. 131, Reed's GEK p. 394

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Bilge injection is a direct suction from the machinery space bilge that is connected to the largest capacity pump(s) that helps prevent flooding of a ship in an emergency.
  - By opening this valve and closing the main sea injection valve, bilge water from the lowest point in the space can be directly pumped overboard.
  - A doubler plate is welded to the skin and machined usually after welding. The sea chest is then bedded to doubler and then studded in place.
  - The joint is either spigot and jointing compound or flat with a joint of canvas and red lead putty.
  - Diameter of bilge injection should be at least 2/3 of main injection valve.
  - Valve spindles should be clear of the engine platform
  - Valves and operating gear require regular examination and greasing and cleaning of strainer.
  - The valves should be screw down non-return so that it will not back flood compartment in case of pipe failure.
61. In what ways could water find its way into the bilges of a ship? If trouble is encountered in pumping out bilge, what might the causes be and how could they be corrected? How often should the bilges be pumped? (Pacific Region Sample)
- Water could find its way into the bilges of a ship in many ways:
    - a. Cleaning the decks or bilges
    - b. Leaks in seawater or freshwater piping or machinery
    - c. Drains from E/R sinks, hatch drains, etc.
    - d. A breach in the hull or deck-head
  - If trouble is encountered pumping out a bilge, the strainers (mud-boxes) probably require cleaning. The pump can be turned off if possible or the line isolated by closing its suction valve. The strainer can then be removed from the mud-box and cleaned of any debris.
  - The suction, discharge and isolation valves should also be checked to see that they are all in the correct position of open or closed.
  - The pump could be primed manually if the water ring primer is not functioning correctly. Make sure its vent is not blocked.
  - The bilges should be kept as empty as possible so pumping should occur when practical. If in port, they can be pumped to a shore facility.
  - If at sea in an unrestricted area, they can be pumped through the approved OWS at an acceptable rate of less than 15ppm, 5ppm or 0ppm depending on the area.

### Pump Types:

62. Sketch and describe a gear pump. Why is it used and how does it work? (2009 Exam)
- Reed's Deck p. 94, McGeorge MAM p. 171, Reed's GEK p. 365
  - Defined as a rotary displacement pump. Used because it is self priming and positive displacement for applications that require constant pressure and flow.
  - Used extensively for pumping lube oil and fuel, especially lube oil to engines and gearboxes. Also for boiler combustion, fuel transfer, etc.
  - Often driven off engine crankshaft for medium and high speed engines.
  - Slow speed engines are normally independently driven.
  - Consist of two geared wheels meshed together that are driven by one shaft so there is a master and slave.
  - The casing around the wheels is fit to tight tolerances to prevent oil pressure loss.
  - As each tooth in one wheel leaves its corresponding space in the other wheel, a partial vacuum is created in that space into which the oil flows.
  - The oil is carried around in the outside of the space through almost 360 degrees when a tooth entering the discharge space pushes it out of the pump.
  - Centrifugal effect contributes to pumping action.
  - Rotors and shaft integrally forged of nitralloy steel. They are hardened all over then ground finished.
  - Cast iron used for casing and bearing housings.
  - Bearings are white metal or roller bearings.
  - Lubrication by oil passing through.
  - No side thrust with straight gear teeth. Single helical gears will cause side thrust. Double helical necessary to prevent this thrust wear.
  - Spring loaded relief valves fitted, normally adjustable to set system pressure.
  - In reversible engines, the lube oil pump is made to flow in the proper direction by adding a pair of non-return suction and delivery valves at each side with communicating ports to the suction and delivery branches.
63. Sketch and describe a centrifugal pump. State the materials from which the various parts are made. What is the purpose of these pumps aboard ships? (Diesel Duck)
- Reed's Deck p. 95, Reed's GEK p. 353, McGeorge GEK p. 1
  - Rotary pump that works on principal that outward radial force set up by a mass rotated in a circular path due to its natural tendency to fly off at a tangent to the circular path and travel in straight line.
  - Consists of a rotating impeller within a stationary volute shaped casing.
  - Impeller is like a hollow disc wheel with internal curved vanes mounted on a shaft driven by an electric motor, engine or other prime mover.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Fluid enters axially through the eye then continues by centrifugal action continues radially and discharges around the entire circumference.
  - The impeller vanes give an increase in pressure and velocity.
  - The pressure is low at the middle of the eye due to fluid being forced outward; this creates suction for the pump.
  - Purpose of volute is to convert part of the kinetic energy to pressure energy. May be fitted with diffusers to enhance this action and therefore be suited for high pressure discharge.
  - Materials;
    - a. Casing – gunmetal or cast iron
    - b. Impeller – aluminum bronze
    - c. Shaft – Stainless steel
  - Not self priming since it does not have positive suction action.
  - Will only pump in one direction.
  - Mainly used where suction is submerged or lift is very small.
  - Normally installed vertically with motor above pump so that it is easier to prime, takes up less space and leaves the motor safe from gland leakage.
64. What is meant by priming a pump? What type of pump requires priming? Why is a simple centrifugal pump unsuitable for bilge pumping duties? Sketch and describe how such a pump can be made suitable for such duties. (CCGC Sample, Pacific Region Sample)
- McGeorge MAM p. 150, Taylor p. 122, McGeorge GEK p. 3
  - Priming a pump can be done a few different ways but the purpose is to fill the pump casing with fluid and displace any air so that the positive pumping action can begin.
  - Centrifugal pumps require priming since they can not displace air without a fluid seal.
  - A simple centrifugal pump does not have means to prime itself if it is placed above the pumping medium. It requires a means of priming, often a liquid ring primer fitted above pump.
  - A liquid ring primer consists of a bladed circular rotor, shrouded on the underside, which rotates in an oval casing.
  - Sealing water is drawn into casing through a make up supply pipe from a header tank.
  - The water is thrown out to the casing periphery by the turning rotor and whirls around. This forms a moving layer against the oval casing.
  - The water seals the rotor blades and also recedes from and approaches the centre twice each revolution.
  - This creates a series of reciprocating water pistons between the blades.
  - As it moves out, the water provides a suction stroke and as it moves in, a discharge stroke.
  - The ports, provided above the rotating water, permit air to be drawn in from the main pump suction pipe float chamber and expelled through discharge ports to atmosphere.
  - A continuous supply of sealing water is circulated from header tank to sealing ring and discharged back with any air.
  - As air is pumped out of float chamber, liquid rises and using a ball float, closes a needle valve leading to primer ensuring it won't become flooded.
65. Describe the pumps fitted in the machinery spaces of a ship. Explain what type they are and which pumps are usually used for what application? Which pumps are usually interconnected? What pumps are self-priming? (2010 Exam, Pacific Region Sample, Limnos Sample)
- Bilge pump – self priming centrifugal – used to discharge water from normally dry spaces due to a flooding emergency
  - Ballast pump - centrifugal – may be self priming if also used as bilge pump. Used to transfer seawater around ballast compartments in order to properly load vessel.
  - General service pump - self priming centrifugal – can be used as bilge or ballast pump or possibly as fire pump depending on connections.
  - Main Fire pump – self priming centrifugal – Used to charge fire main in effort to fight fires with seawater.
  - Emergency fire pump - self priming centrifugal – Used as back-up fire pump. Fed from separate sea bay and power source than main fire pump.
  - Sprinkler pump – self priming centrifugal – Used to charge sprinkler system with seawater to fight fires.
  - Sanitary water pumps – turbine/jet type - Used to charge water system for sewage processing such as flushing heads.
  - Potable water pumps – turbine/jet type – Used to charge accommodation fresh water system for drinking, showers, cooking, etc.
  - Fuel transfer pumps – gear pumps – Used to transfer fuel around storage tanks, settling tanks and day tank.
  - HVAC/Refrigeration cooling pumps – turbine – Used for cooling of condensers.
  - Boiler water feed pumps – turbine/centrifugal – Used to fill boiler from hot well.
  - Bearing oil pumps – gear pumps – used to provide oil to pedestal and shaft bearings.
  - Grey water tank – centrifugal – Used to empty grey water tank to overboard.
  - Sewage pumps – sludge pump (centrifugal), Vacuum pump (centrifugal), effluent overboard pump (progressive cavity), sewage transfer pump (progressive cavity)
  - Main engine pre-lube pumps – gear pumps – Used to charge oil systems of engines prior to starting to lessen wear.
  - Evaporator seawater pumps – supply (centrifugal), discharge (centrifugal), brine discharge (centrifugal)

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Main engine cooling pumps – centrifugal – Used to charge jacket water and sea water cooling systems, may be engine driven or electric.
- The pumps that are usually interconnected are the bilge pump, ballast pump and general service pump to provide redundancy in a flooding emergency.
- The pumps that are self-priming are listed above. They must be self-priming by regulations since they are meant to work in an emergency without the act of manual priming, which may be impossible.

