Feb 2020

February 2020 MDE

5. (a) List FIVE products directly obtained from the distillation of Crude Oil, stating a typical use for EACH on board a vessel. (5)

(b) With reference to ISO 8217, aluminium & silicon oxides in fuel, state EACH of the following:

(i) how they get there; (2)

(ii) what effect they will have on engine performance; (2)

(iii) how they are removed from the fuel. (1)

(a) Distillation Products from Crude Oil and their Uses on a Vessel:

1. **Fuel Oil (Bunker Fuel):** The primary fuel used for powering the main propulsion engine and generators on most commercial vessels. Bunker fuel comes in various grades with different sulfur contents.
2. **Marine Diesel Oil (MDO):** A lighter distillate fuel used for auxiliary engines, generators, and deck machinery on board ships. MDO has a lower sulfur content compared to bunker fuel and offers better combustion characteristics.
3. **Marine Gasoil (MGO):** A very low sulfur content diesel fuel used in emission-controlled engines or in areas with strict emission regulations. MGO is similar to MDO but with even lower sulfur levels.
4. **Lubricating Oils:** A variety of lubricating oils are derived from crude oil and used for various purposes on board. These include engine oil for internal combustion engines, gear oil for gearboxes and transmissions, and hydraulic oil for hydraulic systems.
5. **Asphalt:** While not directly used on board in its final form, asphalt, also known as bitumen, is a product of crude oil distillation. It can be used for waterproofing applications on some vessels or for shore-based maintenance projects.

(b) Aluminium & Silicon Oxides in Fuel according to ISO 8217:

(i) How They Get There:

Aluminium (Al) and silicon (Si) oxides can enter marine fuels through various pathways:

- **Natural Contamination:** Trace amounts of these elements can be present naturally in the crude oil itself due to geological formations.
- **Refinery Processes:** During the refining process, some clay-based materials used for catalysts or adsorbents might contribute aluminium and silicon oxides to the final fuel product.
- **Storage and Handling:** Contamination can occur during storage and transportation due to contact with tanks, pipelines, or equipment containing these materials.

(ii) Effect on Engine Performance:

The presence of aluminium and silicon oxides in fuel can have several negative consequences for engine performance:

- **Abrasive Wear:** These hard oxide particles can act as abrasives, increasing wear and tear on engine components like pistons, cylinder liners, and injector nozzles.
- **Deposit Formation:** Aluminium and silicon oxides can contribute to deposit buildup on pistons, injector tips, and exhaust valves. These deposits can hinder proper fuel injection, reduce combustion efficiency, and lead to power loss.
- **Increased Maintenance Needs:** The abrasive wear and deposit formation caused by these contaminants can necessitate more frequent engine maintenance and component replacements.

(iii) How They Are Removed from Fuel:

There are several methods for removing or reducing aluminium and silicon oxides in marine fuels:

- **Centrifugation:** High-speed centrifuges can separate out solid contaminants, including some oxide particles, from the fuel oil.
- **Microfiltration:** Fine filters can trap smaller oxide particles that might not be removed by centrifuges.
- **Fuel Additives:** Specific fuel additives can be used to disperse or agglomerate these oxides, preventing them from causing wear or deposit formation.
- **Careful Storage and Handling:** Implementing proper storage and handling practices to minimize contamination from tanks and equipment can help prevent the introduction of these oxides in the first place.

The specific method chosen for removing aluminium and silicon oxides will depend on the severity of contamination, economic factors, and the fuel treatment capabilities available on board the vessel. Following the guidelines set forth in ISO 8217, which specifies the maximum allowable limits for various contaminants in marine fuels, helps ensure fuel quality and protects engines from wear and tear.

Oct 2023

October 2023 MDE

5. With reference to microbial infestation of distillate fuel:

(a) describe what is meant by the term *microbe;* (1)

(b) state what microbes need to survive; (2)

(c) describe the possible diesel engine problems; (5)

(d) describe how it can be identified. (2)

Microbial Infestation in Distillate Fuel:

(a) What is a Microbe?

A microbe is a microscopic organism, encompassing a diverse range of life forms too small to be seen with the naked eye. This includes:

- **Bacteria:** Single-celled organisms with a cell wall, some of which can cause biodegradation of fuels.
- **Fungi:** Multicellular organisms that can grow as mold or yeast, also capable of degrading organic materials like fuel.
- **Algae:** Simple aquatic photosynthetic organisms that might be present in trace amounts in contaminated fuel storage tanks.

(b) What Microbes Need to Survive:

Microbes involved in fuel degradation have specific requirements for survival and growth:

- **Moisture:** Water is essential for microbial activity. The presence of even small amounts of water at the fuel-water interface in storage tanks can create a suitable environment for microbial growth.
- **Nutrients:** Microbes require nutrients for growth and reproduction. Distillate fuels themselves don't provide sufficient nutrients, but contaminants like dirt, debris, or organic material introduced during storage or handling can act as nutrient sources.
- **Favorable Temperature:** Microbial growth rates are influenced by temperature. Warmer storage tank temperatures can accelerate microbial growth compared to cooler conditions.

(c) Possible Diesel Engine Problems Caused by Microbial Infestation:

Microbial growth in diesel fuel can lead to several problems in diesel engines:

- **Blocked Filters:** Microbial colonies and associated biomass can clog fuel filters, restricting fuel flow to the engine and potentially causing power loss or engine stalling.
- **Corrosion:** Certain microbes can produce byproducts like organic acids that contribute to fuel system corrosion, damaging pumps, injectors, and other components.
- **Degraded Fuel Quality:** Microbial activity can break down fuel components, reducing its energy content and hindering combustion efficiency. This can lead to increased fuel consumption and decreased engine power output.
- **Gel Formation:** In cold weather conditions, some microbes can produce gel-like substances that can thicken the fuel, further impeding fuel flow and potentially causing engine startup issues.

(d) Identifying Microbial Infestation:

Several methods can be used to identify the presence of microbial contamination in diesel fuel:

- **Visual Inspection:** Fuel samples with a cloudy appearance, presence of water droplets, or visible sludge formation can indicate potential microbial growth.
- **Spot Tests:** Simple test kits can be used to check for the presence of microbial colonies in fuel samples.
- **Fuel Analysis:** Sending fuel samples to a laboratory for detailed analysis can identify specific types of microbes present and assess the severity of the contamination.

Regular fuel sampling and testing, along with proper storage practices to minimize water ingress and contamination, are crucial for preventing microbial growth and ensuring clean fuel for optimal engine performance.

jan 2023

JAN 2023 MDE

5. With reference to diesel engine fuel:

(a) explain the meaning of the term *microbial contamination*; (1)

(b) describe the possible problems the engine may encounter if the fuel received is contaminated with microbes; (4)

(c) explain how *microbial contamination* can be avoided; (3)

(d) explain the actions to be taken if *microbial contamination* is severe. (2)

Diesel Engine Fuel and Microbial Contamination:

(a) Microbial Contamination:

Microbial contamination in diesel fuel refers to the presence and growth of microorganisms like bacteria, fungi, and algae within the fuel. These microscopic organisms can thrive in certain conditions and pose problems for the engine and fuel system.

(b) Problems Caused by Microbial Contamination:

Microbial contamination in diesel fuel can lead to several issues for the engine:

- **Blocked Filters:** Microbial colonies and associated biomass can clog fuel filters, restricting fuel flow to the engine and potentially causing power loss or engine stalling.
- **Corrosion:** Certain microbes can produce byproducts like organic acids that contribute to fuel system corrosion, damaging pumps, injectors, and other components.
- **Degraded Fuel Quality:** Microbial activity can break down fuel components, reducing its energy content and hindering combustion efficiency. This can lead to increased fuel consumption and decreased engine power output.
- **Gel Formation:** In cold weather conditions, some microbes can produce gel-like substances that can thicken the fuel, further impeding fuel flow and potentially causing engine startup issues.

