February 2022

1. (a) Sketch a four stroke timing diagram, showing the position of fuel valve, exhaust valve and inlet valve operation. (8)

   (b) Explain the meaning of the term *valve overlap*, stating its purpose. (2)

February 2022

2. With reference to a turbocharged engine fitted with charge air cooler, It is noticed that boost pressure at the inlet manifold is reducing over a period of time:

   (a) list FOUR possible causes; stating a simple and economical in service maintenance routine that would rectify EACH (8)

   (b) state the effect reduced inlet pressure at full load will have on the engine. (2)

February 2022

3. (a) Describe the procedure for setting tappet clearance on diesel engine inlet/exhaust valves. (6)

   (b) Explain the importance of tappet clearances. (4)

February 2022

4. (a) Outline the actions which must be taken, by the on-watch engineer when the engine crankcase oil mist detector activates. (5)

   (b) Sketch a crankcase explosion relief door, labelling the MAIN components. (5)

February 2022

5. Explain, with the aid of labelled sketches, how a scroll type fuel pump meters the fuel for high and low loads. (10)

February 2022

6. With reference to distillate fuel, explain the potential problem for EACH of the following, stating how they may be avoided:

    (a) flash point; (3)

    (b) wax; (3)

    (c) microbes. (4)

February 2022

7. With reference to the operation of an air starting system of a large medium speed marine diesel engine fitted with individual air starting valves:

    (a) state the checks to be carried out if the engine will not start when initiating the start sequence; (6)

    (b) list FOUR safety devices fitted to the air start system. (4)

February 2022

8. Describe the procedure to be adopted prior to removing a diesel engine cylinder head, including safety precautions. (10)

February 2022

9. With reference to pneumatic clutches used for medium speed main propulsion purposes:

    (a) describe the operating principle of the clutch; (5)

    (b) explain how this clutch may be engaged in the event of failure of the control system; (3)

    (c) state TWO interlocks necessary for clutch operation. (2)

February 2022

10. (a) State how gearbox oil may become contaminated with water. (1)

    (b) Explain the effects of water contamination of gearbox oil. (5)

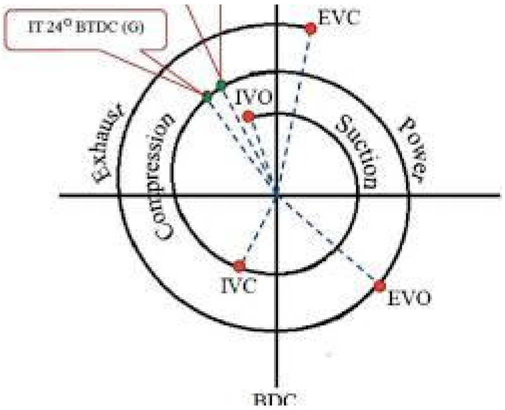
    (c) Describe the actions to be taken should a gearbox become contaminated with water. (4)

February 2022

1. (a) Sketch a four stroke timing diagram, showing the position of fuel valve, exhaust valve and inlet valve operation. (8)

   (b) Explain the meaning of the term *valve overlap*, stating its purpose. (2)

Here's a sketch of a four-stroke timing diagram showing valve operation:



Opens in a new window

www.researchgate.net

Four stroke timing diagram

pen_spark

Labeling:

- **TDC (Top Dead Center):** Highest point of piston travel in the cylinder.
- **BDC (Bottom Dead Center):** Lowest point of piston travel in the cylinder.
- **Intake Valve:** Controls the flow of air-fuel mixture into the cylinder.
- **Exhaust Valve:** Controls the release of exhaust gases from the cylinder.
- **Intake Stroke:** Piston moves down, drawing in air-fuel mixture.
- **Compression Stroke:** Piston moves up, compressing the air-fuel mixture.
- **Combustion Stroke (Power Stroke):** Ignition occurs, burning the compressed mixture and pushing the piston down.
- **Exhaust Stroke:** Piston moves up, forcing exhaust gases out of the cylinder.

