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1. (a) With reference to the combustion of fuel, explain EACH of the following terms:

   (i) atomisation; (3)

   (ii) penetration; (2)

   (iii) compression ratio. (1)

   (b) State the factors which influence the terms explained in part (a). (4)

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2. (a) Describe the function of a main engine turbocharger. (5)

   (b) Describe how the turbocharger is cooled. (2)

   (c) Describe how the turbocharger is lubricated. (3)

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3. (a) Sketch a cross section through a four stroke diesel engine piston, labelling the MAIN components. (6)

   (b) Describe the transfer of gas force from piston crown through to the crankshaft. (4)

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4. The daily engine log shows the engine crankcase pressure gauge is indicating a much higher value than the normal reading.

   (a) State the implications of this and the immediate actions that should be taken. (2)

   (b) Outline the checks and investigations that should be undertaken to ascertain the cause of this increased crankcase pressure. (8)

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5.

Describe, with the aid of a sketch, a typical distillate fuel supply system for a diesel engine, including ALL the safety devices. (10)

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6. With reference to diesel engine water coolers:

   (a) describe how performance is measured; (5)

   (b) describe the possible causes of the performance falling off. (5)

October 2018 MDE

7. The air start pipework on a diesel engine attached to the cylinder head is becoming extremely hot.

   Explain EACH of the following:

   (a) the probable cause; (3)

   (b) the consequences of this situation and the immediate action to be taken; (4)

   (c) how this problem can be minimised. (3)

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8. (a) Describe the procedure for renewing a bottom end bearing of a diesel engine. (8)

   (b) Describe the precautions necessary on initial startup of the engine. (2)

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9. Describe, with the aid of a sketch, the operation of a diesel engine propulsion system air operated radial tyre type clutch. (10)

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10. With reference to a gearbox:

(a) explain why large quantities of lubricating oil are used; (2)

(b) state FOUR possible causes of excessive lubricating oil temperature when at normal operating speeds; (4)

(c) state how EACH cause stated in part (b) may be remedied. (4)

October 2018 MDE

1. (a) With reference to the combustion of fuel, explain EACH of the following terms:

   (i) atomisation; (3)

   (ii) penetration; (2)

   (iii) compression ratio. (1)

   (b) State the factors which influence the terms explained in part (a). (4)

(a) Combustion Terms Explained:

In the context of diesel engine combustion, several key terms play a crucial role in optimizing the process:

(i) Atomization:

- **Definition:** Atomization refers to the process of breaking up a liquid fuel into a fine mist of tiny droplets.
- **Importance:** Proper atomization increases the surface area of the fuel significantly. This allows for better mixing with the compressed air within the engine cylinder, promoting more complete and efficient combustion.
- **Benefits:**
  - Increased Power Output: Better air-fuel mixing leads to more efficient combustion, resulting in higher power output from the engine.
  - Reduced Emissions: Proper atomization contributes to lower emissions of pollutants like soot and NOx by ensuring complete combustion of the fuel.

(ii) Penetration:

- **Definition:** Penetration refers to the ability of the atomized fuel spray to travel a specific distance within the engine cylinder after injection.
- **Importance:** The fuel spray needs to penetrate adequately to reach all areas of the combustion chamber, ensuring proper mixing with air throughout the cylinder volume.
- **Impact:**
  - Efficient Mixing: Good penetration allows for better air-fuel mixing even in larger cylinders, promoting efficient combustion.
  - Power Output: Proper penetration helps ensure all the injected fuel participates in the combustion process, leading to optimal power output.
  - Incomplete Combustion: Insufficient penetration can lead to some fuel droplets not mixing well with air, resulting in incomplete combustion and potentially higher emissions.

(iii) Compression Ratio:

- **Definition:** The compression ratio is a dimensionless parameter that compares the volume of the cylinder with the air-fuel mixture at the bottom of the intake stroke (maximum volume) to the volume of the compressed air-fuel mixture at the top of the compression stroke (minimum volume).

