June 2021

June 2021 MDE

7. Describe, with the aid of a sketch, the operation of a diesel engine hydraulic oil start system, labelling the MAIN components, including all interlocks. (10)

A hydraulic oil start system provides a reliable and independent method for starting a diesel engine. Here's a breakdown of its operation and main components, including interlocks:

Components:

1. **Electric Motor:** Provides power to drive the hydraulic pump.
2. **Hydraulic Pump:** Converts the electric motor's rotational energy into hydraulic pressure in the oil.
3. **Accumulator:** A pressure vessel that stores pressurized hydraulic oil and releases it rapidly for engine starting.
4. **Start Valve:** Controls the flow of pressurized oil from the accumulator to the hydraulic starter motor.
5. **Hydraulic Starter Motor:** A high-torque motor powered by the pressurized oil to crank the engine.
6. **Pressure Relief Valve:** Protects the system from overpressure by venting excess oil back to the reservoir.
7. **Check Valve:** Allows oil to flow in one direction only, typically from the pump to the accumulator.
8. **Interlocks:** Safety mechanisms that prevent unintended operation and ensure proper sequence during starting.

Operation:

1. **System Initialization:** The electric motor is activated, driving the hydraulic pump.
2. **Pressurization:** The pump pressurizes the hydraulic oil and forces it into the accumulator against the pre-charged gas pressure within. The check valve ensures oil flows only into the accumulator.
3. **Engine Start Request:** When the operator initiates a start sequence, the start valve opens.
4. **High-Pressure Flow:** High-pressure oil from the accumulator rushes through the start valve and into the hydraulic starter motor.
5. **Engine Cranking:** The pressurized oil drives the hydraulic starter motor, which in turn cranks the engine flywheel.
6. **Engine Starts:** Once the engine reaches sufficient speed, the engine's own internal combustion process takes over, and the hydraulic starter disengages.
7. **System Reset:** The start valve closes, and the electric motor may stop depending on the system design. The accumulator remains pressurized for subsequent start attempts.

Interlocks:

- **Neutral Gear Interlock:** Prevents starting the engine unless the transmission is in neutral to avoid sudden jerks and potential damage.

- **Low Oil Pressure Interlock:** Disables the start sequence if the oil pressure falls below a safe minimum, indicating insufficient lubrication.
- **Engine Overcrank Protection:** Limits the cranking duration to prevent overheating the starter motor and the engine.

Benefits of Hydraulic Start Systems:

- **Independent Starting:** Provides a reliable means to start the engine even if the main electrical system is unavailable.
- **High Cranking Torque:** Delivers a powerful cranking force even in cold weather conditions.
- **Reduced Load on Battery:** Doesn't rely on the battery for starting, extending battery life.
- **Shockless Start-Up:** Hydraulic power provides a smoother and less stressful starting experience for the engine.

In conclusion, a hydraulic oil start system offers a reliable and efficient way to start a diesel engine, especially in applications where an independent starting method is crucial. The system's components work together to store and deliver high-pressure oil to the hydraulic starter, ensuring smooth and powerful cranking for reliable engine starts. The interlocks provide essential safety features to prevent misuse and protect the engine.

Feb 2021

February 2021 MDE

7. With reference to leaking cylinder air start valves:

(a) describe how this may be detected whilst the engine is running; (2)

(b) describe the procedure on discovery; (4)

(c) list FOUR possible causes. (4)

Several signs can indicate a leaking cylinder air start valve while the engine is running:

- **Overheating of the air line:** The compressed air leaking past the valve heats up due to friction. Feel the air line close to the valve. If it's noticeably hotter than other air lines, it may indicate a leak.
- **Uneven engine running:** A leaking air start valve can introduce unregulated air into the cylinder, disrupting the combustion process and causing uneven running. This may manifest as rough idling, power fluctuations, or misfiring.
- **Unusual hissing or air noise:** A leak can create a hissing sound or a noticeable increase in air noise near the affected cylinder's air start valve.
- **Increased air consumption:** A leaking valve allows compressed air to escape, requiring the compressor to work harder to maintain system pressure. This can lead to a noticeable increase in air consumption.

