



Transition Solutions for 2020

2020 Position Paper

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Gulf Oil Marine 2020 Position Paper

The 2016 IMO decision to implement a 0.50% global Sulphur cap introduced a broad set of far reaching impacts on the shipping industry and on shipping related operations. The challenges for ship operators in preparing their vessels to meet the new legislation is profound and a much more complex and costly development compared to the earlier geographic ECA Zone implementations which first came into effect y in the Baltic Sea in 2006 .

What will now effectively be a global ECA, exponentially multiplies the complexities that need to be faced and resolved by the industry. As a marine lubricant manufacturer Gulf Oil Marine also faces the challenges of providing a new generation of products to meet the new environment.

Over the course of coming months Gulf Oil Marine will be hosting a number of transition seminars around the world under the heading of “Gulf Clean ACT 2020” .The seminars are aimed at helping both ourselves and our customers to be in the best possible state of preparedness for Jan 1st 2020.

These venues will be hosted by our own technical and marketing staff as well as being supported by subject experts on Fuels, exhaust gas treatments (EGCS) and additionally the view of a major OEM. A key highlight of these seminars is an introduction to Gulf Oil Marine’s unique software based solution to document a ship specific implementation plan and a lubricant transition plan.

1. Compliance Options and Challenges

Compliance can be achieved in several ways

- The use of MGO is the obvious option as it is a methodology already understood, with operational experience gained in ECAs and is a fuel widely available. However there could be a significant increase in fuel costs and may require some fuel treatment equipment modifications.
- The use of exhaust gas cleaning technology, normally referred to as Scrubbers. These investments allow the continued use of HSFO but require a significant capital outlay, particularly when introduced as a retrofit. However the investment may have a relatively short pay-back period depending on the price differential between HSFO and MGO/VLSFO (and the alternative fuels). Within this option there are sub-options as to which type of scrubber should be chosen – wet, dry or hybrid. There are the out-of-service costs to be considered as well as the availability of facilities to carry out the installation work in the required timeframe. The availability of HSFO itself may be an issue if local supply chains (bunker suppliers) choose to only supply low Sulphur fuels. Although it is very unlikely refineries will all stop producing HSFO there are nevertheless some investments underway to convert HSFO to other products. One such process is the use of coking. Barging will be an issue, as once cleaned for 0.5% fuel deliveries, barge operators will be reluctant to carry “dirty” fuel

which will require complete tank cleaning. Securing fuel supply and distribution will be a key issue in adopting the scrubber option.

- Very Low Sulphur Fuel Oil (VLSFO) will be a new fuel option as refineries produce new fuels to meet the 0.50% Sulphur specification. As fuel de-sulphurisation is expensive and low Sulphur crude oils are both in short supply and expensive, most refineries will try to blend the VLSFO from the variety of components available in their process stream. This will lead to issues about fuel stability and compatibility and thus the requirement for onboard segregation of different batches of bunker fuel. As more than one type of fuel will be required there will be a need to restructure the onboard fuel tanks and associated systems.
- LNG (Liquefied Natural Gas) is seen as an excellent fuel which meets a variety of emissions regulations however its use will require specialist operating procedures, large storage tanks (potentially eating into valuable cargo space) and specially trained crew. Currently the LNG supply infrastructure is not well established therefore only certain trade routes might offer the benefit of this fuel as a compliance option. The costs of retrofitting an LNG system means that it is expected that most LNG fueled ships will be new build vessels.

With the exception of a scrubber option, all other paths to compliance will require some changes in lubrication requirements and related operational processes.

2. Fuel Compliance Option

Although there is experience in dealing with fuel Sulphur reductions required by the Emission Control Areas (ECAs) and other similar emissions directives the move to 0.50% is a far more significant change and will require detailed forward planning in making the transition.

Optimal planning will not look at a collective fleet. The most effective transition plan will be a series of unique and individual plans for each ship in the respective fleet. This ship level planning will factor in the ship type, age, equipment, trading routes and fuel availability.

