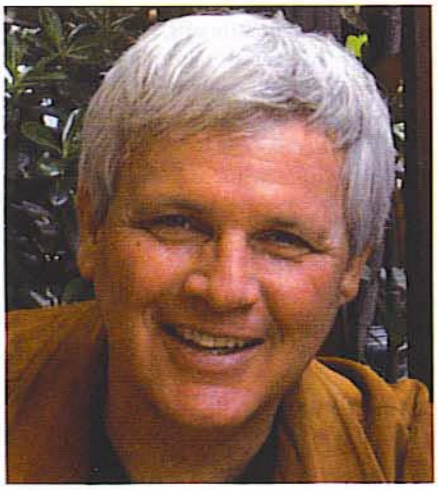
Beyond ISO 8217

Ralph E. Lewis looks at how shipowners can overcome fuel quality problems that are not currently addressed by the ISO 8217 specification



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In recent months, vessel owners have been challenged by an increasing number of nagging realities associated with bunker fuel quality. Although problematic, fuels producing these headaches are well within the limits set under the *ISO 8217* specification. When judged against that standard, these fuels should theoretically not be troublesome in the least.

Serious problems can and do often occur with fuels that meet ISO 8217 standards. Included among them are issues with vanadium, catalytic fines and fuel stability.

In this article, we will closely examine these troubling issues, how they manifest, and how to remedy these seemingly incurable fuel ills.

Firstly, let's look at vanadium. ISO 8217 calls for a 300 parts per million (ppm) limit in the RMG 380 specification. Doubtless many chief engineers would consider an RMG 380 fuel with a vanadium content of 65 ppm nothing to worry about.

Yet vanadium, named after the Norse goddess of beauty, Vanadis, can still have ugly consequences, even at reduced levels. When combined with sodium and sulphur during combustion, vanadium complexes into low melting point materials that generate significant rates of high temperature corrosion – a murderous condition that can quickly destroy exhaust valves, turbocharger blades, and piston crowns.

The classic rule of thumb among motor ship operators is that when vanadium and sodium coexist in a fuel at a respective ratio of 3:1, the likelihood of formation of these deposits is greatly increased. But there is more to the story.

A review of fuel analysis reports from certain vessels that have experienced vanadium-related damages, primarily burned exhaust valves, reveals vanadium/sodium ratios as high as 8:1. Further investigation suggests even higher ratios can be problematic.

General Electric, for example, warns that at a vanadium/sodium ratio of 10:1, problems can be expected. In one service bulletin, engine maker **Wärtsilä** suggests that 'even if the vanadium content of the fuel is moderate, hot corrosion may exist when both the sodium and sulphur contents are high enough'. And in the classic Babcock and Wilcox book, *Steam - Its Generation and Use*, 6:1 is cited as the most hazard-fraught ratio – a number based on extensive research.

So it seems that a ratio range of 3:1 to 10:1 can be highly problematic, even when vanadium content is quite low.

This is a fact not lost on operators of oil-fired power generation facilities in the United States. These massive 500-1000 megawatt (mw) units typically fire on low sulphur heavy fuel oil (HFO) blends with vanadium content in a low 25-50 ppm range. Fireside and super heater tubes often become thickly encrusted with corrosive vanadate slag. The units must be opened and extensively cleaned on an annual basis. For these operators, it is not about the quantity of vanadium in the fuel, but about the vanadium/sodium ratio.

Marine vessel operators should likewise be cautious when the vanadium content of bunker fuel is much less than the ISO 8217 limit. Recently, a vessel operating in the Far East experienced repeated, premature exhaust valve failures on its two Sulzer 16ZAV40S four-stroke engines. Upon review of fuel analysis reports, it was discovered that while average vanadium content was only 63 ppm, the vanadium/sodium ratio was 3.4:1, resulting in destructive high temperature corrosion.

Fortunately, the problem is solvable. At oil-fired power plants, specialty fuel additives composed of magnesium oxide or magnesium hydroxide are applied to fuel injection lines. These additives arrest the chemical process which complexes vanadium, sodium and sulphur during combustion.