Valve Operation:

- **Intake Stroke:** Intake valve opens just before TDC (Top Dead Center) of the intake stroke and closes after BDC (Bottom Dead Center) of the intake stroke.
- **Compression Stroke:** Both valves are closed throughout the compression stroke.
- **Combustion Stroke (Power Stroke):** Both valves are closed throughout the combustion/power stroke.
- **Exhaust Stroke:** Exhaust valve opens just before TDC of the exhaust stroke and closes after BDC of the exhaust stroke.

Valve Overlap (b)

Valve Overlap refers to the period during the engine cycle where both the intake and exhaust valves are open slightly at the same time. This typically occurs near the end of the exhaust stroke and the beginning of the intake stroke, or near the end of the intake stroke and the beginning of the compression stroke, as shown in the diagram.

Purpose of Valve Overlap:

- **Improved Scavenging:** During the overlap at the end of the exhaust stroke and beginning of the intake stroke, some fresh air from the intake valve can help push out any remaining exhaust gases trapped in the cylinder. This improves scavenging and cylinder purging, leading to a more complete intake of fresh air-fuel mixture.
- **Reduced Pumping Losses:** The slight overlap at the end of the intake stroke and beginning of the compression stroke allows some of the already inducted air-fuel mixture to flow back out, reducing the pumping work required to fill the cylinder completely. This can improve engine efficiency at higher RPMs.

Note: The amount of valve overlap is carefully designed by the engine manufacturer to optimize performance and efficiency based on the engine's intended application.

feb 2022Feb 2022

February 2022

2. With reference to a turbocharged engine fitted with charge air cooler, It is noticed that boost pressure at the inlet manifold is reducing over a period of time:

   (a) list FOUR possible causes; stating a simple and economical in service maintenance routine that would rectify EACH (8)

   (b) state the effect reduced inlet pressure at full load will have on the engine. (2)

Reduced Boost Pressure in a Turbocharged Engine with Charge Air Cooler:

(a) Four Possible Causes and Simple Maintenance Solutions:

1. **Air Filter Blockage:** A clogged air filter restricts airflow to the turbocharger, reducing the available mass of air for compression.
- **Simple Maintenance:** Regularly inspect and replace the air filter according to the manufacturer's recommendations. This is a cost-effective and easy service procedure.
2. **Charge Air Cooler Fouling:** Over time, the charge air cooler can become clogged with dirt, debris, or even insect nests. This reduces its ability to cool the compressed air, leading to higher intake temperatures and reduced boost pressure.
- **Simple Maintenance:** Periodically clean the charge air cooler fins using compressed air or a water hose (depending on the manufacturer's instructions). This is a relatively inexpensive maintenance procedure.

3. **Boost Leak:** Leaks in the intake piping between the turbocharger and the engine's intake manifold can allow compressed air to escape, reducing the pressure reaching the cylinders.
- **Simple Maintenance:** A visual inspection of the intake hoses and connections for cracks, loose clamps, or other signs of damage is a good starting point. Tightening loose clamps or replacing damaged hoses are relatively simple repairs.

4. **Turbocharger Issues:** While less common than the previous causes, internal problems within the turbocharger itself, such as worn bearings or faulty wastegate operation, can also lead to reduced boost pressure.
- **Maintenance:** While some basic cleaning of the turbo inlet might be possible, troubleshooting and repairs for internal turbocharger issues typically require a qualified mechanic. This might be a more expensive solution.

(b) Effect of Reduced Inlet Pressure at Full Load:

Reduced inlet manifold pressure at full engine load will have several negative consequences:

- **Lower Power Output:** Less air entering the cylinders leads to a leaner air-fuel mixture. This reduces the amount of fuel that can be burned efficiently, resulting in lower power output.
- **Increased Exhaust Gas Temperatures:** With less air for cooling, combustion temperatures can rise. This can lead to increased exhaust gas temperatures, putting additional stress on engine components.
- **Reduced Engine Efficiency:** The combination of lower power output and potentially higher exhaust temperatures leads to a decrease in overall engine efficiency.