### Firefighting

Fire prevention and detection, fire-fighting equipment, its use, construction and maintenance

#### Fighting Fires

66. You are on watch with your ship traveling at full speed and you have a large fire in the engine room, what do you do? (2010 Exam, Pacific Region Sample, Limnos Sample)
- Fire at sea can escalate very quickly due to numerous fuel sources and cause loss of the ship and injury or death to personnel.
  - An engine room fire is especially serious and could be due to a number of causes:
    - a. Oil/fuel leaks onto hot engine manifolds
    - b. Electrical malfunctions causing arcing
    - c. Hot work sparks falling into oily bilges
    - d. Creosote/carbon lining in stack heating up due to high exhaust temperatures.
    - e. Spontaneous combustion of oily rags or material
  - If a large fire were to be spotted visually or due to a heat or smoke detector, I would immediately signal the fire alarm if it has not sounded automatically.
  - This will alert everyone of the situation and allow him or her to man fire stations as soon as practical.
  - If possible a page could be made giving the location of the fire to warn anyone heading to the E/R.
  - The main fire pump should be started.
  - I would call the bridge and inform them of the situation and let them know they may have to maneuver in case the engines or generators have to be shut down.
  - UHF radio communication should be opened up at this time.
  - Depending on the source of the fire, I would begin to isolate the sources of heat, oxygen and fuel to it in order to extinguish it.
  - This involves closing shutting off engines and closing fuel valves remotely for diesel machinery.
  - Fuel/oil transfer operations should be stopped and pumps isolated if possible.
  - Breakers to affected area should be shut off to isolate electrically if possible.
  - Air dampers can be shut and fans stopped to E/R.
  - Watertight doors should be closed if not already done so.
  - Turn on emergency generator if main generators have to be shut down.
  - Start the emergency fire pump.
  - Hoses can be set up to attack fire and boundary cool affected area to prevent further damage. Fire team will enter with breathing apparatus and protective suits on.
  - If fire were out of control, all personnel would have to be evacuated from space.
  - Ensure E/R is isolated ventilation wise and fuel wise.
  - If order was given by Captain, activate fixed fire fighting system that is normally CO<sub>2</sub> or Halon (now banned).
  - Continue boundary cooling and check for indications that fire has been extinguished.
  - Do not enter area until it has been properly vented. Wear breathing apparatus and protective equipment and use a gas detector to check for breathable oxygen.
  - Bring water hoses and portable extinguishers in case of hot spots.
  - Inspect machinery and report condition to Chief.
67. A fire breaks out on the tank tops and bilges in the engine room of an oil fired vessel. What type of extinguisher would you use and what is the principle of its action? What other steps would you use to control the fire? What precautions are taken to prevent such fires? (Diesel Duck, Limnos Sample)
- Taylor p. 234-235
  - A fire in the bilges of an oil-fired vessel would be classified as a Class B fire since it would petroleum products as the fuel.
  - The best portable extinguisher to use on a Class B fire would be a foam extinguisher that can be activated chemically or mechanically. The foam acts as an insulator and absorber of radiation heat but more importantly, it excludes oxygen from the fire.
    - a. Chemical – Main container filled with sodium bicarbonate and a long inner polythene container is filled with aluminum sulphate.
      - i. The inner container is sealed by a cap held in place by a plunger.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- ii. When the plunger is unlocked by turning it, the cap is released.
  - iii. The extinguisher is then inverted and the two liquids mix.
  - iv. CO<sub>2</sub> is produced by the chemical reaction, which pressurizes the container and forces out the foam to be sprayed on the fire.
- b. Mechanical – Outer container filled with water and central container has a CO<sub>2</sub> charge and a foam solution.
- i. A plunger mechanism with a safety guard is located above central container and when it is depressed, CO<sub>2</sub> is released and the foam solution and water mix.
  - ii. The combination is then forced out by pressure through a special nozzle that mixes the liquids to form a sprayable foam.
  - iii. Extinguisher has an internal pipe and is operated upright
- Indirect water spray (fog) can be used to absorb heat and blanket and oil fire.
  - A fixed gas smothering system can be employed if the fire gets out of hand.
68. Name the three basic ways of extinguishing a fire and give an example of each. State what is meant by Class A, B or C fires and a type of extinguisher used for each. (Pacific Region Sample)
- Extinguishing a fire requires removing one or more sides of the fire triangle:
  - Fuel – Turning off fuel supply. Ex – closing a fuel valve feeding broken oil pipe that is on fire
  - Oxygen – Smothering out oxygen. Ex - Covering a small fire with a fire blanket.
  - Heat – bringing temperature down below flash point of material. – Using water to absorb heat will help extinguish fire.
  - Class A – general combustibles such as wood, paper, coal, etc.
    - a. Can be fought with water, soda acid, CO<sub>2</sub>, dry powder
  - Class B – liquid petroleum products such as diesel, oil, etc.
    - a. Can be fought with fine water spray, foam, dry powder, CO<sub>2</sub>
  - Class C – electrical fires
    - a. Can be fought with non-conductive dry powder or CO<sub>2</sub>

### Extinguishers:

69. Sketch and describe a soda acid fire extinguisher. (2010 Exam, Camosun College Sample, Pacific Region Sample, Limnos Sample)
- Reed's GEK p. 326-327, Taylor p. 234-235, McGeorge MAM p. 451-452
  - Tank is constructed of riveted or welded mild steel and lead-coated internally and externally.
  - A screwed brass neck ring is riveted to the top dome of the mild steel body and the brass head assembly.
  - The head assembly incorporates a plunger (with a safety guard) and acid bottle carrying cage that is screwed on.
  - The head assembly joint is either acid resisting rubber or greased leather.
  - The nozzle is made of brass and the delivery tube with loose gauze filter is made of copper.
  - To ensure the solution does not leak out of the nozzle due to increase of air pressure due to increase in temperature in the enclosed space above the solution, a non return vent valve is usually incorporated in the head assembly.
  - The body contains a 9-litre sodium bicarbonate solution – to the limit of the level indicator.
  - The carrying cage contains a glass bottle full of sulphuric acid.
  - When the plunger is depressed, the acid bottle is shattered and the acid is released.
  - The sulphuric acid will then react with the sodium bicarbonate solution and CO<sub>2</sub> is created. The CO<sub>2</sub> builds up in pressure and the solution is then driven out of the extinguisher through the dip tube and nozzle.
  - Must be kept upright when in use.
  - Length of jet = approx 9m with pressure of 2.7 to 3 bar and duration of 1.5 minutes.
  - Body is hydrostatically tested regularly (every 4 years) to a pressure of 21-25 bar.
  - Should be discharged and refilled yearly.
  - Should be used for type A fires only since primary substance discharged is water, which will not work properly on petroleum products or electrical fires. Can be found in accommodation areas.
70. Describe a portable CO<sub>2</sub> fire extinguisher and what is it primarily used for? How is it inspected and recharged? (2008 Exam, Camosun College Sample, Limnos Sample)
- McGeorge MAM p. 455-457, Taylor p. 237-238, Reed's GEK p. 321-322
  - While CO<sub>2</sub> can be used as an inert propellant, the gas can also be used extensively as a blanketing agent for Class B and C fires.
  - Best suited for Class C electrical fires since it is non-conductive.
  - The gas extinguishes by cooling and smothering and can get into inaccessible places.
  - The CO<sub>2</sub> is in liquid form and is at a weight of 4.5kg normally, pressure of 50+ bar at 20C necessitating a strong container (tested on manufacturing to 227 bar, solid drawn steel)
  - Coated internally and externally with zinc and the outside also painted.
  - A solid brass pressing forms the head assembly and this is screwed into the neck of the steel bottle.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- A central tube provides the outlet passage for the CO<sub>2</sub> that is released either by a plunger bursting disc or a valve operated by a trigger. A safety pin must be released first.
  - CO<sub>2</sub> is picked up near the bottom of the extinguisher from a siphon tube to avoid picking up gas that could cause freezing of the discharge tube, which would block release.
  - Liquid changes to a gas as it leaves the extinguisher and passes through a non-conducting hose/pipe to a discharge horn.
  - Can only be recharged ashore.
  - To check for leaks, a record of weight should be kept or liquid level gauge used regularly but this is mainly used on larger fixed systems.
  - CO<sub>2</sub> could be lethal if discharged accidentally in a confined space since it displaces oxygen; therefore this type of extinguisher is not permitted in the accommodation.
  - Range is approx. 3-4m with length of discharge 20s. About 2.5m<sup>3</sup> gas is produced.
  - Hydrostatic testing must be done every 4 years.
71. Describe a portable foam fire extinguisher and explain how it operates and how it is recharged and maintained in good condition. In what locations is this extinguisher found aboard ship and for what kind of fire is it suitable? (TCMS Sample, Diesel Duck, Camosun College Sample, Pacific Region Sample, Limnos Sample)
- There are two types of foam fire extinguishers:
    - a. Chemical – main container filled with sodium bicarbonate
      - i. Long inner container filled with aluminum sulphate
      - ii. Inner container sealed by cap held by plunger
      - iii. When plunger is unlocked by turning it, pressure cap is released.
      - iv. Operator inverts extinguisher and the two liquids mix.
      - v. CO<sub>2</sub> is produced by the chemical reaction, which pressurizes the container to force foam out of nozzle towards fire.
    - b. Mechanical – outer container filled with water.
      - i. Central container holds CO<sub>2</sub> charge and foam solution.
      - ii. Plunger mechanism is depressed, pierces thin copper seal and CO<sub>2</sub> is released and foam solution bag is ruptured so that chemicals inside mix with water.
      - iii. The combination is forced through a special nozzle that creates mechanical foam.
      - iv. System has internal delivery pipe so can be operated upright without having to invert.
      - v. Can be recharged by filling water to line, adding new CO<sub>2</sub> cartridge and bag of foam solution.
  - These are used primarily on Class B fires – petroleum products.
  - Can be found in engine room near fuel storage or transfer equipment. Also near engines or boilers in case of leaks.
  - The foam provides a heat radiation blanket from flames and cuts off fuel.
  - Also, water content offers cooling and smothering
  - Since foam deteriorates in storage, these extinguishers must be tested and recharged regularly.
  - Small amount can be sampled to see if it produces proper amount of foam. If not, chemicals must be recharged.
72. Describe a dry chemical extinguisher. (Limnos Sample)
- Taylor p. 238, Reed's GEK p. 324, McGeorge MAM p.454-455
  - Can be used on ABC fires but has minimal cooling effect. Smothers the fire like a blanket by interfering with combustion.
  - Can be found near electrical equipment and elsewhere on the ship.
  - Operator can approach quite closely to a fire due to shielding properties of powder.
  - Outer container contains sodium bicarbonate powder (4.5kg). Some magnesium stearate added to prevent the powder from caking.
  - When sodium bicarbonate is heated, it produces CO<sub>2</sub> that helps extinguish the fire.
  - Constructed of riveted or welded steel with a brass neck ring.
  - Neck ring incorporates a CO<sub>2</sub> injection tube.
  - Replaceable capsule of pressurized CO<sub>2</sub> is located beneath a spring loaded plunger mechanism in the head assembly. Protected by safety cap.
  - When plunger is depressed, a hollow cutter pierces a copper disc that seals the CO<sub>2</sub> cartridge.
  - The CO<sub>2</sub> gas forces the powder up a discharge tube and out of the discharge nozzle.
  - Connected to the end of the discharge tube is a reinforced hose that leads to a brass nozzle that is fitted with a lever operated control valve.
  - Range is 3-4m with 15 second duration.
  - Body is regularly hydrostatically tested 35 bar.
73. Describe a pressurized water fire extinguisher. How is it properly maintained and recharged. Why is it not advisable to use on an oil fire? (2011 Exam)

