Government of the People's Republic of Bangladesh

Department of Shipping

Sample Questions & Answer

Motor Engineering Knowledge

Marine Engineer Officer Class 2 and 1 Combined

Version 01 , Nov 2023

QUESTION 1

A crack has been discovered in the lower section of a bedplate transverse girder;

(a) State with reasons why such a crack could occur.

(b) Explain the procedure to be adopted under these circumstances.

(c) Explain how future incidents may be minimized.

a) Possible reasons for a crack appearing would be:

1. Excess load on the transverse girder from
2. High combustion loads due to excessive power output from that cylinder
3. Misalignment of the bedplate
4. Incorrect tension of the tie bolts for a slow speed engine
5. Manufacturing defect

b) Due to the position of the crack in a highly stressed area of the engine structure, investigation into the extent of the damage would be required and prevention measures implemented to limit crack growth. Checks would be made of the crankshaft deflections and tie rod tension to ensure that these are correct/acceptable.

To investigate the crack, the area around it would be exposed, which could include light grinding to remove the protective paint covering. The best NDT method on-board would be used to find the extent of the crack, and methods such as dye penetrant or magnetic particle investigation (MPI) could be used. Once the extent of the crack is established, then advise would be sought from the engine makers to ensure that the engine is safe to operate. To reduce the loads present in the bedplate, the engine power for those cylinders would be removed by lifting the two fuel pumps. This would be a prudent course of action until the extent of the crack had been fully identified. Class would be informed, especially if repairs are to be actioned, to ensure that any proposed method of repair would be acceptable to them.

c) Future incidents would be minimised by preventing the causes stated in part a). Regular checks would be made on the cylinder powers developed by taking indicator cards, and on the crankshaft alignment by taking deflections. Tie bolt tension would be checked every 12 months. Also crankcase inspections would ensure that visual inspections beneath the bedplate are carried out at every inspection.

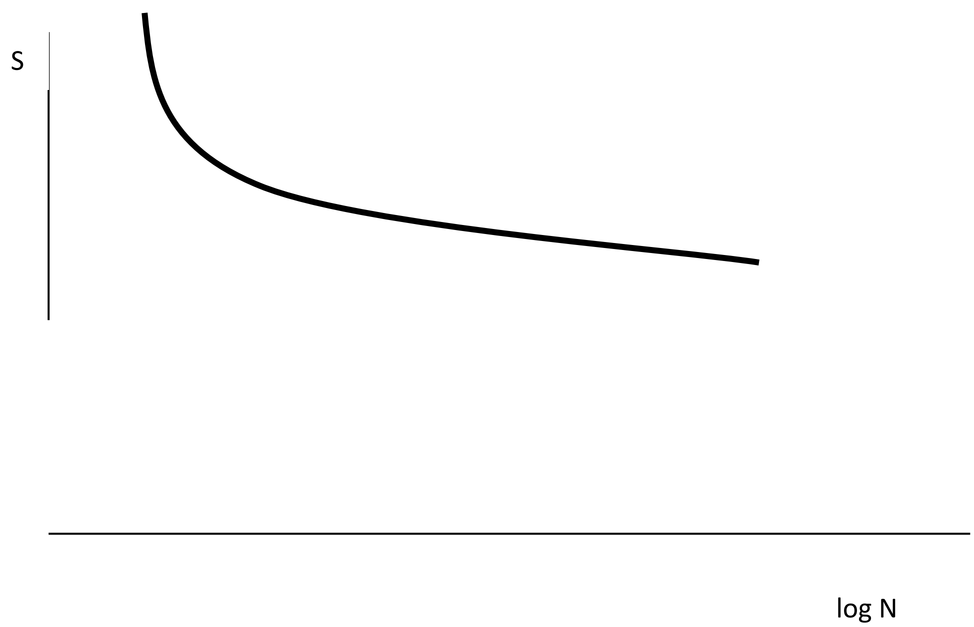
QUESTION 2

(a) With reference to fatigue of engineering components explain the influence of stress level and cyclical frequency on expected operating life.

(b) Explain the influence of material defects on the safe operating life of an engineering component.

(c) **State the factors which influence the possibility of fatigue cracking of a bedplate transverse girder and explain how the risk of such cracking can be minimised.**

a) Fatigue is the failure of a component under fluctuating stress, and as such all components which are exposed to alternating stress must ensure that either it has a defined service lifetime or that the applied level of fluctuating stress is below the fatigue limit for that material. Materials can be tested to find the relationship between the applied stress and the number of stress cycles. These tests produce the characteristic S-N curves as reproduced below, and attempt to define the number of cycles to failure



For the two variables of S and N, it can be seen that if the level of stress increases, then the time to failure is reduced, and the component will fail earlier. Similarly if the component is operated for too many cycles, then it will also fail at the normal level of applied stress.

b) When a material defect occurs, then the level of stress in a localized area around that defect will rise. The level of the stress increase will be dictated by the position of the crack, its orientation to the applied stress, and the level of applied stress in the material. Normally any material defect, which increases the stress level, will cause the component to fail at an earlier stage.

c) The following factors would increase the stress imposed on the girder, and would therefore increase the likelihood of cracking:

a) Engine operating with excessive cylinder pressures
b) Tie bolt tension incorrect, either too high or low
c) Jacking bolts over-tensioned on the Sulzer type slow speed engines
d) Crankshaft alignment poor, either due to local bearing failure or poor chock support, or vessel hull deformation

To minimise these effects the following routine checks should be carried out:

a) Regular monthly checks of engine load using power cards, and measuring the cylinder peak pressures using peak pressure indicators or power cards
b) Regular yearly checks of the tie bolt tension
c) Regular yearly checks of the tension of the main bearing jack bolts
d) Regular three monthly checks of crankshaft alignment.

By preventing an increase the applied stress on the girder, the likelihood of cracking is greatly reduced, however regular visual checks should also be carried out beneath the main bearing.

QUESTION 3

During recent months a number of fuel injector needle valves have seized in their bodies during engine operation.

(a) Explain the effects on engine operation

(b) State the possible causes

(c) As C/E state, with reasons, the instructions to be issued in order to minimise this problem

a) When the fuel injector needle seizes, then this can be when the needle is
- Shut – causing nil or a smaller amount of fuel to be injected (on multi valved engines) causing low cylinder power developed.
- Partly open – causing less fuel to be injected and the injector to dribble causing exhaust smoke and low cylinder power developed.
- Open – causing the injector to inject earlier and the injector to dribble.

b) The possible cause could be either
- Overheating of the fuel injector due to inadequate cooling
- Abrasives in the fuel from inadequate fuel preparation

c) The instructions to be issued would attempt to minimize the present problem and to prevent a re-occurrence. The instructions would

- Take a sample of the fuel entering the engine and send it for analysis to investigate possible contamination from metal elements
- Remove all of the other injectors at the earliest opportunity to examine for defects and to test the injectors.
- Examine the injector tips looking for overheating. If this is present, then check the operation of the injector cooling system (if fitted) and the cylinder head cooling system. Inspect the same system for internal fouling of the heat transfer surfaces. Ensure that the high temp alarms are functioning.
- Ensure that the flow rates for the fuel oil purifiers are as low as possible whilst still maintaining the service tank level. If a gravity disc is used, check that the largest sized disc is fitted without causing water seal failure. Both of these actions will reduce the level of contamination in the purifier clean phase outlet.
- If two settling tanks are available, ensure that the filling of one settling tank differ from that with the active FO separator suction. This will maximise fuel settling time and provide cleaner fuel at the purifier suction.
- Check the condition of the cold and hot fuel oil filters for physical damage, that would allow dirt to pass through the filtering unit.
- Check the correct operation of the fuel injector test unit, with regard to the correct calibration/protective oil

QUESTION 4

(a) Describe the events leading to a crankcase explosion.

(b) State how overheating might be indicated other than by mist detector.

(c) State how the severity of a crankcase explosion is limited.

(d) Emission of flame has in the past caused severe burns to personnel during a crankcase explosion, despite the addition of flame traps. Discuss the procedure in the event of overheating being indicated.

a) The atmosphere inside a crankcase is stable and will not allow combustion or an explosion to occur as there is no ignition or fuel source.

Hence the first event is the production of an explosive mixture. This will occur when the lube oil in the crankcase is heated by a “hot spot” and lube oil coming into contact with this will be evaporated. The evaporated oil then rises within the crankcase, and then condenses in a cooler part of the crankcase. The resultant white mist is within the explosive envelope, and is thus flammable.

The second event is the ignition of this white mist by either the same or another hot spot within the crankcase. When the oil mist is ignited, a crankcase explosion will occur, which will raise the pressure within the crankcase.

b) One of the common areas of overheating is the various bearings within the crankcase. Hence bearing temperature monitors could be used to indicate that a bearing is overheating and could be oil mist generation site.

c) The rapid pressure rise within the crankcase can cause the engine structure to be blown apart, causing physical damage, and the resultant flame travelling across the engine room space causing personnel injury. This pressure rise is limited by the statutory use of relief doors fitted to the crankcase. These doors will open when the pressure rises above 0.02 – 0.1 bar, and prevent the over-pressure of the engine structure. The doors also perform the added function of preventing fresh air ingress into the crankcase where hot burning gases are present, by the quick closing action of the relief door.

d) As the explosion is an uncontrolled event, then great care must be taken to ensure the safety of the engineers within the engine room. MAN B&W recommend that

1. Move away from the crankcase doors immediately
2. Reduce speed to slow, and ask the bridge to stop
3. When the engine has stopped, close the fuel supply
4. Stop the aux blowers
5. Open the skylight and/or stores hatch
6. Leave the engine room
7. Lock engine room entry doors and keep away from them
8. Prepare the firefighting equipment.
9. Do not open the crankcase for at least 20 minutes after stopping the engine, and ensure that the oil mist detector alarm (or bearing temperature monitor) has reset
10. Stop the LO circulating pump. Shut the starting air, and engage the turning gear.
11. Locate the “hot spot” (source of the oil overheating)
12. Make a permanent repair to the fault

QUESTION 5

State why onboard testing of fuel oil whilst taking bunkers can be advantageous.

(b) State how a representative fuel sample may be obtained during the bunkering operation.

(c) Explain how EACH of the following is formed during the combustion of fuel:-

(i) Oxides of Nitrogen, NOx

(ii) Carbon Monoxide, CO

(iii) Oxides of Sulphur, SOx

(d) State how the effects of sulphurous products of combustion on the engine system may be reduced.

a) On-board testing of the fuel could be carried out during the bunker operation by one of the engineering staff not required to supervise or monitor the bunkering operation. The following tests could be carried out:

- Water content
- Viscosity
- Density
- Compatibility
- Check for abrasive fines

Although the tests are not as accurate as a shore based laboratory the tests would indicate whether the fuel loaded is the same as the fuel quality ordered and therefore the bunker receipt.

b) A representative sample would be obtained by a permanent sampling probe fitted close to the bunkering manifold. The rate of sampling would ensure that a sampling quantity required is taken over the full duration of the bunkering operation. The sample container is then thoroughly mixed before being poured into new, clean containers. The containers are then sealed and signed before being sent to the shore testing facility.

c) Oxides of nitrogen are formed when the nitrogen in the fuel, and some of the nitrogen in the air combines with the oxygen present during combustion in the heat of the combustion process. The quantity of NOx produced is dependent on the temperature and duration of combustion, and the quantity of oxygen present in the combustion space.

