SWITCHING TO LOW-SULFUR FUELS IN THE COMMERCIAL MARINE INDUSTRY

INTRODUCTION

For more than 70 years, CIRCOR has been working with the commercial marine industry to keep pace with changing compliance andregulation demands, as well as helping the industry meet evolving environmental issues. This white paper highlights one of our latest efforts: the search for pumping equipment that can meet the demands of low-viscosity, low-sulfur fuels.

MARPOL (marine pollution) Annex VI Regulations for the Prevention of Air Pollution from Ships stipulates that high-sulfur fuel oil combustion is not permitted during European port stays and in emission-controlled areas (ECAs) at sea. Today's low-sulfur fuel oils are in general lighter types, like marine diesel oil (MDO) or marine gas oil (MGO), that often require modifications to the fuel oil pump system. In this document you will find necessary information and our recommendations for how to handle the situation.

LEGISLATION

Since May 2005, specific environmentally friendly MARPOL regulations stipulating that emissions from main and auxiliary machinery are kept within specific limits have been in force. They require, for instance, reduction of carbon dioxide (CO2), as well as sulfur oxide (SOx) and nitrogen oxide (NOx) combinations.

Prior to the new regulations, ships could burn higher-sulfur fuel, which is more viscous. In some cases ships need heaters to warm the fuel enough for it to become less viscous and easier to pump. But the low-sulfur fuel is less viscous to begin with, and ships will need cooling units to bring down the temperature of the fuel, to make it thick enough to pump. Without cooling, operating temperatures near the ship's machinery can heat the low-sulfur fuel to an unacceptable level. Under some of the regulations, ships can continue to burn the higher-sulfur fuel until they near a port, at which point they must burn the lower-sulfur diesel. To do that they need a fluid-handling system flexible enough to handle both.

This legislation will have a significant impact on the industry and the different parts of the fuel oil system, especially the pumps.

FUEL OILS

Ships' fuel oil systems are designed and optimized for running on heavy fuel oils (HFOs), typically 180 to 600 centistokes (cSt); however, a supply of low-sulfur fuels within that range is not available, leading to a supply of low-sulfur MDO or MGO.

VISCOSITY

The existing International Organization for Standardization (ISO) 8217 specification states minimum viscosities for DMX of 1.4 cSt at 40 degrees Celsius and DMA of 1.5 cSt at 40 degrees Celsius. Ambient temperature in an engine room easily reaches 40 degrees Celsius and sometimes even higher – in some cases as much as 55 degrees Celsius. Adding excessive heat from pipes and engines will raise the temperature even further; and as a consequence viscosity will fall, causing a significant change of operating conditions in the system.

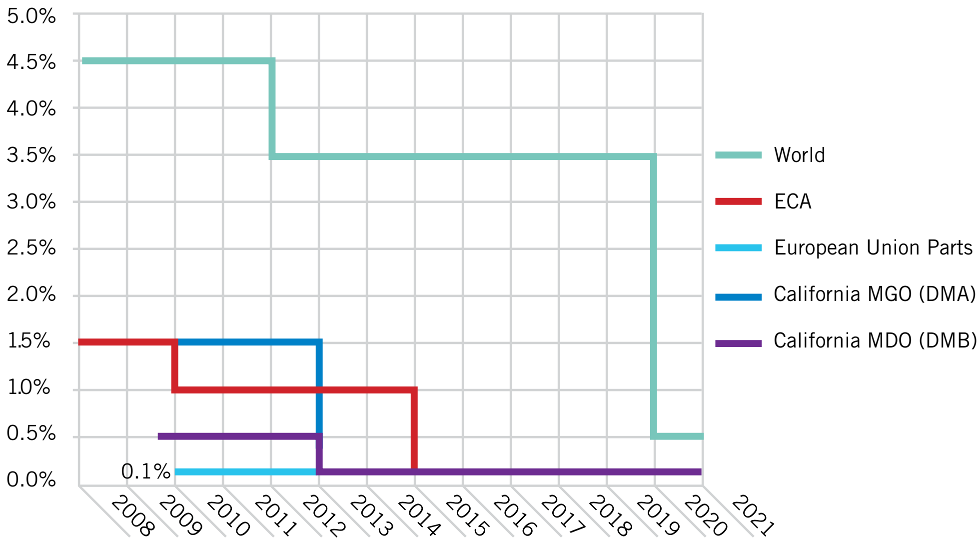

Figure 1: MPEC 57 Sulfur Tiers

DENSITY

In general the density of lighter fuels will be lower than the HFOs; however, the lower density of the fuels will not have any impact on pumps.

