Chevron

marine lubricants

marine lubricants handbook

one supplier, wherever you are in the world

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marine lubricants

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Chevron Marine Safety Data Sheets can be found at:

https://www.chevronmarineproducts.com/en_mp/home/products/product-locator.html

Your personalised lube chart can be found here:

https://chevronproductsuklim.outsystemsenterprise.com/ChevronLubeChart/

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marine lubricants

welcome to the chevron marine lubricants handbook

In this handbook you will find all of the information you need regarding the products and services Chevron Marine Lubricants provides, as well as the contact details of your global representatives, should you need support at any time. We deliver peace of mind — wherever you are in the world.

World-class products and services

By anticipating changes in regulations and technology that impact the shipping industry and continually developing innovative solutions for our customers, we aim to be the lubricants partner of choice for the global marine community.

Our industry-leading high performance lubricants are recognised for their reliability, efficiency and protective properties. All of our marine lubricants are fully approved by, or meet the requirements of, major marine equipment manufacturers (OEMs).

At Chevron Marine Lubricants, we always 'do the right thing' by our customers, developing and delivering rigorously tested, regulation-ready, approved products — without ever cutting corners.

Choice, reliability, integrity

Lead your business forward with Chevron Marine Lubricants solutions and expert support that will future-proof your organisation and keep you regulation-compliant. Whichever operational route you choose — we've got you covered.

FAST™ vessel optimization

Predictive measures and analysis play a vital role in the maintenance of equipment onboard your vessels, and deliver that all-important thing: peace of mind. The FAST service can help identify contamination or wear — before it results in costly downtime. DOT.FAST® and FAST customers benefit from expert recommendations delivered online, from our global ISO-certified laboratories.

DOT.FAST® drip oil analysis

Our drip oil analysis kit DOT.FAST is a complete service for onboard testing of used cylinder oil samples. DOT.FAST can help operators optimise cylinder oil feed rates feed rates, measure total iron wear and detect corrosion in the engine. DOT.FAST is recommended by major slow speed two-stroke engine OEMs MAN Energy Solutions and Wärtsilä to optimize the efficiency of your engine.

FAST services

FAST is a comprehensive fluid analysis service that provides analysis of all lubricated parts aboard your vessel. Technical teams at our global laboratories provide reliable interpretations of FAST test results and actionable recommendations based on the data. DOT.FAST and FAST customers receive regular laboratory analysis from experienced engineers.

Visit our website chevronmarineproducts.com for more information.

Our Family of Brands

Chevron

marine lubricants

marine products

Chevron

marine lubricants

marine engine lubricants

formulated for today and tomorrow

lubricant solutions for a variety of engines

Emission reduction goals are shaping the future of marine engines and driving change in the shipping industry on a global scale. Slow- and medium-speed diesel engines remain the predominant power sources for deep sea shipping, and there are numerous different fuel types available for both two-stroke and four-stroke engines. These are some of the options that can help ensure compliance:

Marine gas oil/marine diesel oil (MGO/MDO)
Fuels with sulphur content below 0.1%; typically of distillate nature can be used in both ECA zones as well as to meet IMO 2020 emission requirements.

Very low sulphur fuel oil (VLSFO)
Blended fuels with sulphur content up to 0.5%; the fuel choice for a large proportion of deep sea vessels.

Liquid natural gas/liquefied petroleum gas (LNG/LPG)
Latest engine technology developments make liquid natural gas an attractive solution, particularly for LNG carriers burning the boil-off gas.

Alternative fuels
Fuels including methanol (MeOH), ammonia (NH_3) biofuels & hydrogen; are becoming viable options.

Exhaust gas abatement systems (scrubbers) for high sulphur heavy fuel oil (HSHFO)
Used to remove elements from fuels of a residual nature with sulphur content over 0.5%.

helping customers to comply with emissions legislation, whichever operational route you choose

Our range of regulation-ready Taro® Ultra cylinder oils work alongside our Veritas® 800 Marine crankcase oil to provide the reassurance of a global lubrication solution, while helping to protect your slow-speed, two-stroke crosshead engine and helping to minimise the total cost of ownership.

Taro Ultra cylinder oils

The Taro Ultra range is designed to offer flexibility in a changing fuels landscape. Taro Ultra has been extensively field tested for over 100,000 hours across a broad range of vessel applications using a variety of bunker fuels, including 0.5% sulphur blends, alternative and hybrid fuels, as well as traditional bunker fuels to mirror almost all operations.

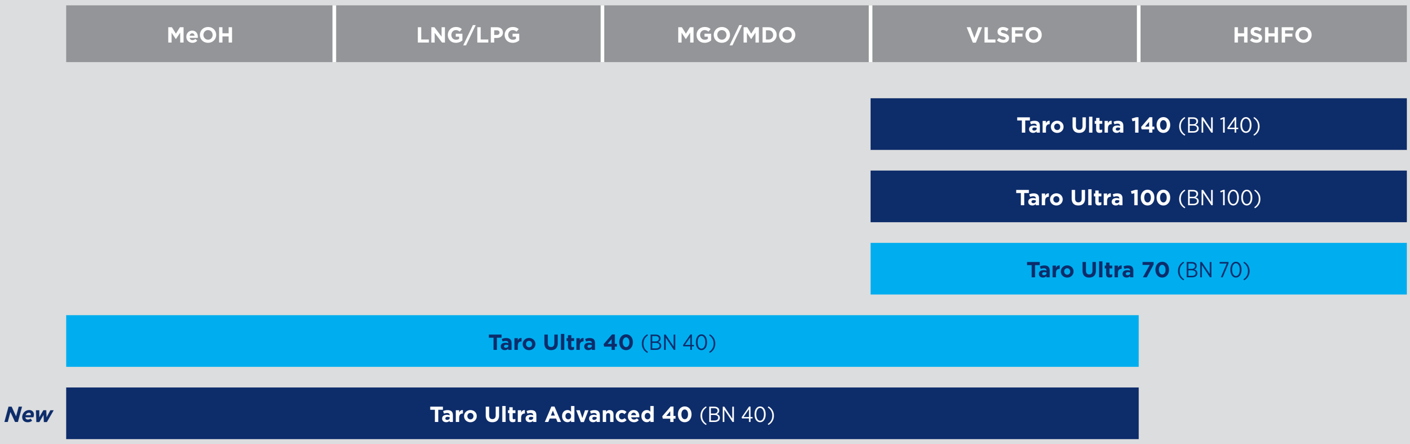
Taro Ultra cylinder oils range from a base number (BN) of 40 to 140 for compatibility with virtually all fuel types, from those with zero or low sulphur content, to those with very high sulphur content when used in combination with exhaust gas abatement systems.

We collaborate with OEMs to ensure our products are compatible with and approved for the very latest marine applications and engine types. Combined with industry leading solution-based services, two-stroke engines provide the reassurance to help you through your journey.

product highlights:

- OEM-approved
- Enables feed rate optimisation
- Offers corrosion protection
- Helps to improve high temperature performance
- Helps keep engines clean.

product range and fuel types



Recommended for and suitable for use in the majority of two-stroke engines; **MAN ES (Category II)** and **WinGD**.

Recommended for and suitable for use in the majority of two-stroke engines; **MAN ES (Category I)** and **WinGD** approved.

Always confirm that the product selected is consistent with the Original Equipment Manufacturer's recommendation for the equipment operating conditions and customer's maintenance practices.

slow-speed, two-stroke crosshead engines

Product	Fuel type	BN	SAE VG	Key approvals and recommendations
cylinder oils for slow-speed, two-stroke crosshead engines				
Taro® Ultra 140 High performance 140 BN SAE 50 cylinder oil for vessels equipped with scrubbers burning HSHFO with sulphur content above 1.5%. Optimised to help protect from corrosion at the lowest possible cylinder oil feed rate.	HSHFO with scrubber and alternation with VLSFO	140	50	Approved for MAN ES (Category II) – Mark 9 engines and higher, and WinGD engines.
Taro Ultra 100 High performance 100 BN SAE 50 cylinder oil, optimised to help combat corrosion. The optimal choice for most vessels equipped with scrubbers, burning HSHFO with sulphur content above 1.5%.	HSHFO with scrubber and alternation with VLSFO	100	50	Approved for MAN ES (Category II) – Mark 9 engines and higher, and WinGD engines.
Taro Ultra 70 High performance 70 BN SAE 50 cylinder oil for a wide range of fuels.	HSHFO with scrubber and alternation with VLSFO	70	50	Approved for MAN ES (Category I) – Mark 8 engines and lower, and WinGD engines.
Taro Ultra Advanced 40 High performance 40 BN SAE 50 cylinder oil that meets MAN ES (Category II) requirements. Delivers piston cleanliness at the level of a high BN cylinder oil (≥100 BN), with moderated BN and oil ash content. Designed to protect your engine for a range of low and zero sulphur fuels including MGO/MDO, VLSFO, LNG and methanol.	VLSFO, MGO/MDO, LNG/LPG, MeOH	40	50	Approved for MAN ES (Category II) – Mark 9 engines and higher.
Taro Ultra 40 High performance 40 BN SAE 50 cylinder oil for engines operating on fuel with a sulphur content up to 1.5% (including VLSFO and HSHFO), as well as those operating on methanol or intermittently operating on MGO/MDO.	VLSFO, MGO/MDO, LNG/LPG, MeOH	40	50	Approved for MAN ES (Category I) – Mark 8 engines and lower, and WinGD engines.
crankcase oils for slow-speed, two-stroke crosshead engines				
Veritas® 800 Marine 30/40 Crankcase oil for two-stroke crosshead marine engines, which is blended with highly refined base oils and carefully selected additives to provide very good anti-corrosion and anti-foam properties.	All fuel types	5.6	30/40	Approved for MAN ES, WinGD and Japan Engine Corp.

For full approvals and recommendations, refer to the relevant PDS sheet.
Always consult your Chevron Marine Lubricants representative for the latest approvals.

medium-speed, four-stroke engines

Our range of Delo® and Taro® diesel engine oils, and HDAX® gas engine oils, are designed for trunk piston engines and are also compatible with a wide range of fuels from zero to high-sulphur content, from liquid fuel to LNG or dual-fuel operations.