(c) Avoiding Microbial Contamination:

Here are some key strategies to prevent microbial contamination in diesel fuel:

- **Minimize Water Ingress:** Water provides a medium for microbial growth. 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.
- **Fuel Filtration:** Utilize appropriate fuel filters that can help trap microbial contaminants before they reach the engine.
- **Biocide Additives:** Consider using biocide fuel additives as a preventative measure. These additives can inhibit the growth of microbes within the fuel.
- **Regular Fuel Testing:** Periodically test fuel samples for signs of microbial contamination.

(d) Actions for Severe Microbial Contamination:

If microbial contamination is identified as severe, here's what to do:

- **Do Not Operate the Engine:** Further running the engine with contaminated fuel can exacerbate problems.
- **Drain and Dispose of Contaminated Fuel:** Safely drain the contaminated fuel from the tank and dispose of it properly according to environmental regulations.
- **Clean the Fuel System:** The fuel tank, lines, and filters need thorough cleaning to remove microbial growth and debris. This might involve using specialized cleaning solutions and procedures.
- **Refill with Clean Fuel:** Only refill the system with fresh, clean fuel after ensuring proper cleaning of the fuel system.
- **Consider System Inspection:** In severe cases, a professional inspection of the fuel system components might be necessary to assess any potential damage caused by the contamination.

By following these preventative measures and taking prompt action when contamination is discovered, you can minimize the risk of engine problems and ensure optimal performance from your diesel engine.

april 2023

April 2023 MDE

5. With reference to distillate fuel oil, explain EACH of the following:

(a) why it often needs treatment before the engine; (6)

(b) why it sometimes needs cooling after the engine. (4)

May 2018 MDE

5. With reference to distillate fuel oil, explain EACH of the following:

(a) why it often needs treatment before the engine; (6)

(b) why it sometimes needs cooling after the engine. (4)

Distillate Fuel Oil Treatment and Cooling:

(a) Why Distillate Fuel Needs Treatment Before the Engine:

Despite being a cleaner-burning fuel compared to residual fuels, distillate fuel oil often requires treatment before entering the engine for several reasons:

- **Improved Stability:** Distillate fuels are prone to degradation over time, especially during storage. Treatment with specific additives can enhance stability and prevent issues like gum formation or sediment buildup within the fuel system.

- **Corrosion Protection:** Distillate fuels lack the natural lubricity of some residual fuels. Additives can provide a protective film on internal engine components to minimize wear and corrosion.
- **Water Contamination:** Even minor water content in the fuel can cause problems like ice crystal formation in cold weather or promote microbial growth. Treatment with water dispersants or demulsifiers can help mitigate these issues.
- **Combustion Optimization:** Certain additives can act as detergents or dispersants, keeping contaminants suspended in the fuel and preventing them from clogging injectors or hindering proper combustion.
- **Cold Flow Properties:** In cold climates, distillate fuels can thicken and impede flow. Additives like wax dispersants can improve the fuel's cold flow properties and ensure proper fuel delivery to the engine.

(b) Why Distillate Fuel Doesn't Always Need Cooling After the Engine:

Distillate fuel itself doesn't necessarily require cooling after exiting the engine. However, the engine itself generates significant heat during operation, and the fuel plays a role in heat transfer:

- **Heat Transfer Medium:** Distillate fuel acts as a heat transfer medium within the engine. It absorbs heat from the hot engine components like pistons and cylinder walls.
- **Engine Cooling System:** The engine's primary cooling system is responsible for dissipating this absorbed heat. This system typically uses a coolant (water-based solution) circulating through the engine block and a radiator to transfer heat to the surrounding air.
- **Fuel Temperature:** The temperature of the fuel exiting the engine will be higher than the incoming fuel due to heat absorption. However, in most cases, the engine's cooling system effectively manages overall engine temperature, and the heated fuel doesn't require dedicated cooling before returning to the tank (if applicable).

Exceptions:

In some specific situations, the fuel itself might require additional cooling before returning to the tank:

- **High Engine Loads or Ambient Temperatures:** Under extreme engine loads or very hot ambient conditions, the engine cooling system might struggle to keep up. In such cases, a fuel cooler could be utilized to further cool the fuel before returning it to the tank and prevent excessive fuel heating that could degrade its properties.
- **Closed-Loop Fuel Systems:** Some engine configurations might have closed-loop fuel systems where the fuel continuously circulates within the engine and a dedicated fuel cooler might be used to maintain optimal fuel temperature within the loop.

In summary, while distillate fuel does pick up heat within the engine, the engine's primary cooling system is usually sufficient. Additional fuel cooling might be necessary only under specific circumstances or in specific engine designs june 2021

June 2021 MDE

3. With reference to distillate fuel oil material safety datasheets, describe with examples the information that would be included for EACH of the following:

(a) hazards; (4)

(b) first aid; (3)

(c) fire fighting measures. (3)

Distillate Fuel Oil MSDS Information: Examples for Specific Sections

Distillate fuel oil Material Safety Data Sheets (MSDS) provide crucial information regarding the safe handling, storage, and disposal of this fuel. Let's explore some key details included in each section, using examples:

(a) Hazards:

This section outlines the potential hazards associated with distillate fuel oil exposure. Examples of information you'll find:

- **Health Hazards:**
  - **Inhalation:** Exposure to fuel vapors can cause irritation of the respiratory system, coughing, dizziness, and headaches. (Example: "Inhalation of vapors may cause irritation of the nose, throat, and lungs. Symptoms may include coughing, shortness of breath, and nausea.")
  - **Skin Contact:** Prolonged or repeated skin contact can cause dryness, irritation, or dermatitis. (Example: "Prolonged or repeated contact with skin may cause irritation or drying.")
  - **Ingestion:** Swallowing fuel oil can be very harmful and lead to aspiration pneumonia. (Example: "Harmful if swallowed. Do not induce vomiting.")
- **Fire Hazards:** Distillate fuel oil is a combustible liquid with a flash point (minimum temperature at which it ignites) typically above 38°C (100°F). (Example: "Combustible liquid. Flash Point (PMCC): >38°C (100°F).")
- **Environmental Hazards:** Spills or leaks can contaminate soil and water, posing risks to aquatic life and ecosystems. (Example: "Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.")

(b) First Aid:

This section provides immediate response steps in case of accidental exposure to distillate fuel oil. Examples include:

- **Inhalation:** Move the person to fresh air and provide medical attention if breathing becomes difficult. (Example: "If inhaled, remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a Poison Control Center or doctor/physician if you feel unwell.")

- **Skin Contact:** Immediately remove contaminated clothing and wash the affected area thoroughly with soap and water. (Example: "Remove contaminated clothing and wash skin thoroughly with soap and water or use a recognized skin cleanser.")
- **Eye Contact:** Flush eyes with clean water for at least 15 minutes, holding eyelids open. Seek medical attention immediately. (Example: "Immediately flush eyes with plenty of water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention immediately.")
- **Ingestion:** Do not induce vomiting. Seek immediate medical attention. (Example: "Do not induce vomiting. Call a Poison Control Center or doctor/physician immediately.")

(c) Fire Fighting Measures:

This section details proper procedures for extinguishing fires involving distillate fuel oil and the associated safety considerations. Examples include:

- **Suitable Extinguishing Media:** Water spray, dry chemical powder, or carbon dioxide can be used to extinguish fires involving distillate fuel oil. (Example: "Use water spray, dry chemical powder, or carbon dioxide to extinguish.")
- **Unsuitable Extinguishing Media:** A direct water stream might not be effective and could spread the burning fuel. (Example: "Do not use a solid water stream as it may spread the fire.")
- **Specific Hazards Arising from the Chemical:** Burning fuel oil can produce dense smoke and toxic fumes containing carbon monoxide and other harmful gases. (Example: "In a fire, may emit acrid smoke and irritating fumes.")
- **Protective Equipment for Firefighters:** Firefighters should wear self-contained breathing apparatus (SCBA) and full protective clothing when responding to a fuel oil fire. (Example: "Firefighters should wear self-contained breathing apparatus and full protective clothing.")

Remember: These are just examples, and the specific information in an MSDS will vary depending on the exact fuel oil product and manufacturer. Always refer to the most recent version of the MSDS for the specific fuel oil you are using.