- **Importance:** A higher compression ratio signifies a greater compression of the air-fuel mixture, leading to a higher temperature and pressure within the cylinder.
- **Impact on Combustion:**
  - Improved Efficiency: Higher compression temperatures promote more efficient ignition and combustion of the fuel, leading to better fuel economy.
  - Increased Power Output: The higher pressure in the cylinder during the power stroke translates to greater force acting on the piston, resulting in increased engine power output.
  - Trade-offs: While beneficial, excessively high compression ratios can lead to problems like engine knocking and the need for higher quality fuels to avoid pre-ignition.

(b) Factors Influencing the Combustion Terms:

(i) Atomization:

- **Injector Nozzle Design:** The size and arrangement of orifices in the injector nozzle tip significantly influence how finely the fuel is atomized.
- **Fuel Injection Pressure:** Higher injection pressure generally leads to finer atomization due to the increased force breaking up the fuel droplets.
- **Fuel Properties:** The viscosity and volatility of the fuel can affect its atomization characteristics.

(ii) Penetration:

- **Injector Nozzle Design:** The spray pattern and angle of the injector nozzle can influence how far the fuel spray penetrates within the cylinder.
- **Injection Timing:** The timing of fuel injection relative to the piston position can affect the available space for the spray to penetrate before combustion starts.
- **Engine Speed:** Higher engine speeds can lead to turbulence within the cylinder, potentially affecting the penetration of the fuel spray.

(iii) Compression Ratio:

- **Engine Design:** The engine's physical design, particularly the cylinder head and piston crown shapes, determines the maximum achievable compression ratio.
- **Clearance Volume:** The volume remaining above the piston at top dead center (TDC) of the compression stroke is called the clearance volume. A smaller clearance volume contributes to a higher compression ratio.
- **Fuel Characteristics:** The octane rating of the fuel determines its resistance to autoignition. Higher compression ratios typically require fuels with higher octane ratings to avoid pre-ignition.

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2. (a) Describe the function of a main engine turbocharger. (5)

(b) Describe how the turbocharger is cooled. (2)

(c) Describe how the turbocharger is lubricated. (3)

Main Engine Turbocharger: Function, Cooling, and Lubrication

(a) Function of a Main Engine Turbocharger:

A turbocharger is a device used in internal combustion engines to increase power output and efficiency. It utilizes the exhaust gas flow from the engine to drive a turbine which, in turn, drives a compressor. Here's a breakdown of its operation:

1. **Exhaust Gas Drives Turbine:** Hot exhaust gases from the engine cylinders flow through the turbine housing, pushing the turbine blades and causing the turbine shaft to spin.
2. **Compressor Boosts Intake Air:** Connected to the same shaft as the turbine, the compressor wheel draws in fresh air from the engine's intake system. As the compressor wheel spins, it compresses this air, increasing its pressure.
3. **Denser Air for More Power:** The compressed, denser air from the compressor is then delivered (often after being cooled by a charge air cooler) to the engine's intake manifold. This denser air allows for a larger and more efficient fuel burn, resulting in increased engine power output.

(b) Turbocharger Cooling:

Turbochargers operate at high temperatures due to the hot exhaust gas flowing through the turbine section. To prevent overheating and ensure proper operation, turbochargers require efficient cooling:

- **Oil Cooling:** The primary cooling method for most turbochargers involves engine oil. Engine oil continuously circulates through passages within the turbocharger housing, absorbing heat from the turbine housing and bearing areas. The hot oil then returns to the engine's lubrication system where it's cooled by the engine oil cooler.
- **Indirect Air Cooling:** In some cases, especially for larger turbochargers, additional cooling fins might be present on the turbine housing to promote some heat dissipation directly to the surrounding air. However, oil circulation remains the primary cooling method.

(c) Turbocharger Lubrication:

The high-speed rotation of the turbocharger shaft requires proper lubrication to minimize friction and wear. Here's how lubrication is achieved:

- **Engine Oil Supply:** The same engine oil used for cooling also provides lubrication. The pressurized oil from the engine's lubrication system reaches the turbocharger through dedicated channels.