Fire Prevention:

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

74. What precautions are taken to minimize a fire on a ship that uses fuel oil? What are drip trays used for? (2008 Exam, Diesel Duck, Camosun College Sample, Limnos Sample)
- Reed's GEK p. 301
  - Cleanliness, vigilance and common sense are the principal weapons with which to fight fire.
  - Tank tops and bilges should be kept clean and well lit, possibly painted white to see oil leaks easier and therefore dealt with sooner.
  - Oily messes should be wiped up as soon as possible and fuels and oils should not be stored next to any heat source.
  - Bilge pumps and strainers should be kept in clean working order.
  - Fire fighting appliances should be maintained and tested regularly:
    - a. Emergency fan, pump and equipment stops
    - b. Fire dampers
    - c. Quick closing oil valves and extended spindle valves
    - d. Watertight doors
    - e. Fire detectors
    - f. Breathing apparatus
    - g. Fire pumps, hoses, hydrants, extinguishers.
    - h. Fixed firefighting system (CO<sub>2</sub>, FM200, etc)
  - Engine room personnel should be practiced in dealing with fire and should know locations of all fire fighting equipment available (frequent fire drills, etc).
  - Drip trays are used to catch small leaks of oil under probable sources of leakage such as fuel transfer manifolds or pumps, filters, etc. They should be observed often and cleaned of oil regularly to minimize fire source.
  - Trays could be permanent such as a welded steel lip around fuelling stations or could be temporary installations under leaking connections.
  - Oily rags and waste should be properly disposed off in sealed metal bins since they can spontaneously combust or add fuel to a fire.
  - Leaks should be fixed as soon as practical.
  - Guards/blankets should be kept on hot surfaces that may flash off oils.
  - Hot work sparks should be kept from hitting any oily surfaces and an extinguisher should be close at hand in case a small fire starts. Fire watch should last an hour after welding/cutting/grinding.
  - Stack fires should be prevented by monitoring their temperatures and condition and cleaning them frequently or carbon residues that are flammable.
  - Fuel aboard must be a minimum flashpoint to prevent an enhanced fire risk, normally 60-66C.
  - Regular rounds of machinery spaces looking for fire sources can help prevent them or minimize damage.
75. What is spontaneous combustion? What conditions and material can it occur in? What precautions are there to avoid it? (Camosun College Sample)
- Reed's p. 302, Witherby's p. 113
  - Spontaneous combustion is caused when cargoes such as coal, hemp, grains, etc are carried in a damp condition.
  - The centre of these cargoes will have very little ventilation to allow for cooling effect.
  - The heat generated naturally can build up to such a degree that combustion takes place.
  - Due to the restriction of oxygen, the cargo will only smolder until part of the cargo is removed. The admittance of oxygen could cause the cargo to burst into flames.
  - Ventilating the cargo and stacking the coal so that it presents as large a surface area as possible lessen the risk of spontaneous combustion in coal.
76. Why are fire drills held? What is the equipment that can be shut down from outside the engine room? (2006 Exam)
- Fire is one of the most dangerous hazards aboard ships, results in losses of many ships and crew lives.
  - Prevention is better than cure so drills help prepare crew members to deal with emergencies so that they won't be overwhelmed.
  - Drills help familiarize crew with locations of fire fighting means such as extinguishers, hydrants and how to use them.
  - Drills help crew members learn how to work in a fire team.
  - It is important to use and test equipment, especially for new employees or if new equipment is fitted.
  - Personnel should know how to maintain and recharge extinguishers.
  - Equipment that can be shut down from outside the engine room in case of fire are:
    - a. Boilers
    - b. Engines
    - c. Generators
    - d. Purifiers
    - e. Fuel transfer pumps
    - f. Fuel valves



# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

### g. Ventilation fans

- This equipment if kept running can add fuel, oxygen or heat to a fire escalating the damage possible.

#### Fixed Systems:

77. Sketch and describe a CO<sub>2</sub> smothering system. What safety precautions are involved in its use? (2006 Exam, Diesel Duck, Camosun College Sample, Pacific Region Sample, CCGC Sample, Limnos Sample)
- Important system especially for engine room spaces where fires can escalate rapidly.
  - CO<sub>2</sub> is a colorless and odorless gas that is denser than air.
  - It will smother flames by forming blanket of oxygen free air, thereby interrupting combustion.
  - Personnel must be evacuated from an enclosed space when using CO<sub>2</sub> since a person will suffocate within an environment rich in the compound since the lungs will not be able to inhale oxygen.
  - CO<sub>2</sub> is stored in drawn steel cylinders at roughly 52 bar. These tanks are hydrostatically tested every 7 years.
  - The tanks have a bursting disk, which will pop at 63C or 177 bar.
  - They are checked for level each year with a level sensor. If less than 90% full, they must be topped up.
  - A siphon tube is fitted inside tank to prevent CO<sub>2</sub> from evaporating at top of liquid during discharge, which would cause freezing and the stoppage of flow.
  - The pipe-work used in the system is galvanized drawn steel, blown through and proven each year.
  - Multi-jet nozzles fitted to ends of distribution pipes can discharge high volume of gas at fast rate.
  - System must be able to give 35-40% of the volume of the affected space. The gas will expand to 450 x liquid size.
  - 85% of stored gas must enter space in 2 minutes.
  - Master valves are fitted to each system. A relief valve is fitted to vent off system to atmosphere in case of accidental discharge.
  - A manual pull wire connected to control head of pilot cylinder is fitted to all remote stations.
  - When released, this pilot gas causes discharge pressure to rise and opens control heads on remainder of system area.
  - There is a 30 second delay with a loud alarm in order to warn employees to vacate area. This may also be connected to the ventilation shut down.
  - The fuel sources into space should be shut off prior to deployment.
  - Watertight doors and other dampers must be closed to isolate area.
  - Captain gives order for release which is a last resort after fighting fire with portable extinguishers and fire main did not work.

#### Equipment:

78. Describe a fire main system with all fittings and connection. (Limnos Sample)
- McGeorge MAM p. 418-420, McGeorge GEK p. 33, Taylor p. 239
  - Normally used as second means of attack, if portable extinguishers fail to control the fire.
  - The fire main is a series of piping that extends from the machinery spaces to the highest levels.
  - Hydrants are served by the fire main so that connected hoses can reach any area of the ship.
  - Water is the chief fire fighting medium aboard ships since seawater is readily available.
  - The system must have two means of providing pressure, normally a main pump and emergency pump.
  - The emergency pump must be fitted in a separate compartment and be fed from the emergency power supply or otherwise independently ran.
  - The piping has a drain at the lowest point so that the pipe can be emptied in cold weather. This prevents ice damaging pipes and hydrants or causing a blockage.
  - Piping is galvanized.
  - Engine room nozzles must have be able to spray fog or jet.
79. Describe the construction and operation of the apparatus normally fitted in the bridge for detecting fires in dry cargo holds. (Pacific Region Sample)
- McGeorge MAM p. 450, Taylor p. 243-244
  - A cargo ship often utilizes a smoke detecting cabinet inside the wheelhouse for monitoring of fires in dry cargo holds.
  - Each cargo compartment is individually connected to the cabinet by a small bore pipe through which a continuous sample of air is drawn by a fan.
  - Part of the sample can be discharged into the wheelhouse to check for the smell, otherwise it is vented to atmosphere.
  - Because the ends of the pipes in holds could become blocked, a flow indicator is fitted at the ends in the cabinet.
  - This telltale is normally a small propeller that will rotate when flow is present.
  - A diffused light will shine behind the pipes to better show any smoke and a photo cell detector will set off an alarm.
  - A 3-way valve is fitted on each pipeline in order to set the pipe from normal detection mode to connect the CO<sub>2</sub> system into fire fighting mode.
  - The same pipes can be used to transmit CO<sub>2</sub> if fire was out of hand and the order from the Captain was given.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- The space would have to be isolated and all personnel evacuated prior to releasing CO<sub>2</sub>.
80. Describe all the fire fighting equipment carried on an oil-burning vessel on deck and in engine room. What maintenance is required? (Diesel Duck, Camosun College Sample, Limnos Sample)

### Safe Working Practices

Safe working practices in machinery rooms and other enclosed spaces.