Oct 2023

October 2023 MDE

6. Sketch a distillate fuel oil centrifugal purifier, showing the direction of all fluid flows labelling the MAIN components. (10)

Distillate Fuel Oil Centrifugal Purifier:

A distillate fuel oil centrifugal purifier is a device that utilizes centrifugal force to separate contaminants like water and solids from the fuel oil. Here's a breakdown of the main components and fluid flow directions:

Components:

1. **Inlet Housing:** This is the entry point for the dirty fuel oil.
2. **Feed Pump (Optional):** An optional pump located before the inlet housing can be used to ensure a consistent flow rate of fuel oil entering the purifier.

3. **Distributor:** This component evenly distributes the incoming fuel oil into the centrifuge bowl.
4. **Centrifuge Bowl:** This is a cylindrical, high-speed rotating vessel that separates the fuel oil from the contaminants based on their densities.
5. **Disc Stack (Optional):** Some purifiers utilize a stack of discs within the bowl to improve separation efficiency by creating a larger effective settling area.
6. **Heavy Phase (Solids and Water) Collection Chamber:** The denser contaminants like water and solids accumulate at the periphery of the rotating bowl due to centrifugal force.
7. **Light Phase (Clean Fuel Oil) Collection Chamber:** The less dense clean fuel oil accumulates near the center of the rotating bowl.
8. **Heavy Phase Outlet:** This allows the separated water and solids to exit the bowl.
9. **Light Phase Outlet:** The cleaned fuel oil exits the bowl through this outlet.
10. **Drive System:** A motor provides the power to rotate the centrifuge bowl at high speeds (typically several thousand rpm).
11. **Control System (Optional):** Modern purifiers might have an electronic control system that monitors and regulates various parameters like speed, temperature, and differential pressure.

Fluid Flow Direction:

1. Dirty fuel oil enters the **inlet housing**.
2. The fuel oil might pass through an optional **feed pump** to ensure consistent flow.
3. The distributor directs the incoming fuel oil towards the center of the rotating **centrifuge bowl**.
4. As the bowl spins at high speed, centrifugal force separates the fluids based on their densities.
5. Denser contaminants (water and solids) migrate outwards and accumulate at the periphery of the bowl in the **heavy phase collection chamber**.
6. Less dense clean fuel oil accumulates near the center of the bowl in the **light phase collection chamber**.
7. Separated water and solids are continuously discharged from the bowl through the **heavy phase outlet**.
8. Cleaned fuel oil exits the bowl through the **light phase outlet**.

Note:

- The specific design and configuration of a centrifugal purifier might vary depending on the manufacturer and application. Some purifiers might have a self-cleaning mechanism for the heavy phase chamber, eliminating the need for frequent manual cleaning.
- Modern purifiers can be automated and integrated into a larger fuel oil handling system.

By utilizing centrifugal force, a distillate fuel oil centrifugal purifier effectively removes contaminants, ensuring cleaner fuel for optimal engine performance and reduced wear and tear.

Feb 2022

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.

Oct 2022

October 2022 MDE

6. Describe, with the aid of a sketch, a coalescer type distillate fuel oil filter. (10)

Distillate Fuel Oil Coalescer Filter

A coalescer type distillate fuel oil filter is a device that utilizes the principle of coalescence to remove water from the fuel oil. Here's a breakdown of its operation and key components:

Function:

Unlike traditional filter media that simply trap water droplets, a coalescer filter promotes the merging of smaller water droplets dispersed throughout the fuel oil into larger water droplets. These larger droplets can then be more easily separated from the fuel oil due to the difference in density (water is denser than oil).

Components:

1. **Filter Housing:** This sturdy container holds all the internal components of the filter.
2. **Inlet Port:** The dirty fuel oil containing water droplets enters the filter through this port.
3. **Coalescing Media:** This is the heart of the filter and is typically made of a pleated or layered synthetic material with a high surface area. The specific design of the media can vary, but it is designed to:
    - **Capture Water Droplets:** As the fuel oil passes through the media, the water droplets come into contact with the fibers and adhere to them due to surface tension.
    - **Coalescence:** The media promotes the merging of these smaller water droplets into larger ones due to the phenomenon of coalescence. Water droplets naturally tend to minimize their surface area, and merging into larger droplets achieves this.
4. **Drainage Mechanism:** A mechanism, such as a drain valve or an automated float system, allows the accumulated larger water droplets to be periodically drained from the filter housing.
5. **Outlet Port:** The cleaned fuel oil, now with significantly reduced water content, exits the filter through this port.

Benefits of Coalescer Filters:

- **High Water Removal Efficiency:** Coalescer filters can remove very small water droplets from fuel oil, offering superior performance compared to traditional filter media.
- **Reduced Maintenance:** By efficiently separating water, coalescer filters can extend the lifespan of downstream filters and reduce maintenance frequency.
- **Improved Engine Performance:** Water in fuel oil can lead to problems like corrosion, reduced combustion efficiency, and potential engine damage. Coalescer filters help prevent these issues by ensuring cleaner, drier fuel for the engine.

Applications:

Coalescer filters are widely used in applications where clean, dry fuel oil is essential, such as:

- Onboard marine engines and generators
- Industrial diesel engines and generators
- Construction equipment
- Off-road vehicles operating in wet or humid environments

By utilizing coalescing technology, these filters effectively remove water from distillate fuel oil, ensuring optimal engine performance and protection from water-related problems.

Feb 2020

February 2020 MDE

6. Describe the engine and system problems created by EACH of the following common contaminants in distillate fuel oil:

(a) water; (3)

(b) solids; (3)

(c) microbes. (4)

Engine and System Problems Caused by Distillate Fuel Oil Contaminants:

Contaminants in distillate fuel oil can lead to various problems affecting engine performance, efficiency, and system integrity. Here's a breakdown of the issues caused by three common contaminants:

(a) Water:

- **Corrosion:** Water in fuel oil can promote corrosion of fuel system components like pumps, injectors, and pipelines. This can lead to premature component failure and costly repairs.
- **Ice Crystal Formation:** In cold weather conditions, water can freeze and form ice crystals within the fuel system. These ice crystals can clog filters and restrict fuel flow, potentially causing engine stalling or power loss.
- **Poor Combustion:** Water reduces the fuel's lubricity and can interfere with proper fuel atomization during injection. This can lead to incomplete combustion, reduced engine power output, and increased smoke emissions.

- **Microbial Growth:** The presence of water can create a suitable environment for microbial growth (bacteria, fungi) within the fuel tank. This can lead to further problems like clogged filters and degraded fuel quality.

(b) Solids:

- **Blocked Filters:** Solid contaminants like dirt, rust, or wear debris can clog fuel filters and restrict fuel flow to the engine. This can lead to power loss, engine stalling, and potential engine damage if the engine is starved of fuel.
- **Abrasive Wear:** Hard, abrasive solids can cause wear and tear on internal engine components like pistons, cylinder liners, and injector nozzles. This can lead to reduced engine lifespan and increased maintenance needs.
- **Sticking Injectors:** Solid particles can become lodged in injector components, causing them to stick or malfunction. This can result in poor fuel atomization, incomplete combustion, and engine performance issues.

(c) Microbes:

- **Blocked Filters:** Microbial colonies (bacteria, fungi) can grow and clog fuel filters, restricting fuel flow to the engine and potentially causing power loss or engine stalling.
- **Corrosion:** Certain microbes can produce byproducts like organic acids that contribute to fuel system corrosion, damaging pumps, injectors, and other components.
- **Degraded Fuel Quality:** Microbial activity can break down fuel components, reducing its energy content and hindering combustion efficiency. This can lead to increased fuel consumption and decreased engine power output.
- **Gel Formation:** In cold weather conditions, some microbes can produce gel-like substances that can thicken the fuel, further impeding fuel flow and potentially causing engine startup issues.

Overall Impact:

The presence of contaminants in distillate fuel oil can have a cumulative negative impact on engine performance, fuel efficiency, and system reliability. It can lead to:

- Increased maintenance costs due to clogged filters, component wear, and potential repairs.
- Reduced engine power output and efficiency.
- Increased fuel consumption.
- Increased risk of engine breakdowns and downtime.

