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Position paper of the International Union of Marine Insurance (IUMI)

Catalytic Fines and Engine Damage

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What Cat Fines are

Cat fines are small particles of metal that are deliberately introduced to 'crack' fuel to improve the efficiency of refining. Unless removed by purification, the cat fines become embedded in engine parts and cause serious and rapid engine damage.

How damage results

Cat fines may enter the engine combustion space when the fuel is injected, where they can become embedded on the surface of the cast iron cylinder liner, piston grooves and rings. Once in the engine these very hard particles act as an abrasive, rapidly wearing the sliding components. Wear rates depend on the quantity and size of the cat fine particles. In certain circumstances, wear beyond the maximum limits can occur in only a few weeks. Indeed a few hours may be sufficient to spoil a new cylinder liner and/or piston rings to the point that blow-by of combustion products render the affected unit useless.

The problem has mainly affected large two stroke engines, but cases involving four stroke engines have also been reported. The costs of these claims can be in excess of one million USD, especially if ship owners take the wrong actions after the problem is diagnosed. Claims adjusters agree there is variable use of separators and there is room for improvement with the treatment of fuel on board, although it is hard to segregate fuels on a voyage.

Situation now

It is believed the a recent rise in claims was largely due to a lack of awareness or good practice by crews in fuel handling at the same time as global environmental legislation to reduce the levels of sulphur in ships fuel made fuel changes more common. It had been thought that unless practices changed, it would be logical to expect increased instances of engine damage because of an increased use of more refined fuels. In fact, the trend has now turned encouragingly downward, in part due to the take up of Gas Oil as the preferred option



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for use in the Emission Control Areas (ECAs) and possibly also as a result of increased awareness by owners.

Consistently, 40% of hull claims by number are machinery damage and they make up 30% of claims costs. Progressive damage and foreign object damage have crept into marine cover as maintenance. There is a legal argument that such damage is avoidable and thus not a covered fortuity.

The current problem is a combination of factors. Ships' crew often have no idea about the purity of the fuel they use, nor is there any compulsion to find out before using it. A discrepancy exists between ISO standards¹ for cat fine content and the content recommended and anticipated by engine manufacturers in engine design. Effective filtration, purification and fuel management is required. Engines need fuel with a concentration of cat fines at no more than 15ppm, but fuel is produced and sold at 60ppm and more.

There is an increasing requirement for ships to use low sulphur fuels, and as these require more refining the level of cat fines will increase. Low sulphur fuels are less lubricating and this, combined with the introduction of increased amounts of abrasive materials, causes damage. Once cat fines become embedded in engine parts, they cannot be removed. Damage can spread to auxiliary engines as well. Until fairly recently, such losses have simply been described as engine damage or crew negligence and the real cause not identified. It is only now that definite attributable losses are being reported, and it would be desirable to build the dataset of incidents to help identify trends and means to prevent occurrence..

Claims have been identified in the range of USD 300,000 to USD 1.5 million, mostly in low speed engines. Wear is very rapid; for example, if liners are replaced, they could be worn out again in three days. Unfortunately, fuel suppliers take the view that it is uneconomic to produce higher grade fuel. There is insufficient capacity of shipyard-provided purifiers and a lack of knowledge of fuel quality by ship's engineers. Often, there is a lack of good maintenance practices such as regular fuel tank cleaning.

Possible mitigation

There are solutions and preventative measures that can be taken to assist in minimising the risk of problems. With the cooperation of legislative and technical bodies, ship owners, charterers and classification societies, the number of damage incidents can be reduced. Indeed, the US Coast Guard issued a Safety Alert² in November 2015, which incorporated a number of useful suggestions for ship owners and operators as it recognised the inherent problems with fuel switching at sea on vessels seeking to comply with MARPOL requirements.

¹ HFO with a cat fines content of up to 60ppm is compliant with the ISO 8217:2010 fuel standard

² US Coast Guard Safety Alert 13-15: Ultra Low Sulphur Fuel Oil & Compliance with MARPOL Requirements, 19 November 2015



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Changes that would help reduce engine damage from cat fines

- Mandatory sampling and testing of fuel before use,
- Improved fuel handling on board,
- Improve the quality of bunkers,
- Alteration of the ISO standard so as to lower the proportion of Cat Fines in fuel,
- Charter/bunkering contracts should specify fuel with less than 60ppm Cat Fines,
- Regular cleaning of filters, frequent drainage of tanks,
- Clean the settling and service tanks during dry dock,
- Check filter centrifuge capacity on specifications for new ships.

Practical Operational Constraints

Whilst there should really be a system of analysing oil at the entrance to the engine, such specific equipment is not currently routinely installed on board. Samples of heavy fuel oil should also be taken before and after each separator at intervals of 4 to 6 months. It would be helpful to monitor the fuel separator efficiency, but that would not necessarily be indicative of the fuel quality on board, as bunkering intervals are up to two months apart.