#### Tank Safety:

81. For what are the double bottoms of a tank used? What precautions must be taken before entering any tanks that have contained (a) oil and (b) water? (TCMS Sample, Camosun College Sample, Pacific Region Sample)
- Taylor p. 252, McGeorge GEK p. 16
  - Double bottom tanks are used for storage of fuel, potable water or ballast.
  - They remain closed up and unventilated for long periods of time. They must be regularly inspected by safety authorities and sometimes may have to be entered for repair or maintenance.
  - These tanks are considered confined spaces, therefore attention must be paid to safety before entry and during occupation:
  - Must be assumed to be an oxygen deficient atmosphere, should be approx. 21%. Proper ventilation (gas freeing) before and during visit. Fans should be used and vents opened since manhole natural ventilation is not enough. If fans stop, personnel must exit space.
  - Oxygen may also be displaced by vapor from cargo, refrigerant, inerting gas, smoke or fumigant.
  - Calibrated gas level monitor on at all times which will alarm if oxygen levels drops or if explosive/poisonous gases exist such as hydrogen sulfide or excess carbon dioxide. If oxygen drops too far, person may lose consciousness and fall. Could cause brain damage, bodily injury or death.
  - Too much oxygen (23%+) can cause extreme explosive hazard.
  - May require gas free certificate authorized by chemist for hot work. Posted at entry.
  - Breathing apparatus tested, ready and available for entry and for rescue personnel standing by the entry point.
  - Communication should be set up before entry, such as radios, hand signals, emergency signal. Entry and exit times recorded.
  - Emergency procedures should be made clear for extraction. Checklist signed by responsible officer.
  - Entry and rescue personnel should be trained and certified.
  - Lifelines and harness should be worn if feasible and available at entry.
  - Protective clothing – coveralls, safety glasses, safety boots, hearing protection, hard hat must be worn.
  - All portable lights must be gas tight and certified safe.
  - Tools must be spark proof.
  - Attendant should not enter unless equipped with breathing apparatus. Should let others know before entry.
  - Liquids in bottoms of tank must be pumped down as far as possible and then vacuumed or drained dry. Scale and sludge must be removed.
  - Valves for liquid entry into tank must be closed and locked out to ensure tank remains dry and to ensure drowning or injury will not occur.
  - Any electricity in space should be off and locked out.
  - Tanks that have contained seawater may have less oxygen since it is used up during steel corrosion.
  - Tanks that have contained oil or fuel may have petroleum vapors that when mixed with air (1-10%) can be flammable or explosive. They may also be poisonous to personnel. They must be lower than the Lower Explosive Limit for entry as shown by calibrated gas tester.
82. How is a fuel tank prepared for cleaning? Describe precautions and tests necessary before personnel are allowed to enter the tank. (Diesel Duck)
- A fuel tank is prepared for cleaning by:
  - Pumping out the tank as far down as possible.
  - Opening tank and venting properly.
  - Follow enclosed space entry procedure as defined in previous question.
83. Describe a safety lamp.
- Normal air contains 21% oxygen. Candles or flame safety lamps cease to burn when oxygen content is lowered to 16%.
  - Unconsciousness in humans occurs at 10% oxygen. Therefore, the user of a safety lamp is warned of oxygen deficiency and can move to a place of safety if the flame were to go out.
  - Flame safety lamps should be used to test the oxygen content before men are allowed to enter places where oxygen deficiency is liable to occur such as enclosed spaces or where CO<sub>2</sub> has been used as an extinguisher.
  - These lamps have been replaced by calibrated gas analyzers in order to also measure concentration of dangerous gases such as Carbon Monoxide, Hydrogen Sulphide or Methane. These gases have levels of toxicity and explosiveness that make a space harmful to humans.
  - The lamp is designed to be safe in spaces that contain combustible gases since the flame is held within a wire gauze mesh so combustion will be restricted to the immediate area of the flame.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- The flame is fuelled by naphtha.
84. Describe a Davey lamp and state how it is used in a fuel tank and a ballast tank. (Diesel Duck)
- This type of lamp is employed for the detection of explosive gases such as methane or hydrogen sulphide.
  - The copper gauze envelope which surrounds the lamp quickly absorbs the low heat of the wick flame. This dissipates the flame before it can pass to the outside of the lamp, which could cause an explosion.
  - The lamp should be carefully handled, not swung around while in a tank.
  - If the percentage of explosive present in the atmosphere, the flame will burn blue.
  - If the flame burns clear, no explosive gases are present.
  - If the flame burns black or goes out, there is not enough oxygen in the compartment, less than 16%.
  - The lamp should be locked before entering tank and the key should be kept outside the space. Do not attempt to open the lamp inside the tank.
  - Ensure the lamp is in good shape and that all guards are in place and that there is sufficient fuel.

### Fuelling:

85. Describe the precautions taken while bunkering. (2006 Exam, Camosun College Sample, Pacific Region Sample)
- Bunkering fuel can be a dangerous procedure to ship's personnel and can be damaging to the environment if proper precautions are not followed:
  - Loading plan should be created and signed off by supervisors involved. Initial soundings should be made known as well as amount planned to be taken on in each tank.
  - Spill cleaning material such as absorbent material, pads, oil boom, etc should be made available.
  - Scuppers should be plugged to contain any spills. Drip trays should be in place and plugged.
  - No smoking signs posted and announcement made.
  - Bravo flag raised (all red) or mast symbol at night (red light) to indicate bunkering to other vessels.
  - Fire extinguishers should be placed near fuelling station.
  - Communication means should be discussed between shore/ship parties. Radios distributed and checked and emergency signals discussed.
  - Emergency procedures should be discussed between all involved. Loading should be stopped in event of any problem.
  - Ventilation systems for accommodation should be on full recirculation so that vapors will not enter ship. Portholes closed.
  - Ship must be properly secured with fire wire attached in case ship has to be led away from dock. Gangway must be in place and secured.
  - Deck should be properly illuminated and safety flashlights nearby.
  - Fire hose should be rigged.
  - Fuel transfer hoses should be tested and certified. Also should be secured and locked together. Flanges should be insulating and hoses non-conductive.
  - Internal fuel transfers and hot-work must stop during bunkering.
  - Distribution valves should all be checked for proper position.
  - Tanks should be filled to 95% max to allow expansion due to heat and slopping during weather.
  - Filling rate should be slowed when tank is nearing full. Room should be allowed at end of bunkering to allow draining of hose.
  - Vents should be checked to ensure they are open during filling.
  - Tank sounding should be taken regularly and communicated to all involved.
  - Samples should be taken to ensure proper flashpoint and quality.
  - Constant watch on filling station and overflows to ensure pollution.

### Electrical Equipment

Safe and efficient operation and maintenance of electrical equipment.

### Ground Faults and Short Circuits:

86. Explain a ground fault. How would you go about finding the fault? How are ground lights fitted in a circuit and how do they function? (2010 Exam, Camosun College Sample, Pacific Region Sample, CCGC Sample, Limnos Sample)
- A ground fault is defined as an accidental electrical connection between the wiring of a piece of equipment and its metal frame or enclosure (e.g. a frayed motor conductor contacting its motor casing).
  - Commonly occur when a decayed wire has some strands of conductor grounding out to metal connected to ship's hull.
  - Can also be caused by water leakage to hull through water such as condensation in an exterior light fixture.
  - The most common ground detection system for a 3 phase AC distribution system utilizes a set of three lamps, each connected between one of the phases and neutral.
  - Normally, the lamps glow with equal brilliance since they are all grounded equally at a common point.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- A ground occurring on one of the phases will cause the lamp for that phase to show a dull light or go out depending on the severity of the fault.
  - This occurs because the ground will create an easier path for current on that phase to flow through rather than the lamp and its resistance.
  - Thus the lamp is short-circuited and cannot glow at normal brilliance.
  - The other ungrounded phase lamps will shine with greater brilliance since the voltage difference between their conductors and ground will be increased with one phase grounded.
  - A test button is fitted to check if lamps are working correctly. When opened, each voltage drop is made identical again so lights should again glow with equal brilliance.
  - Tracing a fault uses the process of elimination. Each panel for the grounded phase is isolated one at a time to see which has ground. Then each circuit breaker for that panel is opened one at a time to see which load is the problem. This can be done with two persons in radio contact, one observing the ground detection lights and one at the affected breaker panel.
  - Unintentional grounds can cause electrical damage and if two grounds occur and there is a path between them, a short circuit results. The stress on electrical insulation is increased due to grounds and leads to more electrical leakage.
87. You have a fuse that keeps blowing, describe your actions. What is short-circuiting? What are the dangers of short-circuiting? (2006, 2011 Exam, Diesel Duck)
- Breakers and fuses are safety devices designed to open circuit to protect against negative effects of high current such as overheating, fire, personal injury / death.
  - A breaker opening or a fuse popping is evidence of a circuit with too much current and likely is evidence of a serious problem that must be looked into.
  - To investigate, the circuit and its consumers must be totally electrically isolated and locked out from all sources and the breaker or fuse tagged "Do not use"
  - A multi-meter could be used to see if proper voltage was getting fed to circuit on source side of breaker/fuse.
  - Each component on circuit could be checked for problems that may lead to grounds/shorts or of a moving component that has become stuck. This could include frayed or burned wiring, bare wires, evidence of arcing or a motor that would not spin freely.
  - A resistance check on multi-meter or megger test could be used to check insulation of components. A low reading tells us that there is a path for current to inadvertently flow to ground.
  - When a problem was found, we would have to re-insulate the problem areas or replace any damaged components.
  - Also, if too many loads are being used on a circuit, this could lead to protective devices opening. The circuit would have to have outlets or loads redistributed.
  - Short circuiting is when an alternate path for current is formed that bypasses all or part of a circuit causing a potentially serious fault.
  - May be a solid (metallic) short or partial (oil/debris) which can vary the amount of current flowing through short
  - The dangers of short circuiting are many. First and foremost, a person who becomes part of a short circuit could be electrocuted by high current flowing through their body. The short could also lead to arcing, fires or equipment damage that may also lead to personal injury or death.
88. Why are fuses fitted to electrical circuits? What could happen if the fuse is replaced with one of higher rating? (2009 Exam, Limnos Sample)
- Current flow through a conductor causes heat.
  - This must be limited to prevent damage.
  - Fuse is merely a piece of metal of specific cross section area and material so that it will heat to the melting point when the specific current rating is exceeded, essentially serving as the circuit's weak link.
  - If a circuit protected by a fuse was to experience an over current situation, fuse melting will open the circuit and protect the conductor and equipment which would be much more expensive to replace.
  - Installing a larger rated fuse (or a solid conductor like a penny) bypasses this safety feature and there would be no protection for the circuit. Wires could get white hot and cause a fire even inside a bulkhead. This would be hard to detect and hard to put out.
89. Why are over current devices necessary in an electrical distribution system? Name three different types of fuses and give uses of each. What is meant by the interrupting capacity of a fuse or breaker? With the aid of simple sketches, explain the operation of a thermal magnetic air circuit breaker. (CCGC Sample)
- McGeorge MEEP p. 149
  - Over current devices are required in an electrical distribution system to protect against damage that excessive currents are capable of including conductor melting and fires.
  - High current flow through a thin fuse wire will raise its temperature, causing it to melt and break the circuit before the current excess reaches a level sufficient to damage other more substantial parts of system.
  - Melting temperatures:
    - a. Tinned Copper – 1080C
    - b. Silver – 960C

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Normal current passes through without overheating.
  - Current Rating – the normal current.
  - Minimum Fusing Current – Smallest current that will cause melting.
  - Fuses are rated for particular AC or DC voltages.
  - Cartridge fuses – Ceramic case, silver wire in quartz with metal end caps. Accurate and safe.
  - Semi-enclosed fuse – Insulated carrier with asbestos lined tube. Fusible wire is replaceable but is exposed and may corrode or be stretched.
90. What is the difference between an Earth and a Short Circuit? (Limnos Sample)
- A short circuit is an electrical fault that provides an alternate path for current, which bypasses all or part of a circuit.
  - A ground fault is an accidental connection between a conductor and the hull that will cause some or all of the current in that conductor to be leaked off to the hull. The circuit may still be complete however is not getting full voltage.
  - A second ground fault on an insulated system will cause a short circuit since the hull creates a path that will bypass loads. This will cause the action of a protective device such as a fuse or breaker.
91. What are the dangers of electric shock to a person?
- Electric shock from a DC source will cause muscle contraction at initial contact and when contact is broken.
  - Shock from AC source causes continuous spasm at 60 Hz that is more serious than DC.
  - Shock may cause unconsciousness, breathing stoppage or heart stoppage depending on current level and where the shock passes through the body.
  - Burns may be visible or internal
  - Due to spasm, body may not allow release of conductor.
  - Current as low as 10mA can be fatal.
  - More dangerous with wet skin due to low resistance. Poor health, cuts or surface damage to skin also lowers resistance.
  - Current flows out through grounded body part.
  - Rubber mats/boots and dry conditions prevent shocks.