Following proper fuel handling practices, using high-quality fuel, and implementing regular fuel testing and filtration helps minimize the risk of contamination and ensures optimal engine performance.

Oct 2022

October 2022 MDE

4. 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.

Jan 2019

January 2019 MDE

5. (a) Describe how contamination of fuel oil by EACH of the following can occur:

(i) microbes; (2)

(ii) sodium. (2)

(b) Describe how to avoid fuel system and engine related problems with reference to the TWO contaminants in part (a). (6)

Distillate Fuel Oil Contamination: Sources and Prevention

(a) Sources of Contamination:

(i) Microbes:

- **Water Ingress:** The primary culprit for microbial growth in fuel oil is water contamination. Microbes require moisture to survive and reproduce. Even small amounts of water at the fuel-oil interface in storage tanks can create a suitable environment for microbial growth.
- **Dirty Storage Tanks:** Improperly cleaned or maintained storage tanks can harbor microbial colonies that can then contaminate the fuel during filling or transfer.
- **Fuel Transfer Practices:** Contamination can occur during fuel transfer if equipment or hoses are not clean or if the transfer process allows for water or other microbial-laden substances to enter the fuel.

(ii) Sodium:

- **Seawater Ingress:** In marine applications, the biggest risk of sodium contamination comes from seawater intrusion. Leaks in heat exchangers or breaches in the fuel system can allow seawater to mix with the fuel oil, introducing sodium chloride (salt).
- **Contaminated Fuel Source:** Less commonly, sodium contamination can occur if the fuel itself is sourced from a well or reserve with naturally high sodium content.
- **Improper Additive Use:** Using certain additives containing sodium-based compounds for purposes like corrosion inhibition can introduce sodium into the fuel if not used within recommended guidelines.

(b) Avoiding System and Engine Problems:

(i) Microbes:

- **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.
- **Fuel Filtration:** Regularly replace fuel filters to remove any captured microbes or debris.

(ii) Sodium:

- **Regular System Inspections:** For marine applications, conduct regular inspections of heat exchangers and the fuel system for leaks or potential seawater intrusion points.
- **Fuel Source Monitoring:** If operating in regions with known high-sodium fuel sources, consider alternative fuel options or implement additional purification steps.
- **Proper Use of Additives:** Follow the manufacturer's recommendations for dosage and application of any sodium-based fuel additives.
- **Fuel Analysis:** For critical applications, consider routine fuel analysis to monitor sodium content and identify potential contamination risks.

By taking these preventive measures, you can significantly reduce the risk of both microbial and sodium contamination, preventing problems within the fuel system and engine. Clean fuel ensures optimal engine performance, efficiency, and lifespan

Jan 2018

January 2018 MDE

5. (a) Explain what is meant by EACH of the following fuel terms:

(i) cloud point; (2)

(ii) compatibility. (2)

(b) Describe how to avoid fuel system and engine related problems with reference to the TWO terms in part (a) (6)

Distillate Fuel Oil Terms and Avoiding Problems:

(a) Fuel Terms:

(i) Cloud Point:

- **Definition:** The cloud point of a distillate fuel oil refers to the temperature at which wax crystals begin to form and separate from the liquid fuel. As the temperature drops below the cloud point, the fuel becomes cloudy due to the suspended wax crystals.

(ii) Compatibility:

- **Definition:** Fuel compatibility refers to the ability of two different fuels to be mixed without causing adverse effects. Incompatible fuels can lead to problems when blended, such as:
    - **Sediment Formation:** Incompatible fuels can react and form sludge or sediment that can clog filters and fuel lines.
    - **Increased Viscosity:** Mixing incompatible fuels can cause the resulting blend to thicken, hindering proper fuel flow within the engine.

- **Corrosion:** Certain fuel blends might lead to increased corrosion within the fuel system components.

(b) Avoiding Problems:

(i) Cloud Point:

- **Fuel Selection:** When operating in cold weather conditions, it's crucial to choose a distillate fuel with a cloud point **lower** than the expected minimum operating temperature. This ensures the fuel remains liquid and flows freely within the fuel system, preventing problems like filter clogging and engine stalling.
- **Fuel Additives:** In some cases, cold flow improver additives can be used to lower the cloud point of the existing fuel and improve its performance in colder temperatures.

(ii) Compatibility:

- **Fuel Storage and Handling:** Always store different fuel types in separate tanks and avoid mixing them unless confirmed to be compatible. Clearly label storage tanks to prevent accidental mixing.
- **Fuel Supplier Guidance:** Consult the fuel supplier or refer to technical data sheets for information on fuel compatibility.
- **Fuel Testing:** In critical applications or when mixing fuels is unavoidable, consider fuel compatibility testing before using the blend in an engine. This can help identify potential issues and prevent problems within the fuel system and engine.

By understanding the cloud point and fuel compatibility, you can select the appropriate fuel type and avoid mixing incompatible fuels. This helps ensure smooth engine operation, prevents filter clogging, and minimizes wear and tear on system components.

May 2018

May 2018 MDE

4. (a) Explain what is meant by the term *flashpoint* of bunker fuel stored on board. (1)

(b) Describe the importance of knowing the flash point of the bunker fuel stored on board. (1)

(c) Describe a method in common use for ascertaining the flashpoint of bunker fuel. (4)

(d) State the SOLAS requirements, with respect to temperature, for storage of bunker fuel in an engine room. (4)

Bunker Fuel Flashpoint: Importance and Measurement

(a) Flashpoint of Bunker Fuel:

The flashpoint of bunker fuel refers to the **lowest temperature** at which the fuel vapor can ignite in the presence of an ignition source (like a spark). It's a crucial parameter for understanding the fire risk associated with bunker fuel storage and handling onboard a ship.

(b) Importance of Knowing Flashpoint:

Knowing the flashpoint of bunker fuel stored on board is critical for several reasons:

- **Safety:** Fuels with lower flash points are more susceptible to igniting and pose a greater fire hazard. Understanding the flashpoint allows for implementing appropriate safety measures during storage, handling, and refueling operations.
- **Regulation Compliance:** The International Maritime Organization (IMO) regulations under SOLAS (Safety of Life at Sea) convention have minimum flashpoint requirements for bunker fuel storage onboard ships. Knowing the flashpoint ensures compliance with these regulations.
- **Safe Storage and Handling:** Flashpoint information helps determine appropriate storage temperatures and handling procedures. For example, fuels with lower flash points might require stricter temperature control or specific ventilation measures.

(c) Ascertaining Bunker Fuel Flashpoint:

A common method for determining the flashpoint of bunker fuel onboard a ship is the **Pensky-Martens closed cup test (PMCC)**. This standardized test uses a small, sealed cup filled with a fuel sample. The cup is gradually heated, and a small flame is introduced at regular intervals to check if the vapors ignite. The temperature at which the vapors first ignite is recorded as the flashpoint.

(d) SOLAS Requirements for Bunker Fuel Storage Temperature:

SOLAS regulations do not directly specify a storage temperature for bunker fuel within the engine room. However, they do set a minimum flashpoint requirement for the fuel itself. Currently, the **minimum flashpoint** for all distillate and residual grades of bunker fuel (except for Designated Marine (DMX) fuel) stored or used onboard ships must be **not less than 60°C (140°F)**.

It's important to note that while flashpoint is a crucial safety parameter, it's not the only factor determining fire risk. Other factors like fuel volatility and storage conditions also play a role. Maintaining safe storage practices and adhering to SOLAS regulations are essential for safe handling of bunker fuel onboard ships.

Oct 2019

October 2019 MDE

5. 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)

(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.
- **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.