(b) Procedure on Discovery:

Upon suspecting a leaking air start valve:

1. **Shut Down the Engine:** Safely shut down the engine following the manufacturer's procedures.

2. **Isolate the Cylinder:** Close the isolation valve for the affected cylinder's air line, preventing further air flow to that cylinder.
3. **Tag and Lock Out:** Tag the affected cylinder and air line as "out of service" to prevent accidental operation.
4. **Further Inspection:** Visually inspect the valve for signs of damage or wear. Consider using a stethoscope to listen for air leaks around the valve body.
5. **Maintenance:** Schedule maintenance to replace or repair the leaking air start valve as soon as possible.

(c) Four Possible Causes of Leaking Cylinder Air Start Valves:

1. **Worn Valve Seat or Seal:** Over time, the valve seat or seal within the air start valve can wear down due to repeated use. This allows compressed air to leak past the seal when the valve is closed.
2. **Foreign Debris:** Dirt, dust, or other foreign particles can become lodged between the valve seat and the valve body, preventing a proper seal and causing a leak.
3. **Improper Valve Adjustment:** If the air start valve is not adjusted correctly, it may not fully close, allowing compressed air to leak through.
4. **Damaged Valve Body:** In extreme cases, the valve body itself may be cracked or damaged, allowing compressed air to leak even if the valve seat and seal are in good condition.

By promptly addressing a leaking air start valve, you can prevent further engine problems like uneven wear, power loss, and potential damage to the air start system.

Feb 2022

February 2022

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

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

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

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

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

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

1. Air System Checks:

- **Air Pressure Verification:** Verify sufficient air pressure in the receivers using the pressure gauges. Ensure the pressure meets the manufacturer's minimum requirements for starting.

- **Drain Trap Inspection:** Check the drain traps at the air receivers and individual air lines for accumulated water condensation. Drain any collected water to prevent it from entering the cylinders and hindering combustion.
- **Leak Inspection:** Visually inspect the air lines and connections for leaks. Listen for any hissing noises that might indicate compressed air escaping. Repair or tighten loose connections promptly.
- **Start Valve Operation:** Verify that all individual air start valves are fully open during the starting sequence. You can use visual inspection (if accessible) or listen for the characteristic air flow through the valves.

2. Engine System Checks:

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

3. Additional Checks:

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

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

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

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

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

May 2021

May 2021 MDE

7. (a) Explain, with the aid of a diagram, the operation of a solenoid operated, battery powered electric starting system for an internal combustion engine. (6)

(b) Explain the term pre-engaged starter. (4)

Solenoid-Operated Electric Starting System (Internal Combustion Engine)

(a) Operation:

A solenoid-operated, battery-powered electric starting system provides a convenient and reliable way to crank an internal combustion engine for starting purposes. Here's a breakdown of its operation:

Components:

- **Battery:** Provides the electrical power for the system.
- **Starter Motor:** An electric motor with high torque output designed to crank the engine.
- **Solenoid:** An electromagnet that acts as a heavy-duty relay.
- **Ignition Switch:** Controls the flow of current to the solenoid.
- **Starter Drive Pinion:** A gear on the starter motor that meshes with the engine's flywheel ring gear.

Operation:

1. **Ignition Switch Turned:** When the operator turns the ignition switch to the "start" position, current flows from the battery to the solenoid.
2. **Solenoid Activation:** The current energizes the solenoid's electromagnet, creating a strong magnetic field.
3. **Plunger Movement:** The magnetic field pulls in a metal plunger within the solenoid.
4. **Circuit Completion:** The movement of the plunger connects two high-current contacts within the solenoid. One contact connects the battery directly to the starter motor, providing full power. The other contact may engage the starter drive pinion with the flywheel ring gear (depending on the system design).
5. **Engine Cranking:** The powerful starter motor begins to spin, cranking the engine flywheel through the engaged drive pinion.
6. **Engine Starts:** Once the engine reaches sufficient speed, the internal combustion process takes over, and the engine continues to run on its own.
7. **Ignition Switch Released:** When the operator releases the ignition switch from the "start" position, the current flow to the solenoid stops.
8. **Solenoid Reset:** The solenoid's magnetic field collapses, releasing the plunger.