### Maintenance:

92. Describe the care and maintenance of electric motors and generators. What precautions should be taken and what would the effect be of overfilling pedestal bearings? (2008 Exam, TCMS Sample, Camosun College Sample, Limnos Sample)
- McGeorge MEEP p. 118-119
  - Dangers of poorly maintained electrical machinery include overheating, fire and explosions that can destroy machinery and injure or kill engine room personnel.
  - For safe and efficient operation of electric generators and motors, constant attention is required. Important maintenance practices include:
  - Machines must be physically and electrically locked out for work/inspection.
  - Check for any signs of arcing or sparking, could mean poor connections or grounds that may lead to short circuiting, damage or fires.
  - Bearing and wearing parts to be checked to see if they are freely turning and within tolerances. If not, to be repaired or replaced.
  - Dirt/oil/moisture should be cleaned off surfaces to prevent insulation breakdown that could lead to ground faults or shorts.
  - An insulation check (megger) should be performed yearly to see how well component is isolated from ground. A low reading should lead to further investigation and repair.
  - Ventilation passages and fan blades should be kept clean and free to allow air cooling. Air filters should be kept clean.
  - Areas surrounding machinery should be free from obstructions and flammable material.
  - Carbon dust from brushes should be cleaned up to prevent arcing, grounding and possible fire.
  - Brush tension should be checked, gear to be inspected for defects. New brushes should be bedded in to prevent poor contact (sparking).
  - The commutator surface can be made smooth with burnishing stone and the mica insulation between segments can be ground down and cleaned to act as better contact surface.
  - Hold down bolts and drive couplings must be secure.
  - Connections must be checked to ensure they stay tight due to vibration.
  - Contacts must be cleaned and change out if worn.
  - Machine should be regularly opened up and inspected for faults.
  - Motor drive belts and shafts should be checked for proper alignment and tension.
  - Anti-condensation heaters should be kept on when machine is not in use. These should also be checked for proper operation.
  - If a pedestal bearing is overfilled, this could cause the oil or grease to expand due to heat and overflow into the generator or motor. Oil is conductive and flammable and this could cause damage from short-circuiting and fire. More importantly, personnel could be injured due to an explosion or fire. Also, if the oil cannot vent properly external to the generator, the end of the generator shaft could be lifted due to oil expansion and cause misalignment with the armature and stator. This changes the air gap and the induction characteristics of the generator and may even cause an explosion if the rotor contacts the stator.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- A person should be very careful when filling this bearing with oil and ensure it is filled exactly to the proper level.
- Regulations are in place for generators that the bearing lubricant cannot be allowed to creep along drive shaft and that an external overflow must expel any excess oil.

### Generators and Motors:

93. Describe fully how you would start up a generator and put it on the switchboard. Also explain how to take a generator off the board and shut it down. (Diesel Duck, Pacific Region Sample, Limnos Sample)
- Diesel powered generators produce the ship service electricity for most vessels. To start and place them online safely, one must:
  - Make sure you are wearing proper safety attire (ear/eye protection, safety boots, etc.)
  - Walk around generator and ensure safety guards are in place, no tools on top, no spilled fuel or oil. No turning gear in place.
  - Oil/coolant levels to be checked. Cooling and fuel valves open and systems primed if not so.
  - Pedestal bearing oil level on generator end should be checked – halfway on sight glass.
  - Should now be OK to press "Start".
  - Check gauges – especially oil pressure. If too low shut down and investigate.
  - Check for fuel and cooling water flow. Check for leaks. Check for abnormal noise. Shut down if engine running poorly. Check tachometer – should be normal value (often 1800 RPM)
  - To manually bring a generator on the board, we will assume there is one already running so a process called paralleling is required:
  - Warm up incoming generator for about ten minutes to get its running parameters close to normal so that it will be able to better take electrical load. Check that it is producing proper voltage.
  - Turn on device called synchroscope so that it points to generator incoming generator. Synchroscope measures relative phase angle between system frequency and the incoming generator frequency.
  - Next use governor control switch to increase or decrease the synchroscope so that it's pointer rotated in a slow clockwise direction. This means that the incoming generator is running at a slightly higher frequency than the one online meaning that it will immediately pick up load when brought on.
  - When the pointer nears 11 o'clock position, the breaker can be closed. This position means that the phases are near identical and this allows the generators to work together. If they were not in phase, the breaker may pop.
  - If the synchroscope was broken or during a blackout, a corresponding set of lights are normally fitted. The breaker can be closed when the lights totally dim – this corresponds to the 12 o'clock position.
  - Now you can use the governor control switches for the online generators to balance the load (measured in kW) by bringing the speed up or down slightly. The faster generator will take more load. Also these switches can be used to bring the generators to the required 60 Hz frequency that North American systems use.
  - The current and power factor of each generator should also be made fairly close if possible through the governor adjustment.
  - The synchroscope can now be turned off and the data detailing the procedure entered into engineering logbook.
  - To take a generator offline when there are at least two running, you must first decrease its load by using the governor control switch to lower its speed. While doing this, you may have to increase the speed of generator (s) remaining online so that it slowly accepts the load and remains close to 60 Hz.
  - When there is roughly 10-50 kW remaining on outgoing generator, its breaker can be tripped open to take it off the bus.
  - The other generator(s) should be checked to see that they are handling the load properly at 60 Hz.
  - The generator can now be let to cool down since it is coming off load. If there is a slow idle speed, then it can be brought to that level for about 10 minutes and then shut down. Normally this is a stop button either on the panel or local.
  - The procedure details should be entered into the engine room log. A walk around of the generator should now be completed to check that it would be ready to start again if required.
94. Describe a four pole compound DC generator or motor. How would you restore the generator's polarity if it were lost? How could it be reversed? What is the main difference between a generator and motor operation? (Diesel Duck, Camosun College Sample)
- Motor characteristics:
    - a. Good starting torque
    - b. Flexible speed control
    - c. Also good with constant load /speed
  - Used for:
    - a. Centrifugal pumps, cargo winches, boat hoists, air compressors
  - The different windings of shunt and series generators are combined in this type of motor.
  - A motor may lose its residual magnetism of the poles that is essential for generation of shunt field strength.
  - A current passed through the shunt field coils in the direction that will re-magnetize the iron core in the right way. Current for restoration can be obtained from another DC generator or from a battery. The machine must be stopped for this "flashing of the field".
95. Describe a DC generator. How does loading affect a compound DC generator and what happens when overloaded? (2008 Exam, Diesel Duck, Camosun College Sample)

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- McGeorge MEEP, p.83-98
  - Operation of a DC generator relies on the principle that when magnetic lines of force are cut by a conductor, a voltage is induced in the conductor.
  - Size of induced voltage and resulting current are dependent on magnetic field strength, length of conductor and speed of cutting.
  - A practical DC generator has a large number of conductors made up of insulated coils that are rotated in the magnetic field.
  - They are fixed in the axial slots of a cylindrical rotor (armature) and retained by wedges and binding wire.
  - The coils are assembled in an overlap arrangement and coil span is equal to pole pitch.
  - When the armature is turning, the two sides of several coils are simultaneously passing a pair of poles and current is generated between them.
  - The magnetic poles of a DC generator are magnetized iron cores with superimposed windings.
  - The residual magnetism of the cores is essential to the initiation of current generation.
  - When the generator is started, the rotating armature windings have current induced in them only because they cut through this weak field.
  - The small generated current passes to the windings on the poles via the commutator and brushes.
  - The electromagnetic effect greatly boosts the initially small residual field.
  - The field pole windings can be connected in series, parallel (shunt) or both (compound) with the armature. The compound is most often used.
  - The commutator is fitted to the end of the armature and it is made up of a large number of copper segments clamped to form a drum-like extension of the armature.
  - Each segment has connections from two adjacent conductor coils.
  - Carbon brushes held in by spring pressure are in contact with the rotating commutator. They take part in current flow from the armature.
  - Overloading of a generator can take place when a load is grounded or if too many loads are energized.
  - This overloading can cause damage to the machine windings and could lead to fire and failure.
  - This is protected from happening by an overload trip that is fitted to the generator circuit breaker. If excess current persists for a short time, the trip opens the breaker protecting the generator.
96. The brushes are staggered on a DC generator. What does this mean? How is it done and what advantage is gained by doing it? What are earths and grounds? Make a sketch showing how the earth lamps are fitted. What information do they give? (Diesel Duck)
- Staggering means placing the brushes so they all do not bear on the same area. Otherwise, this could cause grooving of the commutator.
  - This is done by lifting all brushes and placing a piece of heavy paper around the commutator.
  - Mark the edge of each brush on the paper. Lift brushes again and remove paper. Measure distances between markings and adjust for full coverage.
  - See question #1 for earth lamp info.
97. Describe in detail an electrical generator as used aboard ship. What is the usual method of fitting it aboard ship and why should this be so? (Diesel Duck)
98. Describe the construction and operation of a generator. Explain and give an example of where used: (Diesel Duck, Camosun College Sample, Pacific Region Sample)
- a. Series windings
    - i. The field pole windings are connected in series with the armature.
    - ii. The small current produced in the armature when started due to residual magnetism is delivered to the windings and boosts magnetic field strength.
    - iii. Voltage builds as the armature conductors cut through the stronger field and in turn the voltage pushes a greater current through the field windings.
    - iv. The mutual build up cause voltage to reach its peak quickly.
    - v. Voltage is restricted to a certain maximum due to the many turns of fine wire in the shunt windings, which gives high resistance and limits current.
    - vi. Will run with no load at max voltage.
    - vii. When loaded, terminal voltage will droop, cannot deliver full voltage unless an AVR is fitted which adjusts the shunt field with a rheostat.
    - viii. Speed droop offers good load sharing for machines in parallel.
  - b. Shunt windings
    - i. The field pole windings are connected in parallel with the armature.
    - ii. Circuit is only complete when the breaker is closed and there is a load.
    - iii. With no load, the machine relies on residual magnetism of pole cores to produce voltage.
    - iv. The weak field induces low voltage until load current augments field strength then the terminal voltage rises.
    - v. Increase in current taken by the load results in greater terminal voltage until the field reaches saturation point.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- vi. Series windings are heavier than shunt windings because they carry full load current and must have low resistance for low voltage drop.
  - vii. Have limited use for special applications since.
  - c. Compound windings
    - i. Shunt and series field windings are combined to give almost constant voltage over the operating range.
    - ii. Both shunt and series windings are mounted on the same pole cores but one is parallel and one is in series with the armature.
    - iii. Shunt field provides full voltage after initial build up at no load.
    - iv. With increasing load, shunt field voltage drops but series field voltage rises for balance.
    - v. Ratio of shunt to series can be altered to give different characteristics.
99. Describe the following components on a DC generator and their purpose: (Camosun College Sample)
- d. Armature
    - i. Rotating cylinder that houses poles and field windings for generation of EMF.
  - e. Commutator
    - i. A split ring at end of armature that collects the current
  - f. Brush Gear
    - i. Transmits current from commutator to load.
  - g. Poles and Field windings
    - i. Produce magnetic field (flux) when current is passed through them, allowing the armature to build up generator EMF.
100. What are the probable causes of sparking at the brushes on a generator? How would you install a new set of brushes? (Camosun College Sample)
- Brush sparking could be the result of:
    - a. Overload
    - b. Brushes set wrong
    - c. Poor brush contact
    - d. Rough Commutator
    - e. Weak field
    - f. Armature winding broken or short circuited.
  - To fit a new set of brushes, the neutral point of brushes should be found. The neutral point is where the voltage is the highest and the sparking at the brushes is at the least.
  - With the machine running, loosen the locking gear on the brush rigging and using the handle, shift the brushes back and forth watching the voltmeter. The voltmeter will read the highest when the brushes pass over the neutral point. Lock the brush rigging here.
  - If the brushes are not at the neutral point, more field current must be used to get the required voltage thus heating up the field poles. Sparking at the brushes will cause the commutator to run hot.