2.1 Key operational challenge of the fuel compliance option-Tank Cleaning

Unless a ship is fitted with a scrubber there will be a need to ensure that the fuel tanks and fuel system do not contain any high Sulphur fuel by the IMO deadline. The complete fuel system will have to be running on 0.50% fuel to meet compliance – compliance testing may well be samples taken from the engine fuel rail. As the VLSFO fuels are likely to be blended to the upper limit of the Sulphur cap value the slightest contamination by any remaining HSFO will mean non-compliance. There are already cases of vessels failing to meet the EU emissions directive due to this form of contamination and suffering both detention and heavy fines.

Tank cleaning will have to be included in the ship's transition plan and the exact cleaning procedure will vary on the individual ship transition plan depending each vessel's configuration, chartering schedule and dry-docking schedule. The use of distillate fuel to flush out the system during normal operation may be one option, although even with this option there may be the requirement for manual cleaning and the use of additional chemical cleaners. In addition the ship's fuel treatment system will need to be operating very effectively to remove the potentially engine damaging levels of cat fines and other debris released during the cleaning process. The storage and disposal of this extra sludge and waste oil generated will need to be evaluated and recorded in the overall plan.

2.2 Lubricant requirements for MGO fuel compliance option

The current Gulf ECA cylinder oil is perfectly suited and optimised for operations using MGO. TPEOs also follow suit and the current range of Gulf low BN TPEOs are well suited for MGO operations.

2.3 Lubricant requirements for VLSFO fuel compliance option

Gulf Oil Marine is the final testing phase of a series of new cylinder oil lubricants formulated specifically to manage the unique demands placed on engines running 0.50% VLSFO. These new Cylinder oils feature enhanced cleanliness, better lubrication and compatibility across full blends, rather than simply meeting a specific BN level. The field trials were conducted in close cooperation with the major engine OEMs, and on vessels already using 0.50% Sulphur fuel. The oils being formulated for VLSFO were created from new additive technologies and optimized at the appropriate BN level rather than diluted versions of existing high BN lubricants to achieve high performance.

TPEOs will mirror the philosophy of main engine cylinder oils in that BN levels will reduce and new optimized formulations will be introduced to satisfy the demands of the new VLSFO fuels coming onto the market. Again cleanliness, lubricity and fuel compatibility will be the drivers in creating these products.

3. Exhaust Gas Cleaning Systems (EGCS) Compliance Option

MARPOL Annex VI allows for equivalent means of compliance if approved by the vessel's Flag State (FS) and notified by the FS to the "Organisation" (IMO) where the alternative means of compliance is recorded on the GISIS database. Exhaust Gas Cleaning Systems (EGCS) often known as "Wet Scrubbers" are one such equivalent means of compliance.

The physics and chemistry of an EGCS is complex but the operating principles are simple. The EGCS must thoroughly mix the exhaust gases containing SO₂ and SO₃ with a scrubbing medium which is normally sea water. The SO₂ & SO₃ are readily

soluble and will be captured by the water. The Sulphurous acid formed is neutralised by the alkalinity of the scrubber water to form sulphates. Sulphur ions are the third most common ion in sea water. In fact one cubic metre of sea water contains 20kg of Sulphur. Returning the neutralised SO₂ & SO₃ to sea water is benign.

EGCS have many advantages compared to using compliant fuels. The financial advantages will be dependent upon fuel price differentials but the technical advantages are very evident. These include lower CO₂ footprint (well to wake calculation including refinery CO₂ emissions) when compared to a low Sulphur fuel, so less global warming and less impact on ocean acidification; there are no worries about changing fuels, cleaning tanks, or even changing lubricating oils.