Early detection and rectification of the root cause of reduced boost pressure can help maintain optimal engine performance, fuel economy, and longevity.

feb 2022

February 2022

3. (a) Describe the procedure for setting tappet clearance on diesel engine inlet/exhaust valves. (6)

(b) Explain the importance of tappet clearances. (4)

Setting Tappet Clearance on Diesel Engine Valves (a):

Here's a general procedure for setting tappet clearance on diesel engine inlet and exhaust valves. **Always refer to the specific service manual for your engine** for exact steps and torque specifications.

Tools:

- Feeler gauges (various thicknesses)
- Wrenches (socket or spanner) for adjusting tappet screws/nuts
- Optional: Magnetic parts tray

Steps:

1. **Engine Cool Down and Preparation:** Ensure the engine is cool and off. Disconnect the battery for safety.
2. **Identify Valve Train Components:** Locate the rocker arms, tappet screws/nuts, and pushrods (if applicable) for the valves you're adjusting. Consult the service manual for specific locations.
3. **Reference Valve Adjustment Sequence:** The service manual will specify the recommended order for adjusting valve clearances on all cylinders. This sequence is crucial for maintaining even stress on the head and valves.
4. **Top Dead Center (TDC) Positioning:** For each cylinder you're adjusting, rotate the crankshaft using the appropriate tool (refer to the manual) until the piston for that cylinder reaches Top Dead Center (TDC) of the compression stroke. TDC is usually indicated by alignment marks on the flywheel or crankshaft pulley and a corresponding mark on the engine block.
5. **Intake/Exhaust Valve Selection:** Depending on the engine design, you might adjust both intake and exhaust valves at TDC, or there might be a specific TDC position for each valve type. Refer to the service manual for your engine.
6. **Feeler Gauge Selection:** Choose the appropriate feeler gauge size specified in the service manual for the specific valve (intake or exhaust) you're adjusting.
7. **Checking and Adjusting Clearance:**
    - Insert the chosen feeler gauge between the rocker arm and the valve stem (or tappet adjuster if applicable).
    - There should be a slight drag on the feeler gauge as you move it back and forth. This indicates the correct clearance.
    - If the gauge is too loose (no drag) or too tight (gauge won't fit), use the wrench to adjust the tappet screw/nut accordingly. Tighten the nut while holding the screw to prevent it from turning.
    - Re-check the clearance with the feeler gauge after adjustment.
8. **Repeat for All Valves:** Following the specified sequence, repeat steps 4-7 for all the valves that require tappet clearance adjustment.
9. **Recheck Clearances:** Once all valves have been adjusted, it's recommended to re-check the clearances on all valves after a complete cycle to ensure everything remains within specifications.
10. **Reassemble and Tighten:** Reassemble any removed components like valve covers and tighten them to the specified torque using a torque wrench. Reconnect the battery.

Important Notes:

- This is a general guide, and specific steps and tools might vary based on the engine design.
- Always refer to the manufacturer's service manual for detailed instructions, proper torque specifications, and any special procedures for your specific engine.
- Double-check your work to ensure all clearances are set correctly for optimal engine performance.

Importance of Tappet Clearance (b):

Tappet clearance, also known as valve lash, plays a critical role in the proper operation of a four-stroke diesel engine:

- **Valve Timing:** Correct clearance ensures the valves open and close at the precise moments during the engine cycle (intake, compression, combustion, exhaust). Incorrect clearance can lead to delayed or early valve opening/closing, disrupting the engine's breathing and combustion efficiency.

- **Sealing and Compression:** Proper clearance allows the valves to fully seat against their corresponding seats, creating a tight seal for compression and preventing leakage of combustion gases or intake air.
- **Wear and Tear:** Optimum clearance minimizes wear on the valve train components like rocker arms, pushrods (if applicable), and valve stems.
- **Engine Performance:** Correct tappet clearance contributes to smoother engine operation, improved fuel efficiency, and optimal power output.
- **Noise Reduction:** Excessive clearance can create a knocking or clattering sound during engine operation due to excessive play in the valve train.

Regular inspection and adjustment of tappet clearance are essential for maintaining a healthy and efficient diesel engine.

