THE BENEFITS OF FUEL OIL ANALYSIS



Mark Ford: Senior Surveyor Telephone: +44 20 3320 2316 E-mail: mark.ford@ctcplc.com

During a number of recent ship surveys and Member Risk Reviews, the club surveyors have noticed that a small but significant number of ships and members do not carry out laboratory analysis of bunkered heavy fuel oil. Although the testing of fuel oil is not a statutory or classification requirement, there is overwhelming evidence through experience that regular laboratory analysis of bunkered heavy fuel oil is a very effective tool in reducing the risk to the diesel engine machinery and ultimately the ship. The decision not to carry out representative sampling and detailed fuel oil analysis removes the ability of the company to identify off-specification fuel for its use onboard. Failure to detect low-quality or incompatible fuel oil before it enters the ship's fuel treatment and injection systems can result in serious operational difficulties and extensive machinery damage.

In addition, the club is assisting in a number of disputes and claims that arise from members as owners or charterers in respect to poor bunkers stemmed. The issue is complex and is inevitably difficult to defend if no fuel oil sampling and laboratory analysis is undertaken.

Lubricating oil analysis by approved organisations and the importance this tool affords in monitoring machinery and component condition continues to be recognised within the shipping industry. In view of the potential consequences to the propulsion and auxiliary machinery, and therefore the safety of the ship, crew and cargo, it is highly recommended that laboratory analysis programmes for fuel oil are implemented onboard and are closely monitored by the shorebased technical management. Procedures and requirements should be incorporated within the SMS and specific guidelines given with standard practices detailed within bunkering operational guidelines and checklists. Given the simple equipment required to carry out representative sampling, and the minimum effort and cost involved with conducting fuel oil analysis compared to the potential consequences, it is surprising how many ship owners and operators decide that fuel oil analysis is not necessary. It is accepted that when the cost of fuel oil increases significantly, as experienced recently when the price of residual and distillate fuel reached record levels, there is a marked reduction of fuel oil quality and more operational difficulties are experienced and reported.

WHAT IS THE RISK?

Poor-quality fuel oil can very rapidly disable a ship, with the financial implications of returning an engine to full service being significant, notwithstanding any commercial repercussions. Crew and ship safety, cargo damage and pollution risk should also be considered in addition to any technical and commercial problems that are likely to be encountered.

Off 'spec' and poor-quality fuel can affect the running of a ship and its equipment in the following ways:

- poor-quality fuel oil can cause rapid problems with the ship's fuel treatment systems caused by incompatibility issues due to mixing of bunkered and existing fuel onboard (referred to as admixing). Incompatibility can result in total chemical breakdown of the fuel, which can separate into a light colourless inert liquid and heavy sludge that may require manual removal
- rapid choking of fuel filtration systems and centrifugal purifiers (see Figure 1) requiring round-the-clock maintenance to ensure machinery remains in service, albeit less effectively. This results in increased spare part costs and a drain on engineer resources

v Figure 1: Heavy sludge contamination



_____"The use of the incorrect fuel oil can lead to catastrophic damage to machinery, substantial claims, and can endanger the ship and those aboard."

- rapid wear of engine components such as fuel pumps, fuel injectors, cylinder liners and piston rings due to abrasive particles contained within the fuel see Fig 2. These abrasive particles, known as catalytic fines, are formed during the catalytic cracking process at the oil refinery. The aluminium and silicon content within the ISO standard sets the maximum levels of aluminium plus silicon at 80 mg/kg. Even with well-maintained fuel treatment systems and reduced treatment rates, it is difficult to totally remove or effectively reduce high abrasive particle levels within the fuel
- low and high temperature corrosion can develop due to the presence of vanadium, sodium and sulphur within residual fuel oil. Vanadium is present in soluble compounds, cannot be removed and high concentrations can cause high temperature corrosion
 - high temperature corrosion is directly caused by the presence of compounds of sodium and vanadium at temperatures over 500°C. Sodium and vanadium are found in heavy fuels up to 200ppm and 600ppm respectively, forming vanadium oxides, sodium oxides and, with sulphur also contained in the fuel, sulphates that are able to react further with vanadium oxides. The various compounds that may be formed from these have a wide variety of properties, the most significant of which is the melting points. At the moment of solidification, the compounds release oxygen, which can attack the metal surface. Oxygen may be reabsorbed into the deposits, thus forming an oxygen pump that aggressively attacks the surface of the metal during the melting and solidification processes at around 530 to 600°C. The parts of most concern in marine diesel engines are the exhaust valves, piston crowns as well as the main components of the turbocharger such as the nozzle ring and turbine blades
- sulphur can also lead to low temperature corrosion and is usually neutralised in the engine by correct cylinder lubricating oil and good combustion
 - low temperature corrosion is caused when the sulphur in the fuel combines with oxygen to form sulphur dioxide. Further combination of the sulphur dioxide with oxygen gives sulphur trioxide. When this comes into contact with moisture, it forms sulphuric acid vapours. If this acidic vapour contacts metal surfaces below 160°C (dew point), then sulphuric acid attack occurs resulting in rapid corrosion of the affected area