<table>
<tr><th>Product</th><th>Fuel type</th><th>BN</th><th>SAE VG</th><th>Key approvals and recommendations</th></tr>
<tr><td colspan="5">diesel engine oils for medium-speed, four-stroke trunk piston engines</td></tr>
<tr><td>Taro XL Series (50 XL 40)</td><td>HSHFO, VLSFO; fuels with a sulphur level up to 4.5%</td><td>50</td><td>40</td><td rowspan="5">Approved by major OEMs including MAN ES, Wärtsilä, MaK (Caterpillar), Rolls-Royce Bergen, Daihatsu, Hyundai HiMSEN and Yanmar.</td></tr>
<tr><td>Taro XL Series (40 XL 40)</td><td>HSHFO, VLSFO; fuels with a sulphur level up to 4%</td><td>40</td><td>40</td></tr>
<tr><td>Taro DP Series (30 DP 30/40)</td><td>HSHFO, VLSFO; fuels with a sulphur level up to 4%</td><td>30</td><td>30/40</td></tr>
<tr><td>Taro DP Series (20 DP 30/40)</td><td>HSHFO, VLSFO, MGO/MDO; fuels with a sulphur level up to 2%</td><td>20</td><td>30/40</td></tr>
<tr><td>Delo 1000 Marine 30/40</td><td>MGO/MDO</td><td>12</td><td>30/40</td></tr>
<tr><td>Delo SHP SAE 30/40</td><td>MGO/MDO</td><td>12</td><td>30/40</td><td>Approved by major OEMs including MAN ES, Deutz, MaK (Caterpillar), Rolls-Royce Bergen, Daihatsu, Hyundai HiMSEN and Yanmar.</td></tr>
<tr><td>HDAX 9700 SAE 40</td><td>LNG, MGO/MDO</td><td>5.8</td><td>40</td><td>Approved by MAN ES.</td></tr>
<tr><td>HDAX 5200 SAE 40</td><td>LNG</td><td>4.2</td><td>40</td><td>Approved by major OEMs including Caterpillar CG, GE Jenbacher, MWM, Wärtsilä and Waukesha.</td></tr>
</table>

For full approvals and recommendations, refer to the relevant PDS sheet.
Always consult your Chevron Marine Lubricants representative for the latest approvals.

wherever you are in the world, we've got you covered

Our innovative FAST™ family of services and cloud solution tools are designed to optimise equipment performance, reduce lubricant consumption and help to lower the cost of your operation. Onboard monitoring and laboratory analysis can extend the life of your assets and help your operation become more efficient. We understand the impact of change and provide tailored analysis services for customers, helping to meet the challenges of today's marine shipping industry.

FAST

Our comprehensive lubricant condition monitoring and optimisation program provides a diverse range of test equipment packages that help you achieve maximum performance and predict problems before they arise. Receive actionable recommendations for each sample from Chevron Marine specialists via user-friendly PDF reports emailed within 48 hours of receipt, plus online digital access to data and trending.

FAST OnBoard

A compact, portable and lightweight test kit that offers immediate, accurate and reliable onboard test results for engine lubrication oils as well as for circulating, hydraulic, compressor and gear oils. Measuring critical parameters such as BN, water content and viscosity, the kit is fast and easy to use, providing the continuity of a regular testing regime onboard the vessel to quickly and accurately monitor the performance of the oils used.

DOT.FAST® Drip Oil Analyser

An innovative and unique onboard iron testing kit to help balance conditions within your engine, delivering immediate results with laboratory accuracy. As fuel oil quality varies, DOT.FAST is designed to give ship engineers the ability to optimise cylinder oil consumption and minimise wear by measuring total iron content, enabling immediate action to be taken, supported by expert reviewed onshore analysis. With a robust design for long service life, the kit is easy to use and the consumables include; pre-filled, individual vials that contain the right volume of chemicals to test the drip oil sample right away.

For more details on our Chevron Marine Lubricants products and services, please visit **chevronmarineproducts.com**, or contact your local Chevron representative or marketing office.

our engine oils work hard, so your engines don't have to

With one of the industry's largest distribution networks, Chevron has the infrastructure to deliver the marine products and services you need. From our global operational reach to the depth of our industry knowledge, we offer solutions for your journey.

www.chevronmarineproducts.com

Our Family of Brands

Always confirm that the product selected is consistent with the original equipment manufacturer's recommendation for the equipment operating conditions and customer's maintenance practices.

 CVX011 EU-0 [05/23]

Chevron

marine lubricants

delo® XLI corrosion inhibitor – concentrate cooling water treatment

help extend the life of your engine with OAT corrosion inhibitor technology

The marine environment challenges your equipment.

Chevron marine products help you meet the challenge.

With one of the largest distribution networks in the industry, Chevron has the infrastructure to deliver the marine products and services you need. From our global operational reach to the depth of our experienced personnel, we stand for one thing above all else — **reliability**.

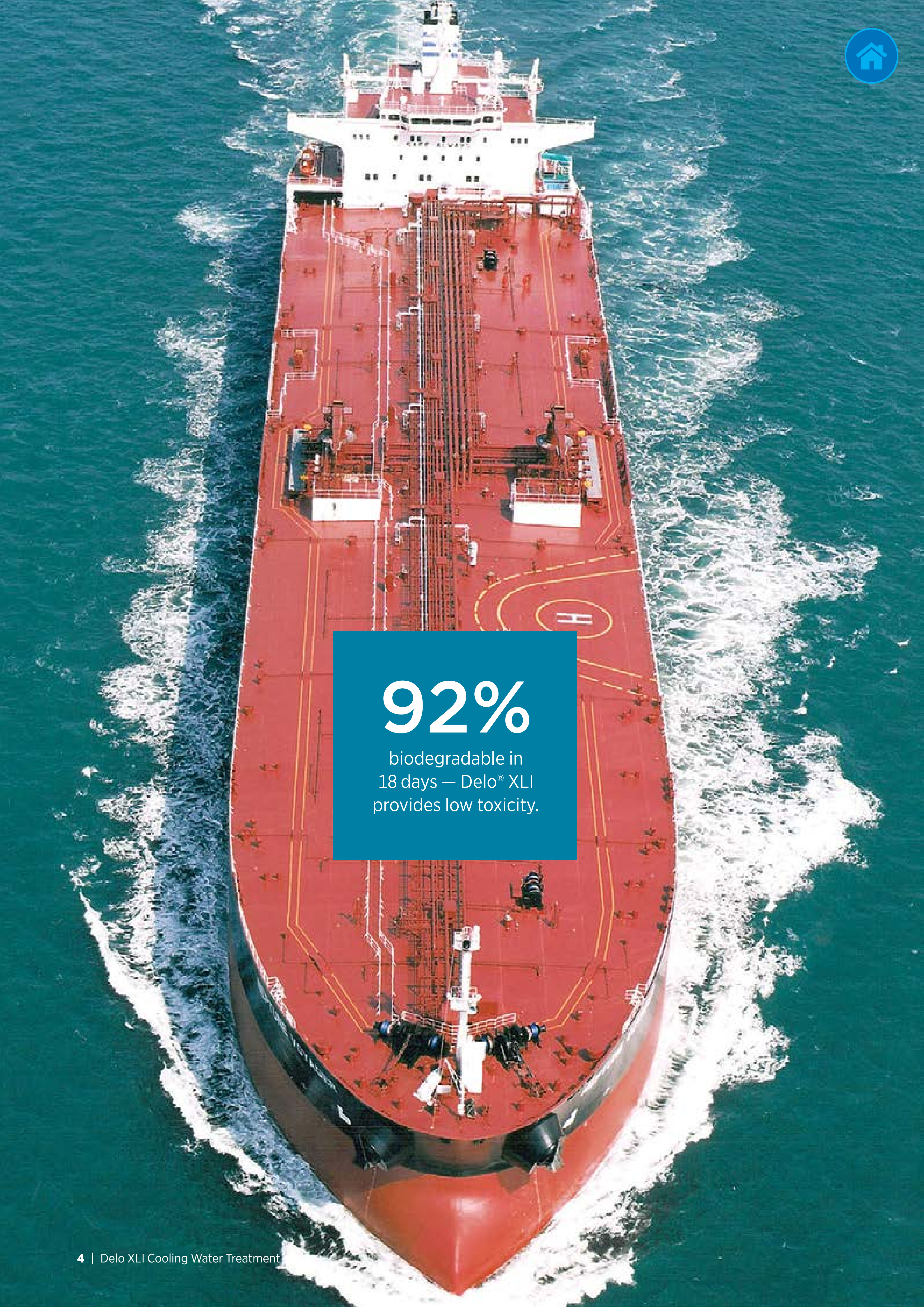
Delo® XLI cooling water treatment

Field and laboratory tests prove that Chevron's Delo® XLI Corrosion Inhibitor – Concentrate (Delo XLI) cooling water treatment helps provide maximum protection and lasts longer than many traditional technologies in your marine or power generation systems. It is recommended for cooling water treatment operating below 100°C. Delo XLI cooling water treatment combines performance with long service life to help keep your engines running for longer.

- Extended service life
- Improved heat transfer
- 92% biodegradable in 18 days
- Organic Acid Inhibitor Technology (OAT)
- Compatible with plastics and elastomers

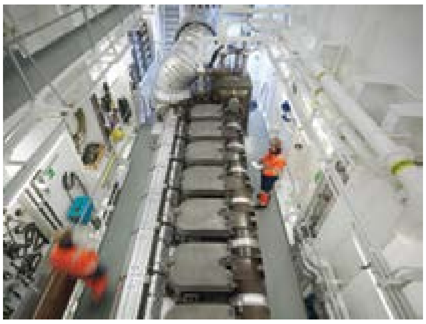
32,000

number of hours recommended maximum service interval for Delo® XLI cooling water treatment.



92%

biodegradable in 18 days — Delo® XLI provides low toxicity.



Delo® XLI cooling water treatment has an extended service life, with recommended maximum service intervals of 32,000 hours.

important advantages

Extended service saves time and money
The Organic Acid Inhibitor Technology (OAT) in our Delo® XLI cooling water treatment has a very low additive depletion rate, helping to ensure long-term corrosion protection under all operating conditions. There is no need for supplementary additive top-ups. Delo XLI cooling water treatment has an extended service life, with recommended maximum service intervals of 32,000 hours.

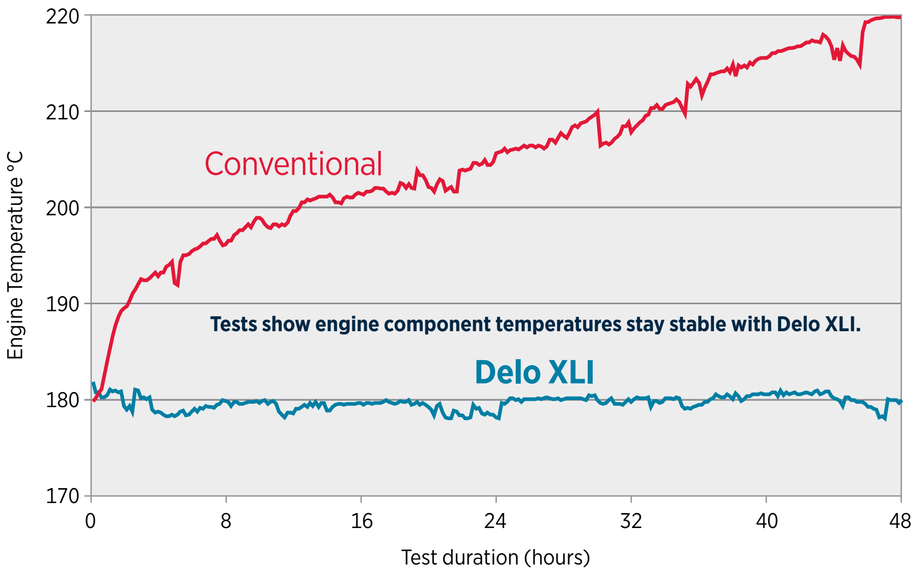
Caring for the environment
Delo XLI cooling water treatment is a water-based, low toxic, readily biodegradable, nitrite-free carboxylate inhibitor treatment.