February 2022

February 2022

4. (a) Outline the actions which must be taken, by the on-watch engineer when the engine crankcase oil mist detector activates. (5)

(b) Sketch a crankcase explosion relief door, labelling the MAIN components. (5)

Diesel Engine Crankcase Emergencies

(a) Actions Upon Crankcase Oil Mist Detector Activation:

When a diesel engine's crankcase oil mist detector activates, the on-watch engineer should follow a specific protocol to ensure safety and minimize engine damage. Here's a breakdown of the recommended actions:

1. **Immediate Shutdown:** Safely reduce engine load and stop the engine as soon as possible. This removes the ignition source and prevents further oil mist generation.
2. **Identify the Cause:** Investigate the reason behind the oil mist detector activation. This may involve checking for:
   - **Piston ring wear or damage**
   - **Fuel injector malfunction**
   - **Crankcase ventilation system blockage**
   - **Other potential issues causing excessive blow-by gases**
3. **Isolate the Engine:** Close any valves or dampers isolating the affected engine from other systems to prevent the spread of oil mist.
4. **Alert Others:** Inform relevant personnel about the situation, especially maintenance or supervisory staff.
5. **Do Not Restart:** Refrain from restarting the engine until the cause of the oil mist is identified and rectified. Running the engine with excessive blow-by can lead to a crankcase explosion.

(b) Sketch of a Crankcase Explosion Relief Door:

Here's a basic sketch of a crankcase explosion relief door with labeled components:

```
 +----------+
  |  HINGE   |  (Top)
  +----------+
     |
     v
+---------+
| DIAPHRAGM |
+---------+
     |
     v
+---------+
| PRESSURE  |
|  PLATE  |
+---------+
     |
     v
  (Opens Outward)
```

Main Components:

- **Hinge:** Allows the door to rotate outward upon pressure buildup.
- **Diaphragm:** A flexible membrane that acts as a pressure sensor.
- **Pressure Plate:** A plate attached to the diaphragm that is exposed to crankcase pressure.
- **Relief Opening:** The opening in the crankcase wall that allows pressure to escape when the door opens.

Functionality:

Under normal engine operation, the diaphragm and pressure plate remain in place. However, when excessive pressure builds up in the crankcase, the force pushes against the diaphragm, causing the door to hinge outward and release the pressure through the relief opening. This helps prevent catastrophic crankcase explosions.

feb 2022

February 2022

5. Explain, with the aid of labelled sketches, how a scroll type fuel pump meters the fuel for high and low loads. (10)

Scroll type fuel pumps are positive displacement pumps commonly used in large diesel engines, particularly marine applications. They offer a simple yet efficient method for metering fuel based on engine load.

Components:

- **Spiral Groove (Scroll):** This is a helical groove machined into the inner surface of the pump housing.
- **Rotor:** A spool-shaped rotor with a tight fit inside the scroll has an eccentrically positioned cam follower pin.
- **Cam Follower:** This pin rides inside a groove on a drive sleeve connected to the engine.
- **Inlet Port:** Located at the base of the scroll, where fuel enters the pump.
- **Outlet Port:** Located at the top of the scroll, where fuel exits the pump towards the engine injectors.

Metering Mechanism:

1. **Rotation:** The drive sleeve rotates the rotor within the scroll housing.
2. **Eccentricity Effect:** Due to the eccentric cam follower pin, the rotor doesn't rotate perfectly centered within the scroll. This creates a varying volume between the rotor and the scroll during each revolution.

(a) High Load:

- **Large Pockets:** As the rotor rotates at high engine load, the eccentric position allows for the formation of larger pockets between the rotor and the scroll.
- **More Fuel Delivery:** During each rotation, these larger pockets fill completely with fuel on the inlet side and are carried towards the outlet on the discharge side. This results in a higher volume of fuel delivered per revolution, satisfying the increased fuel demand at high engine loads.

(b) Low Load:

- **Smaller Pockets:** At low engine load, the cam follower pin position creates smaller pockets between the rotor and the scroll.
- **Less Fuel Delivery:** These smaller pockets fill with less fuel during each rotation, resulting in a lower overall volume of fuel delivered per revolution, matching the reduced fuel requirement at low engine loads.