### Principles:

101. Define the following electrical terms (Diesel Duck, Camosun College Sample):
- h. Volt
    - The derived unit of measure for electric potential difference or electromotive force (EMF)
    - A measure of strength of an electrical source of how much force is produced for a given current and resistance.
    - Equivalent to the potential difference across a resistance of one ohm when 1 ampere is flowing through it.
    - i. Ampere
      - The derived unit of measure for electric current. (1 coulomb per second)
      - Equivalent to the steady current produced by one volt across a resistance of one ohm.
    - j. Ohm
      - The derived unit of measure for electric resistance.
      - Equivalent to the resistance of a circuit in which a potential difference of one volt produces a current of one ampere.
    - k. Watt
      - The derived unit of measure for electrical power. (1 joule per second)
      - Equivalent to the power produced by a current of one ampere across the potential difference of one volt.
      - l. Electrical horsepower
        - The electrical power created by a generator or motor that uses the ratio:
        - 1 HP = 746 W
      - m. Ohm's Law
        - Named after discovering scientist George Ohm in 1827.
        - The potential difference or voltage drop between the ends of a conductor and the current flowing through the conductor are proportional at a given temperature ( $V=IR$ )



# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- If we apply potential of one volt through resistance of one ohm then a current one of 1 amp will flow through.

102. What is an electrical conductor? An insulator? What materials are used for each? (Diesel Duck)

Conductor – an element in which atom electrons in outer orbit are readily removed or added to.

- Allow easy passage of electric current. Low resistance.
- Most metals are conductors, copper used most often since cheaper (than silver which is best).

Insulator – an element that has an atomic structure that greatly impedes the free movement of electrons.

- Do not allow easy passage of electricity. High resistance.
- Glass and rubber are common insulators.

103. What is a rheostat? Why is it used and how does it operate? (Camosun College Sample, CCGC Sample)

- A rheostat is an instrument used for regulating the strength of an electric current by varying the resistance in the circuit.

104. What is the difference between AC and DC electricity? How is DC generated? (CCGC Sample)

- Taylor p. 253
- Alternating current has now all but replaced direct current as the standard supply for all marine installations.
- The use of AC has a number of important advantages:
  - Reduced building cost
  - Less weight and space required
  - Reduced maintenance
- Advantages of DC:
  - Better motor control
- DC generator has armature as rotor and field poles as stator.
- AC generator has armature as stator and field poles as rotor.
- This means:
  - No slip rings or brushes and their required maintenance
- AC sine wave contains no harmonics, eddy current and hysteresis losses are reduced and efficiency is gained.

Switchboard Instruments:

105. Describe the purpose of a voltmeter and ammeter. Sketch and explain how are they fitted into a circuit? (Diesel Duck, Camosun College Sample, CCGC Sample, Limnos Sample)

- Voltmeter – voltage always appears between two points, or across a supply
  - Need high resistance, low current
  - Mounted in parallel
- Ammeter
  - Need low resistance, high current
  - Mounted in series

106. Sketch the connections of an electrical switchboard showing: (Diesel Duck)

- n. Switch
- o. Fuses
- p. Instruments
- q. Ground Lamps

107. List and state the purpose of all the instruments and fittings to be found on the switchboard of a DC generator. Which of these are used to calculate the power output of the generator? (Camosun College Sample, Pacific Region Sample, Limnos Sample)

Batteries:

108. Where are batteries used on a ship? What care must be taken in places where batteries are located? Describe the construction of a storage battery. (2011 Exam, Camosun College Sample, Pacific Region Sample)

- Batteries can be used several places aboard ships:
  - To start engines in auxiliary boats
  - To start engines, generators and emergency generators
  - To start engine for emergency air compressor or fire pump
  - To run emergency lighting, radios (GMDSS), general or fire alarms
- Battery compartments must have some safety considerations:
  - Must be properly vented to exterior to allow escape of hydrogen gas developed by chemical reaction inside a battery. Gas is flammable.
  - Lighting must be explosion proof.
  - Batteries must be housed in protective casings that are made of non-conductive material such as wood or plastic.
  - Batteries must be protected from freezing or over heating.
  - Batteries must be kept upright to prevent spilling of acid. Drip trays installed.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Eye wash kit close by. Goggles, gloves, boots close by and worn when needed.
- No smoking signs, no flames nearby.
- Insulated tools.

109. With the aid of a sketch, describe the chemical reaction of a storage battery. (Diesel Duck, Camosun College Sample, Pacific Region Sample)

- A typical storage battery is a 12 Volt lead acid battery. It has a positive and negative terminal at either end to which loads and the charging system are connected to.
- The casing is typically a non-conductive heavy duty plastic that is acid proof.
- Inside are 6 cells that each produces 2 volts in series to provide 12 volts.
- In each cell, there are at least two plates called electrodes in an electrolyte solution. The greater number of plates, the more current capacity. The anode (negative side) is normally pure lead (Pb). The cathode (positive side) is lead peroxide (PbO<sub>2</sub>). The electrolyte is sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) diluted with water (H<sub>2</sub>O).
- To produce current, the sulfuric acid breaks down into positively charged hydrogen ions (H<sup>+</sup>) and negatively charged sulfate ions (SO<sub>4</sub><sup>2-</sup>). The sulfate ions give their negative charge to the cathode forming lead sulfate. The hydrogen ions give their positive charge to the anode giving them to the lead peroxide and unite with the oxygen to form water.
- The cell continues until both plates are reduced to lead sulfate.
- For the charging process, a current is passed through the cells from an exterior source such as a charger or alternator.
- The water gets broken up into positively charged hydrogen ions and negatively charged oxygen ions.
- Hydrogen ions unite with sulfate on cathode creating sulfuric acid and leaving pure lead on plate.
- Oxygen ions unite with lead on anode to create lead peroxide. The sulfate on anode reacts with both hydrogen and oxygen ions to create more sulfuric acid.
- When all lead sulfate is changed to original materials, battery is fully charged.

Safety:

110. When taking over a watch as engineer, what would be your procedure as far as the electrical equipment in the E/R? (Camosun College Sample)

### Propeller Shaft System

Constructional details of shafting, stern tubes, stern bushings and methods of securing them, constructional details of controllable pitch and fixed pitch propellers, and propeller shafts.