Carbon monoxide is formed when the level of oxygen within the combustion space is insufficient to provide complete combustion to carbon dioxide. As usually there is ample oxygen within a diesel engine, readings of carbon monoxide indicate the present of pockets of fuel rich mixtures burning locally without enough oxygen, hence poor fuel/air mixing from incorrect atomization and air turbulence will cause carbon monoxide levels to rise.

Sulphur oxides are formed when the Sulphur in the fuel reacts with the oxygen to form Sulphur monoxide and dioxide. Increasing levels of fuel Sulphur content will increase the Sulphur oxides produced.

d) In order to reduce the effects of the sulphurous products the following can be used:

- Reduce the level of Sulphur in the fuel by using low sulphur fuels
- Counteract the condensation rate of the Sulphur oxides by elevating metal temperatures at the cylinder walls, and the skin temperature of the exhaust gas boiler tubes
- Use of high alkaline lubricating oils to counteract-neutralize the acids formed on condensation.
- Increased frequency of cleaning of the exhaust gas boiler and turbocharger gas turbine

QUESTION 6

(a) **As Chief Engineer describe the procedure involved in the complete inspection of a cylinder liner and piston assembly, indicating areas of significant interest.**

(b) **Explain with reasons possible faults which might be found.**

(c) **Suggest how such faults might be avoided.**

a) Complete inspection will require all components to be removed from the engine and fully dismantled. The initial inspection should be carried out before the components are cleaned to monitor fouling rates, areas of concern such as very dirty liner wall. Once the components have been cleaned, gauging and measurements can be carried out before the final inspection is done. Specific areas of inspection

- Liner wall
- Coolant side of liner
- Lubricator quills
- Piston crown
- Coolant side of piston
- Piston ring area
- Piston rod
- Piston internals

b) Faults

- Excess wear on liner – insufficient lube oil, abrasives in the fuel, liner too cool
- Cracks on liner wall – fuel impingement (inj fault or FO too cold)
- Deposits on liner coolant side – treatment insufficient or oil in water
- Lubricator quills – poor or nil operation due to supply system defect
- Burning and cracking of piston crown – due to fuel impingement or insufficient coolant
- Deposits on piston coolant side – FW treatment insufficient or LO additive depletion
- Wear of piston rings and grooves - insufficient lube oil, abrasives in the fuel, poor combustion (causes excessive carbon build-up)
- Scoring of piston rod – heavy dirt in scavenge space, excess spring tension
- Cracking of the piston mating surfaces – caused by incorrect tensioning procedures

c) Avoidance

1. Ensure adequate LO supply, clean fuel using separator at low through-puts, operate FW coolant at 80 degrees+

2. Regular inspection + testing of fuel injector, correct setting of FO viscosity control to 12cSt
3. Weekly checks of FW condition for nitrate reserve and low level of chlorides
4. Regular check of flow rate from cyl LO unit, plus daily consumption
5. Check piston coolant flow alarms
6. Use LO analysis to ensure LO condition maintained correctly
7. Regular checks of combustion efficiency by maintained fuel injection equipment
8. Regular cleaning of scavenge space. and monitor condition of stuffing box drain
9. Check the internals of the piston and correctly tension piston studs and apply fastening devices

QUESTION 7

Values of some main engine exhaust temperatures displayed in the engine control room differ from those displayed on the engine for the same cylinders.

i) Explain how it may be determined which readings are inaccurate.

ii) State possible reasons for these inaccurate readings.

iii) Explain how the location of the faults may be detected.

b) State the periodic checks which should be carried undertaken to ensure that remote engine instrumentation is readings accurately.

i) Comparisons would be made between the control room display and the local display. The simplest way of providing an accurate reading would be to exchange the local thermometer for a new unit. This new and correct reading would be used as the datum to check the control room display.

ii) The local thermometer could be defective due to

- Vibrations
- Physical damage to the mercury in glass unit

The control room display could be defective due to

- Cable damage
- Physical damage to the probe
- Incorrect power supply to the display unit.
- Defective display gauge

iii) Physical damage to the probe or thermometer would be inspected for by visual observation. Vibration of the mercury in glass units could be identified by the mercury column being detached internally. Cable damage would be inspected for by measuring the resistance of the cable to test for continuity and then an insulation test to check for insulation breakdown. Power supply would be checked using a multi-meter. To check for a defective gauge, exchange the gauge for a new spare and test by calibration test.

iv) All remote engine instrumentation should be calibrated, usually within a six month period. The measuring probe would be removed and placed in a test unit that would either change the temperature or pressure depending on the probe classification. For temperature probes, the test unit temperature would be varied in stages over the expected range of the unit and the display readings examined for errors. The display unit should have zero and span adjustments, and if required these would be adjusted to ensure that accurate readings are displayed. Following the calibration and adjustment, the process would be recorded in the appropriate records.

QUESTION 8

Fatigue is one of the main causes of crankshaft failure.

(a) Indicate on a sketch the most likely location of a fatigue crack.

(b) Explain how a fatigue failure is identified.

(c) Describe how a fatigue crack may be initiated

(d) Describe with the aid of sketches, the methods used to inhibit fatigue crack.

The sketch should show that the crack could start at either

- Beneath the crank pin when the piston is at TDC, crack starting in radii
- From generation position at oil hole

Fatigue failure is identified as starting at a stress raiser or defect, then the crack generates through the material before causing sudden failure. The crack progress is shown as smooth, rippled formation known as striations or beach marks, whilst the sudden failure is a classic brittle fracture with rough appearance.

The initiation site will be where the local stress is high enough to increase the minute cracks which occur on the metal surface. The stress can be increased locally by a surface defect, or even an extreme stress concentration caused by high applied stress.

The main causes of fatigue cracks are:

a)Stress raisers – these can be reduced by ensuring a smooth surface finish to all area where high stress is applied especially in the web/pin radii area

b)Oil holes – these should be minimised whenever possible, and the oil hole opening have wide and smooth radii

c)Tensile stresses – fatigue strength is reduced when tensile stress are present, so the radii areas are often cold rolled to ensure that the fatigue strength in these areas are increased.

d)Stress applied on hardened materials – fatigue cracks can grow faster when the material is harder, as the dislocations in the metal concentrate the stress on a smaller area of the material structure, hence any hardening of the crank pins must not be applied to the highly stressed radii areas.

The answer should include a sketch of these points

QUESTION 9

Accidental grounding of the ship in which you are Chief Engineer has occurred while on passage between ports

a) **Describe your immediate concerns as attempts are made to refloat the ship using the main engines (6)**
b) **Following failure to refloat and assuming operation on residual fuel at the time of the accident state your next priorities (4)**
c) **Describe any checks or inspection you consider necessary before restarting the main engine after the ship has been refloated (6)**

Once a vessel has grounded there are a number of considerations that need to be addressed:

- Has the hull of the vessel been broached during grounding. Sounding all the various tanks that are situated behind the outer hull can check this. If the hull has been broached, then the vessel should not be refloated unless it is determined that sufficient buoyancy and stability remains once the vessel is floating freely.
- Has the hull of the vessel been deformed in any way. This could lead to increased bearing loads on the main engine and/or main transmission shafting
- Has the propeller or rudder become fouled or damaged. Ensuring both units are free to rotate without any excess loads could check this.
- Is the vessel discharging any oil. A check on the tank levels may assist in locating possible damage, but any external pollution should be controlled as soon as practical.
- Are the sea suction intakes blocked/covered by the seabed. Any reduction in the seawater pressure could require that the sea suctions be changed over.

Soundings around the vessel should take place to determine where the vessel has grounded, and the type of seabed on which the vessel is laid.

Once the vessel has been grounded there should be an estimate of when the vessel may be refloated. This could depend on the local tides, vessel loading condition, and vessel ballast condition. If the vessel were fully loaded, then discharge of the cargo may take a number of days, then it may be prudent to reduce the services supplied by the engine room. This will reduce the fuel consumption whilst aground. The limit of services may be dictated by any possible damage to the vessel’s hull.

One area of concern may be that the if the engine were normally operating on residual fuel, then to keep the fuel injection system warm this has to be circulated at all times. Should a fuel injector be leaking, then this could cause a build-up of fuel on top of the piston, which will cause excessive pressure rises when the engine has started. Thus the main engine should be changed over to diesel oil. This change over must avoid high rates of temperature changes, and once fully flushed the fuel oil system can be shutdown until the main engine is required again.

Once the vessel has been refloated, then the following inspections should take place:

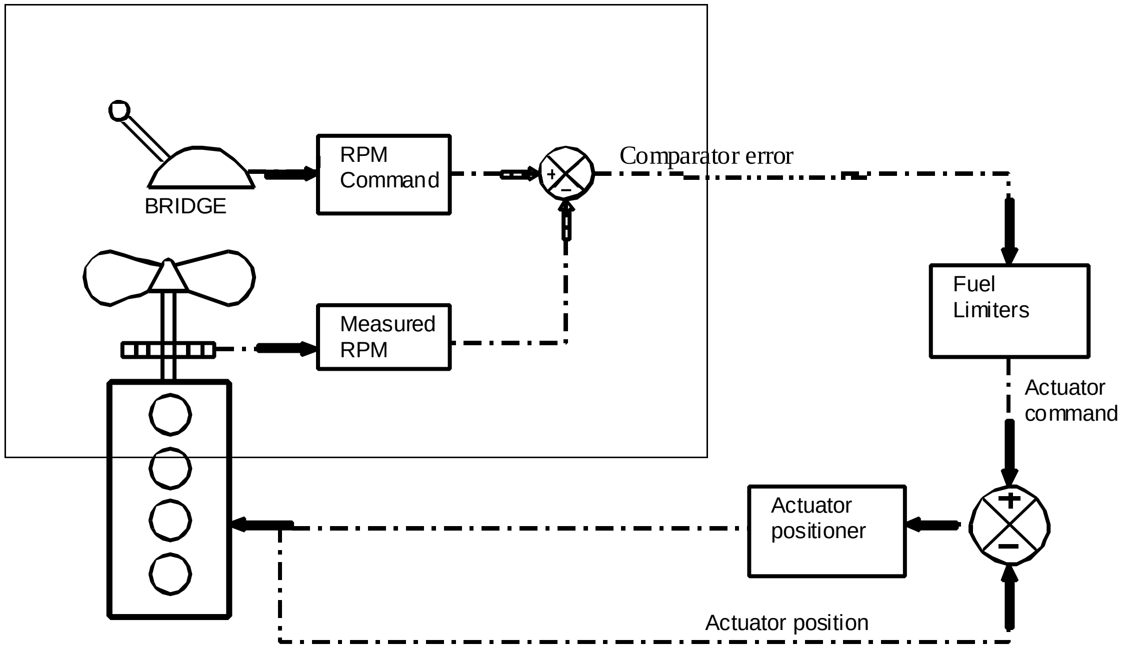
- An in-water survey should be carried out with the agreement of the Classification Society. This will require that the vessel be in clear water, so that divers can examine the underwater portion of the hull. They will examine all hull plating, looking for dents, holes, etc.
- A function test of the rudder and transmission shafting
- A full set of crankshaft deflections should be taken. The readings obtained should be compared with previous readings, and also be within the engine manufacturer's recommendations for that engine. Whilst measuring the deflections, bridge gauge readings may also be taken to ensure that the crankshaft is sitting firmly on the lower bearing half.
- Even though the divers are examining the external hull shell plate, it may also be prudent to examine the cofferdam in way of the main engine seating, to ensure that the full strength of this important seating area is intact before engine power is resumed.