Minimized maintenance costs
Delo XLI cooling water treatment has better heat exchange than many conventional coolants. Our technology inhibitor system is designed to protect against wet liner cavitation erosion and helps provide protection to aluminum and cast iron surfaces under heat transfer conditions.

performance at high temperatures

Tests show Delo XLI cooling water treatment remains stable at high temperatures and does not form a film that can hinder heat transfer. OAT helps to protect metal surfaces by physical absorption or by chemisorption only where needed, and does not impede heat transfer.

The graph below shows that with Delo XLI OAT, heat dissipation is stable over time, while with conventional cooling water treatment heat dissipation may decrease due to build-up of insolation layers (oxides and/or inhibitor salts), leading to increased component thermal stress.

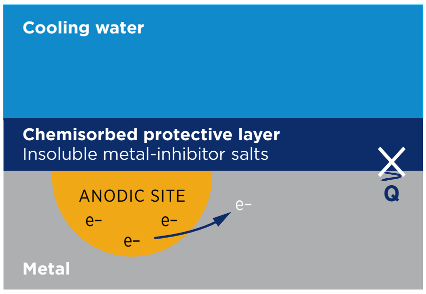


corrosion protection mechanism

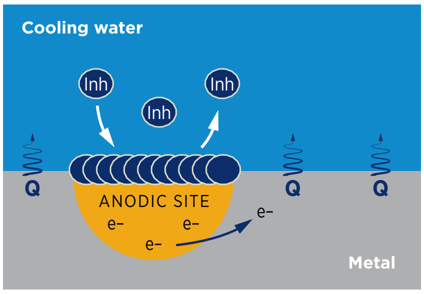
Corrosion is the combination of two processes, an oxidation-reduction of the metal surface and the electron flow from an anodic site to a cathodic site.

Conventional products help to limit corrosion by creating a protective layer over the complete metal surface, thus impeding heat transfer. Chevron's Delo® XLI cooling water treatment is designed to protect against corrosion by electronically bonding with the anodic sites throughout the cooling system.

This polarization process helps protect the metal surface against oxidation-reduction. Because Delo XLI cooling water treatment bonds only with the anodic sites, additive depletion is minimal and heat transfer performance is not impeded, giving the product significant advantages.



Conventional protection mechanism



Chevron Delo XLI cooling water treatment

Delo XLI is suitable for use in some of the most advanced engines in the world*, including:

Manufacturers

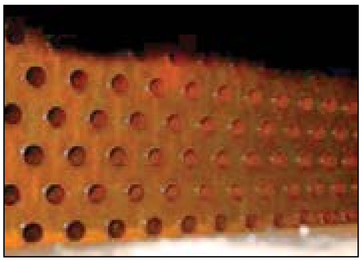
- MAN Energy Solutions
- Winterthur Gas & Diesel
- Rolls-Royce
- Deutz
- MaK/CAT

* Operating with cooling water temperature below 100°C

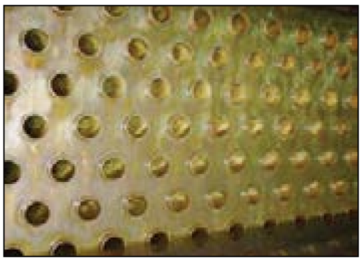
field test examples

Air cooler, Wärtsilä 12RTA84C-UG main engine — pipe bundle:

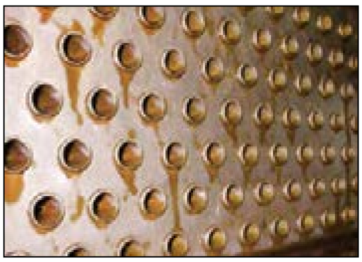
Before change-over



After 4,000 hours



After 13,000 hours



Pipe/pump housing connections:

3,000 hours service with conventional cooling water treatment

3,000 hours service with Delo XLI cooling water treatment

Cleaner inlet air coolers mean cooler inlet air and greater engine efficiency.

Field tests demonstrate Delo® XLI's corrosion and rust protection performance.

Deutz TBD 604BV16 after 43,000 hours (m/v *Le Ponant*).

12RTA96C engine after 21,000 hours (m/v *Cornelia Maersk*).

easy, cost-effective monitoring

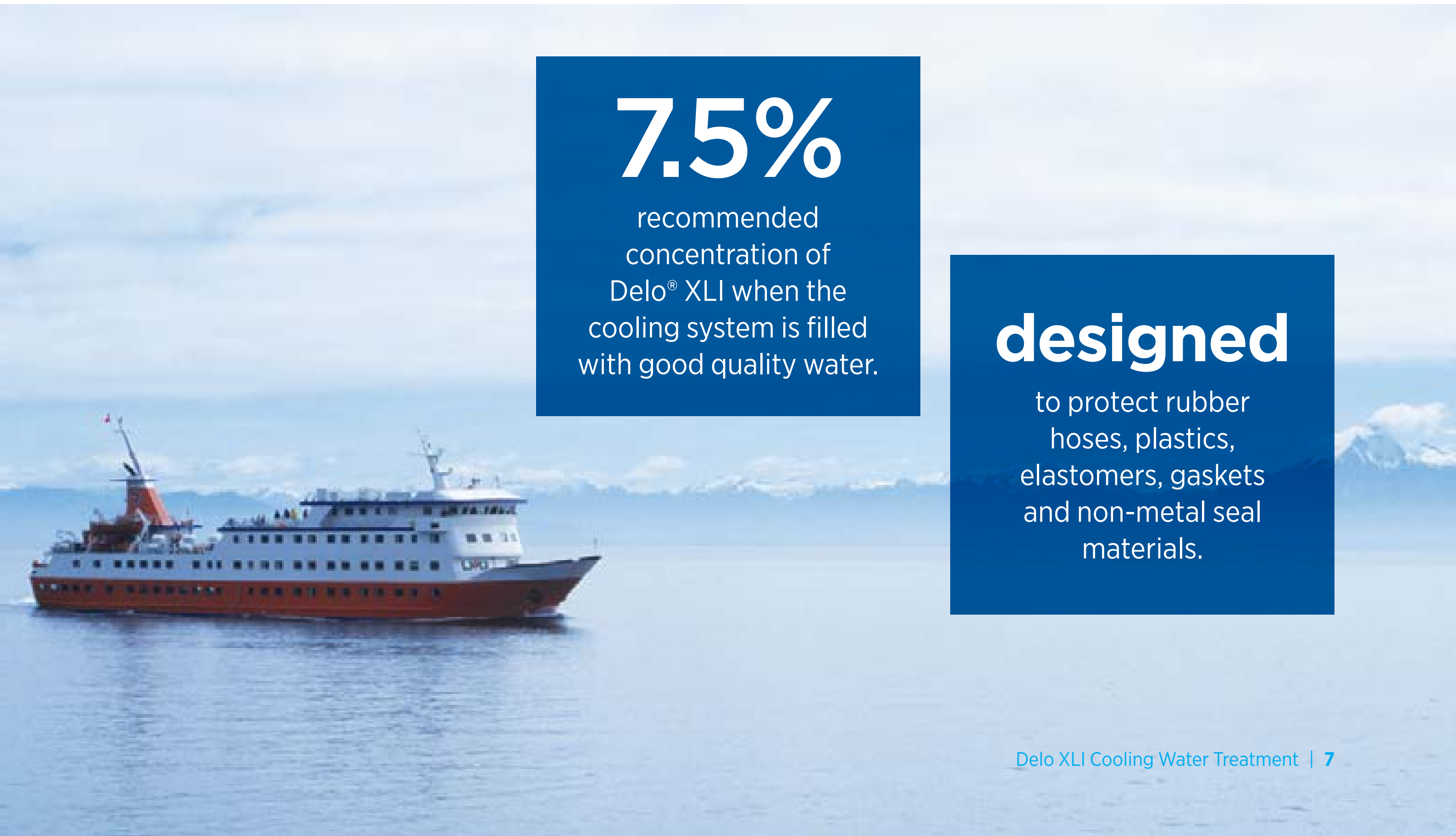
Chloride and pH monitoring is easy
Delo XLI's OAT corrosion inhibitor system is designed to protect aluminum and other system metals at lower pH levels than conventional coolants. Acid and base indicator strips are used to easily measure pH balance. High chloride levels can significantly increase the risk of corrosion, and are also evidence of seawater contamination in the system.

For onboard testing, commercially available test strips can be used for quickly and conveniently measuring rough chloride levels in cooling water. Chevron recommends testing the Delo XLI cooling water treatment's concentration, pH value and chloride levels once a week.

Comprehensive FAST™ reports
Chevron provides in-depth onshore analysis of your cooling water samples at advanced global laboratories. We report on several parameters in your cooling water samples, including: pH, Cl, XLI concentration and elemental analysis.

Contact your sales office for more information.

Chevron provides in-depth onshore analysis of your cooling water samples at advanced global laboratories.



7.5%

recommended concentration of Delo® XLI when the cooling system is filled with good quality water.

designed

to protect rubber hoses, plastics, elastomers, gaskets and non-metal seal materials.

www.chevronmarineproducts.com

Our Family of Brands

Always confirm that the product selected is consistent with the original equipment manufacturer's recommendation for the equipment operating conditions and customer's maintenance practices.

Chevron

marine lubricants

meropa® gear oils

protect your gearboxes — protect your operation

solutions for your journey

Gearboxes are critical to keeping your operation running. If they fail, your productivity is compromised.

And yet, your gearboxes are constantly attacked by severe operating conditions and damaging contaminants, which can lead to downtime — and even complete failures.

meropa® gear oils

We developed the Meropa® family of gear oils to help you fight back against severe conditions. Meropa's special additives are designed to provide extreme pressure protection and anti-wear properties. And the global availability of Meropa products ensures consistent, reliable performance — wherever you operate in the world:

High Thermal Stability to help maintain clean gear and bearing surfaces — designed to minimize deposits that interfere with effective lubrication, thereby helping to minimize the formation of oxidation by-products that can be corrosive to bearing materials or contribute to internally generated contamination.