Key Points:

- The pump doesn't have an external mechanism for actively controlling fuel flow. The varying volume pockets created by the rotor's eccentric movement achieve the metering.
- Engine speed remains relatively constant, and the varying fuel delivery based on load is achieved by the scroll pump's internal design.

Additional Notes:

- The specific shape and dimensions of the scroll and rotor profile determine the pump's performance characteristics and fuel delivery curve.
- Modern scroll type pumps might incorporate control mechanisms for additional adjustments or integration with electronic engine management systems

February 2022

6. With reference to distillate fuel, explain the potential problem for EACH of the following, stating how they may be avoided:

(a) flash point; (3)

(b) wax; (3)

(c) microbes. (4)

Distillate Fuel Oil Potential Problems and Avoidance:

(a) Flash Point:

- **Problem:** Distillate fuel oil has a flash point, the minimum temperature at which it can vaporize and ignite. If the fuel oil temperature reaches or exceeds the flash point in the presence of an ignition source, a fire can occur. This is a safety concern during storage, handling, and refueling.
- **How to Avoid:**
  - **Storage:** Store fuel oil in designated, cool, and well-ventilated areas away from heat sources and ignition sources like open flames or sparks.
  - **Handling:** Implement proper handling procedures to minimize the risk of spills and ensure safe transfer during refueling.
  - **Fuel Selection:** In some cases, depending on the application and climate, you might consider using a distillate fuel with a higher flash point for increased safety margins.

(b) Wax:

- **Problem:** Distillate fuel oil contains paraffin waxes, which can solidify at low temperatures. This can cause problems like:
  - **Filter Plugging:** Wax crystals can clog fuel filters, restricting fuel flow to the engine and potentially leading to engine stalling or power loss.
  - **Poor Flow:** Wax formation can thicken the fuel, hindering proper fuel flow within the fuel system.
- **How to Avoid:**
  - **Fuel Selection:** When operating in cold weather conditions, using a distillate fuel with a lower cloud point (temperature at which wax crystals begin to form) is crucial. This ensures the fuel remains liquid at the expected operating temperatures.
  - **Fuel Additives:** Specific cold flow improver additives can be used to lower the cloud point of the fuel and prevent wax crystal formation at moderate cold temperatures.
  - **Proper Storage:** Avoid storing fuel oil for extended periods in extremely cold conditions, as this can promote wax separation and solidification.

(c) Microbes:

- **Problem:** Microbial growth (bacteria, fungi) can occur in distillate fuel oil, especially if there is water contamination. Microbes can cause several issues:

- ○ **Blocked Filters:** Microbial colonies can clog fuel filters, restricting fuel flow.
- ○ **Corrosion:** Microbial activity can produce byproducts that contribute to fuel system corrosion.
- ○ **Degraded Fuel Quality:** Microbial activity can break down fuel components, reducing its energy content and hindering combustion efficiency.
- **How to Avoid:**
  - **Minimize Water Ingress:** Maintain a water-tight storage system and regularly drain any accumulated water from the fuel tank.
  - **Proper Storage Practices:** Store fuel in clean, sealed containers and avoid prolonged storage times, especially in warm and humid conditions.
  - **Biocide Additives:** Consider using biocide fuel additives as a preventative measure to inhibit microbial growth within the fuel.
  - **Regular Fuel Testing:** Periodically test fuel samples for signs of microbial contamination.

Feb 2022

February 2022

7. With reference to the operation of an air starting system of a large medium speed marine diesel engine fitted with individual air starting valves:

(a) state the checks to be carried out if the engine will not start when initiating the start sequence; (6)

(b) list FOUR safety devices fitted to the air start system. (4)

Troubleshooting Engine No-Start with Individual Air Start Valves (Large/Medium Speed Marine Diesel Engine)

(a) Checks to Perform if Engine Won't Start:

If a large/medium speed marine diesel engine with individual air start valves fails to start during the initiation sequence, a systematic approach is crucial. Here are some key checks to conduct:

1. Air System Checks:

- **Air Pressure Verification:** Verify sufficient air pressure in the receivers using the pressure gauges. Ensure the pressure meets the manufacturer's minimum requirements for starting.
- **Drain Trap Inspection:** Check the drain traps at the air receivers and individual air lines for accumulated water condensation. Drain any collected water to prevent it from entering the cylinders and hindering combustion.
- **Leak Inspection:** Visually inspect the air lines and connections for leaks. Listen for any hissing noises that might indicate compressed air escaping. Repair or tighten loose connections promptly.