Thrust Blocks:

111. What is the purpose of a thrust block? Describe a single collar thrust block. What are the advantages of a single collar over a multi collar? (2006 Exam, Camosun College Sample, Pacific Region Sample, CCGC Sample)
- McGeorge MAM p. 254-255, McGeorge GEK p. 102-103, Reed's Deck p. 147-148, Taylor p. 200-202, Reed's GEK p. 241-243
  - The purpose of a thrust block is to transmit forward or astern propeller thrust to the hull and limit axial movement of the shaft.
  - It must be solidly constructed to withstand normal and shock loads and rigidly mounted to the hull of the ship to perform task.
  - A modern thrust block that is widely in use is the Mitchell single collar thrust block.
  - Works on the principle that the formation of an oil wedge can create a hydrodynamic layer between metallic faces to transmit thrust yet cause very little wear on bearing faces.
  - Unit has upper and lower housing that can be split for inspection or maintenance.
  - Bearings at either end of block support weight of shaft.
  - Shaft diameter is increased to form a collar in centre of bearing which creates the thrust bearing faces.
  - A fixed ring faces each side of flange. Each side of collar bears on a number of kidney shaped white metal faced pads supported in this ring in carriers.
  - The forward side transmits ahead thrust and the aft face transmits astern thrust.
  - The back of each pad has a hump or stem that allows the pad to tilt or pivot so that the lube oil, picked up by the collar from the bottom of the block (sump) can squeeze its way as a wedge shaped film between the pad and collar.
  - Some axial clearance is necessary to form this wedge and allow for thermal expansion. Clearance is limited to protect machinery. Can be checked by jacking shaft back and forth to measure clearance.
  - The radial pivot line on the pad back varies from 1/2 to 2/3 from the leading edge.
  - The oil is dragged over the whole surface and creates a constant film of oil between faces, thereby not allowing any metallic contact. An oil scraper helps deflect the oil onto the pad surfaces.
  - Thrust pressures in region of 24 bar can be carried without risk of overheating.
  - The oil may be cooled with integrated sea water cooler.
  - There is an air vent for oil compartment and a filler cap, which can also be used as an inspection cover while in operation. Also level glass or dip-stick helps to check for proper level.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- In some bearings, bottom half of bearing casing transmits thrust and pads do not extend all the way to the top.
  - A single collar has a few advantages over a multi-collar type:
    - a. Simpler
    - b. Cheaper
    - c. Easier alignment
    - d. Carries more load for amount of material.
112. Describe a thrust shaft and thrust block. What would be the effect on the engine if the thrust block became loose on its seating? How is the thrust block secured in the vessel? (Diesel Duck)
- McGeorge MAM p.255
  - See above for description of Mitchell thrust block.
  - If a thrust block became loose on its seating, the propeller thrust would be transmitted directly to the engine, most likely causing failure of the crankshaft thrust bearing and massive engine failure due to the misalignment of the crank.
  - The thrust block is bolted to the strengthened double bottom section of the hull. The hold down bolts are relieved of stress by the wedges at the base of the block that are tapered to relieve sheer.
  - The floors in the double bottom are closely pitched.
  - See below for securing arrangement.
113. Describe some type of thrust block. Why is it fitted? How is it secured to the hull of the ship? (2008 Exam)
- McGeorge MAM p. 254
  - The substantial double bottom structure under the main propulsion machinery provides an ideal foundation for the thrust block and a further reason for placing it near the engine.
  - The upright thrust block and any supporting frames must have adequate strength to withstand the effect of loading which tends to cause a forward tilt.
  - This results in lift of the aft journal of the thrust block and misalignment of the shaft.
  - Axial vibration of the shaft caused by the propeller or diesel is normally dampened in the thrust block.

### Stern Tubes:

114. Describe a stern tube for use on a single screw steel vessel and explain how the tube is held in position at the stern frame and aft peak bulkhead. (TCMS Sample, 2009 Exam, Diesel Duck, Pacific Region Sample, CCGGC Sample)
- Reed's GEK p. 231-232, Taylor p. 204-205, Reed's Deck p. 150-153, McGeorge MAM p. 260
  - The stern tube carries the weight of the propeller shaft and propeller.
  - It is fitted with bearing material along some of its length which could be lignum vitae, white metal or a composite material.
  - The shaft itself is normally fitted with a bronze liner that is shrunk on to protect it from seawater corrosion
  - There is a rubber seal between liner hub and liner end to stop shaft corrosion inside propeller hub.
  - The tube is often cast iron or steel that is fitted with a shaft gland or mechanical seal at forward end to prevent water from entering vessel.
  - If a gland (stuffing box) is fitted, a slight trickle of water should be visible in shaft tunnel to confirm cooling is taking place. This should be adjusted to avoid overheating or flooding.
  - The tube is fitted between aft peak bulkhead and stern frame. The stern frame boss offers strong support at aft end.
  - A steel nut at outboard end retains the tube in position with its collar hard against stern frame. A brass ring sealed around steel nut protects against corrosion
  - The front of the tube is held by welded studs to aft peak bulkhead.
  - A slotted brass bush is used to hold strips of bearing material fitted fore and aft to a length of at least 4x shaft diameter.
  - Staves have U or V shaped grooves between them to allow cooling water flow and lubrication. This will also accommodate any debris which can then be flushed out.
  - The bush is held by a bushing neck at forward end and ring flange at aft end.
  - Cooling water from central/engine cooling exits through back of tube.
115. State method for measuring wear down. What is meant by wear down and what are effects of a worn bearing? (Diesel Duck, Pacific Region Sample)
- Reed's Deck p. 150
  - Wear down is the amount of clearance between a shaft and the stern tube bearing surface.
  - It is checked in dry-dock with feeler gauges or a poker gauge for perpendicular clearance measurements.
  - Wear down occurs during normal bearing wear of the shaft turning inside tube. Since the shaft or shaft liner is harder than the bearing, it is first to yield material.
  - A worn bearing will allow the shaft to rotate erratically due to centrifugal force. This bending could cause alternating tensile and compressive stresses and possible fracture of shaft. May also cause seal/gland problems, causing flooding.
  - If a bearing were found to be excessively worn, it would have to be replaced to original dimensions.

### Propellers:

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

116. What is meant by pitch of a propeller? If a ship was in dry-dock how would you check pitch? (Diesel Duck)
- Pitch refers to the linear distance each revolution of the propeller should push the vessel in a solid medium with no slip.
  - Pitch can be measured with a pitchometer. It consists of two legs, which will open out on a hinge like a joiners folding rule.
  - One leg is held in the plane of rotation by plumb bob while the other leg is opened out in line with the blade face.
  - An engraved protractor on the instrument reads the pitch off a table for various combinations of pitch angle and radius.
  - The pitch angle of the driving face of the blade is measured in several locations along the blade noting the radius from the centre of the section at which the pitch angle is measured.
  - Then the formula:  $Pitch = 2\pi R(\tan\theta)$ .  $\theta$  is the average angle.
117. How is a keyed propeller fitted to a shaft and secured so it won't work loose at sea? (Diesel Duck)
- The connection is referred to as a friction tapered fit. The inside of the hub must match closely with the outside of the shaft to a percentage governed by regulations. Checked using machinists bluing during dry-dock. The key is then fitted and nut driven on to check if the match is close enough. If not, the inside of the propeller is sanded or scraped to better fit until the inspector is content.
118. With the aid of a sketch, describe a hydraulic method of fitting a keyless propeller. What are the advantages of this system over the keyed propeller? (CCGC Sample)
- Taylor p. 206-207, McGeorge MAM p. 273
  - The Pilgrim Nut is a patented device that provides a predetermined frictional grip between the propeller and shaft.
  - With this arrangement, the engine torque may be transmitted to the propeller without loading of a keyway.
  - The Pilgrim Nut is essentially a threaded hydraulic jack that is screwed onto the tail-shaft.
  - A steel ring receives thrust from a hydraulically pressurized nitrile rubber tire.
  - This thrust pushes against the propeller, which is forced onto the tapered shaft.
  - Propeller removal is achieved by reversing the Pilgrim Nut and using a withdrawal plate that is fastened to the propeller boss by studs.
  - When the tire is pressurized in this mode, the propeller is drawn off the taper.
119. Describe a built up propeller. State the materials used in its construction and explain how the blades are secured to the boss. What are the advantages and disadvantages compared to solid construction and controllable pitch? (Pacific Region Sample)
- A built up propeller is built in sections as compared to the one-piece solid type.
  - It consists of a hub to which a designed number of blades are bolted on.
  - The advantage is that if one blade is damaged it may be replaced independently, possibly without dry-dock.
  - Also, by fitting different blades, it is possible to change pitch.
  - The disadvantage is that this results in a heavier, less efficient design that has a higher initial cost.
  - The advantages of a solid propeller are that it can have a higher number of blades, it is relatively light and more efficient due to streamlined shape.
  - The disadvantages are that if a blade is severely damaged, the whole unit must be replaced. Also, the pitch cannot be altered and a spare requires more storage space than individual hubs.
  - The advantages of controllable pitch are that the engine can be run at its efficient speed at all times, it is well suited for bridge control, quicker to maneuver, blades can also be changed out individually.
  - The disadvantages are that it is more expensive, heavier, additional machinery required (OD box, etc) and the propeller is not as efficient.

### Alignment and Measurement:

120. Describe how you would line up the shafting from engine to propeller when the vessel was afloat. Describe how you would fit a propeller when the vessel was in dry-dock. What are the duties of an engineer when the vessel is in dry-dock? (Inspection of propeller, shaft, rudder – defects and how they could be corrected). (Diesel Duck, Limnos Sample)
- McGeorge MAM p. 247-248
  - The intention of good alignment is to ensure that bearings are correctly loaded and that the shaft is not severely stressed.
  - Alignment can be checked by conventional methods:
    - a. Light and targets
    - b. Laser
    - c. Taut wire deviations
  - However, there is a continuity problem because the line of sight or wire cannot extend over the full length of an installed shaft.
  - There is no access to the shaft inside stern tube and access is difficult in way of propulsion machinery.
  - Results are also uncertain since the hull loading may not be the same as it was during installation or during the last check.
  - The method of jacking to assess correct bearing loads is used as a realistic means of ensuring that the shaft installation is satisfactory.
  - The load on each bearing should be the weight of the shaft divided by the number of bearings.
  - A hydraulic jack is placed under the shaft on each side of a bearing and a dial gauge is fitted to the top of the shaft.
  - Hydraulic pressure is pumped in and this registers a measurable load at the point when the shaft begins to lift.
  - If this load is too high or too low, the bearing must be altered in order to achieve better shaft alignment.

### Shafting:

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

121. How is the rotary motion of the crankshaft transmitted to the propeller (shafts, thrust block, gearbox, etc)? (Diesel Duck)

- McGeorge MAM p. 250
- The crankshaft thrust/motion is transmitted through the engine thrust bearing(s) to the gearbox.
- The gearbox transmits thrust/motion through its thrust bearing to the thrust shaft.
- The thrust shaft transmits thrust/motion through the thrust block to the intermediate shaft(s)
- The intermediate shaft(s) transmit motion through the propeller shaft.
- The propeller shaft transmits motion to the propeller.

### Rudder

Methods of supporting the rudder, constructional details of rudder and pintles.

