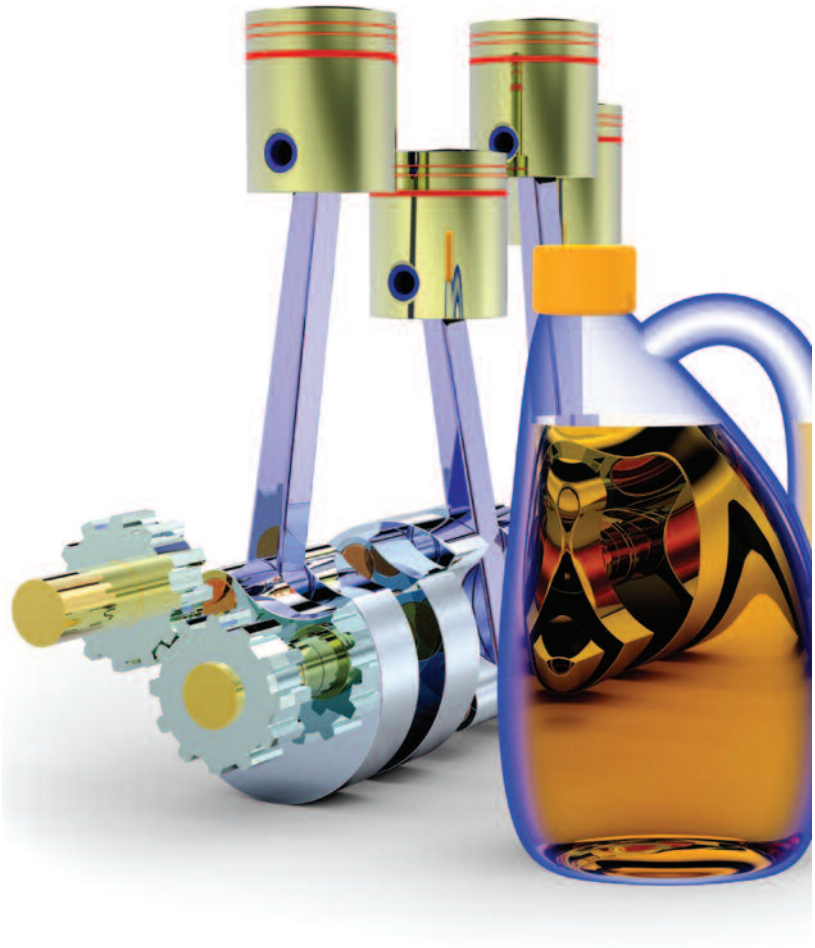
West of England

Loss Prevention Bulletin

Marine Diesel Engine Lubrication

In recent months several entered vessels have experienced main engine breakdowns caused by heavily contaminated lubricating oil. All of the vessels were relatively new.

Modern marine diesel engines are technically complex and are becoming increasingly powerful and efficient. However, newer engines can be less forgiving than older units if not operated, maintained and lubricated correctly.



The lubrication of moving parts is crucial to diesel engine performance and longevity

Lubricating Oil

The lubrication of moving parts is crucial to diesel engine performance and longevity. Lubricating oil reduces friction between components, separates opposing surfaces and prevents metal-to-metal contact. It also acts as a coolant and mitigates the effect of corrosion. However, the condition of the oil tends to deteriorate with use, mainly due to contamination and chemical activity.

The manufacturer's manual for the engine will provide details of the quality and properties of lubricating oil required. The manual will also include guidance on how the oil should be monitored and maintained while the engine is running to ensure that it remains suitable for use. Such advice is generally based on research findings, operational experience, ongoing analysis and other factors including technical common sense. The details will also include a margin of error to minimise the risk of the engine being damaged as the lubricating oil deteriorates, but the extent of this margin is not known to the user. Therefore it is not possible for the user to determine with any degree of confidence whether the outcome of exceeding the limits set by the engine manufacturer will be relatively harmless or potentially disastrous.

Although the engine manual contains important information about the lubricating oil and specifies key requirements and constraints, the fundamental principles rarely differ:

- The viscosity of the lubricating oil must remain within certain prescribed limits. Normally, oil viscosity increases during operation. If it decreases, this may signify an ingress of low viscosity fuel. Increased or decreased viscosity may lead to improper lubrication and thermal distortion.
- The oil must not contain excessive amounts of water or insoluble foreign particles as their effects become increasingly harmful during operation, resulting in poor lubrication and mechanical damage.
- The oil must be capable of protecting the components of the engine from corrosion caused by aggressive chemicals. The ability of the oil to neutralise acidic compounds is termed the Total Base Number (TBN) or, alternatively, the Base Number (BN). The TBN of lubricating oil generally decreases with use.

Acidic corrosion may occur if the TBN falls below the threshold specified by the manufacturer of the lubricating oil, resulting in excessive wear and reducing the life of the parts.

- The flash point of the lubricating oil should remain within the range set by the manufacturer. A flash point lower than specified may signify the presence of lighter hydrocarbons, possibly indicating that the oil has been affected by diesel fuel.