- **Bearing Lubrication:** Oil passages within the turbocharger housing deliver oil to the bearings that support the turbine shaft and compressor shaft. This ensures smooth and efficient rotation of the shaft.
- **Oil Return:** Used oil from the turbocharger bearings drains back to the engine's crankcase through a return line, where it re-enters the lubrication system for filtration and further cooling.

Maintaining a healthy engine oil system with clean oil and proper oil pressure is crucial for optimal turbocharger lubrication and cooling.

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3. (a) Sketch a cross section through a four stroke diesel engine piston, labelling the MAIN components. (6)

(b) Describe the transfer of gas force from piston crown through to the crankshaft. (4)

The provided sketch depicts a cross-section through a four-stroke diesel engine piston, labeled with the following main components:

- **Piston Crown:** The top, flat surface of the piston that directly receives the force from the burning fuel mixture in the cylinder.
- **Piston Rings:** These are typically three rings that fit into grooves around the outer circumference of the piston. They slide within the cylinder wall and perform several crucial functions:
  - **Top Ring (Compression Ring):** Seals the combustion chamber by preventing high-pressure gases from leaking past the piston into the crankcase.
  - **Second Ring (Compression Ring):** Provides additional sealing and helps maintain compression in the cylinder.
  - **Scraper Ring (Oil Control Ring):** Scrapes excess oil from the cylinder wall as the piston moves, returning it to the crankcase and preventing excessive oil consumption.
- **Piston Skirt:** The lower portion of the piston that slides within the cylinder bore. It helps maintain proper piston alignment and minimize friction between the piston and cylinder wall.
- **Piston Pin Boss:** A reinforced area on the piston where the piston pin is fitted. This area is designed to handle the forces transmitted from the connecting rod.
- **Piston Pin:** A hollow steel pin that connects the piston to the connecting rod. It allows the piston to pivot slightly within the cylinder while maintaining its connection to the connecting rod.

Gas Force Transfer to Crankshaft (b):

The force generated by the burning fuel mixture in the cylinder is transferred to the crankshaft through a series of connected components:

1. **Piston Crown:** The combustion pressure acts on the piston crown, pushing it downwards with significant force.
2. **Piston Pin:** This force is then transmitted through the piston pin, which connects the piston to the small end of the connecting rod.

3. **Connecting Rod:** The connecting rod acts as a lever arm. As the piston pushes down on the piston pin, the angle between the connecting rod and the crankshaft changes. This causes the crankshaft to rotate on its axis. The big end of the connecting rod is connected to a bearing that sits on the crankshaft journal (a smooth, round surface).
4. **Crankshaft:** The combined force and leverage from the connecting rod create a turning moment on the crankshaft journals. This turning moment causes the crankshaft to rotate, converting the reciprocating (up-and-down) motion of the piston into rotary motion used by the engine to deliver power.

In simpler terms, the combustion force acts like a push on one end of a lever (connecting rod), causing the other end (crankshaft) to rotate. The design of the piston crown, connecting rod, and crankshaft plays a crucial role in efficiently transferring this force and generating usable power for the engine.

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4. The daily engine log shows the engine crankcase pressure gauge is indicating a much higher value than the normal reading.

   (a) State the implications of this and the immediate actions that should be taken. (2)

   (b) Outline the checks and investigations that should be undertaken to ascertain the cause of this increased crankcase pressure. (8)

High Crankcase Pressure in Diesel Engine

A much higher than normal reading on the engine crankcase pressure gauge indicates a potential problem that needs immediate attention. Here's a breakdown of the implications, actions to take, and potential causes:

(a) Implications and Immediate Actions:

- **Increased Blow-by Gases:** High pressure suggests excessive blow-by gases (unburnt fuel and air) are leaking past the piston rings into the crankcase. This can lead to:
  - **Reduced Engine Power:** Excessive blow-by reduces the pressure available for combustion, impacting engine performance.
  - **Oil Dilution:** Blow-by gases can contaminate the engine oil, reducing its lubricating properties.
  - **Fire Hazard:** Oil mist from the crankcase can create a fire hazard near hot engine components.