The steps involved in testing would be: 1) Collection of samples by ship agent- 2) Courier delivery to laboratory – 3) Testing and reporting – 4) Transmitting results and instructions to the ship. Unfortunately, by the time results arrive, the ship could be 900nm into a voyage having consumed perhaps 3 days fuel (75 to 150 tonnes). Ideally owners should ensure the vessel has sufficient fuel on board to enable the testing of new bunkers prior to usage and should avoid using newly purchased fuel without obtaining and acting on the results of fuel analysis. Unless sufficient extra fuel is carried, the time delay between the tests and results can often mean that the remaining good fuel would be insufficient to complete the voyage without resorting to the new and possibly sub-standard fuel.

If the ship is close enough to a bunkering port, it could deviate to take fresh bunker, but it should get rid of the bad bunker first, which would be problematic due to its bad quality. Normally the bunker would be the charterers' property, and that would also hinder the owner's freedom to make decisions.

In any case, the results of analysis may not prove cat fines are present because the continuous drip fuel sampling procedure is insufficient in itself to guarantee good fuel quality. The problem associated with sampling on delivery of bunker is that the samples obtained only represent the average quality of bunker supplied.

Normally the initial product pumped on board the receiving ship contains the majority of the heavy components (such as silica and aluminium), which in the course of the operation



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become diluted by the lighter elements. It might be helpful to take a separate sample of the fuel transferred during the initial phase of the operation.

It is recognised that there are practical difficulties in cleaning empty tank during ordinary ships' operations but cleaning the fuel tanks at drydock time should be a minimum requirement. However, the time between drydockings (30 to 36 months) is too long in this context as harmful deposits will build-up in this interval

If cat fines are confirmed in the fuel, all necessary work to eradicate them should be carried out immediately. However "immediately" is nearly always impossible as the crew will only realise that there are fuel problems after they have become abnormally severe, i.e. frequent clogging of fuel valves, malfunction of fuel pumps, abnormally frequent clogging of fuel filters and abnormal/frequent build-up of sludge in the fuel separator. This is normally associated with cylinder blow-by and occasional fires in the scavenge space. By then substantial damage has already occurred. The vessel must then reach a suitable repair port to carry out cleaning and repair works, and will likely suffer further engine damage in doing so.

Replacement or machining of all affected engine components would normally require a lengthy stay in the port of repairs as it would be necessary to purchase, take delivery of and fit a large number of spare parts, as well as finding the means to dispose of the bad fuel. If cleaning and repairs are not carried out thoroughly, and the source of the problem is not totally removed, there is a high probability of recurrent damage. Clearly, costs involved can be very considerable.

The Future

IUMI will keep the situation under review and liaise with interested parties. These include IACS, which is working on minimum requirements for the treatment of fuel on board ships and has tasked a project team to develop a Unified Requirement. If ISO fuel standards are changed, the individual ship filtration task will be eased to some extent, but will remain critical.

For the time being, the problem can be in part addressed by reference to the appended guidelines, which were formulated by the Joint Hull Committee ([JHC Catfines Pack](#)) and are supported by IUMI.



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About IUMI:

The International Union of Marine Insurance e.V. (IUMI) is a non-profit association established for the purpose of protecting, safeguarding and advancing insurers' interests in marine and all types of transport insurance. It also provides an essential forum to discuss and exchange ideas, information and statistics of common interest for marine underwriters and in exchange with other marine professionals. IUMI currently represents 46 national and marine market insurance and reinsurance associations.

The roles of IUMI are to

- act as a focal point and representative voice on behalf of the marine and transport insurance industries in dialogue with all interested parties,
- share information and research that are non-commercially sensitive with regard to marine and transport insurance,
- bring together marine insurance practitioners to facilitate the exchange of technical information and best practice, and
- provide information on positions taken by IUMI.



Appendix 1

JHC Guidance Notes (JH2013/006)

Mitigation of Engine Damage due to Catalytic Fines

1 - Prior to Bunker Fuel Delivery

The Vessel should:

- Ensure that there are sufficient empty tanks to store the newly purchased fuel.
- Ensure that the empty tanks are clean.
- Be aware of the analysis statistics on fuel quality of the port of supply, especially if there are any relevant warnings issued by testing laboratories, P&I Clubs and marine press.
- Ensure the vessel has sufficient fuel on board to enable the testing of new bunkers prior to usage. It should avoid using newly purchased fuel without obtaining and acting on the results of fuel analysis.

Contractual Agreements:

In the Charterparty and Bunkering contracts, the agreed value of ppm of Aluminium (Al) and Silicon (Si) should be kept to less than 50ppm (irrespective of the ISO 8217:2012 limit of 60ppm), to ensure that the centrifuges can effectively bring this value down to less than 15ppm at the entry to the engines.