QUESTION 10

(a) With the aid of a block diagram describe the operation of an electronic governor fitted to a main engine.
(b) An engine fitted with an electronic governor behaves erratically during load changes. Explain the possible causes.
(c) Describe a device fitted in order to safeguard an engine in the event of sudden and complete removal of its load.

a) The diagram shows the main components of the electronic or digital governor.

- Bridge command unit. This will indicate both the required direction, and the required speed. This speed signal is sent to the comparator as the RPM command signal
- Engine speed is measured by a toothed wheel fitted at the flywheel. The proximity probe detects the number of teeth per second and sends this signal as the Measured RPM to the comparator.
- The comparator compares the measured and desired values and its output signal is sent to the fuel actuator to minimise this deviation.



DIGITAL GOVERNOR

- The Fuel limiter’s prevent damage to the engine by limiting the fuel during the following conditions
- Insufficient scavenge air
- Excess output torque
- Operation at the critical speed
- Excess fuel command request
- The output from the fuel limiter filter is passed to the actuator fitted at the engine side to control the position of the fuel rack.
- The position of the fuel rack is measured and fed back to the actuator control to prevent excess fuel being requested, which would lead to hunting and instability of the engine speed.

b) Erratic speed control could be due to
- Fluctuating load, due to external weather conditions
- Poor power balance between cylinder, causing the speed to fluctuate even though a stable fuel rack position is present
- Sticking fuel rack, causing the governor input to the engine to be unstable
- Excess gain on the comparators, producing instability. This gain can be adjusted, but is usual a function of speed or external switch position (calm or rough sea)
- Unstable/non-true measurement of the engine speed by the induction pick-ups

- Signal faults between components due to cable damage (earth faults) causing the electrical signals to drift.
- Poor electrical contacts between components due to the effects of vibration.

c) The governor of the engine is fitted to control the engine speed. To enable the engine to be shut down if the load is suddenly removed, then some provision is required to quickly stop fuel injection. This system must be independent of the speed governing system. To enable this to occur, then speed detection and fuel shutoff provision must be made.

- For slow speed engines the speed can be sensed from a digital pick-up similar to the induction pick-up. This speed is measured by the overspeed control system, and if it exceeds the trip value then the fuel rack is shut down. For NSD this is by a collapsible link fitted between the governor and the fuel rack, whereas for MAN B&W this occurs by the puncture valves on the top of each fuel pump opening to spill the high pressure fuel oil.
- For medium speed engines, offset flyweights utilizing centrifugal force sense the speed. At the trip speed, the flyweight will move out activating the stop cylinder. The stop cylinder will move the fuel racks to the no fuel position.

Note the students answer should contain either slow **or** medium speed. Mentioned could also be made that these overspeed trip devices must be manually reset following activation.

QUESTION 11

With reference to torsional vibrations in a main propulsion installation based on medium speed engines, gearbox and controllable pitch propeller:

a) Explain how the vibrations may be caused

b) State the possible effects and damage that could result

c) Discuss the methods employed to minimize the potential problems associated with torsional vibration

a) Torsional vibrations in the installation may be caused by

- Power imbalance of the engine producing a greater variance of torsion produced by the crankshaft
- Operation of the engine at different speeds than normal, which may be closer to the engine critical speeds than normal
- Rotary imbalance of the main engine due to loss of a balance weight
- Damage in the gearing being transmitted to the shafting
- Propeller damage causing rotary imbalance

b)The increase in torsional vibrations would produce an increase in torsional stress. This stress would be imposed on the existing stress levels resulting from torque transmission (torsional shear stress), axial stress resulting from the propeller thrust, and the bending stresses resulting of the shaft alignment.

Hence this increase in stress levels could result in the generation and growth of cracks in the high stress areas of the transmission shaft and propeller. In left in this condition, the cracks could lead to failure of the transmission and hence loss of propulsive power.

The torsional vibrations would also increase wear on the contact faces of the gear teeth, as the contact forces would be varying affecting the lubrication of the gearing.

Torsional vibrations will also distort the crankshaft and shafting, which could result in an increase in bearing loads.

c) The effects of torsional vibrations can be reduced by the following:

- Detuning of the engine. This is carried out by modifying the stiffness of the shaft when the output shaft starts to vibrate. When the shaft starts to torsionally vibrate the springs in the detuner will be compressed, which increases the stiffness of the coupling.
- Dampening. Once the shaft starts to vibrate the energy of vibration is reduced by the free mass moving within the fluid inside the dampener.
- Isolation. The engine can be partly isolated from the gearbox by the use of flexible couplings, whose natural dampening properties will reduce the transmitted level of torsional vibration.
- Operation of the propeller at a different pitch setting, and the propeller pitch change will change the torsional stiffness of the transmission shaft unit.

d) Describe how the natural frequency of the system could be modified

The natural frequency of the system is dependent upon the physical dimensions of the shaft, and its material. Thus the natural frequency can only be changed by altering the shaft dimensions. However consideration must also be given to the minimum size of the shaft required from the torque transmission limit. Thus although the shaft size could be reduced by the utilising of a higher UTS material, this would lead to an increase in possible shaft cracks.

Increasing the size of shaft components such as the flywheel would also affects the natural frequency of the shafting.

QUESTION 12

During the past four months since you have joined the ship as C/E a number of main engine exhaust valves have suffered cracking and corrosion at the seating faces. Write a report to the Superintendent covering the following points:

a) an explanation detailing how the problem became evident

b) **your action upon recognizing the extent and seriousness of the problem**

c) **your reasoned views regarding the possible causes of the problem and recommendations to avoid future incidents**

m.v. Tyneside Trader

Voyage 34L

Yokohama – Pusan

31st September 2023

Main engine exhaust valve failures

Over the past four months, there have been 5 main engine exhaust valve failures, that have twice resulted in an un-scheduled stop at sea. All valves have failed, even though the running hours on each valve are well below the normal overhaul period. The actual and imminent failure of the valves were identified by a sudden rise in cylinder exhaust gas temperature, accompanied by a fall in cylinder compression temperature.

Following the third valve failure, two other exhaust valves were removed and examined, and small cracks were noted from corrosion sites close to the machined sealing face. The size of these cracks did not appear to weaken the material. However since this inspection, two further exhaust valve have failed. Hence it appears that after only 2400 hours in service that all exhaust valve must be removed from service for overhaul. This temporary change in the overhaul schedule for the engine has been implemented until further notice.

Operational factors of the engine such as speed and load have not changed over recent months, nor has other operational parameters such as turbocharger speeds, boost air pressure, or cylinder exhaust gas temperatures. I have included a summary of the engine room log readings as appendix 1 of this report. The small corrosive areas noted in the recent inspections of the valves could indicate a possible cause. To investigate this corrosion further, fuel samples have been taken and forwarded to the Fuel Testing Lab. asking for a full analysis, especially the fuel vanadium and sodium levels. Others possible factors such as incorrect valve clearances and valve carbon build up have been dismissed following detailed investigations on-board.

Until the fuel lab. can confirm or otherwise the level of contaminants in the fuel, then the overhaul period of the valves will be maintained at the low level previously specified. The UMS operations of the engine room has been halted, to enable a closer watch on possible cylinder exhaust gas temperature rises, that could indicate premature valve failures.

Should the vanadium and sodium contamination level be high, then I propose that all fuel ordered for the vessels should specify a lower limit to avoid further problems of this nature. Please note that present spares levels for these valves is presently acceptable.

QUESTION 13

With respect to "Scavenge fire" Describe;

a) What is "scavenge fire" and how it is caused.

b) Action to be taken during Scavenge fire.

c) Action to be taken incase of Scavenge fire during maneuvering.

a) A scavenge fire can occur when the accumulated oil in the scavenge spaces are ignited by blow past from the combustion space. The oil within the scavenge space is present due to the drainage from the piston ring area, and should flow out of the engine under constant "blow down" into a drain tank. Normally no blow past should be present, but when excess liner and ring wear is present thus could occur.

Scavenge fires can cause distortion of the diaphragm sealing the scavenge space from the crankcase, as well as failure of sealing rings in that area. In addition the high temperatures can lead to a crankcase explosion, as oil droplets are evaporated within the crankcase.

b) The following standing orders would be written and issued to all Engineering Staff (engine type MAN B&W MC series)

- In the event of a scavenge fire occurring
- Contact the Bridge and request to slow down immediately and stop engine as soon as possible
- Contact Chief Engineer
- Stop engine, and shut off the fuel supply to the engine
- Stop the auxiliary blowers
- Operate the CO_2 extinguishing medium on the affected cylinders

c) In the event of the scavenge fire occurring and that the main engine cannot be stopped, then the following course of action would be taken (engine type MAN B&W MC engine)

- Contact the Bridge and request to slow down to the lowest power possible
- Increase the cylinder lube oil feed rate to the affected cylinder
- Lift the fuel pump on the affected cylinder, using the manual activation of the air cylinder (option fitted for fuel pipe leakage system).
- Prepare the fire fighting equipment to tackle any fire that may be emitted from the scavenge receiver relief valve.
- Move all personnel away from the engine, should the scavenge fire burn long enough to trigger a crankcase explosion.
- The scavenge fire should burn out, once all the oil is consumed.
- Stop the engine as soon as possible, to allow the fire (if still burning to be extinguished) and the affected areas within the engine to be inspected.