Advanced Extreme Pressure Performance to help protect against shock or sustained severe loading conditions, reducing wear rates and optimizing bearing and gear service life.

High Oxidation Stability to increase oil service life and maintain in-service viscosity grade longer to help improve energy efficiencies.

Foam Control to help protect gear teeth in small reservoir systems through use of a unique low-foam additive. Foam dissipates readily even under severe operating conditions.

Demulsibility to help protect against sludge formation and assure rapid water separation and removal, especially in circulating systems.

The unique combination of additives in Meropa have been shown to offer additional benefits:

- Severe load carrying capabilities
- Good seal compatibility
- Filtration properties
- Improved system cleanliness
- Long equipment life
- Promotes long-term rust and corrosion protection

Meropa® is the gear lubricant to depend on for consistent, reliable performance, no matter where you choose to navigate.

Meropa® means worldwide reliability

When it's miles to the next port — anywhere in the world — the need to keep equipment running reliably is of paramount importance.

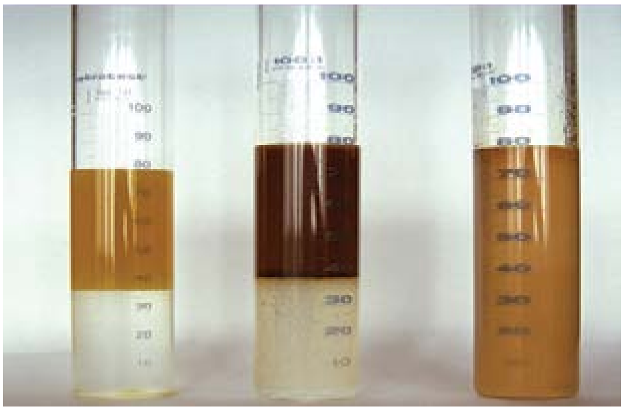
Being able to count on one brand of marine oils for your lubrication needs can have a direct effect on your bottom line through increased production and costs savings.

That's why there's Chevron Meropa — the gear lubricants you can depend on, whatever waters you choose to navigate.

Meropa gear lubricants are specifically designed to meet the demanding requirements of today's marine equipment. In field tests for Meropa gear oils, results showed low operating temperatures, low power consumption, low energy requirements, and low failure rates in severe operating environments.

With Meropa, you can benefit from long equipment life, and low maintenance and downtime — the keys to staying competitive in today's global economy.

Demulsibility performance



Meropa 220 ASTM D 1401: 10 Minutes	Meropa 220 Oxidized* ASTM D 1401: 18 Minutes	Reference Oil ASTM D 1401: >60 minutes

* Test procedure: ASTM D2893 Modified (312 hrs. @ 121°C)

Meets the requirements of today's equipment

Meropa® gear lubricants are premium quality, high-performance gear lubricants. They have been specially developed to meet the demanding load-carrying requirements of gear manufacturers, especially in applications where overloading, wet conditions and high operating temperatures are encountered.

Typical applications include:

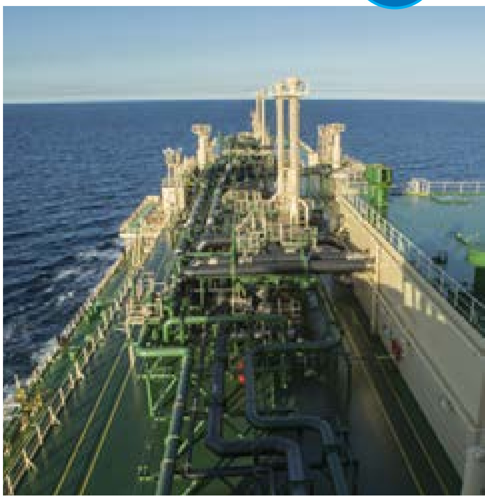
- All heavy-duty enclosed gear drives containing spur gears, helical gears, and bevel gears, as well as spiral bevel gears, hypoid gears, and worm gears, including those operating at high speeds or very high loads.
- Chain drives, sprockets, plain and anti-friction bearings, guide ways and flexible couplings where service conditions require the use of either a mild EP or an EP-type gear lubricant.
- Meropa MG is designed to ensure optimal performance in Renk and Flender/Siemens, Reintjes and Brunvoll clutched gear boxes, extensively used in marine vessels. As such, Meropa MG gear oils carry approvals from those gearbox manufacturers, and also meet or exceed various industrial standards.

Proven reliability

In test after test, Meropa lubricants continue to prove themselves by meeting the demanding requirements of many OEMs and leading manufacturers.

Meropa product line:

- **Meropa®**
  Viscosity Grades 68, 100, 150, 220, 320, 460, 680
- **Meropa® MG**
  Viscosity Grades 100, 150, 220
- **Meropa® EliteSyn WS**
  Viscosity Grades 150, 220, 460, 680
- **Meropa® Synthetic EP**
  Viscosity Grade 150
- **Meropa® Synthetic WM**
  Viscosity Grade 320
- **Meropa® WG**
  Viscosity Grade 460



Meropa® gear lubricants are designed for the lubrication of a wide variety of load-carrying marine equipment.

On your team

Your Chevron Marine Account Manager will work with you to design an industry-leading lubrication program featuring Meropa® gear oils. As always, the Chevron team offers you the knowledge and expertise to make effective use of preventative maintenance, and help reduce downtime and operating costs.

Chevron customers enjoy success from their lubrication program because we give them more than just the right lubricant.

We understand that — in addition to quality lubricants and fuel — predictive measures and analysis are vital to the maintenance of equipment on board your vessels. And that easy and intuitive online ordering and tracking of products has great value for the smooth and seamless operation of your fleet.

Chevron offers a complete suite of services to provide stem-to-stern options to help improve the reliability and logistics of your operation:

FAST™ Service — a comprehensive equipment condition monitoring program which reports the condition of oil in service and plots the trends of important properties of the oil.

DOT.FAST® Service — a complete service including the Drip Oil Analyzer for onboard testing of used cylinder drain oil samples (drip oil) and regular laboratory analysis with expert advice from experienced engineers. Our DOT.FAST Drip Oil Analysis is recommended by the major slow-speed engine builders to better understand piston running conditions in the engine.

Lubrication Charts — each contracted vessel has a detailed lubrication chart, listing all onboard equipment, lubricants, and the suggested application based on manufacturers' recommendations, all available through a secure online portal.

OnePort™ — an online ordering system to check prices at different ports, place orders and track deliveries through the various stages of supply.

Vessel Optimization — Chevron has developed a vessel optimization support program — supported by our industry-experienced technical field staff and lubricants analysis experts — providing advice to reduce your total cost of operation, and helping to improve your performance and overall reliability.

Contact your account manager to find out how Chevron Marine Lubricants can help optimize your operation.

Chevron's proprietary products and services help to reduce operational cost, maximize productivity and keep your fleet sailing.

www.chevronmarineproducts.com

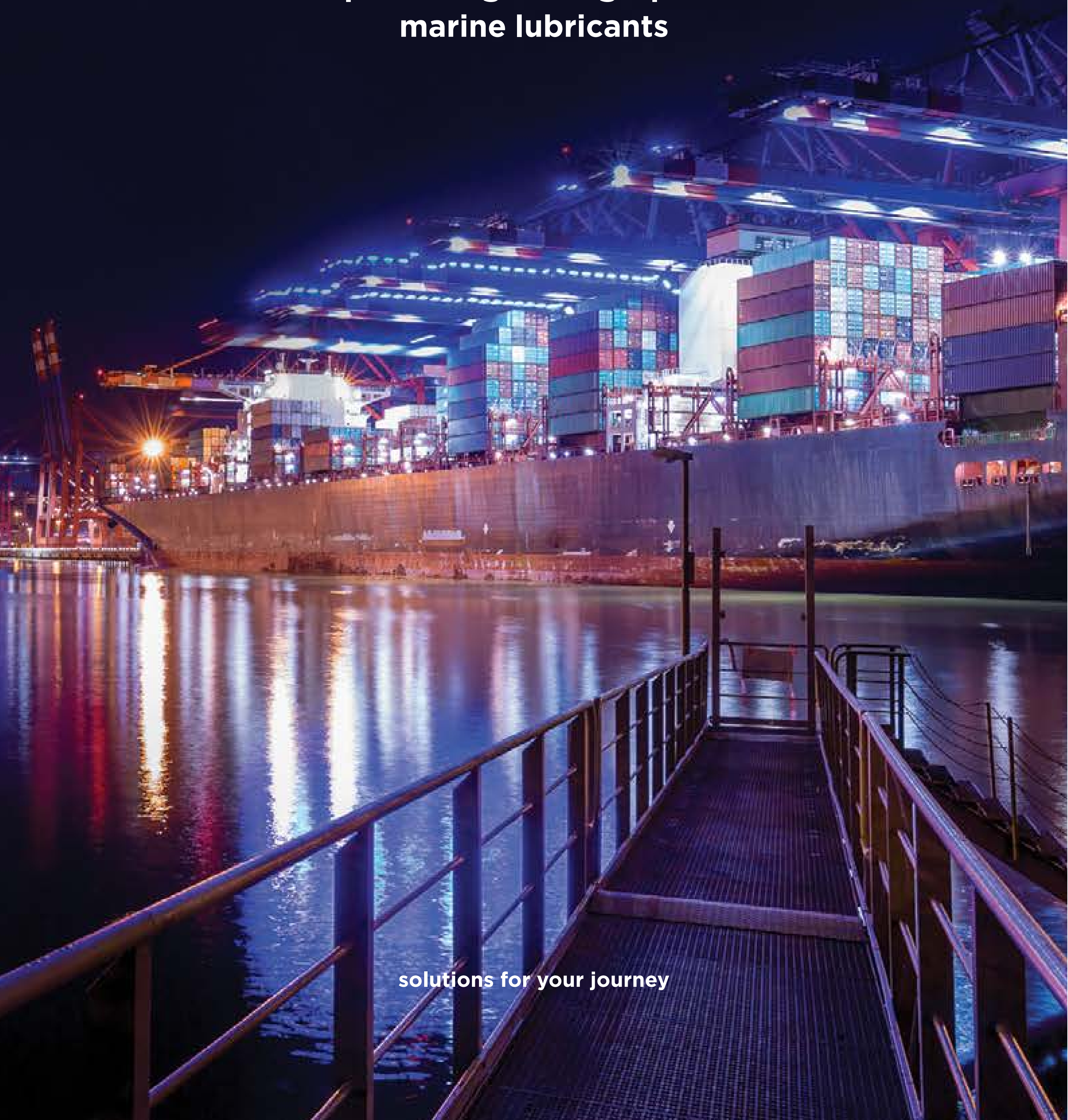
Our Family of Brands

Always confirm that the product selected is consistent with the original equipment manufacturer's recommendation for the equipment operating conditions and customer's maintenance practices.

