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Oil Companies International Marine Forum

Recommendations on the Hazard Assessment of Fuel Changeover Processes

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The OCIMF mission is to be the foremost authority on the safe and environmentally responsible operation of oil tankers, terminals and offshore support vessels, promoting continuous improvement in standards of design and operation

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1 Executive Summary

This paper provides guidelines to oil tanker operators and other interested parties on the potential consequences of fuel switching between residual and distillate fuels where ships' installations have typically been designed and manufactured to be used with residual fuels (HFO).

INTERTANKO and OCIMF have developed this guidance with the aim of providing a simple checklist of items which should be part of a Risk Assessment and a Hazard Identification (HAZID) assessment, for main engines, auxiliary engines and boiler systems in oil tankers covering the switching to, and long term operation on, low sulphur marine distillate fuel. It is recommended that such assessments are conducted in cooperation with classification societies, equipment manufacturers/installers and/or other experienced entities.

The differences between the composition and physical properties of low sulphur marine distillate fuel and residual fuels (HFO) result in significant differences with regard to the safe operation of installed systems which should be addressed by specific operational instructions and procedures. Operators will need to undertake a risk assessment of the fuel switching process and, based on the results, consider the initial design or the need for modification to existing equipment, as well as updating instructions and providing associated training to the crew.

Classification societies should be consulted to determine survey and approval requirements for any modifications. This may include requirements for documentation to be submitted for approval, certification of components and materials together with on board survey and testing.

2 Hazard Identification (HAZID) Assessments

The safe operation of on board installations with marine residual fuel (HFO) and low sulphur marine distillate fuel should be covered by a Hazard Identification (HAZID) assessment. A HAZID should consider all risks and identify necessary preventative and mitigation measures.

A generic checklist for the HAZID is provided in the Annex to this document for illustration purposes only. Training of ship's staff is important and the HAZID may serve to highlight particular training needs.

The HAZID should include the changeover procedure i.e. from marine residual fuel oil to marine distillate fuel and vice versa and include details such as automation timings.

Based on the HAZID assessment, necessary measures will be identified for each ship, installation and operation. Identified changes, including modifications and training, should result in the operation being at an acceptable risk level.

Upon completion of modifications, including testing, all changes should be recorded in documentation, both on board and ashore, and vessel procedures updated accordingly.

Any piping/pumping system modifications should be approved by the vessel's classification society.

3 Background for Hazard Assessments – Use of Different Fuel Types

Where vessels need to switch between different fuel types for operational or legislative reasons, the following differences in fuel characteristics should be considered:

- The combustion characteristics of the fuel may have an effect on the heat release. This can impact heat transfer and circulation, uptake temperatures, quality of the inert gas, emissions, etc. ***(Safety and Environmental Concerns).***

- Viscosity: where marine distillate fuel may have a much lower viscosity range than marine residual fuel (HFO) which may impact on the fuel system design. **(Operational and Safety Concerns).**

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- Density: where marine distillate fuel has a lower density than marine residual fuel (HFO). This may require that the amount of fuel supplied to the burner be different from the original pre-set amount. Most marine installations have the oil amount pre-adjusted, based on a calculation of the main fuel (i.e. marine residual fuel) which takes its density into account. Failure to re-adjust the oil quantity to the burner for the marine distillate fuel may lead to loss of power, ignition problems and/or an increase in smoke emissions. **(Safety, Operational and Environmental Concerns).**

- Flash point: although not under the direct control of ship owners, it is to be noted that the flash point for some low sulphur marine distillate fuels may be below SOLAS requirements, in which case the fuel should be rejected. Particular concerns are associated with the lack of proper control on fuels before their delivery to ships. **(Safety Concern).**

- Lubricating properties: low sulphur marine distillate fuel in particular has lower lubricating properties which, when coupled with reduced viscosity, can lead to reduced performance and abnormal wear conditions. This is an important aspect to consider with relation to fuel system spare part inventories and maintenance schedules. **(Operational Concern).**

4 Scope of Hazard Assessments

Tanker owners should consider the following items as part of their assessment of the changeover and long term use of low sulphur marine distillate fuel:

- Fuel storage and handling.

- Boilers, including combustion control.

- Main and auxiliary engines.

4.1 Fuel Storage and Handling

4.1.1 Fuel Storage Capacity, Segregation and Systems

The fuel storage capacity, segregation, tank and piping layout should be designed to ensure the availability of adequate quantities of compliant fuels and facilitate the changeover process while minimising any possibility of cross contamination and retaining operational flexibility.

Storage capacities should be adequate for the planned operational requirements including contingencies.

Where a dedicated tank for low sulphur fuel oil is not available or when initially filling a dedicated low sulphur fuel oil tank, load on top is not recommended. Proper cleaning and flushing should be carried out to remove the remnants of the previous fuel. Low sulphur fuels can be easily rendered 'off-spec' by mixing with small quantities of high sulphur material.

New ship designs and existing ship modifications should take into consideration factors that include:

- Maintaining adequate separation of different fuel qualities, both high/low sulphur and HFO/Distillate.

