WEBINAR Q&A SUMMARY

Questions and Answers

Webinar: Lubricants for conventional and emerging marine fuels
Date: 20 June 2025
Time: 14:00 – 14:45 BST

Panellists:
Mark Brighty, Global Technical Manager - Large Engines, Richful (MB)
Jurgen Binder, Lead Engineer, Win GD (JB)
Baskaran Balakrishnan, Manager, Global Marine Lubricant Support Product & Technology, Chevron (BB)
John MacKenzie, Commercial Director - Europe, VPS (JM)

1. **WinGD: How does WinGD's X-DF-A combustion chamber geometry accommodate ammonia's 8x slower flame speed while preventing lubricant carbonisation from extended high-temperature exposure?**
   JB: The amount of thermal stress experienced by cylinder lubricants depends on various factors. Higher injection amounts due to lower energy density of ammonia and resulting higher heat of evaporation lead to an inner cooling within the combustion chamber. This partially counteracts the effect lower flame speed. WinGD LNG-validated lubricants which serve as basis for X-DF-A lubrication were developed with high oxidation stability in mind to withstand the conditions of Otto-cycle combustion. Therefore, the experience in that field was used for the initial layout of the X-DF-A lubrication system, settings, and selection of lubricants.

2. **WinGD: How do WinGD's X-DF-A ammonia engines manage the slip phenomenon inherent in ammonia combustion, and what lubrication strategies mitigate resulting cylinder wear?**
   JB: Test engine measurements showed encouraging data with ammonia emissions below 10ppm, N2O below 3ppm and NOx emissions below those generated during diesel use. Therefore, wear is expected to be in the range of engines operating on low sulphur fuels and TBO of piston running components to be well achieved on X-DF-A engines.

3. **WinGD: What specific modifications to WinGD's fuel injection systems accommodate the varying ignition delays between methanol, ammonia, and conventional fuels?**
   JB: Ignition delay and combustion stability has been addressed from the very beginning, starting with investigations in WinGD’s unique Spray Combustion Chamber (SCC). The positioning and timing of the various injections (main injector for ammonia or methanol and diesel pilot injector) can significantly influence the combustion behaviour, emissions etc. This has been optimised at various stages throughout the development process.

4. **WinGD: How does WinGD's cylinder oil validation process account for the different thermal boundary layer effects when burning fuels with varying Lewis numbers?**
   JB: The WinGD cylinder oil validation process takes real world vessel operation into account. Fuels have to fulfil relevant specifications and must match the BN level of

the tested cylinder lubricant. Besides that, there are no restrictions in place as the lubricant will have to perform under various conditions & fuels bunkered worldwide later.

5. **Jurgen, what is WinGD's approach to managing the stuffing box sealing challenges when system oils are exposed to combustion products from alternative fuels?**
   JB: The stuffing box has been redesigned (mainly) for WinGD X-DF-A engines to improve sealing from the piston underside to the crankcase. This is in line with WinGD's rigorous approach to safety (for both, people and machinery) when dealing with future fuels.

6. **Jurgen, how do WinGD's BN ≤60 cylinder oil recommendations address the acid formation kinetics specific to methanol's aldehyde combustion byproducts?**
   JB: There is plenty of experience of burning methanol / ethanol and the related formation of acidic combustion by-products. Both amount and severity are reduced on X-DF-M engines when compared to VLSFO (0.5% sulphur). BN<60 cylinder lubricants, e.g. a BN40 CLO are more than sufficient to deal with acids formed during methanol operation while still providing a good level of detergency to keeping the engine clean.

7. **Jurgen, what combustion chamber design modifications in WinGD X-DF engines optimise the spray pattern geometry for ammonia's different atomisation characteristics?**
   JB: See questions/answers above.

8. **Jurgen, how does WinGD's 10+ years of LNG experience translate to predictive maintenance protocols for ammonia and methanol fuel systems?**
   JB: WinGD's X-DF platform, originally developed for LNG, integrates advanced combustion control and monitoring systems.

9. **What is WinGD's protocol for cylinder oil specification updates as new alternative fuel blends enter commercial maritime use?**
   JB: WinGD is closely collaborating with various additive and lube oil suppliers across the industry. All relevant information for customers is available in our guidelines which are constantly updated if needed. https://wingd.com/design-development/engine-technologies/tribology-fuels-lubricants

10. **Do you have any validated BN25 cylinder oils, how do they perform in terms of cleaning effectiveness, and what are your recommendations regarding Cat II cylinder oils?**
    JB: This question was answered during the webinar. There are no cylinder oil categories for WinGD engines. All validated lubricants can be used on all WinGD engines independent of the technology used if the lubricant is suitable for the fuel in use.