Chevron

marine lubricants product list

the complete range of high-performance marine lubricants



solutions for your journey

We have regulation-ready, tailor-made solutions covering almost every compliant fuel requirement, delivering peace of mind whichever operational route you choose, wherever in the world you are.

Chevron products are subject to extensive field tests, and are designed to meet or exceed original engine manufacturer requirements. Supply is available at major ports all around the globe. The following table gives a brief description and typical physical properties of each product. For more details, please refer to individual product information at chevronmarineproducts.com, or contact your local Chevron representative or marketing office.

Product List

	SAE or ISO VG	Density 15°C kg/l	Kinematic Viscosity mm^2/s (cSt) @ 40°C	Kinematic Viscosity mm^2/s (cSt) @ 100°C	Viscosity Index	Flash Point °C	Pour Point °C	Base No. (BN)	Product Description
Slow-speed Engine Oils									
Taro® Ultra 20	50	0.90	–	19.0	>95	230	−12	20.0	High performance 20 BN cylinder oil formulated for large bore two-stroke engines operating on 0.1% sulphur fuels, including ECA zones and LNG operations.
Taro® Ultra 40	50	0.92	–	19.0	>95	270	−15	40.0	High performance 40 BN cylinder oil for large bore two-stroke engines operating on fuels with a sulphur content up to 1.5%, as well as intermittent ECA zone operations.
Taro® Ultra Advanced 40	50	0.92	–	19.0	>95	220	−15	40.0	High performance 40 BN cylinder oil for latest generation large MAN ES Category II marine diesel engines operating with a range of low to zero sulphur fuels including VLSFO, ULSFO, LNG and methanol.
Taro® Ultra 70	50	0.93	–	19.0	>95	270	−15	70.0	High performance 70 BN cylinder oil for large bore two-stroke engines, compatible with a wide variety of fuels.
Taro® Ultra 100	50	0.95	–	19.0	>95	270	−15	100.0	High performance 100 BN cylinder oil suitable for use with a wide range of large bore two-stroke engines with a sulphur content of 1.5% and above, including scrubber equipped vessels.
Taro® Ultra 140	50	0.98	–	19.0	>95	270	−15	140.0	High performance 140 BN cylinder oil for large bore two-stroke engines operating on fuels with a sulphur content above 1.5%. Optimized for combating cold corrosion on scrubber equipped vessels.
Veritas® 800 Marine 30	30	0.89	111.0	11.9	95	240	−18	5.6	Large bore two-stroke slow speed engine system oil.
Medium-speed Engine Oils									
Taro® 20 DP 30 (X)*	30	0.90	94.0	11.0	102	240	−12	20.0	Medium-speed engine oil. Fuel sulphur level up to 2%.
Taro® 20 DP 40 (X)*	40	0.90	135.0	14.0	100	240	−12	20.0	Medium-speed engine oil. Fuel sulphur level up to 2%.
Taro® 30 DP 30 (X)*	30	0.91	94.0	11.0	104	240	−12	30.0	Medium-speed engine oil. Fuel sulphur level up to 4%.
Taro® 30 DP 40 (X)*	40	0.91	135.0	14.0	105	240	−12	30.0	Medium-speed engine oil. Fuel sulphur level up to 4%.
Taro® 40 XL 40 (X)*	40	0.90	135.0	14.0	105	240	−12	40.0	Medium-speed engine oil. Fuel sulphur level up to 4.5%.
Taro® 50 XL 40 (X)*	40	0.91	135.0	14.0	106	240	−12	50.0	Medium speed engine oil. Fuel sulfur level up to 4.5%. Suitable for operation on fuel of high sulfur content in combination with a low natural engine oil consumption.
Delo® 1000 Marine 30	30	0.89	102.0	11.6	100	240	−18	12.0	Medium-speed engine oil. Fuel sulphur level up to 1.5%.
Delo® 1000 Marine 40	40	0.89	135.0	14.0	100	240	−18	12.0	Medium-speed engine oil. Fuel sulphur level up to 1.5%.
Delo® SHP SAE 30	30	0.89	104.0	11.8	100	240	−15	12.0	High performance SAE 30 diesel engine oil for medium- and high-speed trunk piston diesel engines operating under severe conditions.
Delo® SHP SAE 40	40	0.89	135.0	14.0	100	240	−18	12.0	High performance SAE 40 diesel engine oil for medium- and high-speed trunk piston diesel engines operating under severe conditions.
Delo® 710 LE SAE 20W-40	20W-40	0.88	–	15.5	–	–	−27	–	High performance zinc- and chlorine-free multi-grade diesel engine system oil.
High-speed Engine Oils									
Delo® 400 MGX SAE 15W-40	15W-40	0.88	–	14.6	–	228	−36	9.6	High-speed diesel engine oil with low saps. API CJ-4 performance.
Delo® Gold Ultra SAE 15W-40	15W-40	0.89	115.4	15.2	138	230	−39	10.2	Standard mineral multi-grade four-stroke trunk piston engine oil on light fuels.
Delo® 400 XSP SAE 5W-40	5W-40	0.85	–	15.4	–	–	−46	10.0	Mixed-fleet engine oil for naturally aspirated and turbocharged four-stroke diesel and gasoline engines.
Delo® 400 SAE 40	40	0.89	–	14.7	–	–	−24	10.1	Monograde of SAE 40 viscosity for four-stroke trunk piston engine on light fuels.
Delo® 100 Motor Oil SAE 40	40	0.89	131.0	14.5	109	270	−24	7.3	Low ash, two-stroke diesel engine oil for Detroit Diesel engines.

** Depending on the port designated, products may be delivered with or without the (X) identifier (e.g., Taro® 40 XL 40X or Taro® 40 XL 40). However, the product typical test data both with or without the (X) identifier are miscible and fully compatible.*

	SAE or ISO VG	Density 15°C kg/l	Kinematic Viscosity mm²/s (cSt) @ 40°C	100°C	Viscosity Index	Flash Point °C	Pour Point °C	Base No. (BN)	Product Description
Compressor Oils									
Capella® HFC 32	32	1.00	32.0	5.7	119	>240	-57	–	Refrigeration compressor oil, for chlorine-free refrigerants such as R134a, R404a, and R507.
Capella® HFC 55	55	1.01	53.0	8.4	132	>270	-51	–	Refrigeration compressor oil, for chlorine-free refrigerants such as R134a, R404a, and R507.
Capella® HFC 100	100	0.97	100.0	11.4	100	>260	-30	–	Refrigeration compressor oil, for chlorine-free refrigerants such as R134a, R404a, and R507.
Capella® Low Temp AB 68	68	0.87	68.0	6.5	–	190	-42	–	Synthetic (alkylbenzene based) refrigeration compressor oil for ammonia and R22 or R502 at low evaporator temperatures.
Capella® WF 32	32	0.90	30.0	4.4	6	168	-39	–	Refrigeration compressor oil, for ammonia, methylchloride, CO_2 and certain types of (H)CFC refrigerant gases.
Capella® WF 68	68	0.91	64.0	6.5	13	179	-33	–	Refrigeration compressor oil, for ammonia, methylchloride, CO_2 and certain types of (H)CFC refrigerant gases.
Cetus® DE 100	100	0.96	96.0	10.1	–	252	-39	–	Synthetic (diester based) lubricating oil for reciprocating air compressors.
Cetus® PAG	–	1.06	185.0	35.0	–	260	-30	–	Synthetic (PAG based) lubricating oil for chemical & hydrocarbon gas compressors (including LNG & LPG).
Cetus® PAO 46	46	0.84	46.0	8.1	150	232	-46	–	Synthetic (PAO-based) lubricating oil for rotary air compressors.
Cetus® PAO 68	68	0.85	68.0	10.4	140	240	-47	–	Synthetic (PAO-based) lubricating oil for rotary air compressors and turbochargers.
Compressor Oil EP VDL 100	100	0.89	100.0	11.3	97	248	-12	–	Mild EP oil for reciprocating air compressors.
Capella® A 68	68	0.84	68.7	10.6	143	260	-57	–	Synthetic (PAO-based) lubricating oil for the lubrication of compressors used in refrigeration and air-conditioning systems with ammonia, carbon dioxide and halogenated refrigerants.
Specialty Products									
1000 THF®	–	0.87	59.0	9.3	145	235	-42	–	High quality, multifunctional tractor hydraulic fluid.
Delo® Gear EP-5 SAE 80W-90	–	0.88	135.0	14.3	101	150	-52	–	Automotive gear lubricant suitable for API GL-5 applications.
Havoline® ATF III-H	–	0.86	34.1	7.0	171	–	-50	–	Automatic transmission fluid.
Havoline® Outboard 2T	–	0.87	54.0	8.7	138	134	-39	5.7	Two-stroke marine outboard oil, formulated with an ashless additive system.
HDAX® 5200 Low Ash Gas Engine Oil SAE 40	40	0.88	–	13.5	–	–	-33	4.2	Low ash gas engine oil.
Texatherm® 32	32	0.86	32.0	5.5	106	220	-15	–	Heat transfer fluid for temperatures up to 320°C (max. film temperature 340°C).
Texatherm® 46	46	0.86	46.0	6.9	105	235	-15	–	Heat transfer fluid for temperatures up to 320°C (max. film temperature 340°C).
Gear Oils									
Meropa® 68	68	0.88	68.0	8.8	100	200	-15	–	Extreme pressure industrial gear lubricant.
Meropa® 100	100	0.88	100.0	11.4	100	200	-15	–	Extreme pressure industrial gear lubricant.
Meropa® 150	150	0.89	150.0	14.9	100	215	-15	–	Extreme pressure industrial gear lubricant.
Meropa® 220	220	0.89	220.0	19.2	100	215	-15	–	Extreme pressure industrial gear lubricant.
Meropa® 320	320	0.90	320.0	24.3	100	215	-15	–	Extreme pressure industrial gear lubricant.
Meropa® 460	460	0.90	460.0	30.0	100	215	-15	–	Extreme pressure industrial gear lubricant.
Meropa® 680	680	0.90	680.0	36.5	95	240	-10	–	Extreme pressure industrial gear lubricant.
Meropa® MG 100	100	0.89	100.0	11.3	99	234	-24	–	Premium high-performance gear oil.
Meropa® MG 150	150	0.90	150.0	14.8	98	254	-25	–	Premium high-performance gear oil.
Meropa® MG 220	220	0.90	220.0	19.0	97	268	-26	–	Premium high-performance gear oil.
Meropa® EliteSyn WS 150	150	1.05	150.0	25.0	227	284	-42	–	Premium performance synthetic industrial gear oil (PAG based).
Meropa® EliteSyn WS 220	220	1.06	220.0	42.0	241	284	-42	–	Premium performance synthetic industrial gear oil (PAG based).
Meropa® EliteSyn WS 460	460	1.07	460.0	83.0	262	284	-36	–	Premium performance synthetic industrial gear oil (PAG based).
Meropa® EliteSyn WS 680	680	1.07	680.0	122.0	272	284	-33	–	Premium performance synthetic industrial gear oil (PAG based).
Meropa® Synthetic EP 150	150	0.85	150.0	18.8	150	244	-48	–	Synthetic high VI gear oil of ISO VG 150.
Meropa® Synthetic WM 320	320	0.85	320.0	35.4	156	240	-48	–	Synthetic high VI gear oil of ISO VG 320.
Meropa® WG 460	460	–	439.0	30.0	97	284	-9	–	High viscosity industrial gear and steam cylinder oil with low carbon residue.
Pinnacle® Marine Gear 220	220	0.89	220.0	22.7	115	250	-45	–	Synthetic high VI gear oil of ISO VG 220.
Hydraulic Oils									
Rando® HDZ 15	15	0.88	15.0	3.9	155	144	-60	–	High VI hydraulic oil.
Rando® HDZ 22	22	0.95	22.0	5.0	165	165	-48	–	High VI hydraulic oil.
Rando® HDZ 32	32	0.87	32.0	6.3	151	200	-48	–	High VI hydraulic oil.
Rando® HDZ 46	46	0.87	46.0	8.2	154	215	-47	–	High VI hydraulic oil.
Rando® HDZ 68	68	0.88	68.0	11.0	150	222	-42	–	High VI hydraulic oil.
Rando® HDZ 100	100	0.88	100.0	14.2	139	236	-36	–	High VI hydraulic oil.
Clarity® Hydraulic Oil AW 100	100	–	95.0	13.8	145	260	-40	–	Zinc-free and ashless hydraulic fluid (environmentally sensitive areas).
Clarity® Synthetic Hydraulic Oil AW 32	32	–	32.5	7.0	183	220	-45	–	Synthetic, zinc-free, ashless hydraulic oil with an environmentally acceptable formulation.
Clarity® Synthetic Hydraulic Oil AW 46	46	–	46.5	9.3	183	225	-42	–	Synthetic, zinc-free, ashless hydraulic oil with an environmentally acceptable formulation.
Clarity® Synthetic Hydraulic Oil AW 68	68	–	68.5	11.8	162	240	-42	–	Synthetic, zinc-free, ashless hydraulic oil with an environmentally acceptable formulation.
Hydraulic Oil 5606®	15	0.87	15.0	5.5	300+	82	-63	–	High performance general purpose red-dyed hydraulic oil.
Turbine Oils									
GST® Premium 32	32	0.86	31.5	5.4	105	224	-14	–	Premium turbine oil for special Mitsubishi application under MS04-MA-CL002.
Regal R&O® 32	32	0.88	30.4	5.2	100	220	-15	–	Marine turbine oil, including gas turbines.
Regal R&O® 46	46	0.87	43.7	6.5	98	224	-15	–	Marine turbine oil, including gas turbines.
Regal R&O® 68	68	0.86	64.6	8.4	99	245	-15	–	Marine turbine oil, including gas turbines.
Regal R&O® 100	100	0.88	95.0	10.8	97	215	-15	–	ISO VG 100 turbine oil for steam and hydroelectric turbines.
Regal R&O® 320	320	0.89	43.7	6.5	98	252	-15	–	ISO VG 320 turbine oil for steam and hydroelectric turbines.
Regal SGT® 22	22	–	25.6	5.1	123	270	-57	–	Designed for use in modified aviation type gas turbines in non-aviation stationary applications such as industrial power generation and marine service.