Yet additives designed for power plants are too often unwieldy for vessel operators. The effective dose rates require too large an amount of this type of magnesium-based treatment to be injected, and storage space aboard vessels is limited. Marine engine manufacturers are also wary of products that introduce increased ash to the engines. Wärtsilä policy states: 'If the additive contains ash (e.g. magnesium, iron, etc), we usually do not recommend it.'

One fuel treatment that has passed the 'no objection' scrutiny of Wärtsilä is *PRI-RS* heavy fuel oil treatment, manufactured by **Power Research Inc.** This chemistry has proved to be impressively effective in preventing the high temperature corrosion issues associated with poor vanadium/sodium ratios in both marine diesel engines and at power plants. Additionally, PRI-RS also significantly reduces particulate and unburned hydrocarbon emissions, verified under the *MARPOL Annex VI* protocol in testing by the engine maker **Man B&W** at the company's Holeby, Denmark engine emissions certification facility.

The second area of increasing concern is that of catalytic fines content in fuel. Rudy Kassinger, **DNV Petroleum Services'** (**DNVPS**) senior technical consultant, reports that catalytic fines content has increased more than 20% in bunkers since 2005. The average level of 23.5 milligrammes per kilogramme (mg/kg) for samples received by DVNPS in 2008 is still well below the ISO 8217 limit of 80 mg/kg. Yet as refiners continue to seek greater profitability with the introduction of more efficient catalytic cracking units, the trend of increasing catalytic fines in bunker fuel is expected to continue at a quickening pace.

For refiners, these catalysts are money in the bank, the key to extracting the more profitable lighter fractions from a barrel of crude. Typically composed of certain ratios of aluminium and silicon oxides, the catalyst mixture is fed from a regenerator into a reactor unit during the refining process. In the reactor unit, the feedstock first vaporises, and hydrocarbons are then split into lighter fractions from the catalytic reaction.

As the process continues, back and forth from the regenerator to the reactor, the catalyst material gradually begins to wear out. Some of the catalyst residue gets carried into the next process vessel – the fractionator. Like a distillation tower, fractionators extract lighter hydrocarbon gasoline off the top, mid-range light cycle oils from the middle, and slurry oils from the bottom.

Of course, the tired catalytic residue that sloughs off in the fractionator migrates to the bottom to be commingled with the slurry oil. This is not good news for vessel operators. Slurry oil is often used

Poor fuel stability and incompatibility issues can quickly disable shipboard purification systems.

Both heavy fuels and marine gasoils will deteriorate in long-term storage. Pictured is a sludge-plugged fuel filter taken from a diesel standby generator – the result of fuel gone bad.

PRI-D diesel fuel treatment restored 1.8 million gallons of severely deteriorated fuel to freshness at a frame turbine facility, saving the Tennessee Valley Authority millions of dollars in fuel replacement costs.

Like heavy fuel oil, marine gasoil will deteriorate in long term storage, losing ignition quality. The sample of MGO pictured here has already begun to stratify.

Vessel operators operating on fuels with high catalytic fines risk engine component damage such as the cylinder liner scuffing shown here.

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as a cutter stock in bunker fuel blending. After all, the thinking goes, why waste a good, high quality and profitable distillate fuel as a cutter stock when an inexpensive by-product will do?

This also begs the question as to just how much aluminium and silicon can any marine diesel engine tolerate? It is a bit like asking the question, at what daily dose rate can the human body tolerate arsenic before the expiration process begins?

The general consensus is that modern marine diesel engines can accept catalytic fines, post purifier, at levels below 15 ppm without serious harm to engine components. This is assuming, of course, that a shipboard purification system has the capability to reduce the catalytic fines to this level from a potential maximum of 80 ppm – an 81% reduction.