QUESTION 14

It is reported to you that the vessel you are about to join as Chief Engineer has already suffered a number of top end bearing failures

a) State, with reasons, the information and documents you would require in order to enable you to assess the causes of such failures
b) State, with reasons, possible causes of top end bearing failures
c) State, with reasons, the procedures you would institute in order to minimise the risk of future failures

a)The following information would be useful in assessing the possible causes of the failure

- History of all work carried out on the bearings, to try and establish if any possible pattern or links exist
- History of bearing clearances, to investigate whether the clearances have been maintained at the correct values
- Readings of the power developed by the engine, to establish if the engine has been operating at overload
- Readings of the maximum combustion pressures developed by each cylinder, to establish if the load on the top end bearing has been excessive
- Readings of the lubricating oil analysis, to determine if the oil condition is acceptable

b)

- Wiping of the bearing due to high bearing loads caused by excessive cylinder pressure being developed
- Insufficient lubricating oil supply due to supply pump failure, failure of the oil piping linkage, oil filter blockage
- Impurities within the lubricating oil, causing abrasion of the bearing and pin surface
- Corrosion of the bearing and pin due to oil contamination with acidic products and/or water
- Wiping of the bearing due to low viscosity of the oil caused by excessive oil temperatures and/or water
- Insufficient bearing clearances within the bearing, causing excessive oil temperatures and hence low oil viscosity
- Excessive bearing clearances within the bearing, causing low oil generated pressures due to excessive bearing end leakage.

c)
Prevention of all of the above causes will reduce the probability of future failures. Hence the following procedures would be instigated:

- Bi- monthly monitoring of all bearing clearances, to ensure these are within normal limits

- Bi -monthly oil analysis of the oil by the oil manufacturer, to ensure oil quality is ensured
- Weekly oil tests on-board for water contamination, dirt levels, viscosity and BN levels, to ensure that the oil condition is acceptable.
- Monthly checks of the lubricating oil low pressure alarm and trip, to ensure that the engine is protected at all times
- Three times a day recording of the supply oil pressure and temperature, to monitor the supply oil
- Monthly monitoring of the cylinder pressures using indicator cards, to prevent bearing overload
- Closely monitor any overhaul and repair work carried out on the bearings to ensure that the correct procedure was being followed, and that the re-assembly was correct
- Monitor any replacement parts that have been used to ensure they are the correct specification
- Monthly checks of the general crankcase to ensure all locking devices are still in place

QUESTION 15

a) State, with reasons, THREE properties required of a crankcase oil which is to be used for a trunk piston main engine

b) Explain how a representative sample of crankcase oil would be obtained from a trunk piston engine

c) Briefly describe the action to be taken if the crankcase oil cannot immediately be replaced and analysis shows:

i) Water is present

ii) Alkalinity has fallen

iii) Viscosity has changed appreciably

iv) Carbon content has increased

The answer should contain three of the following:

Detergency – this keeps the crankcase, bearings and piston rings area clean from sludge and carbonaceous deposits. As the trunk piston engine suffers from a higher level of contamination into the lube oil system than a slow speed engine, then higher levels of detergency are important

Dispersency – The dirt which is removed by the cleaning function is kept in suspension by the dispersency additives. These prevent the buildup of sludge in the cooler regions of the engine

Alkalinity – the level of this property is determined by the level of sulphur within the fuel oil. The additive reduces the corrosive effects which result when the products of combustion condense on the cooler surfaces.

Anti wear – this additive is provided to reduce the wear on the highly loaded areas of the engine, such as the camshaft and gearing areas.

Anti-emulsion – this property allows the oil to be cleaned in a purifier and allow any water contamination to be removed

Stable Viscosity – this is ensured by the use of viscosity stabilizers or improvers which reduce the rate of fall in oil viscosity when the oil temperature increases

Clean burning – as the oil is used to lubricate the piston ring pack, the oil should burn without leaving a residue.

b)The engine should be running at normal load for at least one hour. The sampling point should be at the main LO entry point into the engine. The sampling point should be flushed through and when hot oil issues, a one litre container of oil should be drawn. The oil should be decanted into the sampling container, which is then sealed for analysis.

c)

Water in oil – contamination source should be identified and cured. The water in the oil could be reduced by purifier, if the sump charge is large enough for a continuous purifier operation.

Falling alkalinity – water contamination should be checked as when the water is removed then the alkalinity reserve will also fall. If water is not present then a small addition into the crankcase should be considered. The Sulphur content of the fuel should be checked to ensure that the right grade of oil is being used.

Viscosity has fallen – fuel or water contamination should be suspected. If fuel oil is found within the oil, heating the sample to smell the fuel contamination or testing for the flash point if this is available on-board. Source of the fuel contamination should be identified and cured. Note the diesel oil will reduce and fuel oil will increase the lube oil viscosity.

Carbon content has risen – this indicates that the carbon from the combustion process is contaminating the lube oil. Over the short term, regular filter cleaning is the only course of action open to the engineer, but over the long term the piston rings should be changed, and the fuel injection equipment overhauled.

QUESTION 16

a) **The UMS monitoring and control system of your ship has recently started to give false alarms and incorrect data printouts. State, with reasons, possible causes if the false alarms and readings are:**

i) **localized to a particular area of engine operation**

ii) **general to the engine room**

b) **State, with reasons, the action you, as Chief Engineer, would take to ensure continued safe operation of the vessel if the defects were general to the engine room**

c) **Explain the procedure you, as Chief Engineer, would adopt in order to locate and rectify a general fault in the UMS system**

a)

When the alarms are specific to a certain area of the engine room it would be suspected that the following faults could be present

- Cable fault. If the cable connecting the sensors with the control room were damaged, the resulting short/open circuits could generate false alarms
- Control card/panel fault. The alarms could be grouped within a certain alarm or monitoring panel, and there could be a defect within this panel.
- External interference. Machinery could be operating in the suspect area, which is poorly screened, and the resulting interference could be transmitted via the instrument cables to the monitoring panels.

When the alarms are general to the whole engine room, then the main supply to the alarm and monitoring panel would be checked for

- Earth faults. A combination of earth faults could affect the earth potential and hence the reading of the instrumentation.
- Supply voltage level. The monitoring circuit would use low 24V supply, and this would need to be at the correct level without any voltage ripple present.

b)

The problem with intermittent alarms and incorrect printouts would be that the engineer on duty would be unable to rely on the information given to him by the remote instrumentation and alarm panel. Hence a greater use would need to be taken of the local readings from pressure gauges and thermometers.

This would mean that the UMS operation would be stopped and watch-keeping practices with a manned engine room would be commenced. The watchkeepers would be instructed to complete a full manual log of the various operational parameters of pressure, temperature and the various tank levels. This manual log would be taken every watch period of four hours.

The engineering staff would be divided between the various watch duties, ensuring that all watchkeepers were certified and had the appropriate duty and rest periods assigned to them.

Any machinery units requiring manual control would have their operation explained to all engineers, and a procedural checklist compiled for the operation of all such machinery.

c)

The possible faults stated earlier would be the earth fault or supply irregularity. The earth fault could be identified by observing the 24V distribution panel that would have an earth detection unit fitted. If an earth fault was indicated on this panel then

- A positive earth would be traced by disconnecting the supply fuses **in turn** to parts of the engine room to identify the problem area
- A negative earth would require that each instrument have its earth wire disconnected and left disconnected until the fault is traced. This would mean the loss of many of the instruments within the engine room and could only be carried out when watch keeping duties were active. Each wire would be marked to ensure correct replacement.
- The supply irregularity could be identified by using an oscilloscope, which would show both the level of voltage present and if any supply ripple was present. A simple AVO meter would also indicate correct voltage levels.

The earth fault would be rectified by locating the cable/insulation defect and then replacing the cable, or repairing the defect by re-insulating the damaged area.

The supply irregularity would be rectified by replacing the charging unit of the 24V DC supply, and/or replacing any defective batteries.

QUESTION 17

a) **A number of main engine cylinder covers have been subject to cracking during the preceding four months**

i) **Explain possible reasons for this cracking**

ii) **State with reasons the instructions you, as Chief Engineer, would issue in order to reduce the possibility of future cylinder cover cracking**

b) **Cylinder liner wear has increased appreciably during the past six months. Write a brief report to the Engineering Superintendent concerning this matter explaining the possible causes, the immediate action taken to deal with the problem and the**

action you, as Chief Engineer, intend to take in order to reduce the risk of future incidents

i) Cylinder covers are exposed to high levels of working stress resulting from the thermal and pressure stresses of combustion, which are imposed on the stress resulting from initial head tensioning. These stresses could be increased by

- Excess cylinder combustion pressures. This would increase the mechanical or pressure stress on the head.
- Excess cylinder thermal stress produced by excess cylinder temperatures, incorrect cylinder cooling or insufficient cooling water treatment. These would lead to larger temperature differences across the cylinder head material leading to larger thermal stresses.
- Incorrect i.e. over-tensioning of the cylinder cover on assembly. The increase in initial tension would increase the total stress on the cylinder cover, possibly enough to produce cracks in the highly stressed areas of the cylinder cover.

ii) The possibility of cracking would be reduced if all of the above causes were eliminated by correct operation and maintenance of the engine.

- The cylinder combustion pressure would be monitored by indicator cards or peak pressure readings. Engine load could also be measured on-line by exhaust temperatures and turbocharger revolutions, and relating these to the engine model curves or test bed readings. The engine room staff would be told to monitor these readings and ensure the maximum levels given were not exceeded.
- The temperature of the cylinder cooling would be closely monitored to ensure that the temperatures were not excessive (leading to overheating of the liner), or too cold (leading to higher temperature gradients across the liner wall, and hence higher thermal stress). Temperature monitoring would be via control room gauges, and alarm settings.
- Initial tensioning of the cylinder head should be carried out to the recommended hydraulic tension or torque settings. Thus the gauges that are used to determine these levels must be calibrated regularly.
- The reserve of cooling water nitrates must be maintained to reduce scaling or fouling of the cylinder cover heat transfer surfaces, and to maintain the fatigue life of the covers.

b)

During a recent overhaul of No 2 cylinder, the liner wear rate was found to be increasing, and well above the normal and acceptable level of 0.1mm/1000 hours. In order to determine whether this wear was affecting only No 2 cylinder, liner measurements were also taken from No 5 cylinder, which has been recently overhauled. This cylinder also exhibited a rise in liner wear rates, similar to those measured from No 2 cylinder. Visual examination of both the liner surfaces did not show any obvious damage.

Investigations were carried out to check

- Cylinder oil injection rates (found to be normal and the same for the past 18 months)
- Cylinder liner temperatures (all temperatures were normal and steady at the required 85 degrees)
- Fuel oil viscosity (this has been maintained between 13 and 15 cSt)
- Piston ring specification (the same rings have been in use for over 5 years)
- Fuel oil quality. The vessel has changed bunker supplies 9 months ago when the trading area changed. Although usage of the fuel has not presented any other operational difficulties to date, the quality of the fuel could be a possible cause of these high liner wear rates.

I have therefore sent for analysis three samples of fuel from various bunkering dates, including the latest fuel bunkered. These tests indicated that the fuel contaminants were within limits, but the sulphur levels in the fuel were between 3.4 and 3.9%, which are higher than the recommended levels for the grade of cylinder oil presently used on-board. To counteract any further corrosive wear of the liners, I have also increased the cylinder oil dosage rate on all cylinders by 25%, and I await the recommendations of the lubricating oil supplier for advise regarding possible use of a higher BN grade of cylinder oil.

