

Preventing Loss of Propulsion after Fuel Switch to Low Sulfur Distillate Fuel Oil

The California Air Resources Board (ARB) created regulations for vessel emissions reductions for California waters as part of its continued mission to improve air quality around the state. The new requirements came into effect in July 2009, under California Code of Regulations (CCR), Section 2299.2, *Fuel Sulfur and Other Operational Requirements for Ocean Going Vessels within California Waters and 24 Nautical Miles of the California Baseline*.

The regulations require that vessels burn either marine gas oil (MGO) with maximum 1.5% sulfur, or marine diesel oil (MDO) with maximum 0.5% sulfur, in their main and auxiliary engines. Following the implementation of the regulations, California witnessed a 100 percent increase in loss of propulsion (LOP) incidents within state waters during 2009. In 2010, California saw 54 LOP incidents compared to 24 in 2008 (the last full year before ARB regulations took effect).

The LOPs can be loosely categorized into six groups for ease of discussion. ⁱ

GROUP 1

In Group 1, engine failures resulting in the LOP are due to the inability of the main engine, operating with MGO/MDO, to overcome the forces on the propeller from the forward momentum of the ship. The engine may turn over at higher RPM and initiate combustion; however, as the engine reduces speed to come to dead slow or slow astern there is not enough BTUs in the fuel to maintain engine inertia. The engine stalls with the subsequent loss of propulsion.

Similarly, ships not getting engine starts while anchoring when an astern bell is given, typically initiates a "Failure to Start" scenario. The remedy due to the lack of BTUs is to adjust the fuel rack to allow more fuel into the cylinder. This procedure cannot be done from most ship bridges but only from the Engine Control Room or from the Engine Side (manual).

GROUP 2

In Group 2, failures resulting in the LOP are due to problems with controlling the temperature of the MGO/MDO. Each engine has specifications as to the temperature range required to operate using either heavy fuels or lighter fuels. For example, the optimal temperature range for an engine might be 135°C for a heavy fuel oil (HFO) and 40°C for the MGO. Because heavy fuels must be heated (for the right viscosity to burn) and lighter fuels may not need to be heated, there are problems associated during the fuel oil switch over in both heating and cooling the different fuel oil systems (since the fuel oil is supplied through the same auxiliary systems). Heating an MGO/MDO may cause "flashing" of the lighter fuel oil to vapor. The fuel injectors would not work when the fuel flashes causing a loss of power in that cylinder. Multiple cylinder flashes could result in LOP.

GROUP 3

In Group 3, failures resulting in a LOP are associated with the loss of fuel oil pressure to either the fuel pumps or fuel injectors. The loss of pressure could be a result of many factors including wrong control set points, use of bypass valves, in-operable equipment, inattention to operating conditions, or excessive leakage through "O" rings and seals.

The problem lies with physics. Metal expands when heated and contracts when cooled. Ships evolved to burn the heaviest and cheapest fuel available, HFO. To utilize the HFO on ships, the fuel is heated to as much as 150°C to get it to flow. In comparison, MGO/MDO fuel is burned at ambient engine room

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temperature or 40°C and no heating is required. Once the cooler MGO is introduced into the fuel pumps and injectors, they contract causing a loss of fuel pressure at the pump with marginal spray pattern and leaks at the injector.

One of the other issues using MGO in an engine that has successfully run HFO for some time is viscosity. Typically the engine manufacturer's recommended minimum viscosity is 2 centistokes (cst). Fuel viscosity specifications at 40°C temperature for MGO/MDO range from 1.5 cst to 6.5 cst. The MGO loaded in California has a viscosity of 2cst to 3cst at 40°C. When the temperature of the MGO is increased into an already warm engine that just ran on HFO, the heat lowers the viscosity causing the fuel machinery parts to bind or break. Keep in mind that the cylinder temperature is usually maintained at 80°C and this heat migrates into the fuel lines as well.