There are two methods of operation of an EGCS. The so called “Open Loop” takes in seawater and after washing the exhaust gases returns the seawater to the sea. The washing process does remove minor amounts of oil, soot, semi-burnt fuel and ash. IMO has set very tight guideline limits for the discharge of these materials. The second method of operation of EGCS is known as “Closed Loop”. In this method the washing water is dosed with an alkali such as caustic soda or magnesium oxide and the water is recirculated. The closed loop system requires significantly more equipment to be installed to cool the re-circulating water and to attempt to manage the build-up of reaction compounds as well as the concentrating of oil, soot, semi-burnt fuel and ash. The principle challenge is the conversion of the SO₂ and SO₃ to a neutralised compound, principally CaSO₄ commonly known as gypsum. The gypsum will eventually clog the system so the closed loop discharges the gypsum to sea. With the inherent weaknesses in the closed loop system virtually all orders are placed for open loop systems which do not have a track record of any measured harm. In one jurisdiction, it has been decided that open loop operation is not allowed within the ports and harbours but with some exceptions. That is not a real difficulty as in the very few cases where discharge is not be allowed the economic solution is to switch to a compliant fuel and then use the EGCS to reduce the emissions even further. This is already done with Exhaust Gas Recirculation (EGR) for Tier III NO_x compliance.

3.1 Lubricant requirements for EGCS compliance option

The current range of High and Ultra High BN cylinder oils are perfectly suited and optimised for EGCS operations using HFO. TPEOs also follow suit and the current range of TPEOs are well suited and optimised for HFO operations.

3.2 Cylinder Oil Blending Unit (COBU UNIT)

Gulf Oil Marine has run extensive proving trials on a MAN engine vessel and has received the OEM approval for a bespoke cylinder oil mixing unit.

Currently the only control of cylinder oil in a two stroke engine is through managing the cylinder oil feed rate. To change the cylinder oil Base Number (BN) the

ship must carry multiple grades of cylinder oil with different BNs. The ship must also switch the cylinder oil in the day tank, a tank which has a capacity for at least 2 days cylinder oil consumption. When ships enter an ECA they must normally change over the cylinder oil day tank to a lower BN ECA cylinder oil at least one day before arriving in the emission control area. Likewise, when leaving an ECA they need to change cylinder oils about 24 hours prior to exit of the ECA. Ships receive different fuels with varying levels of Sulphur. It is the control of the BN and not the cylinder oil feed rate that is most appropriate for optimising cylinder oil performance with changing fuel Sulphur content. GOM has developed a unit known as COBU (cylinder oil blending unit) that can blend an approved low and a high BN cylinder oil and produce a cost effective tailored BN cylinder oil adjusted to match the fuel Sulphur content. The Gulf Oil Marine COBU unit is fully automated and takes the place of the cylinder oil day tank. The amount of blended cylinder oil is around 30 litres. This means that the unit will blend a fresh batch of cylinder oil about every 1 to 3 hours. Using the COBU unit a ship entering an ECA can match the BN in the cylinder oil to the 0.10%S fuel within 2 to 3 hours and all at the touch of the tabs on a touch screen. Using a COBU unit simplifies BN changeover for ECAs, optimises performance and cost of cylinder when the BN is matched the fuel Sulphur content. The COBU unit also enables optimum cylinder liner and piston performance, especially avoiding deposits of excess alkalinity on the crown land which can disrupt liner oil film conditions as the piston passes down the liner.

4. Alternate Fuels compliance option

As alternative fuels are introduced then particular lubricants will have to be developed to suit. Other than LPG, where the suitable lubricants are already available, most of the alternative fuels are in the early stages of development and adoption. These fuels and the choice of pilot versus main fuel will demand a different style of lubricant which is not based on BN dependence but more on the lubricity and cleanliness aspects of lubrication. Gulf Oil Marine actively seeks discussions with ship operators considering the use of alternative fuels in order to understand the lubricant requirements of the various options before making a final recommendation.

5. Operation in ECA Zones

The requirement to use 0.10% Sulphur fuels in an ECA zone has not changed and ships will continue to change-over fuel prior to entering the ECA. Whether or not the ship changes over to lower BN cylinder oil or continues to use the same cylinder oil is dependent on the operating conditions of the ship. Many ships have built up experience on fuel change-overs over the years and have developed their own ways of managing this situation, particularly if the time spent in the ECA is relatively short.