This seems to be asking a lot. And for some vessels, it is a challenging request. With increasing frequency, fuels with catalytic fines well within the limits of ISO 8217 are proving devastating to propulsion systems of many vessels, resulting in disabled fuel pumps, broken piston rings, cylinder lining scuffing and cracking.

Of course, optimum purification begins with an appropriate system design. Historically, design parameters have been predicated on fuel consumption volumes to determine the correct purifier size. This information is designated in capacity tables developed by centrifuge and engine manufacturers which specify the maximum continuous rating (MCR) of any given centrifuge. Yet with continued problems regarding catalytic fine purification, some think these tables may be a bit too optimistic.

An updated approach is the certified flow rate (CFR) standard for appropriate separation performance. This standard is based on a test method designed by the centrifuge manufacturer **Alfa Laval**. In this test, five micron plastic particles are placed in synthetic oil and the mixture is heated to viscosities simulating that of bunker fuels. The particle-laced oil is then run through the centrifuge at various flow rates. By this method, the proper flow rate of a centrifuge can be determined by measuring the extent to which these particles are removed.

> **'Slurry oil is often used as a cutter stock in bunker fuel blending. After all, the thinking goes, why waste a good, high quality and profitable distillate fuel as a cutter stock when an inexpensive by-product will do?'**

Particle sizes of aluminium and silicon can vary from being submicron to several microns in size. Yet it is generally assumed that, on average, particle size in most bunker fuels will fall within a size range that can be properly managed by the system.

This new standard and improved centrifuge designs are expected to help in years to come. Yet even for new vessels with the latest systems, and older vessels with systems designed under earlier standards, the proper maintenance of fuel purification systems is of paramount importance.

Correct fuel flow rates and fuel temperatures to the centrifuges must be routinely observed and maintained by vessel engineering staff. Purifier bowls must be regularly cleaned. Settling tanks should also be regularly drained to rid tank bottoms of the heavy particulate concentrations that accrue in time.

Regular draining is especially important. Rough sea conditions can stir up bottom sediments rich in aluminium and silicon – sometimes as much as 500 ppm and more. Suddenly, the suction line can pick up the abrasive mess and send it off to a centrifuge for mission impossible. There is nothing more stressful to a chief engineer than watching a main propulsion system grind to a gritty halt in rough sea conditions.

Another critical area affecting purifier efficiency is fuel stability – the third major issue. While all heavy fuels produce sludge, those of poor stability produce more. And the more sludge a fuel produces, the less efficient is a centrifuge in separating catalytic fines.

Today's heavy fuels have especially challenging stability issues. The hydroscopic components of these fuels tend to absorb more water and produce greater amounts of sludge. The cutter stock with which these fuels are blended to meet viscosity and density requirements under ISO 8217 also plays a critical role in the tendency of the fuel to maintain physical stability (see my previous article, entitled *Loss Recovery*, on page 38 of *Bunkerspot*, April/May 2008).

The unassailable fact remains that almost any cutter stock will disrupt the surface tension between the heavier asphaltenes and the mid-range maltene components. This results in fuel sludge precipitation. In the worst cases, a cutter stock conjoined with an eccentric residuum will set up a devastating compatibility conflict: a condition that can occur slowly at first, but which progressively accelerates over time.

When this unhappy mixture erupts, the heavy amount of asphaltenic material released can completely disable the capability of even the heartiest purifier, no matter how well maintained.

Conventional Total Sediment Potential (TSP) testing under ISO 8217 is useful for identifying a fuel that has already experienced excessive sludge generation. But the test can easily miss the onset of a severe compatibility problem. The fuel may test well within specification the day the laboratory receives and evaluates the sample, yet the test method remains incapable of predicting fuel stability for the days and weeks ahead.

More than a few vessels have been temporarily disabled from sludge-laden purifiers, even though the fuel passed muster under the TSP standard under ISO 8217 just days before. Sludge producing fuel incompatibility problems can become quite aggressive in just a few days time.

