Low Sulfur Heavy Fuel: What Can We Expect?

By Ralph Lewis
VP Technical – Power Research Inc.

The introduction of the first Sulfur Emissions Control Areas (SECA) is generating more than a few worrisome concerns – spawning a myriad of questions regarding future supply and fuel quality issues. Will supplies of low sulfur fuel oil (LSFO) be sufficient as SECA areas expand? Can we expect operational problems with these fuels to continue, perhaps even worsen?

In this article, we will take a brief look at the economic reality of LSFO production. We will also review operational problems with LSFO, and the remedies that are helping ship owners meet the challenges.

First, let's take a look at the economics of LSFO and what we can expect for the future.

While Shell and other suppliers suggest that supply problems in the first SECA areas are minimal, refining economics suggest an altogether different scenario in years ahead.

Here are the unavoidable facts:

Today, in March 2007, a burgeoning global demand for profitable distillate products - particularly low-sulfur distillates - is straining both feedstock availability and refining capacity.

First, most sweet, low sulfur crude is now dedicated to low sulfur distillate production, leaving less for LSFO manufacturing. The demand is driven primarily by new mandates for cleaner low sulfur diesel fuels in the USA, the EU and other areas worldwide.

Second, the rapidly growing economies of China and India are gulping as much new distillate as refiners can produce. This is why refinery upgrades today are almost solely targeted on increased distillate production.

But production is not catching up with growing demand. In 1990, refining capacity worldwide was nine percent greater than global requirements. Today it is less than three percent. At present projected demand rates, refineries will have to build at least 30-to-40 new refineries over the next three years worldwide just to maintain the present capacity-over-demand level in 2010.

Here's the catch: Fewer than a half-dozen or so refineries are even in the engineering planning stages, according to some reports. Refineries typically take from five to eight years to build, start to finish. So depending on which analyst you speak with – vessel owners may face an LSFO shortfall ranging from 360,000 bpd to as much as 1 million bpd by 2015.

Today, prices for LSFO are averaging a $20/mt premium, with some areas quoting as much as $35/mt. Long term, some believe the increase may be $60/mt, perhaps even more.

So will refiners step up and build a sufficient number of units dedicated to LSFO production? Not likely.

Instead, refiners will likely rely on the present method of LSFO production, which involves the blending of a sufficient quantity of distillate with residual fuel to achieve the 1.5 percent sulfur requirement.

And this brings us to the second point – the effect of LSFO on vessel operational reliability.

Depending on the chemistry of the distillate cutter stock and the nature of the heavy fuel into which it is blended, a wide variety of negative operational conditions can, and often do, occur.

Heavy fuels cut with a high cetane number distillate, for example, can be expected to have reasonably good ignition quality. But this comes at a price. Simply, these low-aromatic cutter stocks have a greater tendency to create a much higher rate of fuel sludge precipitation, resulting in greater lost fuel value and all of the attendant operational headaches.

Low-aromatic distillates act like a penetrating solvent, disrupting the sticky bond that keeps the maltene and asphaltene components tied together in suspension. BTU-packed asphaltenes drop out of solution, forming the sludge that mucks up fuel storage tank bottoms, fuel lines, and fuel heater components. This process is further aggravated by a series of chemical chain reactions that occur when disparate fuels are commingled.

Standard laboratory analysis, and even onboard compatibility tests, can easily miss incompatibility problems. Initially, the reactions that develop sludge can take time, escaping early detection through standard fuel analysis. The situation may only get ugly in the days, and sometimes weeks, after bunkering.

Case in point: Recently we received a call from a tanker operator with a vessel in Le Havre. Two weeks before, the vessel had stemmed 200 mt of LSFO. Analysis conducted immediately after bunkering under ISO 8217 indicated no problems with the fuel, showing good compatibility and low total sediment potential.

Yet now the vessel was experiencing copious, unrelenting quantities of sludge that thoroughly incapacitated the purifiers. We rushed a drum of PRI-RS HFO treatment chemistry to the ship from our Rotterdam warehouse. The chief engineer gradually blended PRI-RS as the tank re-circulated. Within a few hours, the sludge cleared and the purifiers were back on line. The vessel made schedule and all of the LSFO was successfully consumed with no operational problems

Without PRI-RS treatment, this vessel faced de-bunkering and costly delay. The money saved was far greater than the minimal investment in PRI-RS.

Unlike conventional fuel oil treatments, PRI-RS is formulated to not only dissolve the sludge, but also to reverse the chemical reactions that cause the process to occur in the first place. It is a tricky business. The chemistry of heavy fuel varies greatly – depending on the feed stock source, the cutter stock, and the refining method. PRI-RS provides for all contingencies.

Cutter stocks with high aromatic content, like light cycle oil (LCO) or petroleum naptha, are far less prone to produce incompatibility problems. But there is a potentially disastrous flip side.

These types of cutter stocks typically have very poor ignition quality, often so degraded that some engines simply refuse to start on LSFO fuels blended with LCO.

A major contributing factor is the poor thermal stability of LCO. With degraded thermal stability, fuels will always produce a great amount of dense, unburnable petroleum coke in the second combustion stage. Most of this material - very high carbon weight molecular structures - stubbornly refuses to ignite.