- **Start Valve Operation:** Verify that all individual air start valves are fully open during the starting sequence. You can use visual inspection (if accessible) or listen for the characteristic air flow through the valves.

2. Engine System Checks:

- **Fuel System:** Ensure proper fuel supply to the cylinders. Check for clogged filters, low fuel level, or issues with the fuel injection system.
- **Starting System:** Verify that the starting sequence is initiated correctly and all components like the starting motor (if electric) are functioning properly.
- **Engine Alarms:** Look for any engine alarms that may offer clues about the no-start condition. Consult the engine manual for alarm interpretations.
- **Engine Overcrank Protection:** If the engine cranked excessively during the previous starting attempt, the overcrank protection may have triggered. Allow the system to reset before attempting another start.

3. Additional Checks:

- **Engine Room Ventilation:** Ensure adequate ventilation to avoid excessive exhaust fumes that might hinder proper air intake during starting.
- **Lubricating Oil Level and Condition:** Check the oil level and its condition. Low oil level or degraded oil can affect engine starting and performance.

(b) Four Safety Devices in the Air Start System:

The air start system incorporates several safety features to prevent accidents and equipment damage:

1. **Non-Return Valve:** This valve allows compressed air to flow only in one direction, from the receivers to the engine. It prevents pressurized air from flowing back into the compressor after the start sequence.
2. **Pressure Relief Valve:** This valve protects the air system from overpressure by automatically venting excess air back to the atmosphere if the pressure exceeds a safe limit.
3. **Starting Air Isolation Valve:** This valve allows isolating the entire air start system from the receivers for maintenance or repairs. This ensures no pressurized air flows to the engine while work is being done.
4. **Engine Starting Interlocks:** These interlocks prevent accidental engine starting under unsafe conditions. Examples include:
    - **Neutral Gear Interlock:** Engine can't start unless the transmission is in neutral, avoiding sudden jolts.
    - **Low Lube Oil Pressure Interlock:** Prevents starting if oil pressure is insufficient to adequately lubricate internal components.
    - **Engine Overcrank Protection:** Limits cranking duration to prevent overheating the starter motor and engine.

By conducting these checks and following a structured approach, you can identify the cause of the no-start condition and take appropriate corrective actions to get the engine running safely and efficiently. Remember to consult the engine manufacturer's manual for specific troubleshooting procedures and safety precautions.

February 2022

8. Describe the procedure to be adopted prior to removing a diesel engine cylinder head, including safety precautions. (10)

Procedure Before Removing a Diesel Engine Cylinder Head (Marine Applications) - Safety First!

Removing a cylinder head on a marine diesel engine requires following safe practices specific to the marine environment. Here's a breakdown of the procedure before removal, emphasizing safety precautions:

1. Prepare the Work Area:

- **Lock out/tag out procedures:** Follow established marine safety protocols for locking out and tagging out the engine to prevent accidental startup. This might involve isolating the fuel supply and electrical systems.
- **Work Permit:** Obtain a work permit from the Chief Engineer or designated authority to ensure proper authorization and awareness of the work being performed.
- **Confined Space Entry (if applicable):** If the engine room is considered a confined space, follow all necessary confined space entry procedures, including proper ventilation, buddy system, and communication.
- **Cooling Down:** Allow the engine to cool completely to prevent burns from hot components. Consider circulating cooling water if necessary to expedite the cool-down process.
- **Bilge Management:** Ensure the bilge is clear of any flammable liquids (fuel oil) and has adequate pumping capacity to handle any accidental coolant spills.