- Avoiding unintentional heating of distillate fuels, for example, by avoiding routeing distillate lines and locating tanks adjacent to heated systems.

- Fail-safe operation of recirculation systems to ensure fuel is returned to the correct tank. Higher sulphur fuels should not be allowed to recirculate to lower sulphur storage and heavy fuels should not be allowed to return to distillate tanks. Particular consideration may be necessary where recirculation is to a designated spill tank. In addition, recirculation from boilers should be taken into account.

- As far as is possible, piping systems should be dedicated to specific fuel types. Common use should be avoided, particularly between HFO and distillate fuels, due to the tendency for the distillate fuel to 'scour' the system, dislodging sludge and wax which may cause blockages or clog filters and

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gauge/control lines. The use of common systems also requires careful control over fuel temperature ensuring, for example that trace heating is isolated when using distillate fuels.

- Distillate fuels have a 'searching' tendency which, when used in systems previously in HFO service, may result in leakage from flanges, glands, seals, and pipe fittings. This may be exacerbated by temperature fluctuations. Regular inspections and monitoring for leakage should be implemented.

4.1.2 Fuel Supply and Circulating Pumps

Marine distillate fuels generally have a viscosity between 2 and 6 cSt @ 40 degrees Celsius. The newly-defined DMZ grade under ISO 8217:2010 specifies a viscosity between 3.0 and 6.0 cSt @ 40 degrees Celsius, in order to address some of the negative effects associated with very low viscosities.

Most fuel pumps currently in use are displacement-type pumps, such as screw or gear pumps. According to manufacturers, these pumps are designed to operate with a minimum fluid viscosity of 4 cSt. However, some of the current pumps may cope with lower viscosities such as 3.0 cSt or even slightly lower. For pumps operating well within their design rating, manufacturers may advise that they are suitable for use with lower viscosities. An assessment should be made of all fuel pumps on board to determine whether they are able to operate with the lower viscosity and lubricating properties associated with the low sulphur marine distillate fuel and to consider the need for modification or replacement.

The actual operating temperature of the low sulphur marine distillate fuel should be considered. The viscosity stated in marine distillate fuel specifications is indicated for a reference temperature and actual operating temperatures may be higher, resulting in the actual viscosity being reduced. Fuel pumps running continuously during periods when the boiler/burner is in standby mode may heat up, causing the temperature of the fuel to increase, and thus the viscosity to decrease, which may result in gasification of the fuel. In this case, the control of the pumps should be considered. If the pump control system is not pre-set in advance, it may be preferable to adjust the control system in such a way that the pumps are always shut off when not in operation.

Consideration should be given to cooling the low sulphur marine distillate fuel to control the viscosity, but possible failure of the cooling system should be considered as part of the hazard assessment.

Advice and guidance on remedial measures should be sought from pump manufacturers regarding the low lubricity properties of low sulphur marine distillate fuels. If the pump is not suited for the lower lubricity, there is a risk of increased wear and eventual breakdown.

4.2 Boilers, including Combustion Control

The furnace purge process is a critical safety process and must be functioning correctly in line with manufacturers' recommendations for the specific type of fuel in use. It is essential that the entire furnace space is fully purged before introducing a flame. A post-purge of the furnace whenever low sulphur marine distillate fuel has been used is recommended by all manufacturers and should be considered as an essential part of the procedure.

A flame failure could result in a flammable atmosphere being present in the boiler gas spaces. Purge procedures should be developed in conjunction with the manufacturer or experienced entity.

The spark igniters (or equivalent) should be functioning correctly and positioned so as to readily ignite the fuel spray on start up. All boiler flame detection and related safety systems should be operating correctly. Flame detectors should be correctly positioned to sense the particular flame pattern encountered with the type of fuel and burner being used. Additional flame detectors may be required, for example, in connection with ignition burners.

It is recommended that flame detectors are matched to the fuel used since marine residual fuel and low sulphur marine distillate fuel have different flame flicker frequencies in the furnace. It should be noted that any change will require Class approval.

Automated combustion control system functions should be confirmed to ensure they are operating correctly and reliably. In the event of automation failure, careful consideration should be given before engaging manual operation.

To ensure the minimum quantity of carbon deposition material within the combustion and uptake

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spaces, soot blowers should be operated at the latest possible opportunity before entry into coastal and port waters.

4.2.1 Burners

Burners, in general, and tips, in particular, must be appropriate for each type of fuel to be used. There are three basic types of burner operation:

Pressure jet burner. Typically used on smaller boiler types and run on distillate and residual fuels. It should be noted, however, that the lowest viscosity that the fuel pumps can accommodate is generally 4.5 cSt. The use of low sulphur marine distillate fuel, which typically has a lower viscosity, may require modifications to the pumps. A lower viscosity may also cause an increase in the fuel throughput with the risk of increased smoke emissions.