A report is attached showing measurements of the liner to date. All liners will be monitored for wear monthly over the next six months. Please note that at present total liner wear is still acceptable, but should this level of liner wear continue, then the liners would require replacement in less than two years.

QUESTION 18

As Chief Engineer you are requested to survey, on behalf of a Classification society, a crosshead of the engine of another vessel following an unscheduled repair due to bearing failure

a) Outline the information you would require prior to the survey
b) Briefly describe the survey procedure you would adopt stating with reasons the areas which should receive close attention
c) State with reasons what information you would request and/or operation you would require to observe after reassembly of the crosshead

a) Obtain from Class the identification of which cylinder crosshead bearing is to be inspected. Obtain from the vessel the records of any previous inspections/ maintenance carried out on any engine bearings, especially the crosshead bearing under survey inspection. Also obtain the latest indicator cards and log readings taken from the engine to inspect for excess cylinder pressures, and the latest lube oil analysis to inspect for lube oil condition and impurities. Check that there are no outstanding Conditions of Class on the engine that could affect the crosshead bearing.

b) The old bearing would be inspected to attempt to identify the cause of failure, and to ensure that the replaced bearing will not suffer a similar fate in the short to medium term. The following areas would be inspected (assuming only the bearing is to be replaced)

- Surface condition of the bearings to ensure no corrosion present
- Strong attachment of the white metal to the bearing lining
- Clear and adequate oil reservoirs on the lower half
- No corrosion present on the bolts
- All fastening devices to be renewed
- Visual inspection of the crosshead guides for security is bolted, and /or cracks in the frames especially when welded
- Visual examination of the crosshead guide bearings where possible
- The pin would be inspected thoroughly for cracks by NDT methods, especially in way of any radii.
- The pin would also be examined for scoring and overheating caused by the bearing failure. None should be present.
- Visual examination of the oil input pipe for defects and ensure free movement/operation

c) Once the bearing has been assembled, all crosshead clearances would be taken, checked with maker's tolerances, and recorded. The lube oil pump would be started to ensure a flow of oil from the bearing, and the engine turned on the turning gear to ensure that no restriction to movement is present.
Class would be informed by written statement of all readings taken, and that a visual inspection was acceptable.

QUESTION 19

With reference to diesel engine maintenance:

(a) Describe the various means that are available to check the condition of a diesel engine as a guide to when maintenance is actually needed
(b) Compare the methods described in part (a) with the use of planned maintenance schemes

a)

- Various readings taken from running engine, such as pressures and temperatures. These are easily obtained, and can be used to indicate changes in operating conditions when compared to previous stable readings. The readings need to be taken over an extended period of time to avoid rouge readings producing incorrect analysis. Engine builders software programs are available that can analysis such data to indicate the condition of the engine.
- Indicator cards. These can provide useful information about the various pressures of combustion, such as compression pressures (which indicate if a leaking cylinder head

valve is present), combustion pressures (to avoid over loading the engine) and late fuel timing (which would increase burning of the exhaust valves).

- Previous maintenance measurements. These will give an estimate of when maintenance is required, by applying anticipated wear rate levels to the wear already experienced.

b)

Planned maintenance is based on the idea that wear and fouling will take place at a constant or uniform level, and as such regular time based maintenance will correctly ensure the engine operation at all times. However PM based maintenance does not account for changes in environmental or operating conditions. Hence the engine could be overhauled too early or too late using running hours alone.

Also measuring engine parameters is only partly successful in determining engine condition. They often can not monitor slight changes in engine operation, such as fall off in injector performance, even though this can lead to increased fouling etc. Thus condition monitoring should predict major changes, but regular cleaning of T/C and piston rings still require PM schemes that are usually based on time and/or hours.

QUESTION 20

With respect to crankshafts, explain EACH of the following:

a)The causes and effects of torsional vibrations

b)The term critical speed indicating why it can be a problem

c)The term fatigue cracking and state with reasons TWO factors of crankshaft operation which have greatest influence on the likelihood of fatigue cracking.

d)How a detuner or torsional vibration damper can reduce the effects of torsional vibration

a)Torsional vibrations are inherent within diesel engines, due to the varying torque produced by the piston and crank arrangement from each cylinder. This torque variation is further compounded by the arrangement of the firing order of the crankshaft.

The effects of such vibrations is to increase the shear stress and hence total stress levels carried by the crankshaft in service, when other stresses such as bending and combustion loads are present.

b)The critical speed of a shaft occurs when the shaft rotational speed is at or close to resonant conditions. In this condition the torsional vibration of the shaft increases greatly, and will impose very high shear stress on the crankshaft. These levels of stress could even cause crankshaft failure.

c)Fatigue cracking occurs when the primary cause of crack propagation is due to the fluctuating nature of the stress applied to the component.

The following factors could produce fatigue cracking:

- High combustion pressures, increasing the bending stress applied to each crankshaft throw
- Excessive crankshaft bending due to a main bearing failure, which increases the crankshaft bending stresses.

d)The fitting of either a detuner or vibration damper will reduce the vibration levels of the crankshaft when operating in areas of high torsional vibration, such as close or within a critical speed range. The detuner will change the stiffness of the shaft and hence the natural frequency, thus separating the excitation frequency from the component's natural frequency, whereas the damper will absorb the vibration within the shaft, reducing the effects of the torsional vibration.

QUESTION 21

During normal engine operation a turbocharger rapidly loses speed and the speed reduction is accompanied by appreciable noise.

(a) State with reasons the possible causes.
(b) Explain in detail how the engine might be safely operated if the damage caused by this incident is such that the turbocharger cannot function.
(c) State with reasons the factors which may limit engine operating speed with the turbocharger out of operation.

a)The two factors of loud noise and rapid speed reduction indicates that rotational friction has dramatically increased, or the rotor is in contact with the stator, which could be due to

◊ Bearing failure. This would cause the bearing friction to be increased and affect the rotor clearances, causing the rotor to contact the stator.
◊ Mechanical damage to the rotor. Should a component from the combustion chamber be admitted to the exhaust side of the rotor, this will cause an imbalance in the rotor, leading to possible bearing failure
◊ Failure of the water coolant casing. This will admit water to the gas inlet and cause a reduction in the rotor speed

b)The following engine/turbocharger arrangement will be detailed:
Six cylinder main engine, utilizing a constant pressure turbocharger arrangement with two turbochargers. The turbochargers use ball/roller bearings, externally fitted.

The damaged turbocharger needs to be isolated from the air, exhaust and water sides. The exhaust inlet to the turbocharger can be isolated by the fitting of a spade in the pipeline between the exhaust gas manifold and the turbocharger inlet.

The air side cannot be isolated as the auxiliary blower takes its suction via the air filter, thus air isolation of the turbocharger relies on the non-return valve fitted at the inlet to the scavenge air manifold.

As there is no longer any gas flow through the turbocharger, then the water cooling can be isolated by closing the inlet and outlet valves.

The oil in the bearings can also be drained, and the rotor locking plates fitted to prevent any possible rotation of the defective turbocharger rotor. The rotor can be left in place until replacement parts are obtained and fitted.

If the engine was operated at lower powers then the auxiliary blowers may be operated. The electrical load on the auxiliary blowers would need to be monitored if they were operated, to prevent any overheating of the motor.

c)When one of the two turbochargers is isolated, this will reduce the possible air input to the engine, and hence full engine power cannot be developed. The following factors need to be considered when operating the engine:

- Exhaust temperatures. These will rise with the reduction in air delivery. The engine manual would be consulted as to the maximum limit, and this will be around 500 degrees.
- Exhaust smoke levels. These will also rise, and excessive smoke will cause fouling of the turbocharger and exhaust gas boiler
- Maximum engine power. This will be limited due to the factors stated above, and this will probably be approximately 50% power with the loss of one of the two turbochargers.
- Acceleration of the engine. When the engine load is increased then the time taken to increase the load would need to be extended to prevent excessive thermal load
- Speed of the remaining turbocharger. When the engine load is reduced this will also reduce the gas energy, which should ensure that the speed of the working turbocharger would not be excessive, but the engineering staff should also monitor this.

Hence the engine power would be reduced in consideration with all the above factors.

QUESTION 22
With reference to exhaust valves for medium speed or large slow speed engines:

a) Describe FOUR defects to which exhaust valves are prone

b) Explain why stellite is used for some exhaust valves

c) Discuss critically, the alternatives with respects to exhaust valve and seat angles

d) State why temperatures of seat and valve contact surfaces must be limited, and how this may be achieved

a)Exhaust valves are prone to

- Vanadium induced metal loss at the base of the valve
- Cold corrosion of the valve stem due to sulphurous effects
- Impact damage at the valve sealing face causing eventual valve burn out
- Hot corrosion induced metal loss at the sealing face causing valve burn out

b)Stellite is used as the seating material of exhaust valves to resist the corrosion effects of vanadium and sodium. At high temperatures these elements form highly corrosive compounds that attack the metal oxide layer, causing metal loss and eventual valve sealing loss. This can lead to reduced compression pressure, and eventually total loss of engine power on that cylinder. Stellite will reduce these corrosive effects by 50% over conventional steel valves.

c)Although equal angle valve and seats provide for easier maintenance, the operation of the exhaust valve under combined thermal and pressure loads at the operating conditions, means that excessive valve seat contact loads can result. In order to minimize these effects parallel face contact at operating loads are required, and this means that the engine builder must allow for the conflicting effects of the thermal and pressure loads on that particular engine. Hence on some engines the seat may be at a more acute angle than the valve, and visa versa on other engine designs.

d)The corrosive effects on the valve are accelerated at higher operating temperatures. To reduce corrosion and hence the possibility of valve burn out, contact temperatures must be controlled. This is achieved by localized cooling of the valve seat (using cooling passages within the seat on the larger valves, and cooling of the cylinder head on the smaller valves). The valve is cooled by the seat when valve is closed.

QUESTION 23

a) Outline the problems associated with effective lubrication of the liner and piston assembly of a large slow speed engine

b) Describe the appearance and state the causes of EACH of the following
 i) cloverleafing

 ii) microseizure

c) Describe the composition of a cylinder oil suitable for an engine operating on residual fuel

a)The effective lubrication of the cylinder liner and piston assembly requires a constant lubricant feed over the whole liner surface, and that piston movement will generate the oil pressures required to separate the surfaces.

However in the real situation the following problems occur:

- The oil is injected at defined points which can lead to an oversupply at the feed points, and an under supply away from these points
- The residual fuel normally used contains acids and abrasives that will reduce the lubrication properties of the oil
- The normal operation of the piston will cause the piston movement to stop at top dead center, causing any oil pressure developed between the ring and liner to collapse
- The high temperatures present at top dead center reduce the effectiveness of the lubricant
- The feed rate of the lubricant is regulated usually by the speed of the engine, which will cause a mismatch between actual lube oil requirements over a wide range of engine operation, with usually too little an amount of oil injected at low loads and during engine load changes.

b)Cloverleafing will be caused when the supply of lube oil is not uniform around the radial bore of the liner. The normal effect is for the oil to reduce in alkalinity away from the injection point, thus if the oil becomes acidic then high corrosive wear rates will result. This will cause uneven bore wear rates, with heavy wear in the areas furthest away from the oil injection points.