While in operation, the lubricating oil normally passes through mechanical filters to extract solid foreign particles, and centrifugal separators to remove other impurities and water. It is essential that both are inspected and maintained entirely in accordance with manufacturer's instructions.

The viscosity, flash point and TBN of lubricating oil can only be restored by a full or partial oil change.

Mechanical Filters

Mechanical filters are installed in every lubricating oil system. They need to be changed or cleaned regularly in accordance with the planned maintenance schedule specified by the manufacturer. Replacement filters must be the right size and have the correct filtering capacity.

It should also be borne in mind that the apparent absence of impurities on the surface of used filter elements when inspected visually does not necessarily mean that the oil is clean. The risk of damage to the engine rises progressively if wear particles over 20 µm in size are present. However, even 50 µm particles are difficult to see with the naked eye. By comparison the diameter of a human hair is approximately 70 µm. Any particles that are clearly visible on the filter element surface should be investigated without delay as they may be indicative of abnormal wear.

If the filters are reusable, they should be washed using appropriate chemicals following the procedure specified by the manufacturer. The mesh should be checked for signs of damage and care should be taken to reassemble the filter correctly once it has been cleaned and examined. If the type of filter in use has limited working life, the planned maintenance system should ensure that the replacement interval is not exceeded.

In addition to mechanical filters, smaller engines with a sump size of up to 750 litres may be fitted with centrifugal filters rather than centrifugal separators in order to maintain the condition of the lubricating oil. Centrifugal filters need to be opened and cleaned at regular intervals in the same way as mechanical filters. The absence of hard deposits inside the bowl of a centrifugal filter when opened for cleaning may signify that the filter is not working properly, warranting further investigation.

Centrifugal Separators/Purifiers

Centrifugal separators, also known as purifiers, tend to be installed on vessels where the sump capacity of the engine is greater than 750 litres.

In addition to removing water, separators also extract solid and soluble impurities provided that the specific gravity of such impurities is higher than the specific gravity of the separated oil. Lubricating oil must be at the correct temperature in order for the separation process to be effective, usually 85-95°C. The separation process becomes more efficient towards the upper end of this range. A gravity disc controls the extraction of water and it is essential that the disc is the correct size. Separators must also be run at their maximum design speed. The flow rate should be kept at a minimum (equipment manufacturers generally recommend a flow rate of around 20% of the separator's rated capacity), and all lubricating oil in the system should be circulated approximately 4 to 5 times every 24 hours.

Lubricating oil purifiers extract solid and soluble impurities

Separators should not be taken out of service when the main engine is stopped unless repairs are required or if the vessel will be idle for a long period. In such an event they must be reactivated well before any attempt is made to restart the engine.

Leakage of heavy fuel into the lubricating oil system will make the lubricating oil more viscous. Conversely, diesel fuel unlike heavy fuel reduces the viscosity of lubricating oil. Separators may purify heavy fuel from lubricating oil. However, purification will not separate diesel fuel from lubricating oil as their densities are similar. In practice the viscosity of lubricating oil cannot be restored effectively unless a partial or complete oil change is carried out.

On Board Tests

Lubricating oil must be tested regularly for water content and the viscosity also needs to be monitored. It is important that the samples properly represent the condition of the oil in use, therefore they are usually taken at the inlet manifold where the oil circulating in the system enters the engine. They should be drawn before any fresh oil is added.

The ability of the separator to extract water should also be checked, taking samples from the inlet and outlet pipes and comparing the water content of both thereafter. The tests for water content and viscosity are usually carried out on board by the crew and should be repeated at weekly intervals, recording the results within the planned maintenance system. However, ascertaining whether or not the lubricating oil is acceptable in other respects requires detailed analysis by a specialised laboratory.

Laboratory Analysis

The oils used by marine diesel engines have been developed by lubricant manufacturers to take account of the harsh operating environment including exposure to high temperatures, aggressive chemicals, high pressures and contamination. Many lubricant manufacturers offer laboratory testing services to their clients. As an incentive it is not unusual for supply contracts to agree that a certain number of samples will be tested free of charge. To ensure that samples are fully representative and consistent, the sampling procedures followed by the vessel must be clear, ship-specific and should incorporate the recommendations of the test laboratory.

After the samples have been analysed, the laboratory will provide a report listing the test criteria agreed and showing the results in each case. The report may also include details regarding the apparent condition of the lubricating oil and any corrective action that may be required. However, for the reasons outlined below, the test results should not be accepted at face value.

Firstly, the laboratory's primary task is to check if the oil meets the lubricant manufacturer's own standards and to evaluate whether or not it is still suitable for further use. A "red", "yellow" and "green" traffic light system is often employed to highlight any problems. Although the lubricant manufacturer's criteria will generally reflect the requirements of the engine manufacturer, the test results should be compared with the limits specified in the engine manufacturer's manual as there may be differences. In case of doubt the engine manufacturer should be contacted for advice.

Secondly, the laboratory has no knowledge of the actual working condition or performance of the engine, or the maintenance that has been (or is due to be) carried out or of any incidents that may have occurred.

