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The Engine Users and the Implications of IMO Tier III Coming into Force

11 Users Aspects Maintenance & Monitoring - Marine Applications

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ABSTRACT

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The coming into force of the IMO TIER III requirements have brought many problems for the Engine Users with the conversion of engines to use new fuels plus the need for new lubricating oils to suit these new fuels. At the time of writing the operation of dual-fuel engines is not guaranteed 100%.

All of this represents changes and uncertainties for the Users when the turbocharging situation, especially on 4-S engines and blower failures on 2-S engines have not been fully resolved. In addition, the use of exhaust gas scrubbers, is not yet a certainty for many.

In the European Emission Control Area (ECA) only one case has been recorded so far where Exxon HDMA 50 fuel was mixed with HFO. That gave asphaltenes fall out and the storage tank had to be cleaned manually. With the HFO limited to only 4.0% (not a realistic figure on board ship) the storage tank still needed stripping. Therefore, in the long-term ship operators cannot live with different brands of fuel oil. There must be an ISO Standard which would ensure the mixability of new fuel grades.

Such an ISO Standard must be so that it can fixed within a charter party while quality control and international supply will be the same at every port. The RND 80 mix, according to the ISO Standard 8217, may be the future standard as proposed by many suppliers.

At the same time, there are quite a number of problems with large 4-S engines using Marine Gas Oil (MGO) when operating in ECA's. An example of this is that fuel leaks into the lube oil trunk at a rate of up to 1.5 tonne in 7 hours. Therefore, there is a distinct risk of bearing failures or fire in the lube trunk. The oil cooling system for the fuel injectors is also under investigation.

All of this means increased costs to the operator (the Engine User) at a time when all costs are rising and profits are often in decline.

INTRODUCTION

On behalf of the CIMAC working group 10 Engine Users. The coming into force of the IMO TIER III requirements 1.1.2016 at least in US ECA for new buildings focused on NOx reduction shall be discussed with its challenges from the view point of engine users, ships operator.

Beside the actual NOx discussion and the upcoming Tier III, the past year 2015 has already brought many challenges in regard of SOx-Reduction for the Engine Users.

CHALENGES 2015 (SOx)

The conversion of tank systems and to use new hybrid fuels plus the need for new lubricating oils to suit these new fuels with changed sulfur limits in the most ECA zones. All of this represents changes and uncertainties for the Users in engine and turbo charger operation. In addition, the use of exhaust gas scrubbers, is not yet a certainty for many. In the European ECA (Emission Control Area) cases have been recorded where Hybrid fuel was mixed with HFO. That gave asphaltenes fall out and the storage tank had to be cleaned manually. Tanks suctions blocked by wax fall out of distillates with new compositions in winter in not heat able tanks. Handling and separation of many different fuels without any mixing for safe operation is giving new burdens to the crew. There must be an ISO Standard which would ensure the mix ability of the new hybrid fuel grades. Such an ISO Standard must be fixed in charter party while quality control and international supply chain, to be the same at every port. The RND 80 mix, according to the ISO Standard 8217, may be the future standard of hybrid fuel as proposed by many suppliers under different brands today coming from different sources of refinery. At the same time, there are quite a number of problems with large 4-S engines using Marine Gas Oil (MGO) when operating in ECA's. An example of this is that fuel leaks into the lube oil trunk at a rate of up to 1.5 tons in 7 hours. Therefore, there is a distinct risk of bearing failures or fire in the lube trunk. The oil cooling system for the fuel injectors is also under investigation. All of this means increased costs to the operator (the Engine User) at a time when all costs are rising and profits are often in decline. 2-stroke engines stop at maneuvering with certain new distilled fuels and might bring the ship into trouble due to new required min. rpm set points.

TIER III CHALENGING FUELS

To fulfil the TIER III requirements in this chapter the view point of engine users shall be focused on. This means form one side the investment in the new technologies and the guidance to find the best solution but on the other hand the possibility to operate this kind of ships with TIER III technology must be given by additional crew training in regard of maintenance and monitoring systems.

To meet Tier III almost all engine licensor were following the motor side NOx reduction or after treatment system solutions. The worldwide implementation of the IMO TIER III approach failed and was only brought into force for US-ECA (USA-Emission Controlled Areas) for new buildings keel laid after 1.1.2016. Anyhow many international operating

ships need to comply with these new rules. But it is not so easy to realize the Tier III compliance. And to operate these kind of ships.

OPERATIONAL COSTS AND INVESTMENTS

Beside the operational challenges, consumables and maintenance costs, the investment of about 80-100 US$/kW per installed engine power is required for the TIER III after treatment systems of the main engine. Additional costs are required for auxiliary engine after treatment systems and crew training and maintenance. Boilers are available in Low-NOx design and can meet the requirements without after treatment and are not in the focus of legislation yet. Means for a Main Engine 6S60 ME-C 8.5 typical tanker engine the upgrade from Tier II to Tier III will cost, dependent of rating and the engine manufacturer about one million US$ installation cost of either a SCR (Selective Catalytic Reduction) of EGR system (Exhaust Gas Recirculation). These systems are not standardized or type approved yet and need to be tested on each shop test bead with higher costs. For the auxiliary engines the licensor have almost all sizes available in modular packages and probably soon type approved.