Even with a moderately stable fuel, sludge generation and removal can be quite costly. Fuel sludge not only results in increased wear on fuel systems, it can also interfere with proper fuel atomisation, negatively affecting fuel efficiency. Sludge contributes to reductions in purifier efficiency, and when it is disposed, either through incineration on board or offloaded on a slops barge, fuel value inherent in the energy-rich asphaltenes is simply thrown away.

Again, there is a profitable remedy, which provides substantial payback for vessel operators. Power Research Inc. manufactures fuel treatment chemistries that significantly reduce fuel sludge generation, based both on shipboard studies and independent, third-party laboratory tests.

In a 2009 study of three European cruise ships, for example, sludge reductions with the PRI-RS chemistry ranged from 35% to 69%. Net return on investment (ROI), based on recovered fuel value and reduced sludge discharging costs, achieved an impressive monthly savings of $10,000 to $17,100 per vessel – or an annual average savings of $162,000 per vessel. For vessels presently trading, this is a nice number to have on the plus side of a balance sheet.

But what of the vessels that are temporarily being laid-up because of the slowing market conditions in some sectors?

When markets pick up in a few months and the ships are returned to service, some chief engineers can expect a rude awakening. This is because heavy fuel oils deteriorate over time. Sludge precipitation is, after all, progressive. The lighter hydrocarbons in the fuel slowly oxidise, losing ignition quality. Cutter stock used for blending can separate from the heavier components, resulting in fuel stratification. When a vessel is placed back into service after a long lay-up period, the quality of the fuel in its tanks is rarely the same as when it was freshly bunkered months before.

Fortunately, the same physical and thermal stability chemistries of PRI-RS that improve combustion characteristics and reduce sludge serve to maintain peak fuel freshness during long storage periods. When properly blended with PRI-RS, a heavy fuel will retain the same good ignition quality characteristics it had the day it was bunkered. Sludge precipitation is greatly reduced. Stratification is prevented. Purifier efficiency is maintained and even enhanced for protection against catalytic fines and other contaminants.

PRI-RS even restores severely degraded heavy fuels to a refinery fresh condition. In a recent case, this restorative capability saved the vessel operator an estimated $195,000 in fuel de-bunkering and replacement costs, all for a mere $900 investment in PRI-RS.

This high level of protection of PRI chemistry is also available for marine gasoil (MGO). *PRI-D*, a stabiliser for middle distillate fuels, is a staple for operators of emergency stand-by power generation units throughout the United States to preserve and enhance fuel quality in long term storage. Included among them are emergency service providers, nuclear power plants, electronic data storage facilities, office buildings, cell phone tower sites, federal government fuel storage facilities, among many others.

Like PRI-RS, PRI-D is proven to maintain fuel integrity in long-term storage through industry standard fuel stability testing. PRI-D can also restore severely degraded fuels to refinery freshness.

With PRI-D, the fuel cost savings can also be immense. The **Tennessee Valley Authority (TVA)**, for example, discovered 1.8 million gallons of deteriorated diesel fuel at a frame turbine power generation facility in Memphis, Tennessee. A standard stability pad test rated the fuel at 17 on a scale of 1-to-20, the higher number being the worst. Pad rating specification for the turbine units was 3, so burning the fuel was out of the question.

A sample of the unusable fuel was sent to company headquarters for testing. In repeated stability tests, PRI-D restored the fuel from a pad rating of 17 to a pad rating of 3, thereby meeting the company standard. The 1.8 million gallons of unusable fuel was treated, saving TVA an estimated $2.7 million in fuel replacement costs. The frame turbine units were soon operating on the PRI-D treated fuel problem-free, and for a fraction of the cost of fuel replacement.

Indeed, vessel operators are cautioned to read between the lines of ISO 8217. There is more than meets the eye. And we encourage owners to adopt proven technological approaches that positively alter heavy fuel oil behaviour both in storage and combustion. As discussed here in a few examples, the payback is substantial.

'Once we accept our limits, we go beyond them,' Einstein said. Today's successful vessel operators, we believe, are those who look beyond the limits of today's fuel standards.

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