	Thickener	Color	Penetration worked at 25°C	Average Drop Point °C	Min/Max Operating Temp °C	NGLI-Class	Description/Application
Greases							
Coupling Grease®	Lithium	Dark Brown	330	190	–10 to 120	1	A tacky lithium grease specifically designed for lubrication of industrial flexible couplings.
Delo® Starplex EP 2	Lithium Complex	Dark Red	280	230+	–35 to 140	2	Multi-purpose EP grease for general applications.
Molytex® EP 2	Lithium	Dark Grey	280	210	–25 to 120	2	Multi-purpose EP grease containing MoS_2 as a solid lubricant for high load applications.
Multifak® EP 0	Lithium	Light Brown	370	180	–30 to 120	0	Multi-purpose EP grease for general applications.
Multifak® EP 1	Lithium	Amber to Brown	325	195	–30 to 120	1	Multi-purpose EP grease for general applications.
Multifak® EP 2	Lithium	Brown	280	195	–30 to 120	2	Multi-purpose EP grease for general applications.
Multifak® EP 3	Lithium	Amber to Brown	235	205	–30 to 120	3	Multi-purpose EP grease for general applications.
Novatex® EP 2	Calcium Anhydrous	Light Yellow	280	>140	–30 to 110	2	Water resistant extreme pressure calcium-12-hydroxystearate grease.
Rust Proof Compound L®	—	Dark Brown	280	—	55 (max)	L	Soft film rust preventive for relatively long-term protection of iron and steel components.
Clarity® Synthetic EA Grease 0	Anhydrous Calcium	—	363	186	–40 to 100	0	Multi-purpose biodegradable EP grease formulated for the lubrication of heavily loaded bearings in wet and corrosive environments, even at low temperatures.
Clarity® Synthetic EA Grease 2	Anhydrous Calcium	Yellow	280	>140	–40 to 100	2	This multi-purpose biodegradable EP grease offers excellent adhesion and water resistance.
SRI Grease®	Polyurea	Dark Green	280	243	–20 to 140	2	Specially formulated grease containing a highly refined paraffinic base oil, synthetic polyurea ashless organic thickener and high-performance rust and oxidation inhibitors.
Starplex® EP 3	Lithium Complex	Brown	220–250	>250	–20 to 150	3	High performance multipurpose grease, formulated for long-term service in roller-and ball-bearing applications, operating at high temperatures and under high loads.
Texclad®	Calcium	Black	280	88	–10 to 60	2	Calcium grease with graphite and MoS_2 for open gears, wire ropes & general grease points of deck equipment.
Ulti-Plex® Synthetic EP	Lithium Complex	Light Tan	315	280	–30 to 230	1.5	Synthetic multi-purpose and high-performance grease for high and low temperature applications.

	ISO VG	Kinematic Viscosity mm²/s (cSt) @ 40°C	Kinematic Viscosity mm²/s (cSt) @ 100°C	Viscosity Index	Flash Point °C	Pour Point °C	Description/Application
Environmentally Acceptable Lubricants†							
Clarity® Synthetic EA Gear Oil 100	100	100	18.0	199	185	–39	Environmentally Acceptable, VGP compliant gear oil.
Clarity® Synthetic EA Hydraulic Oil 100	100	100	18.8	210	193	–48	Environmentally Acceptable, VGP compliant hydraulic and stern tube oil.

† *The specifications for Clarity® Synthetic EA Grease 0 and Clarity® Synthetic EA Grease 2 can be found in the Greases section of this product list.*

	Base	Density at 20°C kg/l	Concentration (In water) %	Freeze Protection °C	Toxic Classification	Seal Compatibility	Content on Nitrite; Amine Phosphate Borate, Silicate	Color	Description/Application
Cooling Water Treatments									
Delo® XLC Antifreeze/Coolant – Concentrate	Ethylene-Glycol based Carboxylic Acid	1.11	50	–37	Harmful	No adverse effect on rubber hoses & gasket materials.	Nil	Orange	Long-life protection against freezing, boiling, corrosion‡.
Delo® XLI Corrosion Inhibitor – Concentrate	Water-based Carboxylic Acid	1.06	5–10	Nil	Low		Nil	Green	Long-life corrosion protection‡.

‡ *Chevron's proprietary inhibitor technology operates by attacking free radical sites on the metal surface and sealing them before corrosion begins, also providing a very efficient heat transfer.*

The data contained in the tables above are typical values shown for information only and may vary from location to location. Consult your original equipment manufacturer for recommendations about selecting the appropriate product for your equipment.

Additional Services

FAST™ Service Contracted customers have access to FAST™, a comprehensive equipment condition monitoring program which reports the condition of oil in service and plots the trends of important properties of the oil.

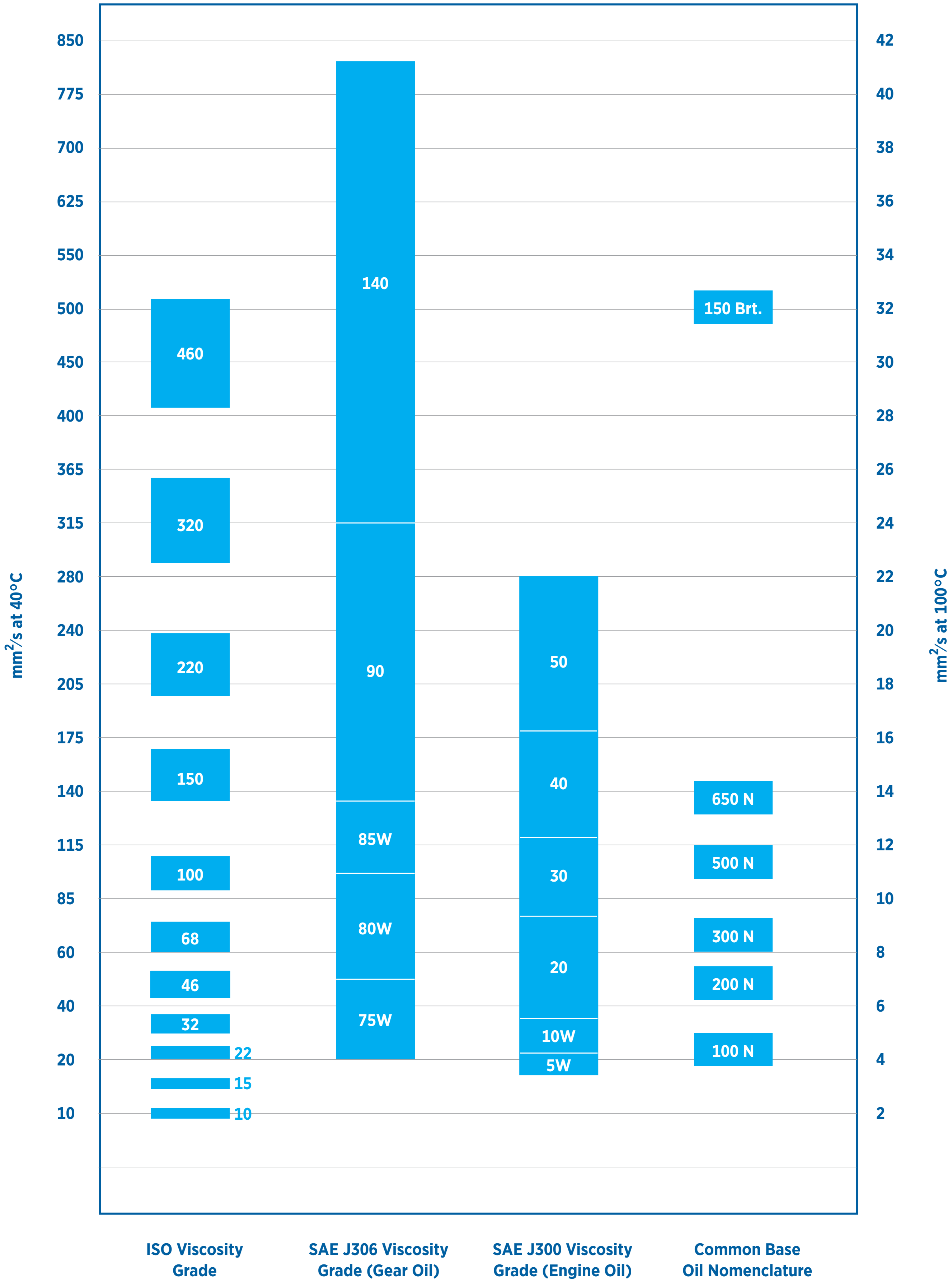
Lubrication Charts Each contracted vessel has a detailed lubrication chart, listing all onboard equipment, lubricants, and the suggested application based on manufacturers' recommendations. Our system enables authorized users to access details on the Internet.