11. **Do WinGD recommend any form of sweep testing for high sulphur fuels?**
    JB: The WinGD Pulse Jet lubrication system does not rely on any form of sweep testing. The process of fuel-based cylinder oil selection, initial feed-rate setting, and optimisation based on drain oil analysis and piston underside inspection is described

in our lubrication guideline. All fuel and lubricant related documents can be downloaded directly from the WinGD website: https://wingd.com/design-development/engine-technologies/tribology-fuels-lubricants

12. **have you obser some particulate matter change with lubricants ?**

13. **Are you validating cylinder oil retrospectively by analysing scrape down oil? Larry Rumbol Spectro Oil Laboratory**
    JB: The validation of lubricants is concluded by issuing a “No Objection Letter” (NOL) to the supplier. The NOL is valid for two years and is extended upon request after that period has expired. WinGD is continuously monitors the performance of validated lubricants in the field. In the rare cases where problems with a validated lubricant are reported, these are discussed with the supplier of the product. In worst case, WinGD may decide not to extend an NOL or even to declare it invalid based on the performance of the lubricant in use.

14. **Baskaran: How does HDAX 9700's additive chemistry specifically neutralize the higher acid formation rates observed when methanol combustion occurs at varying load conditions?**
    BB: It is formulated carefully balancing various performance additives to address various performance requirements and work for dual fuel engines operating on marine fuels less than 1000 ppm Sulfur including LNG/LPG.

15. **Baskaran: What are the tribological implications of ammonia's lack of carbon atoms on cylinder liner wear patterns, and how does HDAX 9700 compensate for reduced boundary lubrication?**
    BB: As the solutions are in a development/testing stage, it would be difficult to comment at this stage.

16. **Baskaran: Given methanol's hygroscopic properties, how does HDAX 9700 maintain thermal stability when water contamination exceeds typical marine fuel specifications?**
    BB: This has been tested during development stage with various lab tests.

17. **Baskaran: What is the mechanism by which HDAX 9700 prevents deposit formation when transitioning between pilot fuel injection and main fuel combustion in dual-fuel engines?**
    BB: It is formulated carefully balancing various performance additives to address these specific performance requirements.

18. **Baskaran: How does HDAX 9700 oil make sure it doesn’t damage rubber seals in the engine, even when different types of fuels are used? What tests have been done to prove this?**
    BB: These aspects are being addressed during product development stage and extensively field tested in real world application/conditions to prove it.

19. **Baskaran: Are there smart systems or computer programs that can tell when it’s the best time to change HDAX 9700 oil, based on what fuels are being used at the moment? How could this help make engines more reliable and cut down on wasted oil?**

BB: As multiple parameters impact the oil life, regular & recommended oil condition monitoring supported with on- board inspections where ever feasible will help to judge the oil life/equipment performance.

20. **Further to prev question ,, if analysing Scrape down oil how are you collecting it as the quantities are so small and the drains common? It is often just a mist?**
    BB: Typically, scrape down oils analysis done in 2 stroke marine engines, drain oil collected over period of time for oil analysis.

21. **Do you recommend any extra testing of lubricants when using biofuels? FAME for example can negatively affect the lubricants viscosity. Do you recommend testing for biofuel/fame dilution?**
    BB: Regular oil condition monitoring is recommended, however when you notice abnormal results, will go for further deep investigation including fuel dilution as required.

22. **Which is the update about HVO fuel..?**

23. **Baskaran, what checks and tests are in place to make sure HDAX 9700 engine oil works well everywhere, no matter what kind of fuel ships are using? How do these checks help deal with the challenges of using many different fuels around the world?**
    BB: Please talk to Chevron field technical specialists to help you on this.

24. **Baskaran, how well does HDAX 9700 oil hold up against breaking down when engines get really hot, like when using ammonia fuel? Is there proof that it stays stable and protects the engine in these tough conditions?**
    BB: As highlighted it has been field tested extensively with various fuels in real world conditions.

25. **Which is the update about HVO fuel...?**

26. **Baskaran, are there ways to figure out how much money can be saved by using the right amount of HDAX 9700 oil when ships switch between regular and alternative fuels? How do these methods affect overall running costs?**
    BB: The saving depends on how many times oil change required with other oils (oil change cost plus vessel down time) vs HDAX 9700.

27. **Baskaran, if methanol isn't enough to stop bugs and microbes from growing in ship fuel systems, how does HDAX 9700 oil help keep things clean and prevent these problems?**
    BB: As the solutions are in a development/testing stage, it would be difficult to comment at this stage.

28. **Mark: How do Richful's Cat I/Cat II performance classifications address the specific wear mechanisms observed in MAN Mark 9 engines operating on ammonia?**
    MB: There are currently very few ships currently operating purely on ammonia and there are no two stroke test engines available at present. Therefore, until those units become readily available it is difficult to predict how MAN or WinGD engines will perform. Richful's R&D department are working on solutions for ammonia, and other

alternatively fuelled engines, and our products will be ready as required by the OEMs.

29. **Mark: What molecular engineering approaches does Richful employ to optimize additive packages for the non-carbon combustion byproducts of alternative fuels?**
    MB: Our chemistry uses the latest additive technology available, when we develop new products these become part of our IP and is something we cannot share at this time.