For 4-stroke engines there will be no reason to change-over the lubricants in the same way that there was no change-over when entering an ECA.

However if a vessel is permanently operating within an ECA then the lubricants will have to be changed to a product more closely meeting the requirements of continual operation with the very low Sulphur fuels supplied within the ECA. Should a vessel's trading pattern change to include longer operating spells within the ECA then the operators should discuss the situation with Gulf Oil Marine to identify the most cost effective lubrication options.

For vessels fitted with scrubbers there are generally no reasons to change lubricants when entering an ECA however some parts in the world do have restrictions on the use of scrubbers within the 12 mile limit and also the type of scrubber fitted, so carrying a small quantity of 0.1% Sulphur fuel and the corresponding low BN cylinder lubricant may be a requirement to ensure compliance at all times.

6. Gulf Oil Marine's Product Slate

Gulf Oil Marine's range of engine lubricants has been designed to give the ship operator the widest choice of product to suit the operator's fleet regardless of the engine type, fuel type and sphere of operation. As part of an ongoing commitment to product development and in conjunction with the major engine OEMs, Gulf Oil Marine is conducting a range of field trials designed to meet the challenges of ever increasing environmental legislation and new engine technologies to produce a range of high performance, cost effective lubricants.

6.1 Lubricants for 2-Stroke Crosshead Diesel Engines

System Oil for all 2-S engines – GulfSea SuperBear 3006

| Type of Lubricant | Description | Product names |
|--|---|--|
| Cylinder Oils for 2-S Engines operating with Scrubber technology | A complete range of cylinder oils to suit the OEM requirements and various fuel Sulphur levels. | GulfSea Cylcare 50140; GulfSea Cylcare 50100; GulfSea Cylcare 5085; GulfSea Cylcare 5070; GulfSea Cylcare 5040 |
| Cylinder Oils for 2-S Engines operating on MGO | ECA Cylinder Oil suitable for operation on MGO. | GulfSea Cylcare ECA50 |

| Type of Lubricant | Description | Product names |
|---|--|------------------------|
| Cylinder Oils for 2-S Engines operating on 0.50% Sulphur fuel | An improved additive framework on our current cylinder oil, designed for optimum performance and protection with 0.50% Sulphur fuel. | GulfSea Cylcare 5040 |
| | ECA Cylinder Oil for use with 0.10% Sulphur Fuels to meet emissions compliance within the ECA. | GulfSea Cylcare ECA 50 |

6.2 Lubricants for 4-S Trunk Piston Engines

| Type of Lubricant | Description | Product names |
|--|--|---|
| TPEO Oils for 4-S Engines operating with Scrubber technology | The GulfSea Power range has a wide variety of viscosities and BN levels to suit the operating needs of all 4-S engines whether used for main propulsion or auxiliary power requirements. | GulfSea Power 3030; GulfSea Power 3040; GulfSea Power 3055; GulfSea Power 4030; GulfSea Power 4040; GulfSea Power 4055 |
| TPEO Oils for 4-S Engines operating on 0.50% Sulphur fuels | The GulfSea MDO Range which offers a wide range of viscosities at low BN levels to facilitate operation on the new 0.50% fuels. | GulfSea Power MDO 3015; GulfSea Power MDO 3020; GulfSea Power MDO 4015; GulfSea Power MDO 4020 |
| TPEO Oils for 4-S Engines operating on MGO | The GulfSea MDO Range which offers a wide range of viscosities at low BN levels to facilitate operation on MGO. | GulfSea Power MDO 3012; GulfSea Power MDO 4012 |