LUBRICITY

In general lubricity of marine fuels has not been discussed in the past, as it has not been relevant to marine pumps; however, as low-sulfur MDOs and MGOs are now entering the market, lubricating properties of fuels are becoming more important.

A three-screw pump is supposed to work under full-film running conditions, which means that the rotors are separated from each other and from the bores by an oil film that carries the load. To achieve a full-film condition, the pump needs to run with relatively high speed, and the oil needs to have a relatively high viscosity to carry the radial forces. Furthermore, the radial forces will increase with higher differential pressure. In order to find out if full-film condition is fulfilled, a Sommerfeld number can be calculated. A higher number means a stronger oil film.

When a three-screw pump operates with light fuel, the Sommerfeld number is sometimes not high enough to fulfill the full oil film condition, and the pump operates in boundary zone. This means that the moving parts are not separated by a film; consequently, some level of metallic contact will take place. When the pump is operating in this zone, the lubricity of the fuel is important. The lubricity of the fluid can be measured as a high-frequency reciprocating rig (HFRR) number with the unit µm. A higher number means less lubricity.

FUEL OIL THREE-SCREW PUMPS

CIRCOR fuel oil pumps are typically designed to handle minimum viscosity of 1.6 cSt; but as conditions change, as described in this paper, viscosity is likely to fall below that limit.

LUBRICATING THE PUMP

The screw pump design is based on having the rotors lubricated by the pumped media. The oil film that builds up by the hydraulic balance in the pump makes the rotors “float” and become lubricated. These parameters determine the working condition for the pump: lubricity (HFRR value), rotation speed, viscosity and differential pressure.

LUBRICITY AND WORKING CONDITIONS

The combination of differential pressure and viscosity determines when the oil film is broken. Under the blue line in Figure 2, the Sommerfeld number is fulfilled, and the pump is running under full-film condition. Within the red zone, the pump might be operating in boundary zone; the HFRR value becomes important, since the pump is working with a completely or partly broken oil film. Previous experience shows that this state of operation occurs when operating below 1.6 cSt. Figure 2 shows the critical area below 1.6 cSt and where a DMX-quality fuel is run at 40 degrees Celsius.