Jan 2018

January 2018 MDE

6. Describe, with the aid of a sketch, a coalescer type distillate fuel oil filter. (10)

lubricating oil

oct 2020

October 2020 MDE

5. (a) Explain what is meant by microbial degradation of a lubricating oil. (4)

(b) State FOUR indications that could be observed if a lubricating oil was suffering from microbial degradation. (4)

(c) Describe TWO actions that should be taken on detecting the early start of microbial degradation of the main engine lubricating oil. (2)

april 2023

April 2023 MDE

6. (a) Explain what is meant by microbial degradation of a lubricating oil. (4)

(b) State FOUR indications that could be observed if a lubricating oil was suffering from microbial degradation. (4)

(c) Describe TWO actions that should be taken on detecting the early start of microbial degradation of the main engine lubricating oil. (2)

Microbial Degradation of Lubricating Oil:

(a) Microbial Degradation:

Microbial degradation of lubricating oil refers to the process by which microorganisms (bacteria, fungi) break down the components of the oil. These microbes utilize the oil as a food source, and their activity can lead to several negative consequences for the oil's performance and lifespan.

(b) Indications of Microbial Degradation:

Here are four indications that could be observed if a lubricating oil is suffering from microbial degradation:

1. **Increased Acidity:** Microbial activity often produces organic acids as byproducts. This can cause the oil's Total Base Number (TBN) to decrease, indicating a decline in its ability to neutralize acids and prevent corrosion.
2. **Increased Viscosity:** Microbial growth can lead to the formation of sludge and biomass within the oil, increasing its viscosity and hindering its ability to flow freely within the engine.
3. **Abnormal Odors:** Some microbes can produce foul-smelling byproducts, leading to a noticeable change in the oil's odor.

4. **Presence of Sediment:** Microbial colonies and debris can accumulate as sediment at the bottom of the oil sump or in oil analysis samples.

(c) Early Detection Actions:

If you suspect early microbial degradation in your engine's lubricating oil, two crucial actions should be taken immediately:

1. **Oil Sampling and Analysis:** Collect a fresh oil sample and send it for laboratory analysis. This analysis can confirm the presence of microbes and identify the specific types involved. It can also measure the TBN and viscosity to assess the extent of degradation.
2. **Identify and Address the Root Cause:** Microbial growth typically requires moisture as a catalyst. Investigate potential sources of water ingress into the lubrication system, such as leaks in cooling systems or condensation buildup. Addressing the root cause is essential to prevent further microbial growth.

By taking these steps promptly, you can potentially mitigate the damage caused by microbial activity and extend the lifespan of your engine oil. Early detection and appropriate action can help prevent costly repairs and downtime.

Oct 2021

October 2021 MDE

5. (a) Describe TWO methods of cylinder liner lubrication in medium speed diesel engines. (6)

(b) Describe the possible effects of EACH of the following:

(i) insufficient lubrication; (2)

(ii) excessive lubrication. (2)

Cylinder Liner Lubrication in Medium Speed Diesel Engines:

(a) Methods of Cylinder Liner Lubrication:

There are two primary methods for lubricating cylinder liners in medium speed diesel engines:

(i) Forced Lubrication:

- **Description:** This method utilizes an external pump and dedicated lubrication system to deliver a measured amount of lubricating oil directly to the cylinder liner walls. The oil is typically injected through quills (nozzles) positioned strategically on the cylinder liner.
- **Mechanism:** The pressurized oil forms a thin film between the piston rings and the cylinder liner, reducing friction and wear during piston movement. Excess oil drains back to the engine sump through designated channels.
- **Benefits:**
    - Precise control over oil delivery allows for optimizing lubrication based on engine load and operating conditions.
    - Ensures a consistent oil film for effective wear reduction.

(ii) Splash Lubrication (Dipping System):

- **Description:** This is a simpler method where the crankcase oil bath serves as the primary source of lubrication. The rotating components like the connecting rods churn the oil in the sump, splashing it onto the cylinder walls.
- **Mechanism:** As the crankshaft rotates, the connecting rods dip into the oil bath and splash oil upwards, lubricating the cylinder liners and pistons. The excess oil drains back into the sump through gravity.
- **Benefits:**
    - Simpler design with fewer moving parts, resulting in lower maintenance requirements.
    - Suitable for engines with less demanding lubrication requirements.

(b) Effects of Lubrication Issues:

(i) Insufficient Lubrication:

Insufficient lubrication due to factors like low oil level, clogged oil passages, or incorrect oil viscosity can lead to several negative consequences:

- **Increased Friction and Wear:** Without a proper oil film, metal-to-metal contact between the piston rings and liner increases friction, leading to accelerated wear and potential scuffing or scoring of the cylinder liner surface.
- **Increased Heat Generation:** Friction creates heat, and insufficient lubrication can lead to excessive heat buildup within the cylinder. This can damage pistons, rings, and other engine components.
- **Piston Ring Sticking:** High temperatures can cause piston rings to stick in their grooves, reducing their sealing effectiveness and leading to compression loss and increased blow-by of combustion gases.
- **Potential for Seizures:** In extreme cases of insufficient lubrication, complete seizure can occur, where the piston becomes welded to the cylinder liner due to excessive heat and friction, causing catastrophic engine failure.

(ii) Excessive Lubrication:

While insufficient lubrication is a major concern, excessive lubrication can also have detrimental effects:

- **Increased Oil Consumption:** Excessive oil being delivered to the cylinders can lead to higher oil consumption as more oil is burned in the combustion process.
- **Spark Plug Fouling:** Excess oil can reach the combustion chamber and foul the spark plugs, hindering proper ignition and engine performance.
- **Increased Emissions:** Burning excess oil contributes to increased emissions of hydrocarbons and pollutants.
- **Degraded Power Output:** Oil film buildup on cylinder walls can increase friction and slightly reduce engine power output.
- **Environmental Impact:** Excessive oil consumption leads to increased oil disposal needs, requiring proper handling and potentially creating environmental concerns.

Maintaining proper lubrication through regular oil changes, using the correct oil viscosity, and monitoring oil levels is crucial for optimal engine performance, longevity, and reduced emissions.

June 2021 MDE

5. With reference to diesel engine lubricating oil:

(a) explain how the oil may become contaminated during service; (5)

(b) describe how to keep the oil in a satisfactory condition. (5)

Diesel Engine Lubricating Oil Contamination and Maintenance:

(a) Contamination During Service:

Diesel engine lubricating oil can become contaminated during service due to several factors:

- **Combustion Byproducts:** Incomplete combustion within the engine allows unburned fuel, soot particles, and acidic blow-by gases to enter the crankcase, contaminating the oil.
- **Oxidation:** Lubricating oil is exposed to oxygen at high operating temperatures, leading to gradual oil oxidation and thickening. This process can also generate acidic byproducts that degrade the oil's properties.
- **Wear Debris:** Normal engine wear generates small metal particles from components like piston rings and bearings. These particles can become suspended in the oil, acting as abrasives and accelerating wear.
- **Water Ingress:** Coolant leaks, condensation buildup, or improper storage can allow moisture to enter the oil. Water contamination reduces the oil's lubricity and promotes corrosion within the engine.
- **Dirt and Dust Ingress:** Airborne dirt and dust particles can enter the engine through the air intake system or during oil changes if proper cleanliness is not maintained. These contaminants can increase wear and clog filters.

(b) Keeping the Oil in Satisfactory Condition:

Maintaining your diesel engine's lubricating oil in good condition is crucial for optimal engine performance, longevity, and reduced maintenance costs. Here are some key strategies:

- **Regular Oil Changes:** Follow the manufacturer's recommended oil change intervals based on engine use and operating conditions. Frequent oil changes help remove contaminants and maintain the oil's lubricating properties.
- **Use the Correct Oil Grade and Type:** Always use the oil grade and type specified by the engine manufacturer. The viscosity and additive package of the oil are formulated for your specific engine's needs.
- **Air Filter Maintenance:** A properly functioning air filter prevents excessive dirt and dust ingress into the engine, reducing wear and contamination of the oil.
- **Coolant System Maintenance:** Regularly inspect the coolant system for leaks to minimize the risk of coolant mixing with the oil.
- **Oil Analysis:** Periodic oil analysis can identify early signs of contamination, wear, or degradation before they cause significant damage. This allows for preventive maintenance and potentially extended oil change intervals.

- **Proper Storage:** Store engine oil in sealed containers in a cool, dry place to prevent oxidation and contamination.
- **Cleanliness During Oil Changes:** Maintain a clean work area and use clean tools during oil changes to minimize the risk of introducing dirt and debris into the engine.