7. Test Ships and their role in the 2020 transition

Gulf Oil Marine operates a number of test ships at any one time. The test ships are selected based on the latest engine technology and severity of operation. New

lubricants are trialled in the test ships for between 4,000 and 6,000 hours in conjunction with the engine designer in order to get the lubricant recorded on the engine builder (OEM) list of lubricants. With the changes in two stroke engine design and the changes in fuel Sulphur legislations much of the recent development and trials has focused on cylinder oils. These lubricants must perform multiple functions as well as providing lubrication. Current focus on cylinder oil development is to improve detergency in a formulation with much lower alkalinity than previous cylinder oils designed for high Sulphur fuels. A test ship for cylinder oil trials requires extensive modifications including an additional cylinder oil day tank and a split cylinder oil delivery to the engine cylinder lubricator units. GOM test ships have additional advanced monitoring which is transmitted from the ship to shore. Measuring and streaming in real time every 10 seconds of the ships' speed, position, fuel mass flow, and fuel Sulphur to a data recorder for onward transmission every 30 minutes. Data can also be monitored in real time enabling the GOM test engineers to ascertain where in the world the ship is, what speed she is doing, the engine revolutions, fuel Sulphur content and fuel consumption. Lubricant sampling and periodic engine inspections form an integral part of the trial ship monitoring. The test ship program enables GOM to simulate and field test a broad spectrum of operational parameters which ensures optimal balance between product performance and consumption. This experience in combining big data, effective monitoring and inspections to balance performance and consumption will be extremely useful in 2020 where we will have to grapple with multiple fuels and operating parameters.

8. Transition Planning towards 2020 – Assess Confirm Transition (Clean ACT 2020)

8.1 Transition Planning for the fuel compliance option

Over 2019 the inventory of engine lubricants will have to be managed carefully such that the ship is not left with large quantities of the wrong lubricant. Volumes of unmatched Cylinder oil will have to be offloaded –incurring significant cost. Inventory management will need to start in early 2019 with the adoption of the compliant fuel in 3Q 2019.

Stocks of Engine cylinder oils and TPEOs suited for HFO operations should be run down to minimum quantities such that there is little or no mixing with the appropriate lubricant loaded to suit the new 0.50% VLSFO fuel or MGO if applicable. Gulf Oil Marine is actively assisting ship operators in the production of vessel transition plans by offering a unique software program to capture all relevant information, like key operational inputs on tank cleaning methodology and dates, to create an individual vessel specific transition plan. A predictive optimization algorithm LOCUS (Location Operation Call Update Supply) which has been our mainstay for the past three years for predicting and optimizing lubricant lifts is playing a special role in understanding trade patterns for individual vessels and planning a switch date and location. The algorithm has already generated a theoretical switch date and location for over 70,000 vessels and is learning and updating the switch date and location in real time as trade patterns change. The

individual vessel level transition plan will ensure that the vessel will meet compliance on time and provide timely delivery of the correct lubricants. This assistance with inventory management will minimize transition costs.

8.2 Transition Planning for the EGCS compliance option

Globally the inventories of high BN and Ultra High BN cylinder oil and TPEOs will significantly reduce. This will make the appropriate location of these inventories absolutely critical in the lead up to 2020 so that vessels using the EGCS option are adequately serviced. Gulf Oil Marine is actively working with vessel operators using EGCS to understand trade patterns to ensure adequate inventories are available.

8.3 Online Ship Specific Implementation Plan & Lubricant Transition Plan

Gulf Oil Marine has designed a simple software platform to assist ship operators to create a ship specific implementation plan. The platform follows the recent IMO guidelines and template released in October 2018. The implementation plan template covers key elements of fuel transition such as tank modification, cleaning, risks and procurement. Mirroring these guidelines Gulf Oil Marine has created a lubricant transition template and a Scrubber transition template to help our customers. Ship operators can now use this platform as a single window for documenting their individual vessel level transition plans irrespective of their compliance option.

We at Gulf Oil Marine are committed to work with you to understand your compliance option and ensure a smooth, hassle free and cost effective transition.

Assess - Confirm - Transition!!