Micro seizure is caused when the liner and piston ring material is pressed together causing localized welding of the material in the absence of sufficient lube oil. The causes are insufficient oil and/or excessive cylinder pressures causes heavy ring/liner contact forces. The appearance is heavy scratching/tearing in the vertical direction, together with a localized hardening of the ring and liner material.

c)The cylinder oil will require

- Ample viscosity to separate the surfaces under high loading conditions
- Sufficient alkaline reserve to neutralize the acids formed by combustion of residual fuel oil
- High levels of detergent to maintain piston ring cleanliness and free ring movement
- A level of anti-wear properties to minimize micro seizure
- The ability to burn without residue

QUESTION 24

With reference to pistons

a) explain the term thermal stress and state how it is caused

b) describe with aid of sketches, a composite piston used for m/s engines state with reasons the material used for each part of the piston

c) state with reasons possible cause of persistent burning of piston crowns

a) Thermal stress is caused when the free expansion of the surface metal is prevented by the relative cool metal of the main structure. This is caused when the piston surface is exposed to the hot temperatures of combustion and the outer skin of the piston expands. However this expansion is prevented by the main piston body, which leads to compressive thermal stress in the piston skin, and tensile thermal stress in the piston body.

b) The sketch of the piston will show the following components

- Piston crown – made from cast steel for high temperature strength
- Piston body – made from aluminium for low weight and inertia loads
- Piston skirt – made from cast iron to minimize liner scuffing
- Gudgeon pin – made from alloy steel for strength & corrosion resistance
- Top end bearing – made from brass and white metal for lubrication purposes
- Crown fastening bolts – made from alloy steel for strength

Remember to show how the piston top end is lubricated and the piston crown cooled by oil.

c) Persistent burning of the piston crown is due to localized excess temperatures in that region. This could be due to either excessive external skin temperatures due to fuel impingement (fuel injector defect or incorrect fuel viscosity), or excessive internal skin temperatures due to fouling/scaling of the coolant surfaces.

QUESTION 25

(a) State the condition of operating Main engine with one unit disabled condition.

(b) State the procedure to cut-off one unit of Main engine

(c) State the precaution to be taken upon one unit cut-off of Main engine.

a) One unit may need to be disabled when any of these conditions exist

- Damage to a main component of the combustion chamber
- Damage to a crosshead or bottom end bearing on that cylinder

b) The following sequence would be carried out for our vessels which use the MAN B&W slow speed engine:

- Stop engine, isolate systems and allow to cool
- Ensure a procedure is written that minimises the risk to personnel during the operation. Discuss the task and written procedure with the engine room personnel to ensure they are familiar with the risks, and the methods to be used to minimise these risks.
- Ensure the fuel pump is de-activated by lifting roller and locking.
- Lift exhaust valve actuators so exhaust valve remains closed during running (Note: the air spring supply to be left open)

- Dismantle air start supply line, and blank with suitable steel plates, the main and control air pipes
- Dismantle bottom end bearing, and turn engine to suspend piston, crosshead and connecting rod from supplied crosshead supports. Secure big end of connecting rod in crankcase.
- Blank off main oil inlet to crosshead within the crankcase with a blanking plate
- Isolate the cylinder lubricator for that cylinder by placing all lubricators on no stroke.

c) When one engine cylinder is isolated, then one problem that may occur is a “dead spot” during maneuvering. This is due to the air start valve being isolated for that unit, and is more likely when a smaller number of cylinders are present. The Master must be informed that this could occur, and the remedy would be to kick the engine in the opposite direction, and then restart in the required direction.

QUESTION 26

a)Explain the possible reasons T/C vibration while operating at a steady speed

b)State how the incidence of turbo charger vibration might be minimized

c)Explain the action to be taken in order to maintain 2 stroke engine operation in the event of a pulse system turbo charger having to be taken out of service

d)Indicate the effect this action will have on engine operation

a)When operating at steady speed, then vibrations could occur when:

Imbalance of the rotor from damage by foreign object striking it Imbalance of the rotor from

breaking of the lacing or binding wirearing failure, which would reduce the support of the rotor

Slack foundation mounting of the T/C casing

b)Point 1 – fitting of a protective grid between the engine and the turbocharger, and regular overhaul of the exhaust valve/piston rings

Point 2 – regular changing of the lacing wire at the inspection stage

Point 3 – regular changing of the bearings and the sump oil

Point 4 – regular checks of the foundation bolts

c)When a pulse system T/C is damaged and cannot be used, then the following cause of action could be used:

- Stop engine
- Remove bearing end covers and fit rotor locking devices at both ends
- Close in the compressor outlet to ensure that scavenge air does not leak out, but at the same time prevent rotor warping
- Maintain FW circulation

d)When the engine is operating, then the engine power must be reduced to avoid thermal overload of the engine. The amount of engine power that can be developed could be limited by one of the following:

- Excess exhaust gas temperatures
- Excess exhaust smoke
- Engine vibration
- Excess speed of the remaining T/C

The time taken for engine speed up would be extended and thus manual engine speed up should be used.

QUESTION 27

a) State why chemical treatment of cooling water is necessary.

b) Sate the effect of excessive cylinder liner lubrication.

c) Why piston ring expander is mandatory during renewing piston ring

d) Function of piston ring diaphragm seals and how it works.

a) Chemical treatment of cooling water systems is required to minimize corrosion (and hence maintain the fatigue strength of the system materials), and scale formation (to maintain the cleanliness of the surfaces and hence expected heat transfer rates). Systems that do not treat with chemicals could expect corrosion and scale, which would require more frequent inspection and reduced component life. With the correct type (nitrate based) and treatment levels, damage to rubber seals should be avoided.

b) The oil that is collected within the scavenge space is generally slightly acidic and has a high level of insoluble. If this oil were placed in the crankcase then corrosion and abrasion of the bearing surfaces would occur, even with a normal level of crankcase oil care onboard. The level of cylinder oil dosage is a compromise between saving oil costs and reducing liner wear costs. Hence the feed rate of the cylinder oil is chosen to minimize overall costs. If the feed rates were found to be much higher than makers recommendations and the expected feed rate within the company fleet on similar vessel's, then a slight reduction could be effected, but only with close monitoring of the liner and piston ring wear rates.

c) When renewing piston rings, the use of the piston ring expander is mandatory. During fitting the hoop stresses placed on the ring, as it is expanded to fit over the piston crown, are very high. Any additional expansion would increase this stress, and possibly lead to the ring failing by breakage during normal service. Using the expander should ensure that the minimum of stress is placed on the ring during fitting.

d) The piston ring diaphragm seals the dirty scavenge space from the crankcase. The sealing rings to minimise air loss, are generally flat faced, and wear evenly along their faces, albeit with a sharp edge formed. The scraper rings, to scrap the excess crankcase oil off the piston rod, and generally shaped to improve their performance. Any wear on these rings would alter their scraping efficiency. Generally any worn rings should be changed, but should no spares be available, then the sealing rings may be re-used, whilst ensuring that the butt clearances are maintained by filing. Scraper rings would only be partly effective, even when the butts are filed, and the surface profile and ring/rod pressure would alter.

QUESTION 28

With respect to medium speed diesel engines, describe how you would direct your staff to
(a) Check engine performance during operation
(b) Establish the condition of the lubricating oil
(c) Monitor the general condition of the engine during the voyage

a) In order to monitor the engine performance, we would need to measure the power output and fuel consumption of the engine. This will allow the performance of the engine to be measured against previous and even test bed readings.

The staff would be instructed to

- Measure the power of the each cylinder by electronic pressure measurement. If the engine was driving an electrical load, then the electrical output power could be used. This will allow the total engine power to be calculated, and also for any power imbalance to be detected. This power measurement would be taken every month.
- Measure the fuel consumption of the engine every day over a 8 and 24 hour period. This consumption would be measured in tonne/hour, and thermal and density conversions from a volumetric flow rate at the meter would be required.
- Calculate the specific fuel consumption of the engine in terms of g/kWh, so that fuel consumption at various engine conditions could be compared.

b)Engine room staff would be instructed to

- Closely monitor the pressure differential across the lube oil filters each day, and to report any increase in this pressure, or the frequency of automatic filter blowdown.
- Take a representative sample from the lube oil inlet to the engine every week.

- This sample would be tested on board for
  - Water content
  - Change in viscosity
  - BN reserve
- In addition every month a representative sample would be taken and sent for shore analysis so that a wider range of variables could be analyzed.

c) The general condition of the engine could be monitored by measuring the various parameters taken by the datalogger or manual log readings.

The staff would be instructed to

- Take a full set of readings twice a day on all the major parameters of the engine, such as
- Exhaust gas temperatures
- Lube oil pressure and temperature
- Fresh water cooling pressure and temperature
- Scavenge air pressure and temperature
- T/C rev/min
- Exhaust gas smoke levels
- These readings would form the basis of the datum readings for that engine, and any major changes to the measurements should be reported to the Chief Engineers without delay.
- In addition, should electronic power measurement not be available on-board, then peak pressure readings of each cylinder would be taken monthly to ensure even loading of the cylinders.

QUESTION 29

a) As a Chief Engineer state the precaution to carry out a full inspection of main engine as requested by Owner.

b) List the items to be inspected during full inspection of main engine.

a) In order to carry out a full inspection as required by Owners, then a list of the major items of the main engine that influence performance and condition would be drawn up. This list would also include the various items that are surveyable by Class.
A schedule of the vessel's anticipated operation or port visits would be drawn up, which would allow the various inspection times in port (or at anchor) to be found. The time available and the list of inspections would be compared. If time were limited, then a cross section of inspections to take place rather than a full inspection. Inspection without dismantling may be effective, if time does not permit a full inspection (such as piston ring inspection through scavenge ports).

Resources such as additional labour, spares, and consumable would be drawn up to ensure the inspection process would proceed as planned.

For the performance checks, these would be carried out during the voyage. Steady conditions under varying loads, including full load would be required, and there may need a slight alteration to expected service or Charter speeds to allow the performance checks of indicators cards, and full machinery log readings to be taken.

b) For engine condition I would ensure that the following areas be inspected:

- Cylinder liner wear, to gauge useful life of liner and to measure future wear rates
- Piston ring condition and wear, to gauge useful life of rings
- Crankcase bearing clearances, to ensure bearing wear is minimal

For engine performance I would ensure the following areas be inspected:

- Power and out of phase cards for each units, for at least three separate measurements and power, to measure power output and specific fuel consumption
- Full log readings of the various pressures and temperatures, to compare with readings when the engine was new
- Fuel and lubricating oil consumption each day for a period exceeding 20 days, to measure the consumption

QUESTION 30

Outline the procedure to be adopted for the safe internal inspection of a fire tube boiler.