Immediate Actions:

1. **Reduce Engine Load:** Gradually decrease engine load and prepare for a safe shutdown.
2. **Investigate the Cause:** Do not ignore the issue. Identify the reason behind the high pressure.

3. **Alert Personnel:** Inform relevant personnel, especially maintenance or supervisory staff, about the situation.
4. **Do Not Restart:** Avoid restarting the engine until the cause is identified and addressed. Running the engine with high crankcase pressure can lead to serious damage.

(b) Checks and Investigations:

To determine the cause of the increased pressure, conduct the following checks and investigations:

- **Piston Rings:** Check for worn, damaged, or broken piston rings, which can allow excessive blow-by.
- **Cylinder Liners:** Inspect cylinder liners for scoring or wear, which can contribute to blow-by.
- **Valve Train:** Examine valve clearances and for any signs of sticking valves, as improper sealing can lead to blow-by.
- **Fuel Injectors:** Investigate the condition of fuel injectors. A faulty injector can deliver too much fuel, resulting in incomplete combustion and increased blow-by.
- **Crankcase Ventilation System:** Ensure the crankcase ventilation system is not clogged, as a blocked system traps blow-by gases.
- **Oil Level and Condition:** Check the oil level and condition. Low oil level can increase blow-by, and contaminated oil may not properly lubricate piston rings.

By systematically examining these potential causes, you can identify the source of the high crankcase pressure and take corrective actions to ensure safe and efficient engine operation.

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5.

Describe, with the aid of a sketch, a typical distillate fuel supply system for a diesel engine, including ALL the safety devices. (10)

Distillate Fuel Supply System for a Diesel Engine (Including Safety Devices)

A typical distillate fuel supply system for a diesel engine ensures a clean, steady flow of fuel to the engine while incorporating safety features to prevent fires, spills, and other hazards. Here's a breakdown of the key components and safety devices:

Components:

1. **Fuel Tank:** This sturdy container holds the main reserve of diesel fuel. It's often made of metal to ensure strength and is vented to allow air intake as fuel is consumed.

- **Safety Devices:**
  - **Filler Cap:** A secured cap with a seal prevents fuel spills during transport and storage.
  - **Vent Line:** This line allows air into the tank as fuel is used, preventing a vacuum that could hinder fuel flow. It may incorporate a flame arrester to prevent external ignition sources from reaching the fuel tank interior.

2. **Fuel Day Tank (Optional):** Some systems utilize a smaller day tank mounted closer to the engine. This tank serves as a buffer and provides a more consistent fuel supply to the engine.
3. **Fuel Lines:** Durable hoses or pipes carry fuel from the tank to the engine.

- **Safety Devices:**
  - **Material:** Fuel lines are made of materials resistant to fuel degradation and able to withstand operating pressures.
  - **Clamps and Connections:** Secure clamps ensure tight connections at all points to prevent leaks.

4. **Fuel Filter (Primary):** This filter removes larger particles like dirt, rust, and debris from the fuel before it enters the engine.
5. **Fuel Transfer Pump (Optional):** Some systems, especially those with high fuel consumption or located higher than the engine, might utilize a pump to ensure a consistent flow of fuel to the engine.
6. **Fuel Shutoff Valve:** This manually operated valve allows for stopping fuel flow to the engine for maintenance or emergency shutdowns.

- **Safety Device:** This valve serves as a critical safety measure to isolate the fuel system in case of emergencies.

7. **Secondary Fuel Filter (Optional):** Some systems might have an additional, finer filter located closer to the engine to remove any remaining microscopic contaminants.
8. **Fuel Injection Pump:** This pump pressurizes the fuel and delivers it to the engine's injectors at high pressure.
9. **Fuel Injection System:** This system meters and injects the pressurized fuel directly into the engine cylinders at the appropriate time during the combustion cycle.