30. **Mark: How do Richful's marine additive formulations prevent the formation of nitrate deposits in cylinder areas when burning ammonia at varying injection pressures?**
    MB: Our chemistry uses the latest additive technology available, when we develop new products these become part of our IP and is something we cannot share at this time.

31. **Mark: What bench-to-engine correlation methodologies validate Richful's additive performance across the spectrum of emerging marine fuels?**
    MB: While we are continually developing our future fuel products, our test methodologies are confidential. However, these tests comprise of bench tests and testing in static engines where available. In time these may be published as we present and launch our products.

32. **Mark, how does Richful’s oil formula adjust to keep working well when fuel mixes with the oil and makes it thinner or thicker?**
    MB: The additive package does not readily adjust, but the 2T engine products both cylinder and system oil do not suffer with fuel dilution in real world use. 4T engines can suffer with this over time and our proprietary technology uses robust detergents and dispersants to help reduce the impact of fuel dilution.

33. **Mark: How does Richful's panel coker test methodology translate to real-world performance in engines experiencing thermal cycling from dual-fuel operations?**
    MB: Our panel coker results provide directional performance indication. The panel coker can help us to demonstrate our technology against known market references or sometimes our own product benchmarks. Sometimes we adjust to the parameters to stress the lubricants further as part of development cycle and thus give us results which we can use to determine the next steps in our development process.

34. **Mark: What is Richful's approach to managing the pH variance in lubricant systems when engines switch between acidic and basic fuel combustion products?**
    MB: This is a process for the ship management/engineers to undertake. They would then need to chose the correct BN level lubricant for the application.

35. **Mark: How do Richful's RF6313 additives maintain dispersancy effectiveness when dealing with the hygroscopic contamination from methanol fuel systems?**

MB: Our chemistry uses the latest additive technology available, when we develop new products these become part of our IP and is something we cannot share at this time.

36. **Mark, how does Richful use computer models or simulations to guess how their oil additives will work in engines running on new types of fuel that aren't being used yet?**
    MB: We do not use computer simulations. We have a number of external test partners with test engines which we use as screening tests for our products. We can run a number of different fuel types. We can also change engine parameters to heavily stress the oil in shortened periods so we can use the results as benchmarks or references for development work. However until the new types of fuel are readily available in test engines or with our ship trial partners we can only test with the fuels that are available.

37. **Mark: What quality assurance protocols ensure Richful additives maintain consistent performance across the 50+ countries in your distribution network?**
    MB: Our production facilities are all ISO certified, and our products go through rigorous Quality Assurance (QA) protocols. We also use external labs to cross check our products as part of our QA process. Having rigorous QA across our production network ensure our products remain at the highest quality.

38. **Have any observations been made regarding the relationship between cylinder oil distribution and the need for maintaining minimum feed rates, particularly in ensuring adequate liner protection under varying engine loads and fuel types?**
    MB: While we undertake various oil development and research projects I think this question should be for the engine OEMs to answer.

39. **Mark, how does Richful protect its new oil additive inventions from being copied, while still working with other companies to make sure their products work with new types of fuels?**
    MB: Our IP is protected by component patents and in some cases by package patents. This stops competitors copying our products but also protects our novel IP where we have created new chemical components and new packages. Our IP gives us competitive advantage over our competitors but this does not stop us collaboratively working with our oil marketer customers to develop products.

40. **John: How does VPS's digital system measure and compare how well engine parts are protected when ships use regular fuels versus new alternative fuels?**

41. **John: What kinds of smart computer programs does VPS use to figure out the best time to change engine oil by looking at how alternative fuels are burning right now?**

42. **John: How does VPS calculate the amount of CO_2 saved, considering that different alternative fuels cause engines to use different amounts of oil?**

43. **John: How does VPS combine different sets of data to link changes in fuel quality with how quickly engine oil breaks down when using multiple fuels?**

44. **John: How does VPS use recent data about biofuel refueling to decide which engine oils work best for ships using different mixes of biofuels?**

45. **John, how does VPS's digital system handle the tricky rules about which engine oils can be used with different fuels in different countries?**

46. **John, how does VPS's digital system help watch engine oil performance live on ships running on ammonia or methanol fuels?**

47. **Monitoring onboard cannot be calibrated for repeatability or reliability -useful like a roadside breathalyser- then lab required for real data (for prosecution!!)**

48. **Mark Brightly of Richful. How much contribution is done by additive Companies in Formulation, as compared to Lubricants blenders.**
    MB: Most formulations are developed by the additive companies. Some additive companies are owned by the oil marketers, but Richful is completely independent and allows us to work freely with anyone who wishes partner or collaborate with us to develop products. Lubricant blenders blend the finished fluid. Finished fluids are made up of two parts, the base oil(s) and the additive. While the additive can make up between 0.5% and 35% of the finished fluid, base oil(s) makes up the remaining percentage.

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