Finally, the report itself may have been generated automatically with minimal human input other than the comments made in response to "red" indicators and perhaps an occasional remark in the case of "yellow" indictors. The laboratory may pay little attention to "green" indicators but they still need to be checked by company superintendents and shipboard engineers in order to identify any emerging trends or problems. If the findings appear to be questionable or inconsistent, further samples should be submitted to the laboratory for testing.

If the engine manufacturer recommends a particular schedule for changing the lubricating oil, the proposed intervals should never be exceeded. Testing the old oil is always worthwhile as the results may indicate that the oil needs to be replaced more frequently. The amount of time required to ship the samples to the laboratory and receive the results should also be taken into account.

In the absence of clear instructions from the engine manufacturer as to how often oil samples should be drawn for testing, the lubricant manufacturer should be contacted for advice.

Irrespective of the test results, during the engine warranty period it is particularly important to ensure that the recommended intervals for exchanging the lubricating oil are strictly followed unless written permission has been obtained from the engine manufacturer beforehand.

Detailed Particle Analysis and Other Methods

Particles created during the combustion process or caused by wear and tear (both normal and excessive) must be removed from the oil as such debris may damage sliding surfaces, obstruct normal movement and cause precision parts to seize. Contaminants of this nature tend to trigger a chain reaction as the resulting wear generates more particles, thereby increasing the rate of deterioration. Although removing them from the oil will reduce this risk, it is equally important to determine the source of the contamination in order to minimise the possibility of a major breakdown.

Several methods may be used to analyse lubricating oil for impurities. These include the detection of asphaltene contamination, spectrometry, microscopy, particle counting and analytical ferrography. In addition to determining whether or not the oil is still suitable for use, these tests also provide valuable information regarding the condition of the engine.

Such checks are usually carried out ad hoc rather than as a part of the vessel's planned maintenance system. When evaluating the findings, all possible influencing factors should be considered including recent engine maintenance and changes to operational conditions and routines. The results should also be scrutinised carefully for tends, comparing the figures with previous reports.

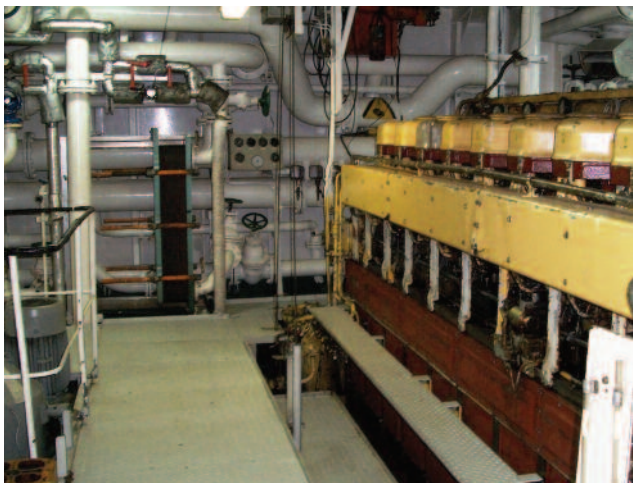
Watch-keeping

The importance of diligent watch-keeping in the engine room cannot be over-emphasised. Checking the engine crankcase dipstick and sight glass regularly can provide an early indication of water in the lubricating oil. Similarly, other signs such as abnormal working pressure, pressure fluctuations, unusual alarms, excessive vapour from the crankcase vent and unexpected changes in the sump tank level should be investigated immediately as remedial action may be required.

Topping Up the Lubricating Oil

Ideally the sump tank should be topped up using exactly the same make and type of lubricating oil. If the same product is not available, the manufacturer of the oil should be contacted for advice. Topping up the lubricating oil with an equivalent product is usually acceptable provided it is produced by the same manufacturer and is made from the same base oil. Although lubricating oil suppliers may suggest topping up with other brands of oil, this is not recommended by many engine manufacturers. In practice, mixing different brands of mineral oil together is unlikely to be problematical as the base oils used to produce such products are broadly similar in structure. However, such action should not be taken unless the lubricating oil supplier has carried out a compatibility test and has confirmed that the oils may be mixed.

Although it is sometimes possible to mix together different types of synthetic oil, this is not recommended as it is more difficult to assess whether or not synthetic oils are compatible. Mineral oil must never be mixed with synthetic oil.



Careful management of lubricating oil usage and renewal can help prevent costly engine breakdowns

Changing the Lubricating Oil

If the necessary make and type of lubricating oil cannot be obtained, the safest option may be to change the lubricating oil completely to avoid any incompatibility problems such as foaming or deposit formation which may result in blocked filters and lubrication starvation.

When changing the lubricating oil:

- Schedule the change to coincide with the overhaul of the main engine, if possible.
- Pump out and clean the sump tank. Drain the system including piping, filters, coolers, purifiers and associated heaters.
- Clean the oil spaces (eg crankcase, camshaft compartment) and the engine side piping.
- Fill the system with fresh oil and circulate using the pre-lubrication pump.
- Monitor the oil level and top up as required, taking thermal expansion into account.

In the event of further queries, please contact the Loss Prevention department.

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