Additional Safety Considerations:

- **Fuel Line Routing:** Fuel lines should be routed away from heat sources and protected from physical damage.
- **Spill Containment:** A spill tray or pan can be placed under the fuel filter or other potential leak points to contain any spills.
- **Regular Maintenance:** Regular inspection and replacement of fuel filters and other components are crucial to ensure proper system function and prevent issues.

By incorporating these components and safety devices, a distillate fuel supply system ensures a clean and reliable fuel source for the diesel engine while minimizing the risk of fires, leaks, and other hazards.

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6. With reference to diesel engine water coolers:

(a) describe how performance is measured; (5)

(b) describe the possible causes of the performance falling off. (5)

(a) Measuring Diesel Engine Water Cooler Performance:

The performance of a diesel engine water cooler is evaluated based on its ability to maintain the engine's optimal operating temperature range. Here are some key metrics used for measurement:

- **Coolant Outlet Temperature:** This is the primary indicator of the water cooler's effectiveness. The coolant exiting the water cooler should be within a specific range specified by the engine manufacturer. A lower coolant outlet temperature indicates better heat dissipation by the water cooler.
- **Coolant Flow Rate:** A sufficient flow rate of coolant through the engine and the water cooler is crucial for effective heat transfer. The recommended flow rate is typically specified by the engine manufacturer and can be measured using flow meters installed in the cooling system.
- **Airflow Rate:** The volume of air passing through the radiator core of the water cooler is essential for heat exchange with the surrounding environment. Airflow rate can be measured using anemometers positioned strategically in front of the radiator.
- **Pressure Drop:** The pressure difference between the coolant inlet and outlet of the water cooler indicates the resistance to flow within the system. A high pressure drop can signify blockages, scaling within the water cooler core, or an undersized unit struggling to handle the coolant flow.

(b) Possible Causes of Performance Decline:

Several factors can contribute to a decrease in the performance of a diesel engine water cooler:

- **Fouling and Blockages:** Dust, debris, and other contaminants can accumulate on the radiator fins and within the water passages, reducing airflow and hindering heat dissipation. Leaves, insects, or even mud buildup can significantly impact airflow. Internal blockages within the water cooler core due to scale formation or corrosion deposits can also impede coolant flow.
- **Deteriorating Fan Performance:** If the fan belt becomes loose or worn, or if the fan itself is damaged or malfunctions, the airflow through the radiator will be reduced, affecting the water cooler's ability to reject heat.
- **Coolant Degradation:** Over time, coolant loses its anti-corrosion and anti-freeze properties. Degraded coolant can lead to internal corrosion within the water cooler core, reducing its heat transfer efficiency. Additionally, low coolant levels can compromise the system's ability to absorb and remove heat from the engine.
- **Incorrect Coolant Mix:** Using an improper coolant concentration or a coolant type not suited for the engine and operating conditions can lead to inefficiencies.
- **Thermostat Issues:** A malfunctioning thermostat can cause the engine to run too hot or too cold. If the thermostat is stuck open, the coolant will continuously circulate through the radiator even when cooling is not required, potentially leading to engine under-temperature operation. Conversely, a stuck-closed thermostat will prevent coolant from reaching the radiator for cooling, causing overheating.
- **Water Cooler Age and Wear:** Over time, the water cooler core can become less efficient due to fin degradation, corrosion, or internal leaks. Regular maintenance and cleaning are crucial to extend the lifespan and performance of the water cooler.

By monitoring the key performance metrics and addressing these potential causes, you can ensure that the diesel engine water cooler maintains optimal engine operating temperature and prevents overheating issues.

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7. The air start pipework on a diesel engine attached to the cylinder head is becoming extremely hot.