v Figure 2: Piston damage due to poor quality HFO



- the formation of SOx (sulphur oxides) during combustion has led to new legislation within the Marpol Convention under Annex 6, regulation 14 and a maximum sulphur content level of 1.0% within fuel oil is required for ships operating in Sulphur Emission Control Areas (SECAs) and 0.1% when the ship is 'at berth' in any EU port (Sulphur Directive 2005/33/EU)
- fouling of engine running components is also a common defect (see Figure 3), which reduces the mechanical and thermal efficiency of the engine. Fouling due to poor or incomplete combustion can rapidly increase wear rates, which may ultimately require a full overhaul of an engine as well as increasing the risk of scavenge and exhaust gas economiser fires occurring whilst in service

THE BENEFITS OF FUEL OIL ANALYSIS CONT.

THE ISO 8217 STANDARD

Requirements for the quality of marine fuel oil are detailed within the ISO 8217 specification and determine the criteria for correct onboard treatment and injection. ISO 8217, which is the international standard that governs the quality of petroleum fuels for use in marine diesel engines and boilers, was originally drafted in 1982 and came into force in 1987.

It is generally considered less critical when burning poorer-quality fuel in ships' boilers due to their design, construction and operating method; however, at the beginning of the 21st century, motor ships accounted for around 98% of the entire world fleet. The ISO standard is regularly revised to account for engine technology development and statutory environmental requirements such as Marpol Annex 6. Recent amendments in 2005 addressed the level of used lubricating oils contained within fuel oils.

The ISO 8217 standard defines maximum and minimum values for the following parameters, including:

- density, which is required to determine purification settings and is used to calculate the amount of fuel bunkered
- viscosity, which is expressed as a fluid's resistance to flow. In everyday terms for a fluid, it is its 'thickness'. Viscous (thick) fuels require preheating to reduce the viscosity to enable good purification, injection and combustion in the engine cylinder
- the flash point of the fuel indicates the temperature at which a fuel vapour is produced and is able to be ignited. In accordance with SOLAS requirements, the flash point must be above 60°C. (This does not apply for fuel that will be used for emergency purposes such as generators, fire pumps and lifeboat engines)
- what does all this mean? Aluminium and silicon are naturally occurring in crude oil and are introduced during the cracking process at the refinery. These highly abrasive particles can cause

v Figure 3: Exhaust valve carbon build-up



rapid wear of engine components and can be difficult to remove or separate using the ship's fuel treatment equipment

- the ISO standard is not restricted to the above properties and further characteristics are contained within the ISO specification for residual and distillate fuels
- the ISO 8217 has now been revised and the updated version was issued in July 2010 as ISO 8217/Final Draft International Standard (FDIS) Rev.4. This new revision changes certain percentage constituents; however, it does not necessarily cover all the requirements that an owner may have with respect to fuel quality.

NEW ADDITIONS IN ISO 8217: 2010 FDIS REV.4:

Aluminium and silicon (AI+Si)

• Compared to ISO 8217: 2005, the level of aluminium and silicon in the 8217: 2010 has been reduced and the new maximum limits range from 25 mg/kg for the lowest residual grades to 60 mg/kg for the highest grades. This revision should reduce the risk of too-high levels of abrasive particles reaching the engine's inlet

Sulphur content

• Limit values are no longer included in the ISO 8217: 2010 standard at all. Instead, it is up to the bunker purchaser to specify the maximum sulphur content of fuels to the supplier in line with the regulatory requirements for the use of that fuel

Amendment to Clause 5 of ISO 8217

• The general requirements in Clause 5 have been expanded to include more reference to materials that render marine fuels unacceptable for use in diesel engines. Both ISO and CIMAC have initiated research on the analysis and interpretation of the chemical composition of waste materials, as well as the levels at which these materials may start to cause engine problems

Ash, vanadium and sodium

 Similarly, the vanadium and ash limits specified in the 8217: 2010 for most residual grades are now reduced. Maximum levels for sodium are also added as a new parameter. Traditionally, sodium is associated with sea water contamination, but this element may also originate from the pre-treatment of crude oils at the refineries. Experience has shown that sodium from this source may not be removed from the fuels by onboard treatment and could contribute to post-combustion deposits