By following these practices, you can help ensure your engine oil remains in good condition, promoting extended engine life and optimal performance. Remember, clean oil is vital for a healthy diesel engine.

Feb 2021

February 2021 MDE

5. Describe, with reasons, FIVE properties required of lubricating oil. (10)

Lubricating oils play a critical role in minimizing friction and wear within an engine. Here are five essential properties required of lubricating oil, along with the reasons why they are important:

1. **Viscosity:**
- **Reason:** Viscosity refers to a fluid's resistance to flow. Engine oil needs to have the right viscosity to provide a lubricating film between moving parts.
    - **Too Thin:** If the oil is too thin, it won't create a strong enough film to adequately separate moving parts, leading to increased friction and wear.
    - **Too Thick:** Thick oil will have difficulty flowing freely at low temperatures, causing increased resistance during startup and potentially leading to oil starvation in certain engine components.

2. **Film Strength:**
- **Reason:** Film strength refers to the oil's ability to maintain its lubricating film under pressure and high temperatures encountered within an engine.
    - **Strong Film:** A strong oil film prevents metal-to-metal contact between components, minimizing friction and wear even under demanding operating conditions.
    - **Weak Film:** A weak film can rupture under pressure or high temperatures, leading to increased friction and potential engine damage.

3. **Detergency and Dispersive Properties:**
- **Reason:** Engine operation generates contaminants like soot, dirt, and wear debris. These contaminants can increase wear and sludge formation if not properly managed.
    - **Detergency:** Detergent additives in the oil help suspend contaminants within the oil, preventing them from settling on engine components and forming sludge.
    - **Dispersive Properties:** Dispersants keep the suspended contaminants from clumping together and ensure they are carried throughout the oil until they are removed by the filter during an oil change.

4. **Oxidation Stability:**
- **Reason:** Engine oil is exposed to high temperatures and oxygen, leading to gradual oxidation. Oxidation can thicken the oil, increase its acidity, and reduce its ability to lubricate effectively.
    - **High Oxidation Stability:** Oil with high oxidation stability resists thickening and breakdown due to oxidation, maintaining its lubricating properties for longer service intervals.

5. **Anti-Wear Additives:**

- **Reason:** Even with a lubricating film, some metal-to-metal contact can occur within an engine. Anti-wear additives form a microscopic protective layer on metal surfaces, further reducing wear during operation.
  - **Effective Anti-Wear Additives:** These additives help minimize wear on critical engine components, extending engine lifespan and reducing maintenance costs.

By possessing these five key properties, lubricating oil ensures smooth operation, minimizes friction and wear, protects engine components, and extends engine life

Jan 2023

JAN 2023 MDE

6. (a) State FOUR functions of lubricating oil. (4)

(b) Explain EACH of the following terms:

(i) hydrostatic lubrication; (2)

(ii) boundary lubrication. (2)

(c) State ONE advantage and ONE disadvantage of using grease as a lubricant in a plain bearing. (2)

Lubricating Oil Functions and Types of Lubrication:

(a) Functions of Lubricating Oil:

Lubricating oil plays a critical role in engine operation by performing several essential functions:

1. **Reduces Friction:** The primary function of lubricating oil is to create a thin film between moving parts, reducing friction and minimizing wear on components. This ensures smooth operation and improves engine efficiency.
2. **Heat Transfer:** Engine operation generates significant heat. Lubricating oil helps transfer heat away from critical components like pistons, rings, and bearings, preventing overheating and potential damage.
3. **Corrosion Protection:** Lubricating oil forms a protective layer on metal surfaces, inhibiting corrosion caused by moisture, combustion byproducts, or acidic contaminants within the engine.
4. **Sealing and Leak Prevention:** In some engines, the lubricating oil film helps to seal clearances between pistons and rings, reducing blow-by of combustion gases and preventing oil leaks.

(b) Types of Lubrication:

(i) Hydrostatic Lubrication:

- **Description:** Hydrostatic lubrication utilizes an external pressure source, such as a pump, to force oil between the bearing surfaces. This pressurized oil film separates the moving parts completely, preventing metal-to-metal contact.

- **Advantages:** This method provides a very effective lubrication regime, offering excellent wear protection and minimal friction. It is well-suited for high load applications.

(ii) Boundary Lubrication:

- **Description:** Boundary lubrication occurs when the lubricating oil film is too thin or the pressure between the bearing surfaces is too high to completely separate them. In this regime, special lubricant additives play a crucial role. These additives form a microscopic protective layer on the metal surfaces, reducing friction and wear even under conditions of partial metal-to-metal contact.
- **Disadvantages:** Boundary lubrication offers less wear protection compared to hydrostatic lubrication and is more susceptible to friction increases under high loads or extreme temperatures.

(c) Grease as a Lubricant in Plain Bearings:

Advantage:

- **Long Service Intervals:** Grease has a thicker consistency than oil and can stay in place for longer periods, requiring less frequent re-lubrication compared to oil in plain bearings. This can be beneficial for applications where access to lubrication points is difficult.

Disadvantage:

- **Heat Dissipation:** Grease generally has a lower heat transfer capacity compared to oil. This can be a disadvantage in high-temperature applications where efficient heat dissipation is crucial for preventing overheating of bearing components.

Feb 2021

February 2021 MDE

6. Explain the principle of operation of EACH of the following types of lubricating oil filter:

(a) magnetic; (2)

(b) centrifugal; (2)

(c) coalescer; (3)

(d) plate edge (eg auto-klean). (3)

Lubricating Oil Filter Principles:

Here's a breakdown of the operating principles for each type of lubricating oil filter:

(a) Magnetic Oil Filter:

- **Principle:** Magnetic oil filters utilize strong magnets to attract and trap ferrous (iron-containing) wear debris from the lubricating oil.
- **Operation:** As the oil flows through the filter, the magnet attracts ferrous particles suspended within the oil. These particles are held onto the magnet, preventing them from circulating within the engine and causing further wear.

- **Benefits:** Simple and relatively inexpensive design. Effective at removing large ferrous particles.
- **Limitations:** Doesn't remove non-ferrous wear debris or other contaminants like dirt or soot. Requires periodic cleaning or replacement of the magnet to maintain effectiveness.

(b) Centrifugal Oil Filter:

- **Principle:** Centrifugal oil filters utilize the principles of centrifugal force to separate contaminants from the lubricating oil.
- **Operation:** The oil enters the filter and is spun at high speed within a rotating element. Centrifugal force pushes denser contaminants like wear debris and dirt outwards, away from the oil. The clean oil then flows through an outlet, while the separated contaminants accumulate in a collection chamber.
- **Benefits:** Can be effective at removing both ferrous and non-ferrous debris along with some heavier contaminants.
- **Limitations:** More complex design compared to magnetic filters. Requires a source of power to spin the element. May not be as effective at removing very fine particles.

(c) Coalescer Oil Filter:

- **Principle:** Coalescer oil filters target water contamination within the lubricating oil. They utilize a specialized media that allows oil to pass through but causes water droplets to merge (coalesce) into larger droplets.
- **Operation:** As the oil containing water droplets flows through the coalescer media, the water droplets come into contact with the fibers. The surface tension of the water causes the droplets to combine, forming larger water droplets. These larger droplets can then be separated from the oil by gravity or differential pressure within the filter.
- **Benefits:** Effective at removing water contamination from lubricating oil, which can be harmful to engine components.
- **Limitations:** May not be as effective at removing solid contaminants like wear debris. May require replacement of the coalescer media at specific intervals.

(d) Plate Edge Filter (e.g., Auto-Klean)

- **Principle:** Plate edge filters, also known as automatic self-cleaning or edge filtration systems, utilize a series of stacked metal discs or plates with specially designed edges.
- **Operation:** The oil flows through the narrow gap between the stacked plates. As the oil flows, contaminants get trapped on the edges of the plates due to their size and differential pressure. A cleaning mechanism, often a wiper blade or differential pressure system, periodically removes the accumulated contaminants from the edges, allowing them to fall into a collection chamber or be flushed out of the system.
- **Benefits:** Continuous filtration and automatic cleaning provide extended service intervals compared to some other filter types. Can be effective at removing a wider range of contaminants.
- **Limitations:** More complex design compared to basic filters. May require maintenance or replacement of cleaning mechanisms.