NB: If bunkered oil contains more than 50ppm of catalytic fines, injected oil is still likely to have higher than the recommended levels of cat fines due to the limitations of on board fuel treatment equipment.

2 - During and immediately after Bunker Fuel Delivery

The Vessel should:

Ensure that representative bunker samples are drawn in line with industry guidelines and tested by a suitable independent laboratory against the ISO 8217:2012 specification requirements:



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- Drip fuel samples should be taken during bunkering, from each bunker source/barge/tanker.
- Expedient dispatch to follow, from bunker port to analysis laboratories with the provision that the Fuel Analysis Report returns to the vessel as soon as possible and in any case prior to using the bunkered oil.

In the unlikely case of emergency where the use of bunker fuel has to be used without receipt of analysis results, contact the technical superintendent for permission to proceed.

3 - During use of Bunker Fuel

Regular Testing post Bunker Fuel Purchase:

- There should be a system of analyzing oil at the entrance to the engine through a system of fuel system audits to ascertain and improve the efficiency of the purification and filtering system.
- Samples of heavy fuel oil should also be taken before and after each separator at intervals of 4 to a maximum 6 months. The samples should be sent to accredited laboratories such as DNVPS, FOBAS or Intertek for analysis using the ISO 8217 standard specification for comparison.
- In the event of an amber warning on levels of silicon and aluminium levels in the fuel, then fuel samples should be taken before and after purifiers. Max allowable total Si + Al 50ppm before purifier, and 15ppm after purifier.

Purifiers:

- Where possible, run two purifiers in parallel with minimum flow and keep the HFO inlet temperature at the optimal of 98° C to ensure efficient purification.
- Purifier capacity should be sufficient to cope with daily fuel consumption plus 10% in order to enable some recirculation of fuel in the settling tank to occur.
- Purifier efficiency tests should be carried out annually by fuel specialist bodies, such as DNVPS or FOBAS.
- Regular checks of the purifiers should be made by the manufacturer's service engineers to enhance system efficiency.



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- Fuel system filters should be regularly inspected and cleaned - not only when high differential alarms are activated.

Fuel Storage, Settling & Service Tanks:

- New bunkers should be put into empty tanks, and blending of different fuels should be avoided.
- Frequent (daily) draining of water and settled bottom sediments from fuel storage, settling and service tanks should take place. During calm weather, the heavy components in the HFO (Heavy Fuel Oil), such as cat fines, will settle in the tank bottom, and in heavy weather these abrasive particulates can be stirred up and fed into the purifiers in concentrations exceeding the maximum acceptable levels of 50ppm. If unchecked, this can impede the efficiency of the treatment system, leading to large quantities of cat fines at the engine inlet.
- Drained oil from automatic fuel oil backwash filters should not be reintroduced into the fuel treatment system.
- Clean settling and service tanks during dry docking in order to deal with any long term build-up of cat fines and sediment in the bottom of the fuel oil storage tanks.

Equipment Maintenance:

- Fuel treatment heaters should be opened and cleaned regularly to ensure that the optimal temperature of 98 ° C for purification is reached.
- Purifiers should be opened for cleaning at the scheduled intervals recommended by the manufacturers, or more often if poor fuel quality is suspected. Vessels should maintain the necessary spare parts on board.

Training:

- There should be company Bunker Procurement, Handling and Management plans provided to vessels.
- The Operator should ensure that the responsible personnel are sufficiently trained to fully and independently operate and maintain all above mentioned equipment as appropriate, both through existing qualifications prior to employment as well as on-going training courses and market practice updates, if and where necessary.
- The responsible personnel should be familiar with the issues raised in these guidance notes (JH2013/006).



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Record Keeping:

Crew and operator to maintain records of bunker fuel management procedures, including maintenance records and reports of mechanical or procedural failures.

4 - If a Problem is Found

If engine damage is thought to be due to cat fines, experts should be instructed to confirm the presence of cat fines. Such confirmation can only be achieved by replica testing of the affected cylinder liners and piston rings carried out by the engine maker technicians.

If cat fines are confirmed, all necessary work to eradicate them from the fuel should be carried out immediately. This should include the:

- Removal of contaminated fuel oil from the vessel,
- Cleaning of storage, settling and storage tanks, and fuel system components,
- Replacement or machining of all affected engine components.

This will help to avoid the escalation of further engine damage caused by cat fines, and minimise further delays in commercial operations and the unnecessary additional costs and insurance claims.

5 - Options for Improvement

Operators may wish to focus their attention on the subjects noted in these guidance notes and carry out an internal review of their bunker handling and treatment procedures. They may also wish to enhance their planned maintenance by increasing inspections of engine cylinder assembly parts in order to provide early identification of fuel related problems.

The fitting of proprietary cat fine analysis equipment that enables the vessel engineers to see levels of cat fines in the system in real time should be actively considered.