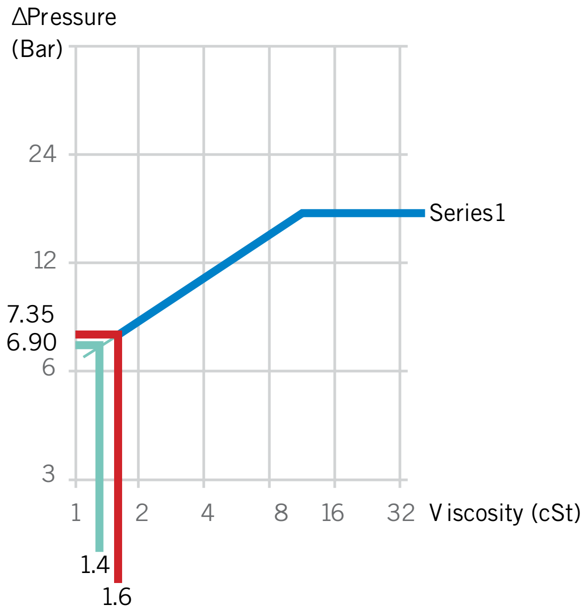

Figure 2: Differential Pressure Limits

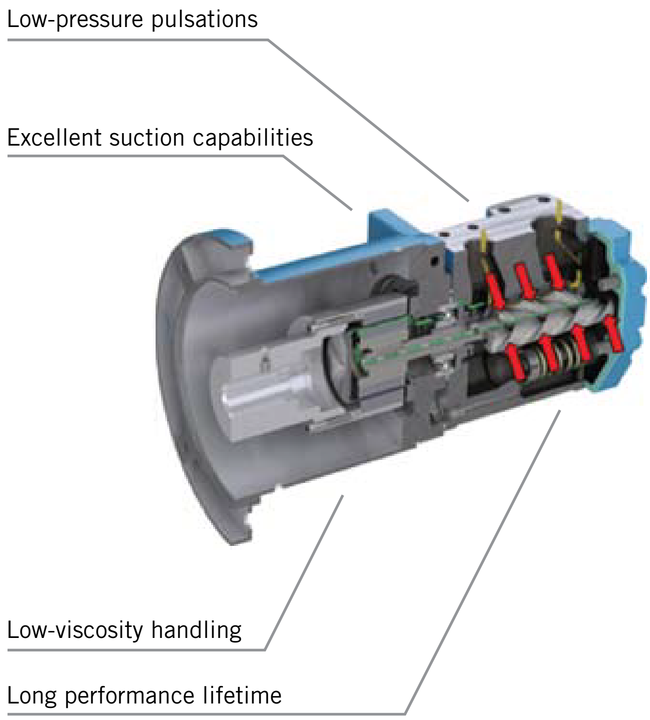

Figure 3: Screw Pump Design
CIRCOR's IMO® OptiLine pump is pictured.

LIFE-CYCLE COMPARISONS

There can also be significant life-cycle cost differences between screw and gear pumps. In recent testing CIRCOR found that screw models delivered more leak-free operation and longer periods between service intervals (five years), a combination that led to lower costs for spare parts, repair man-hours and cleaning.

Results of the program were measured in several ways. The first was leakage and spare-parts consumption. CIRCOR screw pumps have been designed without a mechanical seal, so they are 100 percent leak-free. That can be especially vital, since leakage can result in actions from external parties, such as harbor authorities, class authorities and others. Pump leakage and related oil around the pumps could also result in denial to port access, a delay in port or an extensive cleaning operation that could not be handled by an engine-room crew.

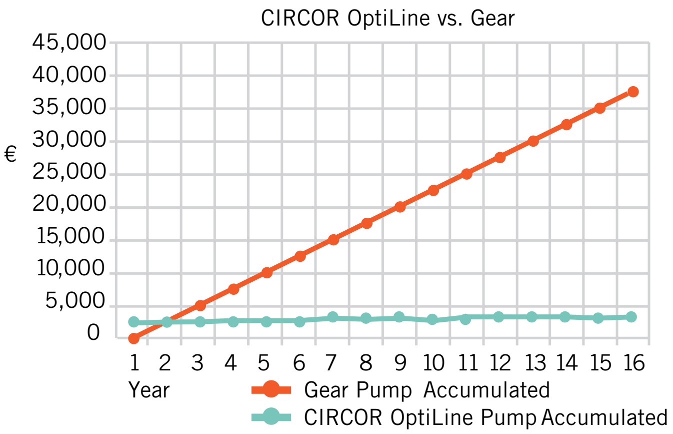

Figure 4: Life-Cycle Costs
The red dotted line in Figure 4 describes the operating cost accumulated over time of an existing gear pump with stuffing-box/mechanical-seal installation. The green line describes the operating cost of the CIRCOR OptiLine pump. Payoff time in this case is about two years.

PERFORMANCE TESTING

In order to guarantee the performance of existing products suitable for low-sulfur applications, CIRCOR has conducted a number of tests to verify that our pumps can meet the demands of the new fuel requirements.

SCREW PUMP TESTING

CIRCOR conducted preliminary screw pump testing on 10 units with varying rotor materials, with and without heat treatment, together with standard modular cast-iron houses, with and without heat treatment.

The testing included:

- Running time – 2,650 hours
- Rotation speed – 2,950 revolutions per minute (rpm)
- Differential pressure – 7.35 bar
- Temperature – 55 degrees Celsius
- Viscosity – 1.13 cSt

Note: 1.13 cSt was chosen, to be more challenging to pump than the existing ISO 8217 specification stating minimum viscosities for DMX of 1.4 cSt and DMA of 1.5 cSt at 40 degrees Celsius. This is due to a possible higher ambient temperature in the machine room (55 degrees Celsius).

FOR ADDITIONAL INFORMATION VISIT:
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