The NOx-After treatment solutions were clustered into EGR and SCR Systems with Urea Injection under low pressure or high pressure injection systems in very fine droplets to react in a ceramic catalytic reactor. Urea is a chemical substance which can be ordered in dry-powder and mixed with fresh water or ordered as pre-mixed liquid in tank cubitainer.

Urea follows the stock exchange and is listed for example [1]. The past 12 months urea has been very volatile and has changed from 492 US$/mt to 192 US$/mt against the trend of potential higher demand with TIER III into force. Urea follows about the fuel price of IFO 380 Rotterdam and is about 50% of this price. The market is still localized and need to be checked with certain suppliers in the related ports. Urea dosing is carried out with approx. 32,5% dilution at 180°C-200°C exhaust gas temperature in outmost fine droplets to convert the NOx to ammonia [2]. Ammonia NH_3 is both caustic and hazardous in its concentrated form and needs special care if the system is opened up. The needed consumption of urea is related to the engine power about 5 g/kWh [3]. For a 10MW plant at full power approx. 1,2 ton/day are required which cannot be neglected in regard of water demand for dilution and handling cost of urea. For the auxiliary engines on container ships the auxiliary power can be the same quantity as the main engine power due to reefer container power demand, which double up the urea quantity.

On some ships the urea consumption for main engine and auxiliary engine demand relatively high dilution water amount which cannot be produced on board. Additional shore water supply has to be bunkered, the fresh water evaporator capacity has to be increased or an expensive osmosis plant has to be installed additionally not to run into fresh water shortage.

For high urea demands on board a urea mixing plant and a storage tank need to be installed space wise and will increase the newbuilding cost.

It is also very important to control the injection quantity and quality of urea droplet size. An over dosing or lack of temperature control will lead to residues in the SCR such as solid or ammonium nitrate and/or ammonium sulphate deposits which have to be removed by crew or may block the SCR honeycomb. The urea injection and control of the SCR catalyst has to be done by a closed loop monitoring system, so called NOx detector. But NOx is just a headline, a mix of gases needs to be monitored: N20, 2NO, 2NO2 and by products are listed as NOx to be separated of the nitrogen N2 which is about 78 % of the atmosphere and also in small percentage in the fuel existent. This gives a difficult task to the analyser and the related crew to handle this analyser. To keep the exhaust gas analysers accurately running reference gases and re-calibration is frequently needed. The Oxygen content is mostly used as reference and its probe is very sensitive to humidity. The probe must be redundant and cannot be installed where water washing or nut shell washing of Turbo Chargers takes place, it severely effects the sampling of cold spots were condensate may effects the measurements at loading up the engine or slow steaming.

Nut shell cleaning of 2-stroke and 4 stroke turbo chargers and exhaust gas boilers are day to day business on board. The former water washing has been deleted due to corrosive wear and severe boiler failures and turbocharger bearing failures. This washing procedure will clock immediately the fine capillary of SCR catalytic reactor and provoke a need of new procedures.

At ports the boilers are cleaned by soot blowers or mechanical vibration brushes. This massive dust is collected in the syphon and may effect also the SCR performance. [12]

From time to time the SCR needs to be heated up to about 400°C for free-burning. The signal is triggered by a differential pressure transmitter. This is done mostly by an exhaust gas bypass for 1-2 hours, a so called waste gate to by-pass exhaust gas around the TC for SCR heating with charging losses, how this effect the manoeuvrability of the engine, of the ship and SFOC (specific fuel oil consumption) need to be worked out.

The 2 stroke main engine is very sensitive in backpressure due to its charging principle. At 400 mmWC backpressure the engine already “dies” with liner scuffing. Backpressure over 250 mmWC should not be allowed to avoid effects on SFOC. Auxilary engine working with 4stroke principle are more reluctant against back pressure effects.

OPERATONAL RISK

Risk of SCR operation: In operation the lubrication oil of 2-stroke engines and 4-stroke engine system oil is effecting, is poisoning the SCR, as well Vanadium from HFO operation may built up a passive layer on top of the SCR surface which cannot be removed by free-burning and may hinder the effective operation. The expensive honeycomb ceramic blocks need to be exchanged by crew or service. Spare set to be available. Vibration in certain frequencies destroyed honeycomb ceramics. when it comes to a leakage in between the honeycomb modules the exhaust gas flow will take this short cut with lower differential pressure and will pass through without been treated. Therefore regular inspections have to take place and a fully functioning online exhaust gas probe is mandatory if the plant is approved according to approval process scheme B. To keep an exhaust gas sampling system up and running with its sensitively of humidity and regular calibration gas use will need improvements of crew educations for at least container and bulker crews were such systems were not common in the past. Special training for SCR is also required for check and removal of catalysts and corrects re-installation. In the past waste gates on several engines were the week point simply put out of operation after a certain time while engine licensor gave up to support the warranty repairs. With this system the need to keep the waste gate operational and will give extra burden to the crew. To operate an SCR on exhaust gas with poor HFO quality the effectivity might be severely limited.

