UK P&I CLUB

TECHNICAL ADVICE

Reducing the risk of serious engine damage caused by catalytic fines

Refinery catalytic fines in marine fuel oil are not a new problem but in recent years there appears to have been an increase in the frequency of engine damage caused by these highly abrasive particles.

In contrast to this apparent increase in damages, the incidence of fuels as supplied containing aluminium and silicon above specification limits has not increased. Shipowners are therefore reminded that consuming fuel that is within the ISO specification for catalytic fines, at the time of delivery, does not guarantee engines will not suffer unexpected wear. At high risk of wear are fuel pump plungers and barrels, fuel valves, piston rings and cylinder liners.

What are catalytic fines?

Refineries use catalysts to improve the yield of high value products, such as gasoline, refined from crude oil.

Unfortunately, some of these fine particles escape into side stream products that are used as blend components in the production of residual grades of marine fuel.

This particulate matter, comprising of aluminium and silicon oxides, is extremely hard and, if entrained in the fuel as it enters engines, can cause severe abrasive wear.

Specification limits

The ISO 8217 Specifications of Marine Fuels set out upper limits for combined levels of aluminium and silicon for fuels as delivered. The 2005 specification upper limit of 80mg/kg was reduced to 60mg/kg in the 2010 edition, and the upper limit has been kept at this level in the latest ISO 8217 edition of 2017, for commonly utilised RMG & RMK fuel grades.

Unfortunately, many fuel suppliers today still refuse to supply to ISO 8217:2010 and only accept the 2005 edition limits. Charter parties often incorporate the following bunker clause “Fuel to be compliant with ISO 8217 – latest version”. With this clause, it would seem that a Charterer would need to supply fuel with a combined aluminium and silicon upper limit of 60mg/kg but they may only be able to purchase fuel with an upper limit of 80mg/kg. If the fuel is tested and combined aluminium and silicon is reported to be greater than 60mg/kg but lower than 80mg/kg, this problem can lead to disputes.

The earlier upper limit of 80mg/kg was set on the basis that if this was not exceeded in fuels as supplied, then on board treatment by settling, purification and filtration should reduce this to a maximum of 15mg/kg (the maximum recommended by most engine makers to avoid excessive wear) by the time the fuel was injected into an engine. Some engine makers have suggested that combined aluminium and silicon should be a maximum of only 10mg/kg. In any event, these low levels, at the point of fuel injection, require the fuel treatment process to be around 80% to 85% efficient, if the fuel supplied contains aluminium and silicon at total 80mg/kg.

In reality, tests of before and after separator samples have suggested that typical, in service separator efficiency can be, at best, 75%, and often much lower.

The ISO 8217 working group took this into account when they developed the 2010 edition of the standard and reduced the maximum content of combined aluminium and silicon for fuels supplied to 60mg/kg, giving ship's engines a little more protection. Clearly, if a fuel as supplied contained 60mg/kg, and the maximum permitted at the engine was 10mg/kg, a separator efficiency of 83% would be necessary (if 15mg/kg at the engine was accepted, then an efficiency of 75% would be needed).

Fortunately, the vast majority of fuels supplied have combined aluminium and silicon levels well below 60mg/kg, nonetheless, effective fuel treatment remains imperative.

On board treatment

Catalytic fines have a tendency to settle towards the bottom of a tank during storage; this process depends very much on the fuel temperature and storage time. In practice, settling out of catalytic fines in primary (storage) tanks (where the temperature would typically be around 30°C) is rather low and most likely less than around 10% of the total suspended catalytic fine content. So, a fuel with 80mg/kg combined aluminium and silicon at delivery may be transferred from a storage tank to a settling tank with around 72mg/kg. As the fuel is held at around 70°C in a settling tank, we may expect a greater reduction in catalytic fines but this tends to be restricted when the ship is at sea and the tank is lowered and filled periodically. However, when the ship is in port and consumption is low, dwell time increases and settling will be improved. Tests on bottom sediment samples from these tanks have shown very high levels of catalytic fines. Levels of several thousand mg/kg are not uncommon. Clearly, this situation is potentially dangerous as if these sediments are disturbed by the ship rolling and pitching in heavy weather, they could pass through the fuel system to the engines, causing rapid wear.

After the settling tank, the fuel should be treated by centrifugal separation. Although the makers of separators claim that their equipment should be capable of reducing catalytic fines by around 75%-80%, tests on fuel samples taken from before and after separators in service, have shown efficiencies substantially lower. In some cases, Brookes Bell have encountered this to be as low as 45% and have found typical efficiency to be around 65%. Poor separation efficiency can be a result of using incorrect gravity discs (in a 'conventional' separator), too low fuel inlet temperature and/or too high a feed rate. Clearly, if a fuel entering a separator contained 80mg/kg combined aluminium and silicon and the separator efficiency was down to 65% or lower, then the fuel leaving the separator would contain at least 28mg/kg, well above the recommended maximum of 15mg/kg at engine injection.

The importance of correct operation and maintenance of separators cannot be overstated. It is recommended that the manufacturer's maintenance procedures are included in the ship's planned maintenance schedule and that the equipment is correctly operated. In addition to the proper operation and maintenance of the separators, regular drainage ('dewatering' or 'desludging') of service and settling tanks will assist in the fuel treatment process.

For effective residual fuel oil treatment, separators should be operated at minimum flow rate, considering consumption, and the fuel inlet temperature should be 98°C. It should be ensured that the correct gravity disc is fitted (if applicable) with reference to the density of the fuel in use.