Feb 2020

Oct 2020

February 2020 MDE

7. Describe, with the aid of a sketch, the operation of a centrifugal type lubricating oil filter, labelling the MAIN components. (10)

Components:

1. **Oil Inlet:** Port where the dirty lubricating oil enters the filter.
2. **Rotor:** Rotating element within the filter housing.
3. **Vanes:** Blades on the rotor that help impart centrifugal force to the oil.
4. **Filter Housing:** Enclosed chamber containing the rotor and other components.
5. **Clean Oil Outlet:** Port where the filtered lubricating oil exits the filter.
6. **Contaminant Collection Chamber:** Area where separated contaminants accumulate.
7. **Drain Plug:** Allows for removal of collected contaminants during maintenance.

Operation:

1. Dirty lubricating oil enters the filter through the **oil inlet (1)**.
2. The oil flows into the **rotor (2)** chamber.
3. The rotor spins at high speed due to an external power source (not shown).
4. As the rotor spins, the oil is subjected to **centrifugal force**. This force pushes denser particles like wear debris and dirt outwards, away from the oil.
5. The **vanes (3)** on the rotor help to further distribute the oil and increase the effect of centrifugal force.
6. The cleaner oil, less dense than the contaminants, remains near the center of the rotor.
7. Clean oil exits the filter through the **clean oil outlet (5)**.
8. Denser contaminants like wear debris and dirt are forced outwards and accumulate in the **contaminant collection chamber (6)**.
9. The **drain plug (7)** allows for periodic removal of collected contaminants for maintenance purposes.

June 2021

June 2021 MDE

/4. With reference to diesel engine lubricating oil:

(a) state the main functions; (6)

(b) list FOUR contaminants that may be identified from laboratory analysis of a lubricating oil sample, stating their effects on the engine. (4)

Diesel Engine Lubricating Oil: Functions and Contaminants

(a) Main Functions of Lubricating Oil:

Diesel engine lubricating oil plays a critical role in ensuring smooth operation and protecting engine components. Here are its main functions:

- **Reduces Friction:** By creating a lubricating film between moving parts, oil minimizes friction and wear on pistons, rings, bearings, and other components.
- **Heat Transfer:** Oil helps transfer heat away from critical engine parts like pistons and cylinders, preventing overheating and potential damage.
- **Corrosion Protection:** The oil film acts as a barrier, protecting metal surfaces from corrosion caused by moisture, combustion byproducts, and acidic contaminants.
- **Sealing and Leak Prevention:** In some engines, the oil film helps to seal clearances between pistons and rings, reducing blow-by of combustion gases and preventing oil leaks.
- **Cleaning and Detergency:** Lubricating oil contains detergents and dispersants that help suspend wear debris and contaminants within the oil, preventing them from settling on engine components and forming sludge.

(b) Contaminants Identified by Oil Analysis and their Effects:

Laboratory analysis of a used lubricating oil sample can reveal the presence of various contaminants. Here are four common ones and their negative impacts:

1. **Wear Debris:**
    - **Origin:** Metal particles generated through normal wear and tear of engine components like piston rings, bearings, or camshaft lobes.
    - **Effect:** Increased wear rates, potential scoring or scuffing of cylinder liners and other surfaces.
2. **Unburned Fuel and Soot:**
    - **Origin:** Incomplete combustion within the engine allows unburned fuel and soot particles to bypass the piston rings and enter the crankcase, contaminating the oil.
    - **Effect:** Increased oil viscosity, reduced lubrication effectiveness, potential oil thickening and sludge formation.
3. **Water:**
    - **Origin:** Coolant leaks, condensation buildup, or improper storage can allow moisture to enter the oil.
    - **Effect:** Reduced lubrication effectiveness, increased corrosion potential, formation of oil emulsions (oil and water mixture) that can harm engine components.
4. **Oxidation Products:**
    - **Origin:** Lubricating oil is exposed to high temperatures and oxygen during operation, leading to gradual oxidation and breakdown of the oil.
    - **Effect:** Increased oil viscosity, reduced lubrication effectiveness, formation of acidic byproducts that can contribute to corrosion.

Regular oil analysis helps identify these contaminants early on, allowing for corrective actions such as addressing the source of contamination or performing an oil change before significant damage occurs. This proactive maintenance approach plays a vital role in extending engine life and reducing repair costs.

Oct 2023

October 2023 MDE

7. (a) Explain how the lubricating oil of a diesel engine may become contaminated with water. (6)

(b) Outline the problems that water in an engine oil may cause. (4)

Water Contamination in Diesel Engine Lubricating Oil:

(a) How Water Enters Engine Oil:

Several factors can contribute to water contamination in diesel engine lubricating oil:

- **Coolant Leaks:** Leaks in the engine cooling system, such as a faulty head gasket, cracked radiator, or loose hose connections, can allow coolant (which contains water) to mix with the engine oil.
- **Condensation Buildup:** During engine operation, particularly in cold weather, moisture from the atmosphere can condense within the crankcase if the engine doesn't reach operating temperature for extended periods. Short trips with frequent starts and stops can exacerbate this issue.
- **Improper Storage:** Storing an engine that's not in regular use for extended periods in a humid environment can allow moisture to accumulate in the oil through condensation.
- **Air Intake Ingestion:** In some cases, if the air intake system is not properly sealed or has leaks, water from rain, humidity, or even car washes can potentially enter the crankcase through the intake. This is less common but can occur.

(b) Problems Caused by Water in Engine Oil:

Water in engine oil can lead to several detrimental effects on engine performance and longevity:

- **Reduced Lubrication Effectiveness:** Water doesn't mix well with oil and can disrupt the lubricating film, reducing its ability to separate moving parts and minimize friction. This can lead to increased wear and potential damage to engine components.
- **Corrosion:** Water can accelerate corrosion of internal engine components like bearings, camshafts, and cylinder liners. The acidic byproducts formed during oil oxidation can further exacerbate this issue.
- **Sludge Formation:** Water can react with certain additives in the oil and create sludge, a thick, sticky substance that can clog oil passages and restrict oil flow to critical engine components.
- **Foam Formation:** Water can cause the oil to foam, reducing its ability to circulate properly and hindering its heat transfer capabilities.
- **Freezing:** In extremely cold climates, water can freeze within the crankcase, potentially causing damage to components or hindering engine startup.

Additional Considerations:

- The severity of the problems caused by water contamination depends on the amount of water present in the oil. Small amounts might not cause immediate issues, but the negative effects can become more pronounced over time.

- Regular oil changes and proper engine maintenance practices can help minimize the risk of water contamination.

By preventing water ingress and maintaining a healthy lubricating oil system, you can protect your diesel engine from the harmful effects of water contamination.

Oct 2022

October 2022 MDE

7. Describe how large medium speed diesel engine lubricating oil is kept in optimum condition. (10)

Here's an explanation of how large medium speed diesel engine lubricating oil is kept in optimum condition:

Preventative Maintenance Practices:

- **Regular Oil Changes:** Following the manufacturer's recommended oil change intervals is crucial. Used oil accumulates contaminants and degrades over time, losing its lubricating properties. Timely oil changes ensure clean oil is present to protect engine components.
- **Using the Correct Oil Grade and Type:** Always use the oil grade and type specified by the engine manufacturer. The viscosity and additive package of the oil are formulated for the specific needs of your engine.
- **Air Filter Maintenance:** A clean and functioning air filter prevents excessive dirt and dust particles from entering the engine and contaminating the oil.
- **Coolant System Maintenance:** Regularly inspect the coolant system for leaks to minimize the risk of coolant (which contains water) mixing with the oil.
- **Oil Analysis:** Periodic oil analysis can identify early signs of contamination, wear, or degradation before they cause significant damage. This allows for preventive maintenance and potentially extended oil change intervals.