The HFO quality in nower days cannot be kept under control, even with 100 % screening of each fuel sample, even with support of high reputation laboratories there for SCR operation risk is high in HFO mode.

The second solution is the EGR operation, also with certain risk: Well-known problems of waste gate valves of 2-stoke and 4-stoke engines may occur as well here. Special designed flaps with special flame spray coating need to be applied to avoid the risk of abrasion and false operation due to deposits. To return up to 30 % of the exhaust gas require by dirty exhaust gas some kind of scrubber with all its problems, sulfuric acid will be build up installation of mixed materials “black steel” and SUS316L will lead to pitting corrosive ware in the stainless steel part in operation. To purify washing water if the fuel contains sulfur will lead to challenges for the chosen material. Already now 0,5% acid destroy the sensitive purifier bowls. Stainless steel cooler, washer and pipe ducts and a circulation fan need to be implemented.

If it can be secured that the used fuel is free of sulfur the EGR might be the preferred solution. But if the size of the engine increase 10 MW the SCR seem to be the only offered solution. For owners in 2014 and 2015 it was almost impossible to get a quotation and at least dimensional drawing for EGR and SCR solutions of 2-stroke engines. In 2015 all most all new build projects have been set up and keel-laid for the coming years. In the first quarter of 2016 almost only 10 % of the volume of 2016 has been ordered as main engine volume with the leading manufacturers of engines in the same time period.

In general prototypes have a certain higher risk, the field experience will show the initial problem to be overcome.

ACTUAL SHIPPING SITUATION AND FURTURE PROSPECT

In parallel the bulker crisis and container transport over capacity of very large container ship lead to the lowest transport fee per TEU (Twenty Foot Equivalent Unit) and consequentially to the conclusion that the ordered newbuilding's will be delayed to avoid a collapse of the container market as well. Until newbuilding market pick up again the operational TIER III problems might be solved by the prototype plant experiences.

To avoid TIER III technical challenges investment costs, operational costs such as chemicals, crew training maintenance and spare part costs and penalties in fuel consumption worldwide yards have already keel-laid hundreds of ships to serve customer with TIER II ships. Other solutions can be the longer operation of TIER I and TIER II ships or there upgrade by Widening [13] to bring the ships capacity to EEDI (Energy Efficiency Design Index) of 2025 comparable efficient to newbuilding but 90 % lower investment.

With high tension the decision of IMO in October 2016 is expected whether the world wide Sulphur contend in marine fuels will be reduced to 0,5% S. This will also have an effect of exhaust gas after treatment for NOx reduction while more and more distillates or hybrid fuel, LNG and Methanol will be used. EGR operation will be easier the SCR operation of diver fuels may be more challenging.

CHANCES

In the moment the demand for retrofit solutions, upgrades for Tier I to Tier II engines or Tier II to Tier III engines is rather low, but this might be a trend in fuel saving if the fuel price pick up again. The fuel saving potential is given to rate especially Tier II engines to higher pmax more fuel efficient and fight the NOx with an exhaust gas after treatment system has to be taken into account. Space wise it might be possible for 4-stroke engines as a retrofit solution [5], [9]. Almost impossible for 2-stroke engines at the actual point of view due to space and legislation certification on board of such a system might be problematic at full power. The higher penalty of Tier III engines in regard of SFOC can be overcome in this regard, but the investment and operational cost will eat up the savings at low fuel price.

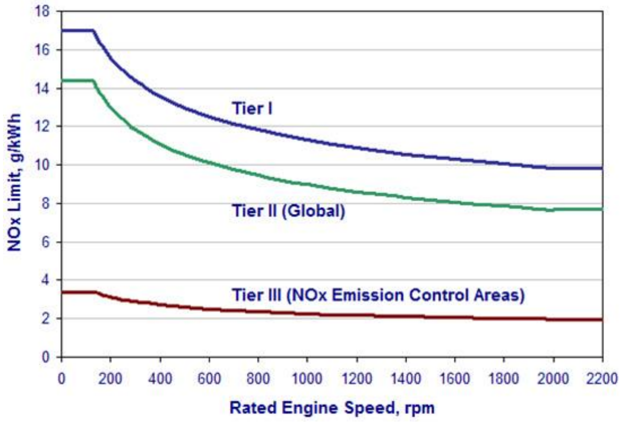

Fig.1:[14] Left side of diagram 0-100 rpm NOx limits of two stroke main engines. 600-1000 rpm medium speed auxiliary engines and 4 stroke engines above 1000 rpm high speed engines, Time line: 1.1.2000 globally for new buildings and Tier I limit introduced April 2012 in reverse for some older Wärtsilä engines and MAN S-Type engines. 1.1.2011 Tier II limits globally for new buildings. 1.1.2016 locally for US ECA for new buildings only.

Shipping made a very big jump of 75% down to reduce NOx in one go, from Tier II to Tier III in one step. Compared to the car industry or aviation. Tier 4 at least at US EPA (USA Environmental Protection Agency) is under discussion for a better environment on the planet. [11]

CO2 Reporting of EU not harmonized yet with IMO regulations will be one of the future challenges 2017.

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