OnePort™ Authorized users can use this Internet-based ordering system to check prices at different ports, place orders and track deliveries through the various stages of supply.

DOT.FAST® Service Contracted customers have access to DOT.FAST®, a complete service including the Drip Oil Analyzer for onboard testing of used cylinder drain oil samples (drip oil) and regular laboratory analysis with expert advice from experienced engineers. Drip Oil Analysis is recommended by the major slow-speed engine builders to better understand piston running conditions in the engine.

Vessel Optimization To protect the equipment that drives your business, Chevron has developed a vessel optimization support program — supported by our industry-experienced technical field staff and lubricants analysis experts — providing advice to reduce your total cost of operation, maximizing uptime and improving reliability. Contact your account manager to find out how Chevron Marine Lubricants can optimize your operation.

Comparative Viscosity Classifications



Chevron

Our Family of Brands

Always confirm that the product selected is consistent with the original equipment manufacturer's recommendation for the equipment operating conditions and customer's maintenance practices.

Chevron

marine lubricants

technical services

Chevron

FAST™ lubricant analysis services

maintain and protect crucial equipment onboard and increase the efficiency of your vessel

protecting your assets in a changing world

The marine industry has experienced great change over recent years and with even more change on the horizon with global sulphur limit legislation, it's more important than ever to protect and ensure optimal operation of your vessels equipment.

In recent years the global marine industry has seen tremendous changes triggered by:

- demand for more efficient engines
- increased environmental awareness and legislation
- global upward pressures on fuel and lubricant prices
- changes in residual fuel oil quality

the range of FAST™ lubricant analysis services:

1

scan to watch a YouTube video about our FAST™ Service

FAST™ Service

Tools and technical support to optimize the efficiency of your engine.

Predictive measures and analysis play a vital role in the maintenance of equipment on board your vessels, and Chevron's FAST™ service can help you identify contamination and wear — **before** it results in costly downtime.

What is FAST?

FAST is a comprehensive fluid analysis service performed in our ISO 17025 certified labs. FAST helps protect your vessels, with online access to a readily accessible database of fluid analysis reports and expert commentary.

FAST™ features and benefits

The advantages of using FAST™ for managing and monitoring the condition of all lubricated equipment on board are numerous:

- ✔ Accurate results on diverse test packages and flexibility for specialized testing procedures
- ✔ Reliable interpretations of test results and actionable recommendations based on the data
- ✔ Reports which have been optimized for readability
- ✔ Expert advice on reports via helpdesk: CMLfast@chevron.com
- ✔ Samples are tested at our dedicated ISO certified laboratories in Belgium and China
- ✔ Cost-effective standard and specialty tests
- ✔ Online access to complete historical records (downloadable through Excel® 5.0 or higher)

what you can expect from implementing this program

FAST™ enables you to track the performance of equipment that your business depends on to get your cargo to points around the globe on time and without incident.

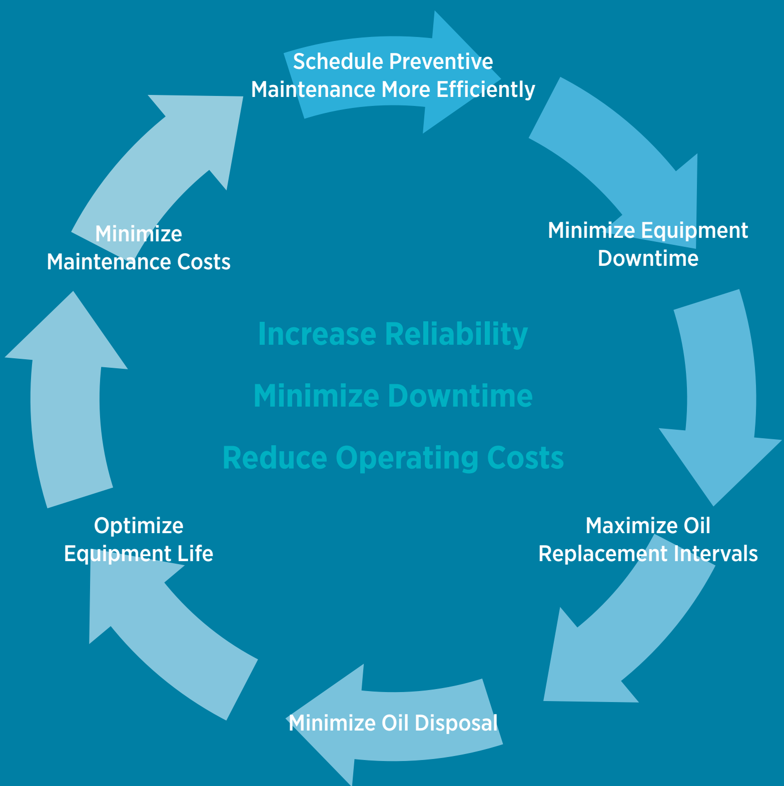
By analyzing operating fluid on a regular basis, you can optimize equipment life and oil replacement intervals — and identify issues before they result in damage — through follow up on the trends of the different parameters.

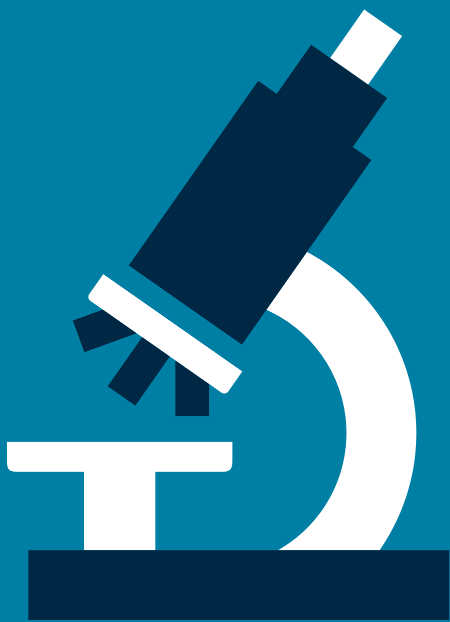
This knowledge helps in the precise scheduling of maintenance work that can help reduce downtime and minimize the risk of equipment failure.

complete fluid analysis for improved marine reliability

The FAST program provides comprehensive analyses for all vessel equipment that requires lubricating oil, greases or coolants. Our stern tube advanced testing, for example, complies with the requirements of the major shipping classification societies.

A FAST report with satisfactory results on the analysis of the stern tube lubricant is a valuable tool when considering the extension of the period between dry-dockings for classification surveys.





ISO 17025 certified laboratories

Chevron's laboratories are some of the best equipped in the marine industry. With facilities in China and Belgium we deliver reliable, expert support wherever you are in the world.

Our global marine team is on call to accurately diagnose the condition of your equipment — FAST!

the FAST™ process

Submitting samples for FAST™ analysis is as easy as 1–2–3.

Prepare sample and complete the information on Label 3.

Add Label 2 to the bottle, keeping Part 1 for your records.

Send the sample bottle along with Label 3 in the sample bag provided.

Customers calling at China mainland ports can send samples to our FAST Chinese laboratory. All other samples should be mailed to our laboratory in Belgium. Most sample analysis will be completed within 24–48 hours of receipt, and your reports are conveniently delivered by email. Address labels can also be downloaded from the Chevron Marine Lubricants website.

standard test packages

FAST simplifies the process of testing with a list of standard tests for frequent, typical applications. Samples are analyzed according to a particular test schedule, depending on the type of lubricant and the application. Examples of typical analysis are indicated to the right.