Unsurprisingly, the introduction of distillate fuel into the fuel system causes leaks, sometimes excessive leaks. With MGO/MDO there is a very real risk of external combustion or fire. Replacing "O" rings at the manufacturer's recommended intervals has proven not to be adequate. For example, in the case of injector "O" rings on a ship, the manufacturer suggested interval for replacing fuel injector "O" rings is 10,000 hours. The engineers on this ship found an interval of 2,000 hours was more appropriate to change injector "O" rings to prevent potential fire hazards. These fuel leaks tend to disappear when engines are switched back to the heavier fuel oil.

GROUP 4

In Group 4, failures resulting in LOP are associated with the loss of fuel oil pressure or the loss of flow in sufficient quantities to maintain operation. Strainers and filters or the lack of a strainer and filter contribute to clogging or restrictions in the fuel oil supply system.

The MGO/MDO acts as a solvent causing a de-coking effect, clogging fuel filters. This is due to burning a lower grade of HFO that has excessive amounts of asphaltenes. These asphaltenes adhere to the inside of the fuel lines and assorted other fuel components. When MGO is introduced the asphaltenes are released, collecting in the fuel filters/strainers.

GROUP 5

In Group 5, failures resulting in the Loss of Propulsion appear to be associated with problems in either the starting air system or the control air systems. Problems with starting air systems are not fuel related and only need to be mentioned as a cause of LOPs.

GROUP 6

In Group 6, failures resulting in the Loss of Propulsion appear to be associated with mechanical failure not associated with other groups.

Having defined the groups of LOPs, the intent of this guide is to reduce the Loss of Propulsion incidents occurring within the state of California boundaries. The time to deal with problems aboard ship is either miles out at sea or alongside the dock. Not in Maneuvering/Pilotage waters!

Many of the LOP incidents that occurred in 2010 involved "First Timers" (ships making first entry into California waters since July 2009). Since California sees between one to two first timers per week, based upon my knowledge and experience, the Office of Spill Prevention and Response (OSPR) decided to provide suggestions for ships working with low sulfur distillate fuel oil (LSDFO).

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OPERATIONS

Initial Entry

For vessels intending to enter the California ARB Emissions Control area for the first time since July 2009, I recommended and California advises the crew should conduct a "TRIAL" (actual) fuel switching within 45 days prior to entering California waters. Run main and auxiliary engines no less than four (4) hours on low sulfur distillate fuel (LSDFO). This will help identify any specific change over or operational issues or problems.

If ships perform a trial fuel switch, the operators will be more prone to avoid problems that could occur versus learning underway upon entering California waters and not knowing the sundry issues. Forty five days was chosen based upon an understanding of containership operations where schedule is everything. Somewhere within that schedule there is always time to perform a trial maneuvering and 45 days should allow the ship's personnel to experience the fuel switchover and document remedial fixes, if any, mitigating Groups 1,2,3,4.

Repeat and Initial Entry

Part One-TRAINING:

- *Within 45 days prior to entering the waters of California it is strongly advised ship engineers should exercise:*
 - A. Operating main engine from the engine control room.
 - B. Operating main engine from engine side (local).
- *Crew should become familiar with "Failure to Start" procedures while maneuvering and establish corrective protocols for "Failure to Start" incidents.*

Following, the "Perfect practice ensures proper performance" creed, if the bridge and engineering crew is practiced in the event of a "Failure to Start" scenario, they will perform satisfactorily when called upon in the event of a real failure. This is especially important in maneuvering/pilotage waters.

The air and fuel in the start sequence can be adjusted in the engine control room and at engine side. These items cannot be adjusted from the bridge on most ships; hence, the provision of the advisory/guide establishes protocols for dealing with the "Failure to Start" scenario as outlined in LOP Groups 1 and 2.

Too many ships have run out of "start air" because they continue to initiate starts from the bridge where control of the fuel rack and amount of air for starting cannot be adjusted.