Rotary cup burner. Rotary cup burners are used on many boiler types and run on distillate and residual fuels. However, when using low sulphur marine distillate fuel having a typical lower viscosity of 4.5 cSt,, the fuel pumps may need to be re-adjusted/modified. For smaller burners, the fuel amount (pressure) should be checked/adjusted in order to obtain smoke free combustion. For larger burners, there is a risk of coke deposit build-up at the burner cup if the installation is not fitted with a suitable heat shield. This coke build-up is caused by radiated heat into the rotary cup generating very high temperature in the cup, resulting in the fuel carbonising. The rotary cup installation may need to be checked and modified as necessary. The control system of the main burner should also be checked/adjusted so that the low sulphur marine distillate fuel does not auto-ignite.

Steam atomising burner. Steam atomising burners are typically used on medium and larger boilers and run on distillate and residual fuels. The use of low sulphur marine distillate fuel having a viscosity lower than 4.5 cSt may require adjustments/modifications to the fuel pumps. The viscosity of the fuel traditionally burnt in steam atomising burners is commonly in the range 15 – 30 cSt.

Some burner lance designs utilise a concentric steam/fuel line configuration which causes heating of the fuel by the atomising steam which may lead to vaporisation of marine distillate fuel prior to exit from the pipe. For continuous operation with marine distillate fuel, changing the atomising medium to compressed air should be considered. Alternatively, consideration may be given to changing the lance to a parallel steam/fuel line type where heating of the fuel is reduced. If the compressed air atomising option is implemented, the volume of air required for an entire discharge operation may require installation of additional air compressors.

4.3 Main and Auxiliary Engines

4.3.1 High Pressure Fuel Injection Systems

On some vessels, the fitting of a diesel oil cooler/chiller may be required to ensure that the viscosity of the low sulphur marine distillate fuel is in accordance with the engine manufacturer's recommended limits.

New or updated pumps may be necessary, particularly on older vessels. Existing fuel oil booster pumps may not be able to reliably pump the low viscosity, low lubricity marine distillate fuel without seizing or scuffing. Furthermore, old and worn pumps could lead to reduced power being available, as well as starting problems due to difficulties in achieving a sufficiently high pressure for proper atomisation of the fuel.

Products are available which are designed to mitigate the increased wear by increasing the lubricity of the fuel. Consideration should be given to the effect that such additives may have on engine emissions.

Pulsation dampers in the fuel oil system may require overhauling at an increased frequency due to the poor lubrication qualities of low sulphur marine distillate fuels.

4.3.2 Engine Manufacturer's Recommendations

Specific operational guidance for switching to low sulphur marine distillate fuel should be sought from the engine manufacturer. In general, these guidelines relate to the minimum viscosity of a fuel and the avoidance of thermal shock which would be harmful to fuel injection equipment. Typically, a maximum of 2 degrees C per minute temperature variation is recommended.

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For extended operation on marine distillate fuel, consideration should be given to the possibility of lube oil contamination due to leakage from fuel pumps. Close attention should be paid to lube oil analysis and consideration given to the possible use of lower Total Base Number (TBN) of system and cylinder oils.

4.3.3 Procedures for Fuel Switching/Changeover for Main and Auxiliary Engines

The fuel changeover operation should be clearly defined for each vessel by means of comprehensive procedures. They should include instructions on relevant logbook entries such as for the Engine Room Logbook and the Sulphur Emissions Control Area Logbook, as required by authorities. Joining crew who will be involved in fuel changeovers should be familiar with the procedures applicable to the particular vessel.

The procedures should include:

- Instructions on when to initiate the fuel changeover operation in order to ensure timely changeover to low sulphur marine distillate fuel, always taking safety of navigation into consideration. Details should be included in the vessel's passage plan.

- The sequence of valve operation during the fuel changeover process together with cautionary notes on the management of fuel oil heaters, the control of trace heating systems, the possible contamination of fuel tanks and fuel compatibility tests.

- Advice and guidance on any associated issues that could be a consequence of the fuel changeover operation. In particular, engine room arrangements, such as filters, should be addressed in the procedure.

5 Summary

It is recommended that fuel changeover procedures are subjected to a thorough hazard analysis (HAZID) to identify risks and necessary preventative and mitigation measures.

Engine, boiler and fuel system manufacturers should be consulted for fuel switching guidance and to confirm that the engines, boiler, combustion control systems and associated fuel system components, such as pumps, are suitable for the intended types of fuel.

Solutions and modifications to the boiler/burner system should be considered carefully and executed by competent and authorised personnel after consultation with manufacturers and classification societies.

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ANNEX 1

An Example of a Hazard Identification (HAZID) Analysis Document

(For illustrative purposes only)

ITEM/AREA	HAZARD	CAUSE	POTENTIAL EFFECTS	SAFEGUARDS	RECOMMENDATIONS/ACTION
Operational Manual					
Capacity of Tanks					
Tank Location					
Mixing Tanks					
Piping Systems					
Trace Heating					
Pumps					
Burner Lance					
Atomising					
Boiler and Combustion Control					
Flame Detection Equipment					
Viscosity Management					
Flashpoint					
Lubricity Management					
Sampling Procedures					

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