Oil Cleanliness Practices:

- **Cleanliness During Oil Changes:** Maintain a clean work area and use clean tools during oil changes to minimize the risk of introducing dirt and debris into the engine crankcase.
- **Proper Oil Storage:** Store engine oil in sealed containers in a cool, dry place to prevent oxidation and contamination.

Additional Considerations:

- **Moisture Control:** Address potential sources of water ingress, such as condensation buildup or coolant leaks, to prevent water contamination within the oil.
- **Monitoring Oil Level and Condition:** Regularly check the oil level using the dipstick and visually inspect the oil for any signs of discoloration or abnormal consistency.
- **Fuel Quality:** Using clean, high-quality fuel can help minimize soot and unburned fuel contamination of the oil.

By implementing these practices, you can help maintain your large medium speed diesel engine's lubricating oil in optimum condition. This promotes extended engine life, improved performance, reduced wear and tear, and lower maintenance costs. Remember, clean and well-maintained oil is vital for a healthy and reliable engine.

April 2022 MDE

7. (a) Describe FOUR factors influencing centrifugal separator efficiency. (4)

(b) Explain how oil loss occurs in a separator, stating how this can be minimised. (4)

(c) State the factors determining the discharge frequency of an engine lubricating oil purifier. (2)

Centrifugal Separator Efficiency in Engine Lubricating Oil Purification:

(a) Factors Influencing Efficiency:

Several factors influence the efficiency of centrifugal separators used in engine lubricating oil purification:

1. **Particle Size and Density:** Centrifugal separators are most effective at separating particles with a significant density difference from the oil. Larger and denser particles (like wear debris) are separated more efficiently compared to smaller or less dense contaminants.
2. **Centrifugal Force:** The efficiency of separation is directly proportional to the centrifugal force generated within the separator. This force is influenced by the rotation speed of the bowl and the bowl diameter. Higher rotation speeds and larger diameters create greater centrifugal force, enhancing separation efficiency.
3. **Oil Viscosity:** The viscosity of the oil plays a role. Thicker oil creates more resistance to particle movement within the separator, potentially reducing separation efficiency. Using oil with the recommended viscosity for operating conditions is crucial.
4. **Feed Rate:** The rate at which oil is fed into the separator can impact efficiency. Exceeding the separator's design capacity can lead to incomplete separation and carryover of contaminants in the purified oil. Maintaining the recommended feed rate optimizes performance.

(b) Oil Loss in Separators and Minimization:

Oil loss in a centrifugal separator can occur in two main ways:

1. **Carryover:** This happens when some oil gets entrained with the separated contaminants being discharged from the separator. This is often a result of factors like high feed rate, small particle size, or inadequate residence time within the separator.
2. **Emulsions:** Water contamination in the oil can lead to the formation of oil-in-water emulsions. These emulsions can be difficult to separate completely, resulting in some oil loss with the water discharge.

Minimizing Oil Loss:

- **Maintaining Proper Operating Conditions:** Following the manufacturer's recommendations for feed rate, oil viscosity, and rotation speed ensures optimal separation efficiency and minimizes oil carryover.
- **Coalescing Media:** Some separators utilize coalescing media to promote the separation of water from oil, reducing the formation of emulsions and associated oil loss.

- **Regular Maintenance:** Proper cleaning and maintenance of the separator, including replacing worn components like seals, helps maintain optimal performance and minimize oil loss.

(c) Discharge Frequency of Lubricating Oil Purifier:

Several factors determine the discharge frequency of an engine lubricating oil purifier:

- **Oil Contamination Level:** Heavily contaminated oil will require more frequent discharge of separated solids compared to cleaner oil. Oil analysis can help determine optimal discharge intervals.
- **Separator Capacity:** The size and capacity of the separator's solids collection chamber will influence discharge frequency. Smaller separators may require more frequent purging compared to larger models.
- **Engine Operation:** Engines operating under severe conditions, such as high loads or dusty environments, will generate more contaminants, requiring more frequent discharge from the separator.

Typically, the separator will have automated sensors or alarms that trigger discharge based on pre-set parameters, such as a certain level of accumulated solids within the collection chamber. Following the manufacturer's recommendations and monitoring the system's performance will help establish an appropriate discharge frequency for your specific application.

April 2022

April 2022 MDE

5. (a) Sketch an overspeed trip of the centrifugal type. (6)

(b) Describe the operation of the overspeed trip sketched in part (a). (4)

feb 2020

February 2020 MDE

4. (a) Sketch an overspeed trip of the centrifugal type. (6)

(b) Describe the operation of the overspeed trip sketched in part (a). (4)

june 2021

June 2021 MDE

/2. (a) Sketch an overspeed trip of the centrifugal type. (6)

(b) Describe the operation of the overspeed trip sketched in part (a). (4)

In large, medium-speed diesel engines, a centrifugal overspeed trip acts as a critical safety mechanism to prevent catastrophic failure caused by excessive engine speed. It utilizes the principle of centrifugal force to detect and respond to overspeed conditions.

Here's how it works:

- **Components:** The trip mechanism consists of a pre-compressed spring, a weighted arm or bolt connected to the engine's rotating shaft (often called the weight), a stationary lever positioned near the weight's travel path, and a trip mechanism linked to the fuel injection system or other control mechanisms.
- **Normal Operation:** During normal engine operation, the spring's force keeps the weight in its initial position.
- **Increasing Engine Speed:** As the engine speed increases, the centrifugal force acting on the weight also increases.
- **Overspeed Condition:** If the engine speed surpasses a pre-set limit designed into the trip mechanism, the centrifugal force acting on the weight overcomes the spring's force.
- **Weight Movement and Lever Trip:** This imbalance in forces causes the weight to move outward, hitting and tripping the lever.
- **Trip Mechanism Activation:** The trip mechanism then activates, typically by cutting off fuel supply to the engine.
- **Engine Speed Reduction:** This rapid reduction in fuel delivery causes the engine speed to decrease and prevents a potential catastrophic failure.

Importance: Centrifugal overspeed trips are crucial for safeguarding diesel engines. By automatically shutting down or reducing fuel supply in overspeed conditions, they prevent catastrophic failures that could cause extensive damage to the engine and pose safety risks. These trips are essential for ensuring the safe and reliable operation of large, medium-speed diesel engines.

Jan 2018

January 2018 MDE

7. Describe how the lubricating oil of a large medium speed diesel engine may be assessed on board. (10)

Centrifugal Overspeed Trip in Diesel Engines

(a) Description:

A centrifugal overspeed trip is a safety device crucial for large and medium-speed diesel engines. It safeguards the engine from catastrophic failure caused by exceeding a safe rotational speed (overspeed). This trip mechanism utilizes the principle of centrifugal force to detect and respond to overspeed conditions.

Components:

- **Spring:** A pre-compressed spring maintains the trip mechanism in its normal operating position.
- **Weight:** A weighted arm or bolt connected directly to the engine's rotating shaft.
- **Lever:** A stationary lever positioned strategically near the weight's travel path.
- **Trip Mechanism:** This mechanism is linked to the engine's control system, such as the fuel injection system, and activates when the weight trips the lever.

(b) Operation:

1. **Normal Operation:** During regular engine operation, the spring's force keeps the weight in its designated position.
2. **Increasing Engine Speed:** As the engine speed increases, the centrifugal force acting on the weight also increases proportionally.
3. **Overspeed Condition:** If the engine speed surpasses the pre-set limit designed into the trip mechanism, the centrifugal force acting on the weight overcomes the spring's opposing force.
4. **Weight Movement and Lever Trip:** This imbalance in forces causes the weight to be pushed outward due to the stronger centrifugal force. The weight then strikes and trips the stationary lever.
5. **Trip Mechanism Activation:** The tripped lever triggers the trip mechanism, which typically acts by cutting off fuel supply to the engine.
6. **Engine Speed Reduction:** This rapid reduction in fuel delivery forces the engine speed to decrease, preventing a potential catastrophic failure.

Importance:

Centrifugal overspeed trips are vital for the safe operation of diesel engines. By automatically shutting down or reducing fuel supply in overspeed situations, they prevent catastrophic failures that could cause extensive engine damage and pose safety hazards. These trips play a critical role in ensuring the reliability and safety of large, medium-speed diesel engines.