2. Gather Necessary Tools and Equipment:

- **Marine-rated tools:** Use tools specifically designed for the marine environment to ensure corrosion resistance and proper functionality.
- **Socket wrench set with various sizes for removing head bolts and other fasteners.**
- **Torque wrench calibrated for marine applications**: Crucial for proper tightening of head bolts during reassembly.
- **Head gasket removal scraper set: Marine-grade scrapers preferred.**
- **Gasket scraper for cleaning mating surfaces.**
- **Rubber mallet for gentle tapping during removal.**
- **Cleaning rags and degreaser suitable for marine applications.**
- **Personal Protective Equipment (PPE):**
  - Safety glasses to shield from debris.
  - Gloves to protect hands from cuts, scrapes, and chemicals.
  - Steel-toed boots for foot protection.
  - Depending on the situation, consider a respirator if working with significant dust or fumes.

3. Identify and Disconnect Components:

- **Electrical Disconnection:** Disconnect all electrical connectors attached to the cylinder head. Label them clearly for proper reassembly.
- **Fluid System Disconnection:**
    - Drain the engine coolant system following the manufacturer's instructions and approved disposal practices for the coolant.
    - Disconnect and remove any hoses or pipes connected to the cylinder head, such as coolant hoses, fuel lines, or injector lines. Drain any residual fluids and securely cap the open ends of the hoses/pipes to prevent contamination. Dispose of drained fluids responsibly following marine regulations.
    - Consider using drip pans or funnels to catch any unexpected spills and prevent them from entering the bilge.

4. Exhaust System Disconnection:

- **Disconnect the exhaust manifold from the cylinder head by removing the nuts/bolts that secure them together.** Utilize proper lifting tools if the exhaust manifold is heavy.

5. Additional Components:

- **Remove any other components attached to the cylinder head as per the engine's service manual.** This might involve removing rocker arms, valve springs, or injector assemblies. Ensure proper labeling for reassembly.

6. Label and Loosen Head Bolts (Crucial Step):

- **Label each head bolt with its location number using a tag or marker.** This ensures they are reinstalled in the correct sequence and position during assembly (critical for proper head clamping force).
- **Loosen the head bolts in the reverse order they were tightened during assembly (consult the service manual for the specific pattern).** Loosen the bolts in stages, a few turns at a time, to avoid warping the head.

7. Support and Lifting:

- **Support the weight of the cylinder head.** Depending on the engine design, you might need an engine hoist or a jack specifically designed for marine applications to support the head once the bolts are fully removed. Consider using certified lifting slings for safe lifting.
- **Have a clean and designated workspace** to place the removed head to prevent damage to the mating surface. A designated stand or workbench within the engine room is ideal.

Remember:

- Always refer to the specific service manual for your marine diesel engine for detailed instructions and torque specifications for head bolt removal and reassembly.
- Never attempt to remove a cylinder head without proper knowledge, tools, and authorization.
- Prioritize safety throughout the process, following established marine safety protocols and using appropriate PPE.

February 2022

9. With reference to pneumatic clutches used for medium speed main propulsion purposes:

(a) describe the operating principle of the clutch; (5)

(b) explain how this clutch may be engaged in the event of failure of the control system; (3)

(c) state TWO interlocks necessary for clutch operation. (2)

(a) Operating Principle:

A pneumatic clutch for medium-speed main propulsion utilizes compressed air to control engagement and disengagement between the engine and the propeller shaft. Here's how it works:

1. **Compressed Air Supply:** The clutch is connected to a compressed air system that provides pressurized air.
2. **Engagement Cylinder:** An air cylinder (actuator) is connected to the clutch housing. When compressed air is directed into the cylinder, the piston inside the cylinder extends.
3. **Pressure Plate and Friction Plates:** The extending piston applies force to a pressure plate. This pressure plate clamps multiple friction plates between itself and a driven plate (connected to the propeller shaft).
4. **Friction and Torque Transmission:** The clamping force from the pressure plate creates friction between the interleaved friction plates, holding them together. This friction transmits torque from the engine flywheel (connected to the pressure plate) to the driven plate and ultimately the propeller shaft.
5. **Disengagement:** When compressed air is vented from the actuator cylinder, the piston retracts due to spring pressure or compressed air from the opposite side of the cylinder (depending on the design). This allows the pressure plate to move away from the friction plates, disengaging the clutch and interrupting power transmission.