It is suggested that before and after separator samples are taken when fuels as supplied contain more than 40mg/kg aluminium plus silicon. Indeed, at least one engine manufacturer now recommends this testing when fuels as supplied contain more than 25mg/kg aluminium plus silicon. Sending these samples for ash, water, density and aluminium plus silicon testing and comparison of the results between the samples, will indicate the efficiency of the separator. Any significant reduction in efficiency should be investigated.

After centrifuging, the fuel will be stored in a service tank. Settling of catalytic fines in this tank will again depend on how long the fuel is stored. As this fuel will be at around 98°C after purification, some catalytic fines will deposit out and over time the bottom of this tank will become rich in catalytic fines. If the ship is in heavy weather, pitching and rolling, these deposits may be disturbed, entering the fuel system and passing to the engines. Ordinarily the only line of defence after the service tank is the supply system fuel filters.

Typically, the fuel supply line to the main engine will be equipped with auto-backflush filters with a mesh size of between 35 and 50 microns (although some operators are installing 10 micron filters in main engine systems). The auxiliary engine fuel systems may be equipped with 10 micron fuel filters. However, it must not be assumed that filters will take out all remaining catalyst particles after purification.

Particle size

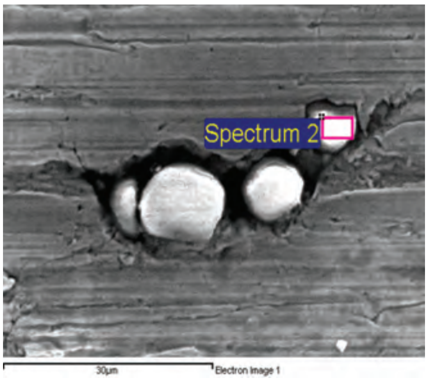
The size (and shape) of catalytic fines varies, probably due to the service life of the particles in the refinery processes. The data below shows the range of particle sizes against the percentage for each size range. The first column shows results from tests on a ship's sample and the second column shows typical data according to a document published by Alfa Laval, BP Marine and MAN B&W Diesel[1].

Particle size Microns	Ship Sample %	BP %
0-10	31	57
10-15	32	27
15-35	35	15
35-100	0.7	1

It can be seen from the above, that the majority of catalytic fines have a particle size of less than 15 micron and

[1] *'Marine diesel engines, catalytic fines and a new standard to ensure safe operation – Separation Performance Standard'*, written by Alfa Laval, BP Marine and MAN B&W Diesel.

a considerable amount are in the range 15-35 micron. Obviously, filters with a mesh size larger than this will not remove these small particles. The image below shows catalytic fines embedded in a piston ring. The size of these particles is up to around 15 microns.



Different sized particles can create different risks with the potential to cause damage at different locations in the fuel system. For example, particles can be small enough to pass through fuel pump barrel/plunger clearances, or large enough not to enter those same clearances. In either case, they will not cause abrasion at the fuel pump barrels/plungers, whereas those of a size comparable to the relevant clearances would be expected to cause damage in way of the fuel pumps.

Consider reducing risk by incorporating the following into management systems

1. Insist on a maximum combined level of aluminium and silicon in fuel deliveries of 60mg/kg. (ISO 8217:2010 or later versions). This may be incorporated into a time charter party or an order direct with a bunker supplier.

2. Sample and test all deliveries. Ensure a representative bulk drip sample is taken throughout each delivery and that this bulk sample is thoroughly mixed before pouring into sub-sample bottles. Failure to do this can result in an uneven distribution of catalytic fines in each of the sub-samples. Ensure the crew fully understand this process. Ideally, do not use the bunkered fuel until the analysis results are known.

3. Always operate separators with minimum acceptable flow rate (with consideration to consumption) and with a fuel inlet temperature of 98°C. Ensure the correct set up of the separator, including (where appropriate) the selection of the appropriate gravity disc to suit the density of the fuel. Consider the operation of two separators in parallel.

4. As general guidance, take samples before and after the separators each time the delivery sample analysis shows combined aluminium and silicon above 40mg/kg. It should, however, be noted that some engine manufacturers may recommend instigating testing at lower levels, for example above 25mg/kg; OEM advice and service letters/bulletins should be considered as applicable. Send these samples for testing to check separator efficiency. Consider routine separator efficiency analysis and the use of on board test kits.

5. Review and adhere to the auto-backflush filter manufacturer's operating instructions, ensuring shipboard operational procedures cover such requirements.

6. Manually clean and thoroughly inspect the condition of all fuel filters on a regular basis, and when high differential pressures are observed or auto-backflush periods start to increase.

7. Ensure a complete set of spare filter elements is available on board at all times.

8. Regularly 'dewater/desludge' settling and service tanks.

9. Routinely open and clean the bottom of settling tanks and service tanks (possibly to coincide with interim/special surveys, for example).

10. Routinely open and clean the bottom of primary storage tanks (possibly to coincide with special surveys, for example).

11. As well as regular scavenge/under-piston space inspections take main engine cylinder oil scrape down samples every two months and send for analyses. Monitor the trend of iron content as this will provide early indication of piston ring and cylinder liner wear.

12. If it becomes necessary to renew piston rings due to unusual wear, obtain replicas of cylinder liners for examination. Embedded catalytic fines will need to be removed by honing of the liners to prevent further wear of new piston rings.

13. Keep detailed records of all the above and of fuel consumption history. Such evidence is crucial and may be decisive if fuel related engine damage is suspected.

THE AUTHORS

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