9. **Circuit Disconnection:** The high-current contacts disconnect, stopping the flow of current to the starter motor.
10. **Drive Pinion Disengagement (if applicable):** The starter drive pinion may disengage from the flywheel ring gear (depending on the system design).

Benefits:

- **Convenience:** Solenoid-operated systems offer a simple and convenient way to start an engine compared to manual crank starting.
- **Reliability:** Solenoids provide a reliable and consistent means of engaging the starter motor.
- **Safety:** Ignition switches and interlocks can prevent accidental starter engagement.

(b) Pre-Engaged Starter:

In some starter systems, a pre-engaged design is employed. Here's what it means:

- **Drive Pinion Engagement:** The starter drive pinion is already engaged with the flywheel ring gear when the engine is at rest. This engagement can be achieved through a spring-loaded mechanism or a gear arrangement.
- **Solenoid Function:** The solenoid in a pre-engaged system primarily functions to connect the battery directly to the starter motor for cranking. It may not have a separate mechanism for engaging the drive pinion because it's already in mesh with the ring gear.
- **Benefits:** Pre-engaged starters offer faster cranking since there's no delay for pinion engagement. This can be beneficial in cold weather conditions where easier starting is desired.

Note: Some pre-engaged starters may incorporate a solenoid design that performs both functions - engaging the drive pinion and supplying full power to the starter motor.

Oct 2021

October 2021 MDE

7. (a) List FOUR safety interlocks that may be fitted to a direct air start medium speed diesel engine to prevent inadvertent starting during maintenance. (4)

(b) Explain, with the aid of a diagram, the opening period of an air start valve on a four stroke diesel engine in relation to the crank angle, inlet and exhaust valves. (6)

Safety Interlocks for Direct Air Start Medium Speed Diesel Engines (a)

Here are FOUR safety interlocks commonly fitted to a direct air start medium speed diesel engine to prevent inadvertent starting during maintenance:

1. **Starting Air Isolation Valve:** This is a manually operated valve that isolates the entire air start system from the receivers. When closed, no compressed air can flow to the engine's air start valves, preventing accidental starting.

2. **Neutral Gear Interlock:** This interlock prevents the engine from starting unless the transmission is in neutral. This avoids sudden jerks and potential damage to the drivetrain if the engine were to start unexpectedly in gear.
3. **Engine Stop Switch:** A physical switch that cuts off fuel supply or electrical power to the engine, immediately stopping it or preventing it from starting. This allows for quick shutdown in case of emergencies during maintenance.
4. **Crankshaft Position Sensor Interlock:** This electronic interlock uses a sensor to detect the crankshaft position. In some systems, the engine may not start unless the crankshaft is positioned at a specific top dead center (TDC) for a particular cylinder, ensuring the engine is in a safe starting position.

Air Start Valve Opening Period on a Four-Stroke Diesel Engine (b)

In a four-stroke diesel engine, the opening period of the air start valve is precisely controlled in relation to the crank angle, inlet, and exhaust valves to ensure efficient starting:

- **Crank Angle:** The air start valve typically opens slightly **before** the piston reaches Top Dead Center (TDC) of the compression stroke. This timing ensures sufficient compressed air is present in the cylinder when the piston begins its downward power stroke.
- **Inlet Valve:** The inlet valve on a four-stroke engine remains closed during the compression and combustion strokes. Therefore, the air start valve operates during a period when the inlet valve is closed.
- **Exhaust Valve:** The exhaust valve typically closes just before TDC of the compression stroke. The air start valve opens shortly after the exhaust valve closes, ensuring no remaining exhaust gases are pushed back out and the cylinder receives a full charge of clean air for starting.

Overall, the precise timing of the air start valve opening maximizes the compressed air available for initiating combustion during the power stroke, leading to efficient engine starting.