(b) Engaging Clutch During Control System Failure:

In case of a pneumatic control system failure, there are typically emergency engagement mechanisms to ensure minimal disruption to propulsion:

1. **Spring-Engaged Design:** Some pneumatic clutches are designed to be "spring-engaged, air-disengaged." This means a strong spring holds the pressure plate and friction plates together by default. Compressed air is used to overcome the spring force and disengage the clutch. In case of air pressure loss, the spring automatically forces the clutch into the engaged position, allowing the vessel to maintain some level of propulsion.
2. **Manual Override:** Some clutches might have a manual override mechanism. This could involve a lever or handwheel that allows the operator to directly apply mechanical force on the pressure plate, mimicking the effect of compressed air and engaging the clutch. This would require manual operation and wouldn't be as smooth as normal pneumatic actuation, but it could allow the vessel to maintain basic operability until repairs are made.

(c) Interlocks for Clutch Operation (2):

1. **Engine Speed Interlock:** This interlock prevents clutch engagement above a certain engine speed (RPM) limit. This is crucial to avoid excessive wear and tear on the clutch components during high-speed engagement. The clutch can only be engaged when the engine RPM falls within the safe operating range.
2. **Lubrication Oil Pressure Interlock:** This interlock ensures sufficient lubrication oil pressure before allowing clutch engagement. This protects the clutch components from damage due to dry operation and overheating. The clutch will only engage when the oil pressure reaches the minimum required level.

February 2022

10. (a) State how gearbox oil may become contaminated with water. (1)

(b) Explain the effects of water contamination of gearbox oil. (5)

(c) Describe the actions to be taken should a gearbox become contaminated with water. (4)

Water Contamination in Gearbox Oil

Water contamination in gearbox oil can be a serious problem, leading to reduced performance and potential component damage. Here's a breakdown of how it happens, its effects, and how to address it:

(a) Causes of Water Contamination:

- **Condensation:** Moisture in the air can condense inside a cold gearbox, especially during temperature fluctuations. This is more likely in environments with high humidity.
- **Leaking Seals:** Worn or damaged seals around the gearbox input or output shafts can allow water to ingress from the external environment during rain, car washes, or driving through puddles.
- **Coolant System Leak:** If the gearbox cooling system (if applicable) has a leak in its heat exchanger, coolant containing water can mix with the gearbox oil.

(b) Effects of Water Contamination:

- **Loss of Lubricity:** Water dilutes the oil's lubricating properties, leading to increased friction and wear on gears and bearings.
- **Corrosion:** Water promotes rust and corrosion on metal components within the gearbox, accelerating wear and tear.
- **Formation of Sludge:** Water can react with additives in the oil to form sludge, which can clog oil passages and hinder proper lubrication.
- **Foaming:** Water can cause the oil to foam, reducing its ability to absorb pressure and transmit power efficiently.
- **Freezing (in cold climates):** In very cold environments, water contamination can lead to ice formation within the gearbox, potentially causing damage to components.

(c) Actions Upon Water Contamination:

- **Stop Operation:** If you suspect water contamination, immediately stop operating the vehicle to prevent further damage.
- **Diagnosis:** Check the oil dipstick for a milky appearance, which can be a sign of water contamination. Additionally, unusual noises from the gearbox during operation can indicate problems.
- **Oil Drain and Flush:** The most crucial step is to drain the contaminated oil and thoroughly flush the gearbox to remove any remaining water traces. Consult a qualified mechanic for this procedure, as they can ensure proper disposal of the used oil and utilize the appropriate flushing techniques.
- **New Oil and Filter:** After flushing, refill the gearbox with fresh, high-quality oil of the recommended grade and replace the oil filter to ensure clean, uncontaminated lubrication.
- **Identify the Source:** Investigate the source of the water contamination, such as a leaking seal or coolant system issue. Address the root cause to prevent future contamination.

By taking these steps promptly upon discovering water contamination, you can minimize damage to your gearbox and ensure its smooth operation. Remember, preventive maintenance, such as regular oil changes and seal inspections, can help reduce the risk of water contamination in the first place