State the types of defect, which are likely to be encountered during such an inspection and their possible causes.

Describe how a leaking boiler tube may be:- (i) plugged. (ii) replaced.

Before the internal inspection of the boiler can commence, the boiler must be cooled, isolated, drained and tested internally. The actual details of the isolation operation will be contained in the task sheets written following the risk procedure. All persons carrying out this work must be fully aware of the possible dangers involved, and the need to comply with the guidance contained in publications such as Code of Safe Working Practice (COSWOP).

The following defects could be found inside the water and fire side of the boiler:

- Cracking of the fire side refractory - caused by overheating due to possible flame impingement
- Distortion of the heat transfer surfaces – caused by fouling of the water side and/or lack of water within the boiler
- Oil contamination of the furnace – caused by leaking burners
- Corrosion of the water side – caused by lack of alkaline reserve in the boiler water
- Scale of the water side – caused by poor feed water quality and/or lack of phosphate reserve in the boiler water
- Small pitting in the shell plating – oxygen pitting due to insufficient chemical reserve in the feed water and/or low hotwell temperatures
- Corrosion around the manhole door - due to caustic build-up due to leakage at the door joint

To plug a leaking tube of a fire tube boiler, the ends of the tube would be cleaned to bare metal. A threaded stay bar would be fitted through the tube, and a plug fitted to the stay bar at each end. The plugs would then be tightened into the tube plate by the nuts fitted behind each tube plug. Once the plugs and bar were in place and tight, then the boiler would be hydraulically tested to working pressure to ensure that the repair was satisfactory.

To replace the leaking tube, the old tube must first be removed. The method stated will assume that the tube is rolled into the tube plate rather than welded. A number of removal methods could be used to achieve this including heating the ends of the tube gently with a gas torch to stress relieve the tube. The tube is then punched out of the tubeplate. The tubeplate hole would be closely examined for possible cracks and corrosion. If the inspection showed no defects, then the new tube would be inserted. The tube would be sealed into the tubeplate by expanding the tube with increased torque on the expanding tool. The length of the tube exposed from the tubeplate must be measured and if excessive trimmed to avoid thermally induced cracks. The boiler would be hydraulically tested to working pressure to ensure that the repair was satisfactory.

QUESTION 31

a) Describe how a main engine fuel pump would be set and checked for:

- **i) timing**
- **ii) quantity**

b) Explain how a setting of a variable injection timing fuel pump is checked and adjusted

c) State why it be necessary to adjust the settings of a variable injection timed fuel pump

a) The primary method of checking the fuel pump timing would be using the manufacturer’s instructions of setting the fuel pump with the engine stopped.

For the Bosch type fuel pumps, a small window is present at the base of the fuel pump. Within this window an engraved line can be seen on the spring holder of the fuel pump. When the cam follower is displaced by the cam, it pushes the spring holder up. When the engraved line coincides with the line on the fuel pump body, then the fuel pump plunger is at the position where it is just covering the spill ports. Hence at this moment the fuel pump is starting to pressurize the trapped fuel volume, and hence fuel delivery will commence. Thus the engine is rotated to the point where the two lines coincide, and this indicates the commencement of fuel delivery. The actual crank angle would be read off the flywheel.

Should the fuel pump timing be required to be changed, then the shims fitted underneath the fuel pump would be changed. If shims are added the fuel pump will inject later, and visa versa for removing the shims.

The fuel pump is attached to the fuel rack, and the fuel control lever set to the same readings as the other fuel pumps. This should deliver the same fuel quantity. The fuel pump rack should always read zero when the governor is in the no-fuel position, to ensure the engine will stop when required.

To enable the actual fuel quantity delivered from each fuel pump to be measured, indicator cards would be required. Indicator cards would be taken from each cylinder and the power developed would be found, either directly from the software for the electronic cylinder units, or using a planimeter to determine the area of the power card for the mechanically taken indicator cards.

b) A variable injection fuel pump can also be adjusted for fuel timing with the engine running. Thus whilst the engine is running the fuel pump timing can be checked by the draw card type of indicator card. On this type of card the position when the fuel has ignited can be seen by either

- The point at which the pressure-volume curve moves away from the normal compression curve, or
- The point on the pressure derivative curve on the electronic indicator when the rate of pressure rise suddenly increases. The derivative curve makes the point of fuel ignition much easier to determine.

Once the point of fuel timing is determined, then the fuel pump can be adjusted either

- Collectively for the whole engine by adjusting the sensor which determines the quantity of fuel timing advancement by measuring the position of the fuel rack position. Any adjustment of this sensor will advance or retard the fuel timing of all fuel pumps at once.
- Individually by adjusting the linkage from the individual fuel timing servo to the fuel pump. This adjustment will adjust the fuel timing of an individual fuel pump.

c)The fuel pumps would need to be adjusted collectively, when the fuel combustion quality reduces.

Hence if combustion was slower than normal, possibility due to a high level of Conradson Carbon or Ashalptenes, then the fuel timing could be advanced. This will allow more time for combustion, and should reduce exhaust temperatures and smoke levels. When fuel timing is advanced it is important that the cylinder maximum pressures are measured to ensure that they are not excessive.

Should the ignition quality of the fuel be lower than normal, then the initial raise in cylinder pressure when combustion occurs will be higher than normal, and may even lead to bearing damage. In these cases the fuel timing would be retarded to depress the rate of pressure rise.

Individual fuel pump timing adjustment would be required when the fuel pump is internally worn. This will cause a lower amount of fuel to be injected, but also later in the engine cycle. Hence the performance of the pump could be regained by increasing the quantity delivered at the fuel rack, and advancing the individual fuel pump timing as stated in part b).

QUESTION 32
With reference to turbo-chargers:

a) **State how the in-service performance checks are undertaken for EACH of the following:**
   - **i) the gas side**   **ii) the compressor**
   - **iii) the suction filter**   **iv) the after cooler**

a) **State with reasons the action require to maintain satisfactory performance of**
   - **i) the turbine**
   - **ii) the compressor**

b) **Should in-service vibration be experienced state with reasons the possible causes**

a) The gas side refers to the nozzle ring and turbine blading. The fall off in performance of these components would be mainly due to fouling, which would also cause the inlet gas temperature and pressure to rise, and hence these should be monitored.

The compressor performance would be reduced by fouling of the compressor wheel and diffuser. This fouling would also cause the delivery pressure to fall, whilst the T/C was maintaining a stable speed and all other parameters were normal. Hence the delivery pressure of the compressor would be monitored.

The suction filter performance would reduce when fouling is present. This would be monitored by measuring the pressure drop across the filter.

The after cooler performance would reduce when fouling is present. This would be monitored by measuring the air pressure drop across the cooler, and the temperature of the cooling water.

b) The performance of the turbine is maintained by regular in-service cleaning, supplemented by manual cleaning of the turbocharger on a yearly operational running hour routine. The in-service cleaning can be carried out using either dry cleaning involving dry particle cleaning, and/or water washing of the turbocharger using warm water and air blast (only when the engine and T/C speed has been reduced). The in-service cleaning should be carried out twice weekly, or at any stage the performance of the turbine indicates a high rate of fouling.

The performance of the compressor is maintained by regular in-service cleaning, supplemented by manual cleaning of the compressor and diffuser on a yearly operational running hour routine. The in-service cleaning can be carried out using a small quantity of warm water injected into the turbocharger suction housing at full T/C speed. This cleaning can be carried out twice weekly.

c)The T/C can vibrate due to the following causes:

- Rotor imbalance following inadequate in-service cleaning
- Rotor imbalance due to failure of the rotor support bearings
- Rotor imbalance due to rotor damage from an object displaced from the cylinder, such as a broken piston ring or exhaust valve
- Surging of the turbocharger, when the unit is operated close to the surge line possibly due to a fouled hull
- Vibration transmitted to the turbocharger unit from an adjacent machinery unit.

QUESTION 33

a) Describe, with the aid of a sketch, an exhaust gas economizer and oil fired boiler arrangement, showing feed system and stating how steam output is controlled

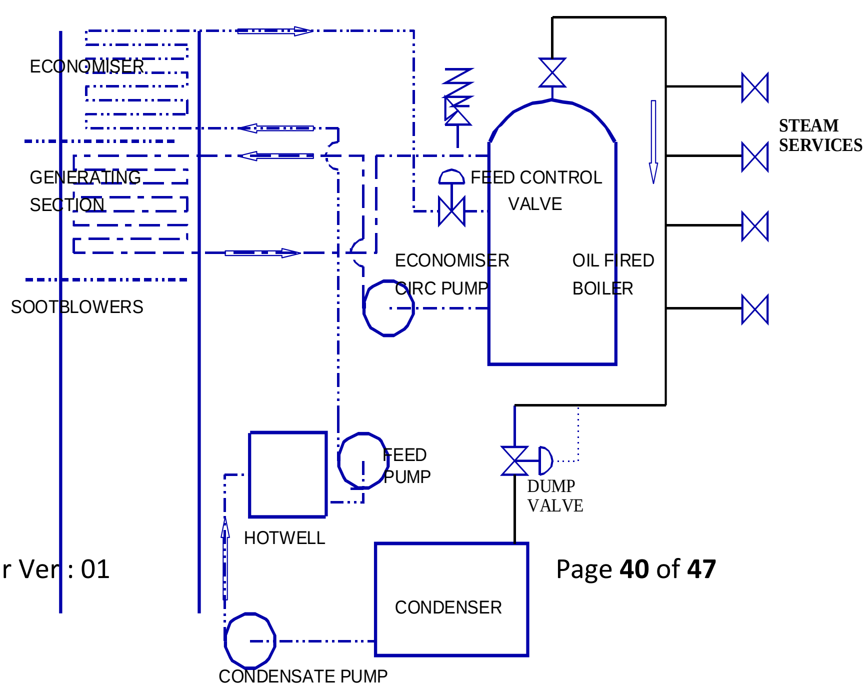
b)Uptake fires have become a serious problem with contemporary exhaust gas boilers. State how uptake fires are caused, prevented, and dealt with

a) The sketch show the feed and steam system of a motor vessel fitted with an exhaust gas economizer.

The boiler water is circulated from the oil fired boiler by means of the circulating pumps. These pump the water through the economizer, so that the waste heat from the engine exhaust can be reclaimed, and this water is discharged back into the oil fired boiler.

Thus when the engine is running the system should provide sufficient steam output for the services, which could include turbo alternators for the larger vessels.

Steam output or pressure is controlled by the use of a dump valve fitted on the oil fired boiler steam output line. This valve would only operate above the automatic cut off pressure of the oil fired boiler, to prevent the dump valve and burners being operational at the same time. The



dumped steam would discharge into the condenser

b)Uptake fires are caused by the burning of collected soot within the exhaust gas boiler. The initial burning of the soot causes localized heat buildup at the tube wall which can cause the tube temperature to rise excessively, especially when the flow of steam/water phase within the tube is not present. Should this scenario occur, then an intense soot and iron fire will result causing serious boiler damage.