Explain EACH of the following:

(a) the probable cause; (3)

(b) the consequences of this situation and the immediate action to be taken; (4)

(c) how this problem can be minimised. (3)

Here's a breakdown of the potential causes, consequences, and preventative measures for excessively hot air start pipes on a diesel engine:

(a) Probable Causes:

- **Insufficient Air Flow:**
  - Blocked air filter: A clogged air filter restricts the incoming cool compressed air, causing the air to heat up more as it struggles to flow through the filter element.
  - Leaking air lines: Leaks in the air supply line between the compressor and the cylinder head can allow compressed air to escape, reducing the overall volume available for starting. This can lead to the remaining air heating up significantly as it expands to fill the system.
- **Excessive Air Consumption:**
  - Faulty air starting valve: A leaking or malfunctioning air start valve can allow compressed air to continuously flow into the cylinder even after starting, leading to overheating of the pipes.

(b) Consequences and Immediate Action:

- **Consequences:**
  1. **Premature Pipe Failure:** The extreme heat can weaken the air start pipes, making them more susceptible to cracks, leaks, or even bursting.
  2. **Fire Hazard:** Leaking hot air near engine components can increase the risk of fire.
  3. **Starting Difficulties:** Reduced air pressure due to leaks or excessive heating can make starting the engine more difficult.
- **Immediate Action:**
  1. **Stop the Engine:** Safely shut down the engine to prevent further heat buildup.
  2. **Isolate the Air Supply:** Close the main air isolation valve to stop compressed air from entering the system.
  3. **Allow Cooling Down:** Let the engine and air start pipes cool down completely before further inspection.
  4. **Investigate the Cause:** Once cool, identify the reason behind the overheating using the troubleshooting steps mentioned in part (c).

(c) Minimizing the Problem:

- **Regular Maintenance:**
  - Schedule regular cleaning or replacement of the air filter to ensure proper airflow.
  - Inspect air lines for leaks and address them promptly with proper repairs or replacements.
  - Follow the manufacturer's recommended maintenance intervals for air starting components like valves and solenoids.
- **Monitoring:**
  - During operation, periodically feel the air start pipes for abnormal heat. Excessive heat indicates a potential issue that needs investigation.
- **Addressing Underlying Issues:**
  - If the problem persists, further investigation might be required to identify and address any underlying issues, such as a malfunctioning air compressor or excessive internal engine wear leading to increased air consumption.

By implementing these preventative measures and taking prompt action when overheating occurs, you can minimize the risk of damaged air start pipes, fire hazards, and starting difficulties with your diesel engine.

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8. (a) Describe the procedure for renewing a bottom end bearing of a diesel engine. (8)

(b) Describe the precautions necessary on initial startup of the engine. (2)

(a) Renewing a Bottom End Bearing in a Diesel Engine:

Renewing a bottom end bearing, also known as a main bearing replacement, in a diesel engine is a complex procedure requiring specialized knowledge and tools. Here's a general outline of the process:

Preparation:

1. **Safety First:** Ensure proper lockout/tagout procedures are followed to prevent accidental energization during the process.
2. **Engine Preparation:** Drain engine oil and coolant. Disconnect batteries and remove any components obstructing access to the bottom end (e.g., starter motor, exhaust downpipe).
3. **Engine Lifting and Support:** Safely support the engine using a hoist or lifting equipment. Depending on the engine design, the engine might need to be partially lifted or completely removed from the frame for better access.

Disassembly:

1. **Crankshaft Damper Removal:** Remove the crankshaft damper (harmonic balancer) that reduces torsional vibrations.
2. **Flywheel Removal:** Unbolt and remove the flywheel, ensuring proper alignment markings are made for reassembly.
3. **Oil Sump Removal:** Detach the oil sump to access the main bearing caps and crankshaft.

4. **Main Bearing Cap Removal:** Following a specific sequence (often in a reverse tightening order), loosen and remove the main bearing caps that hold the crankshaft in place.