Part Two- While Underway after Fuel Switching Completed (HFO to LSDFO):

Ships should ensure one of the senior engineering officers is in the engine control room while the ship is in pilotage waters to be able:*

1. *To operate the ship main engine from the engine control room.*
2. *To operate the ship main engine from engine Side (Local).*

***Special Attention to International Standards of Training, Certification and Watchkeeping (STCW) Rest Requirements**

While interviewing Chief Engineers (CE), I found they were putting in excessive hours. CE's are not subject to the STCW rest requirements as they are non-watchstanders. However the CE is human and

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subject to fatigue just as junior officers. It has been proven too many times that fatigue can cause errors in judgment and which could contribute to a LOP incident.

Usually the Senior Engineers consist of the CE and Second Engineer on internationally flagged ships while CE and First Assistant Engineer (on US flag ships) have the most experience with the ship engine operation. If the CE is comfortable with anyone substituting on duty, it is usually the other Senior engineer. Hopefully, a substitution will allow the CE some rest. Some ships have the CE down in the engine room for the fuel switchover, then the CE retires for rest while assigning the other Senior engineer to standby in the Engine Room, mitigating Groups 1, 2, 3, 4, 5, 6.

The following Engine Advisory Guidelines were taken from the US Coast Guard MSA 03-09 with additions and clarifications from industry partners.

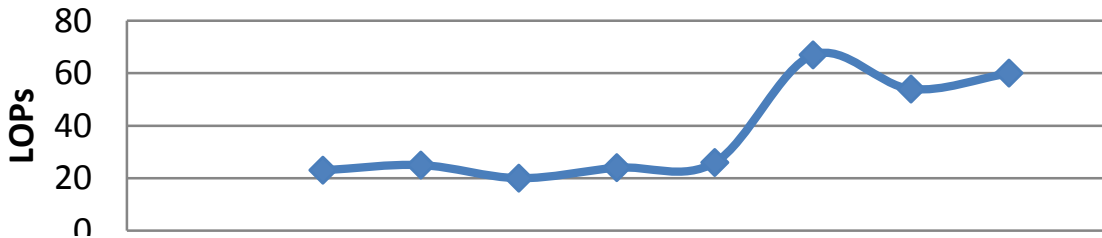
Part Three-ENGINE GUIDELINES:

- Consult engine and boiler manufacturers for fuel switching guidance.
- Consult fuel suppliers for proper fuel selection. Exercise strict control when possible over the quality of the fuel oils received.
- Consult manufacturers to determine if system modifications or additional safeguards are necessary for intended fuels.
- Develop detailed fuel switching procedures.
- Establish a fuel system inspection and maintenance schedule.
- Ensure system pressure and temperature alarms, flow indicators, filter differential pressure transmitters, etc., are all operational.
- Ensure system purifiers, filters and strainers are maintained.
- Ensure system seals, gaskets, flanges, fittings, brackets and supports are maintained.
- Ensure that the steam isolation valves on fuel lines, filters, heaters etc. are fully tight in closed position while running LSDFO.
- Ensure that the fuel oil viscosity and temperature control equipment is accurate and operational.
- Ensure detailed system diagrams are available and engineers are familiar with systems and troubleshooting techniques.
- Ensure Senior engineers know the location and function of all automation components associated with starting the main engine.

California hopes that ships choosing to use these guidelines will alleviate some of the LOP incidents occurring within the waters of California. It is my shared belief that it will only take one LOP incident to change lawful maritime trade internationally. So on behalf of my sea going brethren, any reduction of a Loss of Propulsion incident is one less chance of catastrophe.

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About the author - CAPT Jeff Cowan sailed aboard various containerships as Master, capping a 35 year seagoing career. He now works for the State of California, Office of Spill Prevention and Response where his experience at sea and onboard vessels helps California make sound recommendations to industry. Cowan has two sons, one just graduating from and the other attending his alma mater, California Maritime Academy.

ⁱ Industry generated categories

ⁱⁱ From USCG data

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