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Changing between HFO and MGO brings operational challenges

Since July 2009, the US state of California has enforced a rule requiring incoming ships to run on DMA marine gas oil (MGO) with 1.5% m/m maximum sulphur content, or DMB marine diesel oil (MDO) with 0.5% m/m maximum sulphur if sailing within a 24 nautical mile zone from the Californian coast.


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The California Office of Spill Prevention and Response has also been monitoring incidents of loss of propulsion (LOP) related to compliance with this rule. In 2011, a third of the 93 reported LOP cases had to do with the change-over from heavy fuel oil (HFO) to MGO.

It is reasonable to premise that three years from now when MARPOL Annex VI mandates the use of fuels with maximum 0.1% m/m sulphur for ships operating in the Emission Control Areas (ECAs), LOP incidents could become geographically widespread.

If these vessels are not equipped with onboard abatement technology to reduce SOx emissions to the specified levels, they will have to change to distillate fuels, typically MGO, when operating in the ECAs. This is because HFO products with 0.1% or lower sulphur content are unlikely to be found in the market – now and probably also in the future.

Although ships can operate continuously on distillate fuels, most for economic reasons will change between HFO in global waters and the more expensive distillate fuel in the ECAs.

Fuel change-over is a complex process. The timing must be correct in order to resolve the mixing of fuels with different sulphur content in the system and to ensure compliance with the sulphur regulations at the engine inlet upon entering the ECA. Several other technical factors must also be considered.

Firstly, the operator has to mind the temperature changes in the system. If the fuel injection system experiences drastic temperature differences, the resulting thermal expansions may cause irregular fuel pump operation, or seizures in the worst cases.

Engine manufacturers have guidelines on the temperature steps that their systems can handle during the fuel change-over. MAN, for instance, recommends a 2°C per-minute increase.

The temperature-dependent nature of fuel viscosity also affects the change-over process. The higher the temperature, the lower the fuel viscosity. It is neither practical to reduce the HFO temperature too much as the fuel pumps may become overloaded, nor is it practical to raise the MGO temperature too much at the risk of gassing in the system.

During the fuel switch, the crew must therefore determine the correct change-over temperature increments.

Marine engines are traditionally designed to operate on high viscosity HFO, which must be heated before it can be injected into the engine at the correct viscosity. Depending on the engine type, the injection viscosity should typically be in the 10-18 cSt range.

Due to the high temperature in the fuel system and engine room (even with the heating system turned off), gas oil viscosity is reduced. This may result in internal leakage in the engine fuel pump, in turn causing difficulties during engine start-up, astern operation, or when the ship is operating at low load; for example, during maneuvering.

Incidentally, a common misunderstanding in the industry is that such engine-starting problems are caused by poor lubricity of the MGO in use.

While poor fuel lubricity may increase the wear rates on the fuel pumps, the same fuel pumps that exhibit problems during operation on low viscosity MGO will work fine with HFO.

Again, depending on the engine make and type, engine manufacturers recommend the minimum fuel viscosity at the engine inlet to be in the 1.8-2.8 cSt range. They also advise ship operators to prevent LOP by making start checks before entering ports or congested areas.

Ship operators should further note that engine fuel pumps are not the only ones requiring a minimum fuel viscosity of 2cSt for proper operation. Many external pumps in the fuel system – transfer pumps, circulating pumps and supply pumps – also have the same specification.

Incorrect change-over procedures in some cases have led to a too-high temperature and too-low viscosity combination, making MGO operation unreliable.

In order to account for the low viscosity issues, the minimum fuel viscosity limits have been raised from 1.5cSt at 40ºC in ISO 8217:2005 to 2cSt at 40ºC in ISO 8217:2010.

ISO 8217:2010 has also introduced DMZ, a new distillate grade. The limits of this grade are identical to DMA except that the minimum viscosity is set at 3 cSt at 40ºC. As such, DMZ provides better protection against LOP.

To control fuel pump damage, ISO 8217:2010 has further spelled out limits for fuel lubricity.

Fuel change-over is a challenging undertaking that involves robust procedures, careful fuel handling and correctly timed steps. Once it is successfully executed, shipboard personnel must also monitor the engine operation closely.

A good working knowledge of fuel characteristics, such as viscosity, and how these can change under different conditions, will help ship operators minimise the occurrence of LOP and other potentially dangerous situations.

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