Bearing Replacement:

1. **Crankshaft Inspection:** Carefully inspect the crankshaft journals for wear, scoring, or cracks. If excessive wear is present, the crankshaft might require grinding or replacement.
2. **Old Bearing Removal:** Remove the old bearing shells from the bearing caps and engine block using specialized tools to avoid damaging the surrounding surfaces.
3. **Cleaning and Inspection:** Thoroughly clean the bearing surfaces on the crankshaft and bearing caps, checking for any signs of damage or debris.
4. **New Bearing Installation:** Install new, properly sized main bearings into the bearing caps and engine block according to the manufacturer's specifications. Some bearings might require slight clearance adjustments using shims.

Reassembly:

1. **Main Bearing Cap Installation:** Following the designated tightening sequence and torque specifications, reinstall the main bearing caps.
2. **Crankshaft End Play Check:** Measure the crankshaft end play (axial movement) within the specified tolerance. Shims might need adjustment to achieve the correct end play.
3. **Flywheel and Damper Reattachment:** Reinstall the flywheel and crankshaft damper, aligning them with the previously made markings.
4. **Oil Sump and Other Components:** Reinstall the oil sump and any previously removed components.

Final Checks and Startup:

1. **Leak Checks:** Check for any leaks around the oil sump, flywheel, and other reassembled components.
2. **Engine Oil and Coolant:** Refill the engine with fresh oil and coolant according to the manufacturer's recommendations.
3. **Initial Startup Precautions (see part (b) for details).**

Important Note: This is a simplified overview. The specific procedure for renewing bottom end bearings can vary significantly depending on the engine model and size. Always refer to the manufacturer's service manual for detailed instructions, torque specifications, and proper procedures for your specific engine.

(b) Precautions Necessary on Initial Startup of the Engine After Bottom End Bearing Replacement:

After renewing the bottom end bearings, several precautions are crucial during the initial engine startup:

- **Pre-crank Checks:**
  - Verify proper oil level and pressure.
  - Ensure there are no leaks around the replaced bearings or other components.
  - Double-check all connections and ensure no tools or debris are left inside the engine.

- **Initial Crank:** Perform a short cranking session (without attempting to start the engine) to prime the oil system and ensure proper oil circulation to the new bearings.
- **Low RPM Operation:** During the initial startup, avoid high engine speeds or heavy loads. Run the engine at low RPM for a short period to allow the new bearings to properly seat and bed in.
- **Monitor Oil Pressure and Temperature:** Closely monitor engine oil pressure and temperature during the initial run. Any abnormal readings or fluctuations might indicate potential issues.
- **Listen for Unusual Noises:** Pay close attention to any unusual noises or vibrations during operation. These could be signs of improper bearing clearances or other problems.
- **Gradual Load Increase:** Gradually increase engine load and RPM over time, allowing the new bearings to fully adapt.

By following these precautions, you can minimize the risk of damage to the newly replaced bearings and ensure proper engine operation after a bottom end bearing replacement.

October 2018 MDE

9. Describe, with the aid of a sketch, the operation of a diesel engine propulsion system air operated radial tyre type clutch. (10)

It's important to clarify a few points about the terminology used:

- **Radial Tyre Type Clutch:** This term is not typically used in diesel engine propulsion systems. Radial tire clutches are more commonly found in agricultural equipment and utilize the inflated shape of a tire to create clamping force.
- **Air Operated Clutch:** This is a more likely description for a compressed air-actuated clutch used in a diesel engine propulsion system.

Here's a breakdown of a typical air-operated clutch operation in a diesel engine propulsion system for a medium-speed application:

Components:

- **Compressed Air System:** Provides pressurized air for clutch actuation.
- **Air Actuator Cylinder:** A piston cylinder connected to the clutch housing.
- **Pressure Plate:** Clamps the friction plates against the driven plate.
- **Friction Plates:** Multiple interleaved discs with high-friction material surfaces.
- **Driven Plate:** Connects to the propeller shaft and rotates with the engine flywheel when engaged.
- **Control System:** Regulates compressed air flow to the actuator for engagement and disengagement.