While newer two stroke engines are a bit more forgiving of poor ignition quality, they nonetheless will suffer fouling and premature wear. For older two strokes, and all four-stroke engines, the consequences can be especially severe, including the following:

- High exhaust gas temperatures and thermal stress on engine components
- Excessive carbon deposits - resulting in burned valves, and a high incidence of broken piston rings and increased liner wear.
- Reduced turbocharger and exhaust gas boiler efficiency owing to excessive soot fouling and increased back pressure,
- Shortened lubricating oil life
- Dramatic increases in visible particulate emissions (as smoke), particularly at reduced operating loads, and increased NOx emissions owing to elevated exhaust gas temperatures.

The irony of the last point is obvious. A fuel mandated to reduce emissions does, in many cases, increase them. After all, few legislators are chemists, fewer still, marine engineers. The good news is that PRI-RS chemistry has been well documented to reduce smoke opacity, as evidenced by long term usage and data from cruise ships in Alaska, where smoke opacity reductions with PRI-RS treated bunkers have averaged 45 percent since Alaska state readings began in 2000.

Man B&W has already conducted some studies on the combustion characteristics of LSFO made with various cutter stock blends. The findings reveal increased cases of poor liner and piston ring conditions, damage to the combustion chamber, and difficult operation in four stroke engines.

In one costly case, the manufacturer concluded, the cause of catastrophic damage was probably the result of “blending components, causing incomplete combustion, deposits and, eventually, engine failure”

Dr. Rudy Kassinger, a D.N.V. Petroleum Services consultant, suggests that blending with cutter stock to meet the 1.5% low sulfur specification will be, by far, the greatest challenge vessel owners face with these fuels.

Such has already been the case for Ro-Ro operator Wallenius Wilhelmsen, which has suffered ignition quality problems with some LSFO stems since initiating a low-sulfur fuel oil policy in 2005 as part of its proactive environmental strategy.

“Blending is what we consider the main problem,” says Lena Blomqvist, the company’s vice president of environment. She is frustrated by the fact that while the 1.5% fuel meets ISO 8217 specifications, it has proven unusable in some cases.

Fortunately, our PRI research team has made innovative chemical discoveries that positively affect combustion chemistry through highly specialized fuel additives. When properly applied, these components minimize issues with ignition delay, as well as those associated with excessive sludge precipitation.

This PRI approach differs greatly from that of most fuel additive manufacturers, a majority of which lace a basic sludge dispersant product with the iron salts of ferrocene. It is a cheap way to go, but too often inexpensive treatments can omit chemical components that are critical in affording maximum protection to marine diesel engines.

Ferrocene, for example, can help burn off carbon residue in some engines. But it has drawbacks. Ferrocene is ash producing, making engine manufacturers wary. Effectiveness is spotty, seemingly dependent on engine type. Many of our clients once used these chemicals. Today, they have upgraded to PRI-RS.

Early on, we eschewed the “combustion catalyst” approach, taking a fresh look at the chemistry of fuel behavior in combustion. We recognized that ignition quality is highly dependent on the thermal stability of the fuel. Our solution was development of a particular combination of complex compounds that block the chemical process that creates dense carbon mass in combustion in the first place. Hence, PRI-RS directly addresses poor thermal stability.

By elevating thermal stability, PRI-RS enhances ignition quality. Post-combustion residue is greatly reduced. Engine components remain clean and free of thick, abrasive deposits, exhibiting impressively low wear rates. Turbocharger efficiency is optimized, and with soot-free exhaust gas boilers, backpressure is reduced. Aside from being a safer approach to fuel treatment, it is also much more effective.

Applicable under all operating conditions with RME 180, RMG 380 and LSFO fuels, among others, PRI-RS has proven exceptionally beneficial for vessels that operate for extended periods at reduced loads – such as tankers and cruise ships. The results are remarkably

consistent, ship after ship, year after year. Effectiveness is not dependent on engine make or model.

A final major area of concern for LSFO is the sometimes very poor lubrication value of the fuel. We at Power Research Inc. have a long and successful history of addressing this problem.

Our experience with reduced fuel lubricity dates back to the early 1990s when low sulfur distillates began causing fuel pump failures with on-road diesel vehicles in California where low sulfur diesel was first introduced. This quickly prompted our development of highly effective lubricity additive packages, the latest generation of which is specifically formulated for LSFO and included as an essential component of PRI-RS.

PRI-RS performance is well established, buttressed by a wealth of shipboard records, independent laboratory testing, including sludge and ignition quality tests, stationery engine evaluations, and emissions testing conducted under industry-accepted protocols in a wide range of venues, including large oil-fired power plants and two and four stroke marine diesel engines.

LSFO is here to stay, with all of the attendant problems of high cost and operational challenges. Problems with some stems will be exceedingly costly for those unwilling to take preventative measures. Considering that it takes but one very expensive instance of problematic fuel to dwarf the investment in a regular fuel treatment program, we invite all vessel owners with concerns to call us and set up a consultation regarding fuel quality issues – whether LSFO, or conventional HFO.

Your call costs little, and the consultation is free. It may just be the best return on investment that you make this year.

In USA:

Power Research Inc.
6970 Portwest Drive, Suite 180
Houston, Texas 77024
Office: 713.490.1100
E-mail: rel@priproducts.com
Internet: www.priproducts.com

In Europe:

Power Research Inc.
Florence, Italy
+39 333.1899.361

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