Soot fires are prevented by removing the root causes of soot build up and loss of cooling steam flow. Hence regular sootblowing (at least twice a day) and manual cleaning (every month) should occur to ensure that the tubes are clean. In addition the causes of the soot build-up (poor main combustion conditions) should be attended to, by avoiding prolonged engine operation at low loads, and frequent maintenance of the fuel injection equipment.

The operation of the circulating pumps must be maintained at all times, to avoid dry operation.

Should a fire occur within the boiler then the following action should be carried out (as specified by MAN B&W):

- Contact Bridge and request engine slow down and stop
- Ensure circulating water flow is correct
- Stop main engine
- Isolate economizer by exhaust gas flaps if fitted
- Stop auxiliary blowers, and fuel oil pumps
- Monitor casing temperature and boundary cool if required.
- Once fire has reduced/stopped, open boiler casing for inspection

QUESTION 34

The main engine normally burns fuel with properties given in column I but fuel with properties given in column II has been delivered and must be burned

Comment on the possible problems with respect to EACH of the EIGHT fuel properties if no engine or system adjustment were made and the adjustments you, as Chief Engineer, would require in order to ensure satisfactory engine operation (16)

Viscosity (cSt @ 50 degree C)	**250**	**380**
Flash point (degree C)	**75**	**90**
Conradson Carbon (% wt)	**12**	**22**
Pour point (degree C)	**30**	**40**
Sulphur (% wt)	**4**	**7**
Water (% wt)	**0.5**	**1.3**

Vanadium (ppm)	**120**	**450**
Sodium (ppm)	**20**	**150**

Viscosity. The increase in viscosity could cause problems when the oil is heated for injection into the engine. The increase in viscosity means that the fuel temperature needs to increased from 125 to 134 degrees C to achieve the minimum oil viscosity recommended by the engine manufacturer. If when burning fuel II the heater capacity is not large enough then either both fuel oil heaters could be used in parallel, or the engine will need to be operated at reduced power.

Flash point The flash point of the delivered oil is above the minimum of 60 degrees C, so it would be considered stable in storage and not produce any flammable vapours. Hence fuel II would not cause any problems in this area.

Conradson carbon This will increase the fouling tendency of the fuel. As such when burning fuel II all the components in the exhaust stream would require cleaning more readily in-service, such as the turbocharger blading, exhaust gas boiler.

Pour point The increase in the pour point would require that the storage tank temperatures were maintained by a minimum 44 degrees at all times, when fuel II was loaded. This would prevent any cold plugging of the fuel system whilst transferring.

Sulphur The increase in the Sulphur content for fuel II would greatly increase the corrosive effects on the cooler regions of the engine, such as the cylinder liner and piston rings. The oil feed rate of the cylinder oil would need to be increased to counter these corrosive effects. The C/E should also ensure that the cooling water temperature is maintained at its highest optimum temperature.

Water Although the purifiers would be expected to remove traces of water in the fuel oil, the higher quantity of water in fuel II would need slower purification rates, possibility even operating the purifiers in parallel. The storage tanks should also be heated and regularly drained to maximize the systems removal of water from the oil.

Vanadium The increased level of vanadium in fuel II will cause corrosive problems on the hot metal surfaces such as exhaust valves and T/C blading. As this impurity can not be removed during fuel cleaning, then to minimize these effects the engine power should be reduced to reduce metal temperatures.

Sodium This can combine with the vanadium present to greatly increase the corrosive attack on the exhaust valves and T/C blading. This impurity can be removed during fuel cleaning (i.e. purification), and water tests should be carried out on the fuel oil to ensure that the water content has been reduced. If water is still present, then the engine power should be reduced to reduce metal temperatures, and minimize the corrosive effects when burning fuel II.

QUESTION 35

With reference to the burning of heavy residual fuel in the main engine:

(a) State with reasons FOUR modifications which need to be made as compared with the same engine burning distillate fuels
(b) As Chief Engineer state with reasons SIX properties you would require to see in the specification for residual fuel indicating the effect EACH of these properties might have with respect to the storage and burning of the fuel

Four of the following modifications should be in the answer:

Improved FO filtration – residual fuel contains more impurities and dirt than diesel oil, and to protect the injection equipment cold and hot filters would need to be fitted

Re-circulation of the fuel pumps – with distillate burning engines only a fuel pump vent line is required to prevent air locks, but when heated fuel oil is used there must be positive re-circulation to ensure that all fuel pumps are maintained at the correct temperature

Fuel valve cooling – if the same engine was modified, then cylinder head coolant would not be sufficient to ensure that injector overheating did not occur. Hence a light oil coolant system would be required.

Change of sump lube oil charge – when burning residual oil, increased alkalinity of the sump oil would be required to counter the effects of the Sulphur content of the fuel
Improved LO filtration - residual fuel contains more impurities than diesel oil, and to protect the bearings, increased sized LO filters would need to be fitted

In-service T/C equipment – Water washing facilities would be required on the gas side of the T/C to remove the impurities and deposit that settle on the T/C blading

Change of exhaust valve material – The vanadium and sodium impurities within the residual fuel will corrode the exhaust valves at a greater rate than when distillate fuel is used.

Fuel oil timing - the timing of the fuel pump would be checked when residual fuel is used as this could retard the fuel ignition.

Six of the following points should be included in the answer:

Viscosity – the heating equipment on-board must be capable of increasing the fuel temperature, but the capacity of the heating will be limited. A maximum viscosity should be stated in the specification.

Density – the cleaning equipment on-board will have limitations as to its maximum density, and this limitation should be stated in the fuel specification

Sulphur – the level of Sulphur is limited by the ability of the lube oil to neutralize it. Thus the lube oil manufacturer's information should be consulted as to the highest level of Sulphur that can be accepted.

Vanadium – vanadium will cause corrosion problems on the T/C and exhaust valve, and it should be limited on the specification

Micro carbon residue – A high level of residue will produce heavy fouling on the exhaust side, and to reduce this premature fouling should be limited on the spec.

Aluminium – This parameter will indicate abrasive particles in the fuel that the cleaning equipment would be unable to remove.

Silicon - This parameter will indicate abrasive particles in the fuel that the cleaning equipment would be unable to remove.

Pour point – if the pour point of the fuel is too high, then the tank heating capacity could be insufficient to ensure the fuel remains fluid at all times

Total sediment after ageing – the fuel could be unstable whilst under storage if this parameter is too high.

Flash point – All marine fuels stored within the vessel tanks should have a minimum flash point of 60 degrees C

QUESTION 36

With reference to the taking of fuel bunkers:

a) **Explain how you, as C/E, would assess the quantity and quality of fuel bunkers to be taken at a port**
b) **State with reasons SIX properties which would be quoted in the fuel specification**
c) **Write a letter to the ship's owner/manager advising, with reasons, on the purchasing of a shipboard fuel testing kit**

a) The quantity of bunker required would be dependent upon:

- The capacity of the fuel oil tanks. A maximum level of 95% full is possible.
- The intended next voyage or voyages to the next bunker port, allowing for weather and ample reserves against unpumpable stock.

The quality of bunkers required would be dependent upon:

- The recommendations of the engine builder, re a specified ISO 8217(1996) standard
- The auxiliary equipment fitted to the vessel, i.e. heating coils in tanks, purification capabilities
- Previous operational experiences with residual fuel operation for that engine type

b)The following properties would be specified

- Fuel oil density, a maximum of 0.991 is possible for all water seal operation purifiers
- Fuel oil viscosity, a maximum level would be specified depending upon the capacity of the fuel oil heaters
- The minimum closed flash point of 60^{o}C would be specified to ensure safe storage
- The Sulphur level of 3% would be issued to minimize corrosive effects of the cylinder liner
- The vanadium level of 400ppm would be issued to minimize the effects of high temperature corrosion
- The water content of 1% would be specified to ensure low levels of water to minimize tank corrosion and operational problems.

m.v Happy Days

at Sea (S'pore to Suez)

13th March 2001

Shipboard testing kit

Dear Sir,

Recent bunker operations and the subsequent main engine operational problems have highlighted the need to ensure best quality for the bunkered fuel on board. The present system of analyzing fuel after the engine problems become evident is not effective, hence I would like to suggest a fuel testing kit is purchased for testing on board.

This test kit should be able to measure

- Fuel oil density, to ensure the correct level is supplied, to prevent low tonnage supplies when low densities are loaded, and purifier operational problems when high densities are loaded
- Fuel oil viscosity, to ensure the correct blending levels of the loaded fuel oil
- Abrasive levels, to minimize abrasive particles in the fuel
- Water content, to prevent high water levels

Testing of the fuel will be carried out during each bunker operation, and if any parameter is outside the expected level, then the representative bunker sample will be immediately sent for shore analysis.

I believe the purchase of the test kit will minimize the operational problems that have been occurring, and result in a significant saving in maintenance and labour costs on board.

Yours faithfully,

Big Ears

Chief Engineer

QUESTION 37

State as a Chief engineer how you will determine the quality and quantity of fuel oil remaining onboard

In order to determine the quality and quantity of fuel remaining on board, the Chief Engineer will need to:

- Provide a full list of all fuel tanks onboard, including waste oil tanks
- Provide the last six months bunker receipts, especially the last two bunkering operations with regard to fuel density and type
- Provide the last six months fuel testing results, especially the last two bunkering operations. These should correlate with the bunker receipts.
- Ensure the temperature measurement of each heated tank is accurate. Sea water temperature would be used for double bottom tanks.
- Ensure the measuring system has been tested for accuracy. For example the sounding tape should be checked to ensure it is dimensionally correct, if in doubt a new sounding tape should be used.
- Check that there is no water in the fuel tank using water detecting paste on the MDO tanks, and possible draining on the HFO tanks.
- Accurately measure the trim and list of the vessel, preferably by sight of the actual draft markings and the forward, mid and aft positions on both sides of the vessel.

Once the initial preparation has been confirmed then the Chief will witness the actual measurement of tank, ensuring two measurements are taken to improve accuracy. Gauge readings would not be used. The tank measurement and temperature will be recorded for bunker quantity calculation.

Using the vessel's tank tables, the actual volume of the contents would be calculated with the known sounding, trim and list of the vessel. This cubic capacity would then be converted in a mass.

With reference to the bunkering records, the type and density of fuel in each tank will be determined. In tanks where a mixture is present, then a representative density value would be used.

The actual density of the fuel is temperature dependent, so Petroleum tables would be consulted to ensure a temperature correction factor is taken into consideration. This density would then be used to convert the tank volume into a mass of fuel within the tank.

The figures that are derived from the actual fuel tank survey should be similar to the daily Remains on Board (ROB) of each type of fuel held onboard.