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Low Sulfur Marine Fuels: Refinery Incentive or Risk?

The International Maritime Organization's (IMO) International Convention for the Prevention of Pollution from Ships (MARPOL) developed international regulations for the Prevention of Air Pollution from Ships (Annex VI). These regulations seek to minimize airborne emissions from ships: sulfur oxides (SOx), nitrous oxides (NOx), ozone depleting substances (ODSS) and volatile organic compounds (VOC).

Regarding sulfur emissions, the IMO announced this past October that it was going ahead with a global sulfur cap of 0.5% on marine fuels starting from January 1, 2020 for ships operating outside emissions control areas (ECA) in open waters. The current level, effective in January 2012, is 3.5%. For ships operating within an ECA, the sulfur limit has been 0.1% since January 2015. Instead of meeting these fuel restrictions, shippers can also consider on-board scrubbers or the use of other fuels to reduce sulfur emissions.

In addition to shipping lines, the IMO's decision will also impact refiners, crude producers, and bunker fuel suppliers. This article discusses some important issues affecting refiners with regards to producing a low sulfur marine bunker fuel.

SUMMARY

- There is very little incentive and interest for refiners to desulfurize residual fuel oil, if it can be done at all. Residual fuel oil is the only product whose current value is less than the crude source price.

- Past trends show that thermal upgrading of resid was overwhelmingly the choice over hydrotreating. That's because hydrotreating processes are way more expensive to build and operate than thermal treating processes. To meet future marine fuel sulfur specifications, refiners will most likely use thermal processes to upgrade the resid rather than hydrotreating to desulfurize, if they do anything at all. This would produce higher value gas oils and distillates which could be desulfurized, if need be, at a much lower cost than resids. This would require the marine carriers to switch to a gas oil / distillate fuel from a residual fuel oil.

- There is a good possibility that the low sulfur marine fuel would not contain any resid at all. Ship engine and infrastructure cost increases would be incurred as well as higher fuel prices for the lower sulfur fuel. In addition, many doubt that the refining industry can produce enough low sulfur marine gas oil to meet requirements. For example, it has been estimated that for just the US/Canada ECA, if high sulfur marine fuel oil were replaced by low sulfur marine distillate, that would virtually double the world's current demand for ECA-quality marine-based diesel fuel.

- According to Platts, estimates of the cost differential for 0.5% marine fuel versus 3.5% marine fuel is upwards of $30/metric ton. However, over the last five years, the premium of marine gas oil (0.1 %w S) over 380 CST 3.5% bunker fuel in Rotterdam has averaged $270/mt. These higher costs may make installation of scrubbers on ships very attractive. Scrubbers are already being built to meet current ECA requirements. Potential mass implementation of scrubbers adds to the risk for refiners to produce low sulfur marine fuel.

- The cost of crude oil is another unknown risk. As crude oil prices increase, the differential between a low sulfur marine distillate and the current high sulfur marine fuel oil increases. Again, this makes the installation of scrubbers attractive to ship owners.

- The IMO regulations are international regulations—not national ones. Before passage of these requirements, both the USA and China had different sulfur requirements within their respective areas. There is talk that China will push ahead with their own sulfur regulations. Also, it is unknow whether the current administration in the USA will abide by these international rules or implement modified ones.

- The study upon which the IMO based its decision to lower the fuel sulfur content is being criticized both on technical and economic issues. For example, their study assumed existing refinery sulfur plant capacity is adequate for handling the extra sulfur taken out of the fuel. That is potentially a severe oversight since many refineries are at their sulfur limits. A study by Ensys and Navigistics show that refinery sulfur plant capacity needs to be increased by as much as 75% over currently planned projects by 2020 to meet the requirements (Ref. 1). If sulfur processing capacity is not available, will the regulations be relaxed?

DETAILS

A variety of fuels are available for marine engines. A set of four marine distillate fuels (mostly No. 2 and No. 4 diesel) contain small amounts of resid. These are currently used in small, Category 1 marine engines (< 5 liters per cylinder). There is also a set of 15 marine residual fuels in which resid is the majority constituent. Residual fuel is most common for large commercial transport ships and is a combination of residual fuel oil mixed with various heavy gas oils and distillates. However, to meet current, existing regulations for 0.1% sulfur within ECAs, the marine fuel is composed exclusively of distillates which are already low in sulfur. When switching to this type of fuel within ECAs, the larger marine engines have had significant operating issues. To meet the new 0.5% regulation on open waters, the resid content would have to be significantly reduced or the resid would have to be desulfurized. Since desulfurization of resid is extremely expensive, most likely, the resid content of the marine fuel would have to be significantly reduced in favor of more distillate fuel. In fact, it may need to be 100% distillate. But can the refining industry produce enough diesel to satisfy the demand? Do they want to?

In the past, resid from the refinery Vacuum Unit might have been used as a low value, high-sulfur fuel oil for marine fuel. However, to obtain as much high value product as possible from every barrel of crude, refiners have been processing this resid to lighter products. As a result, refineries have resorted to thermal, carbon extraction processes or to processes that add hydrogen. EIA data shows that the yield of residual fuel oil from US refineries has decreased from about 6% in 1994 to about 2.5% in 2016. Since hydrotreating of resids requires extremely high pressures and very large amounts of hydrogen, adding hydrogen to the resid is an extremely expensive proposition. As a result, based on published numbers, the worldwide distribution of resid processing capacity shows about 78% of that capacity to be carbon rejection based: Cokers, Visbreakers, Deasphalting. Most of these processes have already been installed.

For the USA, the advantage for carbon rejection is even more pronounced. According to EIA data, as of January 1, 2016:

- Resid hydrocracking was practiced by only two refineries at a combined rate of only 127,000 BPD.
- But Resid thermal carbon rejection capacity was about 3,210,800 BPD, with 87% being Delayed Coking.

Very few US refineries desulfurize resid. In fact, according to EIA data, only four refineries do so with a combined capacity of only 246,000 BPD, and 45% of that capacity is from only one refinery. If one were to invest hundreds of millions of dollars, it would be to upgrade the resid to more valuable, lighter products - not to make low sulfur resid, unless the refinery had guaranteed, long term, marine fuel contracts. If a refiner wanted to make marine fuel to meet the new regulations, they would most likely install a thermal carbon rejection technology to upgrade resid or revamp a current process to increase throughput. However, economic, technical and political risks are all barriers which need to be considered.

Going from a residual heavy fuel oil marine product meeting the current 3.50% sulfur limit to a 0.50% limit is a change on an unprecedented scale for the refinery industry. There are serious concerns whether there will be enough distillate product to meet marine fuel demand. Most estimates show that the industry has to replace almost 250 million metric tons of high sulfur marine fuel with a fuel that meets the 0.5% maximum sulfur specification. However, currently, refiners are not prepared to make the capital investments required to upgrade refineries to produce more middle distillates. Also, if the investments are made, the resulting cost of the lower sulfur fuel for ship owners may skyrocket. Installation of scrubbers on the ships may become more viable.

Another unknown issue is the price of crude oil. The lower the price, the lower the cost differential between low sulfur marine distillate and high sulfur marine fuel oil. This lower differential acts as a disincentive to refiners who might be contemplating the expensive upgrades needed to produce more distillate. But as the differential rises, so does the cost to ship owners with scrubbers, again, becoming more attractive.

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