Operation:

1. **Engagement:**
    - The control system directs compressed air into the actuator cylinder.
    - The pressurized air pushes the piston within the cylinder, extending the piston rod.
    - The extending piston rod applies force to the pressure plate through levers or linkages.

  - The pressure plate clamps the friction plates between itself and the driven plate.
  - Friction between the plates transmits torque from the engine flywheel (connected to the pressure plate) to the driven plate and ultimately the propeller shaft.
  - The engine and propeller become connected, propelling the vessel.
2. **Disengagement:**
  - When the control system vents compressed air 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 due to spring force.
  - With the pressure plate disengaged, friction between the plates is eliminated, and the connection between the engine and propeller shaft is interrupted.
  - The engine can continue to run without propelling the vessel (idling).

Additional Points:

- **Spring-Engaged Design:** Some clutches might be 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.
- **Interlocks:** Safety interlocks might be implemented. For example, the clutch might not engage until engine speed falls below a certain RPM or until lubrication oil pressure reaches a minimum level.

This description provides a general overview of an air-operated clutch in a diesel engine propulsion system. The specific design and control system might vary depending on the application and manufacturer.

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10. With reference to a gearbox:

(a) explain why large quantities of lubricating oil are used; (2)

(b) state FOUR possible causes of excessive lubricating oil temperature when at normal operating speeds; (4)

(c) state how EACH cause stated in part (b) may be remedied. (4)

Gearbox Lubrication:

(a) Large Quantities of Lubricating Oil:

Gearboxes use relatively large quantities of lubricating oil for several reasons:

- **Heat Dissipation:** Gearboxes generate significant heat due to friction between meshing gears and bearings. The oil acts as a heat sink, absorbing heat from these components and carrying it away. A larger volume of oil allows for better heat transfer and maintains a cooler operating temperature for the gearbox.

- **Lubrication:** The oil provides a lubricating film between gear teeth and bearing surfaces, reducing friction and wear. A sufficient amount of oil ensures all critical components are adequately lubricated.
- **Sealing:** The oil helps to seal clearances between gears and shafts, preventing leaks and minimizing contamination ingress.
- **Corrosion Protection:** The oil forms a protective layer on internal components, helping to prevent corrosion.

(b) Excessive Gearbox Oil Temperature (4 Causes):

1. **Insufficient Oil Level:** If the oil level is too low, there's not enough oil to absorb and dissipate heat effectively, leading to a rise in temperature.
2. **Incorrect Oil Viscosity:** Using oil with an incorrect viscosity can lead to problems. Oil that is too thin won't provide adequate lubrication and will flow too easily, reducing its ability to absorb heat. Conversely, oil that is too thick will create excessive drag and friction, also contributing to higher operating temperatures.
3. **Contamination:** Contamination of the oil with dirt, debris, or coolant can reduce its lubricating properties and heat transfer efficiency, leading to increased friction and higher temperatures.
4. **Internal Gearbox Faults:** Worn or damaged gear teeth, bearings, or internal components can create excessive friction and heat generation, causing the oil temperature to rise even at normal operating speeds.

(c) Remedies for Excessive Oil Temperature:

1. **Correct Oil Level:** Check and adjust the oil level to the manufacturer's recommended specification. This ensures optimal oil circulation and heat dissipation.
2. **Proper Oil Selection:** Use the correct oil grade and viscosity recommended in the owner's manual. Consult a qualified mechanic if unsure about the appropriate oil type for your specific gearbox.
3. **Oil Change and System Flush:** Regularly change the oil and filter according to the manufacturer's maintenance schedule. In some cases, if contamination is suspected, a gearbox oil flush might be necessary to remove contaminants and ensure clean oil circulation.
4. **Gearbox Inspection and Repair:** If internal component wear or damage is suspected, a qualified mechanic should inspect the gearbox to identify the fault and perform necessary repairs or replacements. Early detection and addressing internal issues can prevent further damage and overheating.

By maintaining proper oil level, using the right lubricant, and addressing contamination or internal faults promptly, you can help ensure optimal operating temperature and extend the life of your gearbox.