122. Describe a rudder and its pintles as fitted to a ship. Show in detail how the rudder is supported. What limits its movements? How is wear down measured and remedied? How are the quadrant and tiller fitted? (2008 Exam, Diesel Duck, Pacific Region Sample)

- Built streamlined in shape to reduce resistance of water passing over surface and to minimize cavitation.
- In order to provide sufficient strength, ship rudders are generally made with two plates with internal vertical and horizontal stiffening.
- Internal stiffening usually fabricated from steel plate but a cast frame and webs could be found in older style rudders.
- One side of double plate rudder is welded using fillet welds. The closing side must be attached using backing bars and slot welds.
- Leading edge of rudder often fitted with a casting and the trailing edge is fitted with a steel bar.
- Internal webs are fitted with lightening holes to lessen weight and provide drainage.
- Bottom of rudder fitted with drain plug.
- Top of rudder fitted with horizontal coupling called a palm that joins to rudder stock.
- Plating at connections is normally thicker to provide additional strength.
- Vertical couplings may be used instead of palm or the rudder stock may be keyed or keyless and taper fitted to rudder.
- A means of lifting rudder is provided for inspection or repair. Often a pipe welded through the rudder at a position that will balance during lift.
- Rudder is coated internally with anticorrosive treatment.
- Pressure tested to ensure watertight.
- Sacrificial anodes fitted to protect steel.
- Surface area roughly 1/60<sup>th</sup> to 1/70<sup>th</sup> of ship's length times depth. Normally twice as tall as wide.
- There are three basic types of rudders:
  - Unbalanced: full steering axis aft of turning axis
    - Supported by use of gudgeons and pintles
    - Gudgeons fitted on forward end of rudder and aft end of stern frame rudder post.
    - Gudgeons may be forged, cast or fabricated and welded on.
    - Bushings normally pressed into gudgeons. May be brass, stainless, synthetic material and lignum vitae.
    - Pintles are pins that are fitted into gudgeons. Have straight, tapered and threaded sections.
    - Tapered middle section fits tightly into one half of gudgeon set and a nut secures pintles to this gudgeon.
    - The straight bottom section fits in other half of gudgeon set.
    - Common to see stainless or brass liner shrunk on here to protect against wear.
    - Top pintle has a head on straight bottom section that creates a locking pintle to stop it from moving up too much.
    - Lower pintle is a bearing pintle and rests on hardened steel disc or a set of bearing rings.
    - Most of weight is carried by carrier bearing not this bottom end bearing.
    - Middle pintles known as intermediate pintles.
    - Once installed, a detachable eddy plate is installed on its leading edge covering the gudgeon pintle arrangements. Helps streamline rudder.
  - Semi-balanced
    - Portion of steering surface forward of turning axis. (Less than 20%.)
    - Offsets some torque required to turn rudder.
    - Can reduce size of steering gear.
    - May use gudgeons and pintles for support or may be completely under-hung – known as a spade rudder. Bearings inside vessel, exposed to damage due to lack of stern frame.
    - May also use a rudder horn or stern frame known as semi spade or mariner.
    - A turning axle may also be fitted passing through a pipe vertically through rudder.
  - Balanced

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- Larger portion of steering surface forward of turning surface (20-40%)
- Same style mounting as semi balanced.
- A rudder's movement is normally limited to roughly 37.5 degrees each way to port and starboard. This is restricted by rudder stops that are flat built up sections that butt up on either side of the tiller to make physical contact.
- Wear down for the carrier bearing is done by comparing the bearings thickness to its original thickness if able to remove it. If not, the rudder can be jacked up and the gap measured with feeler gauges. If excessive, the bearing must be replaced with new.
- The tiller is keyed to the shaft and secured with a nut with locking pin.
- The quadrant is loose on the rudder stock and is connected to the tiller with stiff springs in order to absorb shocks in case the rudder was hit with a heavy sea. The springs stretch and compress to rotate the rudder.

### Hydraulic Systems and Governors

Principles of operation and maintenance of pneumatic, hydraulic, and electronic governors

123. Describe a governor for a generator. Why is it used and what could happen if it became defective? (Diesel Duck)

### Refrigeration

Working principles of operation and maintenance of refrigeration systems

124. Describe a Freon compressor. How would you detect a leak? (Diesel Duck)

- Red Book, Reed's Deck, McGeorge GEK p. 69
- The function of the compressor in a Freon refrigeration circuit is:
  - a. To pull the gas through the system
  - b. Compress refrigerant to a higher pressure and temperature so that its saturation temperature is higher than that of the seawater or air cooling the condenser.
  - c. Discharge refrigerant it to the condenser.
- Driven by an electric motor.
- Started and stopped by the low pressure controller in response to the pressure in the compressor suction.
- Most often are reciprocating in line type and for larger installations V or W type. May also be rotary screw displacement.
- Materials:
  - a. Modern pistons are aluminum alloy
  - b. Rings are cast iron,
  - c. Connecting rods are H section steel forgings with white metal lined steel small end bushes.
  - d. Liners are high tensile cast iron.
  - e. Crankcase and cylinders are iron casting.
  - f. Crankshaft is graphite cast iron.
  - g. Main bearings are also white metal lined steel shells.
- Gas from the evaporator passes through a strainer lined with felt in the suction connection of compressor to trap scale and other impurities.
- Any oil returning with the refrigerant drains to the crankcase through the flaps at the side of the cylinder.
- Delivery valve is held in place by a safety spring which will all valve to lift in the event of liquid carryover to the compressor.
- Suction valve passes gas from the suction space to the cylinders.
- For unloading, this valve is held open to allow gas through machine without compression.
- A strong shaft seal prevents leaking of refrigerant and ingress of air.
- Leak detection on a Freon system can be done with a halide torch that will burn green in the presence of Freon. Also modern electronic detectors can be used at joints or any suspected leak points. If none aboard, a solution of soapy water can be sprayed on to show a leak by bubbling.

### Ship Construction

Elementary knowledge of ship construction and terminology used

125. Describe a double bottom fuel oil storage tank with all its fittings. (Diesel Duck, Camosun College Sample, Pacific Region Sample)

126. Describe a fuel oil settling tank with all its fittings. (Diesel Duck)

- Settling tanks use gravity for the purification of fuel oil.
- When the oil is allowed to stand undisturbed, particles and liquids of higher density will gravitate to the bottom where they are discharged every so often with a manually operated spring loaded sludge cock.

# Mike's Guide

## Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

- This process can be sped up with heat. Steam coils can be used for this purpose.
- These tanks are often lagged to keep the heat in.
- Normally fitted in pairs so that one can be in use for purification while the other is settling.
- Fittings include:
  - a. Sounding pipe with cap and weighted cock.
  - b. Vent with flame trap
  - c. High and low suction valves (extended spindles or quick closing)
  - d. Sludge cock with funnel and pipe to sludge tank.
  - e. Steam heating coils
  - f. Sight glass and overflow alarm along pipe to overflow tank
  - g. Manhole
  - h. Discharge valve near top
  - i. Remote sounding instrument
  - j. Thermometer pocket.

127. What is the purpose of wire gauze diaphragms on fuel vent pipes? (Diesel Duck, Camosun College Sample, Pacific Region Sample)

- Wire diaphragms are used to prevent the spread of fire either out of or into a fuel tank. The flame is spread out over the surface area of the gauze and stopped from penetrating.
- Will also stop sparks from entering tanks.

### Deck Machinery

#### Operations and maintenance of cargo handling equipment and deck machinery

128. Sketch and describe a power driven windlass with which you are familiar. What regular care and attention does it require? How is the machinery protected from seawater? (CCGC Sample)

- Reed's Deck. P. 110-111
- The duty of the windlass is to lift the anchors and assist in warping the ship to a dock.
- Size and power depend on masses of anchor and cable and ship.
- Modern units powered by electric motors.
- Basic design is that of a double purchase lifting machine consisting of a primary shaft, intermediate shaft and two main half shafts with corresponding pinions and gear wheels.
- Primary shaft is driven by worm and worm-wheel through a worm shaft couple to an electric motor.
- Primary shaft carries a pinion that meshes with a gear wheel on the intermediate shaft and then two pinions on the intermediate shaft mesh with two main gear wheels, one on each main half shaft.
- Each main half shaft carries a cable lifter that has snugs around its circumference of the size and pitch to suit the links of the cable.
- The cable lifters are not fixed on the shafts but are mounted freely to allow them to rotate independently.
- A screw operated steel band brake is fitted around a brake drum on the outer edge of the rim to control speed when paying out cable and for locking it when required.
- Power for hoisting is transmitted through a clutch formed by jaws on the side of the main gear wheel that fit correspondingly in a set of jaws on the cable lifter.
- A screwed control rod attached to a cod-piece riding in a groove of either the main gear wheel or cable lifter operates the clutch.
- This allows each anchor to be operated up or down independently.
- Each end of the intermediate shaft extends to a dog clutch to operate a warping drum.
- The windlass requires regular inspection and greasing of moving parts.
- Chain and anchors should be inspected for cracks.
- Oil level should be monitored and regularly changed out with new.
- For protection from the corrosive effects of seawater, the motor must be weatherproof or mounted inside an enclosure.
- Regular painting must be performed to protect from corrosion.
- The threads must be kept clean and well lubricated with weather-proof grease.

## Mike's Guide

---

### Study guide for Transport Canada 3<sup>rd</sup> Class Marine Engineer – EK General

#### Some tips to remember:

- Give at least 2 weeks notice to TCMS office for scheduling.
- General must be written first and it is normally a Monday morning and Motor is normally Tuesday afternoon.
- Exam is 3.5 hours long and 6 out of 9 essay style questions are to be answered.
- Bring money there is a fee for written exams
- Always initial the end of each page/question
- Do a sketch/diagram where possible
- Use your ruler. Do as little freehand as possible
- Try to write as neatly as possible
- Watch your time, allot 1/2 hour to each question
- For oral exam:
  - i. Arrive early to get the fees paid. Fee for oral exam is double the written fees
  - ii. Dress respectfully (golf shirt and khakis at least)
  - iii. Brush up on any exam questions that you were doubtful on. Could have second chance for marks here.
  - iv. Canada Labor Code, Canada Shipping Act, Oil Pollution Prevention, IMO, SOLAS could be topics
  - v. Don't argue unless you are 150% sure you are correct.
  - vi. If the inspector talks, let them. You can say, "I don't know".