Calculated Carbon Aromaticity Index (CCAI)

• This is calculated from the density and viscosity and provides an estimate of the ignition delay of the fuel. CCAI is now included in the specification for all residual grades. The revised maximum limit is 870

Hydrogen sulphide (H2S)

• This is aimed to add protection to onboard staff whilst storing and handling fuels

Lubricity test (distillates)

• Lubricity testing is required only for marine fuels with sulphur levels lower than 0.050% mass (500mg/kg). If the fuel lubricity is too low, fuel pumps in diesel engines may experience wear from prolonged operation on such fuel It is accepted that the majority of fuel-related machinery problems are attributable to poor-quality residual fuel oil. However, problems with distillate fuels such as marine diesel oil or marine gas oil are also reported and microbial contamination is a common problem. The presence of micro-organisms (bugs) in distillate fuel can lead to rapid choking of filtration systems, fuel starvation and engine shutdown. Microbial contamination can also cause corrosion within fuel tank structures. Although the risk of problems with distillate fuel may be relatively low, its use at ambient temperature can increase the risk of microbes developing.

Onboard testing of these fuels using a suitable kit is considered advisable. Good fuel housekeeping can prevent the risk of serious operational problems occurring. Should operational problems develop, the hazy appearance of a sample may indicate microbial contamination, although this should be confirmed by a laboratory. Professional assistance should be sought if microbial contamination develops and the use of biocides is necessary as part of the treatment process. Without water, it is not possible to have microbial growth. Thus, the first line in prevention is the removal of water. As a general rule, the more water the greater will be the problem.

However, it is inevitable that there will always be some water with the fuel oil, whether brought in when bunkering, through leaks or through condensation. Therefore, the need to constantly purify a system is necessary. This is seen on fuel systems where fuel oil is taken from a settling tank to a service tank where it overflows back to the settling tank. It should be noted that purifiers can act as a source of cross-contamination between an infected tank and a non-infected tank, and thus rigorous sterilisation after their use on a system is highly recommended. Tanks should be fitted with drain cocks at their lowest points and should be drained regularly as part of the routine watchkeeping duties.

APPROVED OR RECOGNISED FUEL OIL TESTING ORGANISATIONS

There are a number of approved and certified organisations providing established fuel oil testing services. These are often associated with the classification societies and/or the oil majors/fuel oil suppliers. Technological advances and communications available to ships allow fuel oil test results to be available online within three days of sending samples ashore.

In addition to the benefits of conducting detailed laboratory analysis, onboard fuel oil test kits are available that allow ship's staff to test fuel density, viscosity and compatibility that may help to indicate fuel quality defects soon after bunker operations have been completed and before the fuel is used. It is highly recommended where practicable to keep any freshly bunkered fuel completely separate from existing onboard fuel until the bunker sample laboratory results have been analysed. If it is not possible to keep the fuel separate, then every measure should be taken to not use the fuel in the engines until the results of the fuel sample are returned.

These approved organisations also provide regular advice and warnings when poor-quality fuel has been found to be supplied from a particular port or country. The disparity of fuel oil supplied even from well-regulated ports can be astonishing.

RISK ANALYSIS

If, for whatever reason, a company has decided that fuel analysis is not necessary, then a full and formal risk analysis should be carried out to support that decision. The relatively minor costs of regular fuel oil analysis, compared with the cost of the fuel, far outweigh the potential damage and resulting costs that are associated with mechanical failure due to poor fuel quality.

Conducting representative sampling, laboratory analysis and onboard testing provides an effective tool to identify poor-quality fuel and a method of avoiding serious operational problems and expensive mechanical repairs.

CHARTERPARTY DISPUTES – THE BUNKER CLAUSE

The company must be clear in its view in respect to the bunker clause and what it will accept. It is a clause that is often not given much consideration and often it is blindly accepted that if the bunkers supplied are within the ISO 8217 standard then that is as far as the clause needs to go. That is not the case. The ISO 8217 standard is now revised as noted above; however, the high fuel oil price, the introduction of low sulphur fuel oils and the recession have made the issue complex. Fuel oil providers in some jurisdictions are cutting fuel oil with ingredients that still allow compliance with the ISO standard but can be detrimental to the engine or the engine's output.

CONCLUSION

- carry out routine fuel oil analysis on all bunkered heavy fuel oil
- do not use the fuel until analysis results have been received and approved
- keep newly bunkered fuel oil separate from that already onboard
- make sure your bunker clause is fit for purpose