Oct 2019

October 2019 MDE

8. Describe the checks and maintenance required for a main engine starting system that uses an air motor. (10)

may 2018

May 2018 MDE

7. Describe the checks and maintenance required for a main engine starting system that uses an air motor. (10)

While air motor starting systems are generally considered low-maintenance, there are still some crucial checks and maintenance tasks to ensure reliable operation:

Air Filtration:

- Regularly inspect and replace the air filters according to the manufacturer's recommendations. Dirty filters restrict airflow, reducing the air motor's performance and potentially causing damage.

Air Quality:

- Ensure the compressed air supply is clean and dry. Moisture can cause corrosion inside the air motor and reduce its lifespan.

Lubrication:

- Depending on the specific air motor design, it might require lubrication. If so, follow the manufacturer's instructions for lubricant type and frequency of application (usually for gearboxes).

Vanes:

- These are internal components that convert compressed air into rotational motion. They experience wear over time. The inspection interval for vanes depends on the usage and typically falls between 1,000 to 2,000 hours of operation. Worn vanes will reduce the starting torque.

General Checks:

- Regularly perform visual inspections for any leaks, loose connections, or signs of external damage.
- Listen for any unusual noises during operation.

Manufacturer's Recommendations:

- Always refer to the specific air motor and starting system's manual for detailed maintenance procedures and recommended service intervals.

Jan 2018

January 2018 MDE

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

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

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

Air Starting System Checks for Non-Starting Engine (Large, Medium Speed Marine Diesel with Individual Valves)

(a) Checks to be carried out if the engine won't start:

If a large, medium-speed marine diesel engine with individual air starting valves fails to start during the initiation sequence, a systematic approach is needed to identify the issue. Here are some key checks to perform:

1. **Air Pressure:**
    - Verify sufficient air pressure in the starting air receivers using pressure gauges. Minimum pressure requirements are specified in the engine manual and typically range between 25-42 bar (363-614 psi).
    - Check for leaks in the air piping system by listening for hissing sounds or using a soapy water solution on connections.
2. **Starting Air System Valves:**
    - Ensure the starting air isolation valve is open, allowing air flow to the engine.
    - Verify the proper operation of the non-return valve by isolating the engine and briefly activating the starting sequence. Listen for a distinctive "whoosh" sound as air attempts to flow back through the valve, indicating proper closure.
3. **Engine Crankshaft Turning:**
    - Confirm the turning gear (if fitted) is disengaged before initiating a start sequence. Engaged turning gear prevents the engine from cranking freely with compressed air.
    - If the engine cranks very slowly with the starter, it might indicate internal engine issues like mechanical problems or tight tolerances.
4. **Individual Starting Valves:**
    - While the engine is stopped, use a hand wheel or remote control to activate each individual air starting valve momentarily. Listen for a distinct blow of air at each cylinder, indicating proper valve operation. If a valve is silent, it might be stuck closed, damaged, or not receiving the pilot air signal.
5. **Pilot Air System:**
    - Verify adequate pressure in the pilot air system, which controls the opening of the main starting air valves. This pressure is usually much lower than the main starting air pressure.
6. **Engine Alarms:**
    - Check for any engine alarms that might indicate problems like low lube oil pressure, cooling water system issues, or starting air system faults. Consult the engine manual for specific alarm interpretations.
7. **Fuel System:**
    - Though less likely during a starting sequence, ensure there is sufficient fuel in the day tank and that the fuel system is free from air or contamination.

(b) Four Safety Devices in an Air Starting System:

1. **Non-return Valve:** This valve allows compressed air to flow in one direction only (towards the engine) and prevents backflow, protecting the air compressors from pressure surges.
2. **Starting Air Isolation Valve:** This manually operated valve allows isolation of the entire starting air system from the engine for maintenance or repairs.
3. **Turning Gear Interlock:** This interlock prevents the starting air sequence from initiating if the turning gear is engaged. This safeguards against accidental damage to the engine.
4. **Over-speed Protection:** Some systems might have an overspeed protection device that cuts off the starting air supply if the engine cranks too quickly, potentially indicating internal problems.