Engine Oils

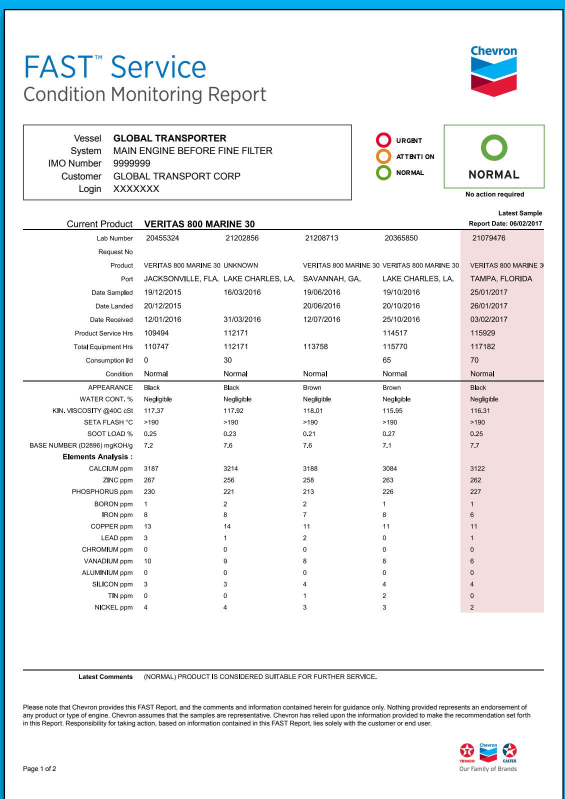
- Appearance
- Water
- Viscosity@40°C
- Base Number
- Soot Load, %wt
- Flash point
- Additive elements
- Wear elements
- (Nature of water*)

* on stern tube and thruster systems

Non-Engine Oils

- Appearance
- Water
- Viscosity@40°C
- Wear elements
- Additive elements
- Total Acid Number
- (Nature of water)

For more information on standard test packages, visit www.chevronmarineproducts.com



FAST™ Service
Condition Monitoring Report

Chevron

Vessel	GLOBAL TRANSPORTER
System	MAIN ENGINE BEFORE FINE FILTER
IMO Number	9999999
Customer	GLOBAL TRANSPORT CORP
Login	XXXXXXX

URGENT
ATTENTI ON
NORMAL

NORMAL
No action required

Current Product	VERITAS 800 MARINE 30				Latest Sample Report Date: 06/02/2017
Lab Number	20455324	21202856	21208713	20365850	21079476
Request No					
Product	VERITAS 800 MARINE 30	UNKNOWN	VERITAS 800 MARINE 30	VERITAS 800 MARINE 30	VERITAS 800 MARINE 3
Port	JACKSONVILLE, FLA.	LAKE CHARLES, LA.	SAVANNAH, GA.	LAKE CHARLES, LA.	TAMPA, FLORIDA
Date Sampled	19/12/2015	16/03/2016	19/06/2016	19/10/2016	25/01/2017
Date Landed	20/12/2015		20/06/2016	20/10/2016	26/01/2017
Date Received	12/01/2016	31/03/2016	12/07/2016	25/10/2016	03/02/2017
Product Service Hrs	109494	112171		114517	115929
Total Equipment Hrs	110747	112171	113758	115770	117182
Consumption l/d	0	30		65	70
Condition	Normal	Normal	Normal	Normal	Normal
APPEARANCE	Black	Black	Brown	Brown	Black
WATER CONT. %	Negligible	Negligible	Negligible	Negligible	Negligible
KIN. VISCOSITY @40C cSt	117.37	117.92	118.01	115.95	116.31
SETA FLASH °C	>190	>190	>190	>190	>190
SOOT LOAD %	0.25	0.23	0.21	0.27	0.25
BASE NUMBER (D2896) mgKOH/g	7.2	7.6	7.6	7.1	7.7
Elements Analysis :					
CALCIUM ppm	3187	3214	3188	3084	3122
ZINC ppm	267	256	258	263	262
PHOSPHORUS ppm	230	221	213	226	227
BORON ppm	1	2	2	1	1
IRON ppm	8	8	7	8	6
COPPER ppm	13	14	11	11	11
LEAD ppm	3	1	2	0	1
CHROMIUM ppm	0	0	0	0	0
VANADIUM ppm	10	9	8	8	6
ALUMINIUM ppm	0	0	0	0	0
SILICON ppm	3	3	4	4	4
TIN ppm	0	0	1	2	0
NICKEL ppm	4	4	3	3	2

Latest Comments (NORMAL) PRODUCT IS CONSIDERED SUITABLE FOR FURTHER SERVICE.

Please note that Chevron provides this FAST Report, and the comments and information contained herein for guidance only. Nothing provided represents an endorsement of any product or type of engine. Chevron assumes that the samples are representative. Chevron has relied upon the information provided to make the recommendation set forth in this Report. Responsibility for taking action, based on information contained in this FAST Report, lies solely with the customer or end user.

Page 1 of 2

TEXACO Chevron CALTEX
Our Family of Brands

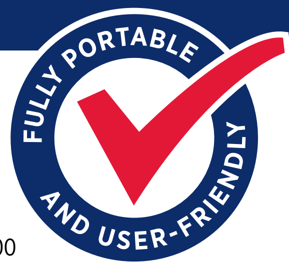
the FAST report

As soon as the lab has completed testing your samples, our in-house experts review the data and provide comprehensive comments and recommendations. Each report includes a traffic light icon, indicating whether the condition of the sample is normal or if further action needs to be taken. The reports also contain historical data for follow up on the trends of the different parameters, providing operators with a full overview of the condition of their equipment.

2

FAST™ OnBoard

Accurately trend the performance of the oils used aboard your vessels.



The FAST OnBoard test kit from Chevron Marine Lubricants offers ship engineers a compact, portable and easy-to-use array of tests to quickly and accurately assess the performance of oils used aboard their vessels.

Benefits of FAST OnBoard

- Portable, lightweight, robust kit
- Fast and easy to use
- Suitable for lubricants, hydraulic, gear, compressor and fuel oils
- Immediate test results, no 'lab lag'
- Continuity in sampling and testing regime
- Key oil parameters monitored
- Non-hazardous reagents
- Supplied with full instruction manual
- Allows the user to monitor trends
- Greater optimization when used alongside DOT.FAST®

Multi-parameter test features

Water — The supplied water test cell, with its easy-to-read digital display, provides instructions and results at various concentrations from 200–10,000 ppm, 0–10%.

Base Number — Utilizing the same reaction cell used for water, the FAST OnBoard Kit reports the used BN value for oils up to 150 BN.

Insolubles — Chromatography papers easily display soot/carbon accumulation in the lubricating oil. High insoluble content in engine oils can be caused by poor combustion, poor filtration/separation, or keeping the oil in service for too long. High soot content can lead to increased viscosity and filter blocking.

Viscosity Comparator — Recognized as one of the most important oil characteristics, the Viscostick provides a direct comparison of a used oil viscosity against a sample of the new oil, helping to identify fuel dilution, oxidation, emulsification issues.

Salt Water Determination — A simple colour change pad easily indicates Sodium Chloride contamination from seawater.

Why should you use FAST OnBoard?

- Identifies earliest onset of change in the condition of your asset
- Allows engineers to take immediate action based on results
- Enables identification and use of correct grades and types of oil
- Encourages a monitoring culture on-board vessels
- Regular testing of critical operating equipment saves costs

FAST OnBoard features by application

Application	Water	Base Number	Insolubles	Viscosity	Salt Water
New diesel engine oil	✔	✔	✔	✔	✔
Used diesel engine oil	✔	✔	✔	✔	✔
Cylinder/Scrapedown oil	✔	✔			
Hydraulic oil	✔			✔	✔
Gear oil	✔			✔	✔
Greases	✔				
Compressor oil	✔		✔	✔	
Turbine oil	✔		✔	✔	
Heavy fuel oil (HFO)	✔			✔	✔
Marine gas oil (MGO)	✔				✔
Diesel fuel	✔		✔		✔

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scan to watch a YouTube video about our DOT.FAST® Service

DOT.FAST® service

"Continuous monitoring of drain oil samples is a good way to optimize the cylinder oil feed rate and consumption and to safeguard the engine against excessive wear. The fastest way to evaluate the corrosive behavior of an engine and optimize the feed rate is to do a stress test, a so-called sweep test. It can also be used in the ACC familiarization period to find the suitable lube oil feed rate for your particular engine, operating pattern and lube oil used."

MAN Energy Solutions SE

"Measuring the total iron content of piston underside drain oil with Chevron's DOT.FAST® Service provides very valuable feedback of the piston running conditions in each cylinder, and allows operators to optimize cylinder oil feed rates for a specific set of operating conditions."

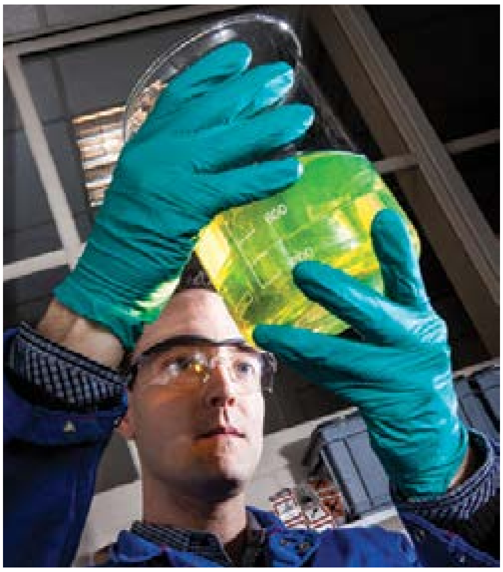
Wärtsilä Switzerland

why should your fleet use drip oil analysis?

With IMO 2020 bringing the greatest change to the marine industry in many years, it's critical to ensure optimized engine operation as you navigate change. Whatever your 2020 compliance option, DOT.FAST will help you reduce wear and corrosion, ensure the correct feed-rate and increase engine efficiency.

For this reason, it is now more important than ever to better understand and balance conditions in your engine.

Drip oil analysis can give you the answers and is recommended by the major slow speed 2-stroke engine OEMs (MAN Energy Solutions SE & Winterthur Gas & Diesel Ltd.). Analysis of unburned cylinder lubricant which has passed the piston and rings to the main engine stuffing box is an effective way to monitor engine wear using DOT.FAST.



The DOT.FAST Onboard Test Kit consists of the Drip Oil Analyzer, pipette, DispoRack™, and DOT.FAST Onboard Software.

"It is MAN's experience that, in addition to regular scavenge port inspections, drip oil analysis can be a very useful tool to monitor combustion and cylinder conditions.

"Drip oil analysis can detect changes in cylinder liner wear and help to optimize the cylinder oil feed rate.

"Chevron's DOT.FAST® Service makes it possible to monitor, both onboard and onshore, the total amount of adhesive, abrasive and corrosive wear."

MAN Energy Solutions SE

the DOT.FAST® service provides your fleet with accurate and comprehensive onboard and onshore analysis of drip oil, and takes the *total iron wear* into account

Everything you need to get started is supplied with your first order, where we then make sure that with every DOT.FAST onboard analyzer at least one DispoRack is included.

Chevron's Drip Oil Analyzer and MicroMan® Pipette

DispoRack™ with 12 ITUs (Iron Testing Units)

onboard analysis

The benefits you may receive from onboard analysis include:

- Reliable OnBoard wear measurement with laboratory accuracy
- Immediate feedback on cylinder running conditions
- Optimized cylinder lubrication at different engine operating modes
- Early indication of elevated engine wear of any type
- Minimized build-up of abrasive deposits and engine fouling
- Reduced risk of scuffing
- Minimized cylinder oil consumption by optimizing cylinder oil feed rate
- Combined with on board testing of the Base Number, it is possible to determine if the wear is of corrosive nature.
- Easy compliance with engine builders' recommendations
- Better engine protection while fuels of varying quality and catfine content are in use
- Increased time between overhauls
- Predictive maintenance and less downtime, i.e., Condition Based Monitoring (CBM)
- Monitoring of running-in of new units
- A valuable complement to regular engine inspections

onshore analysis

The additional benefits of onshore analysis may include:

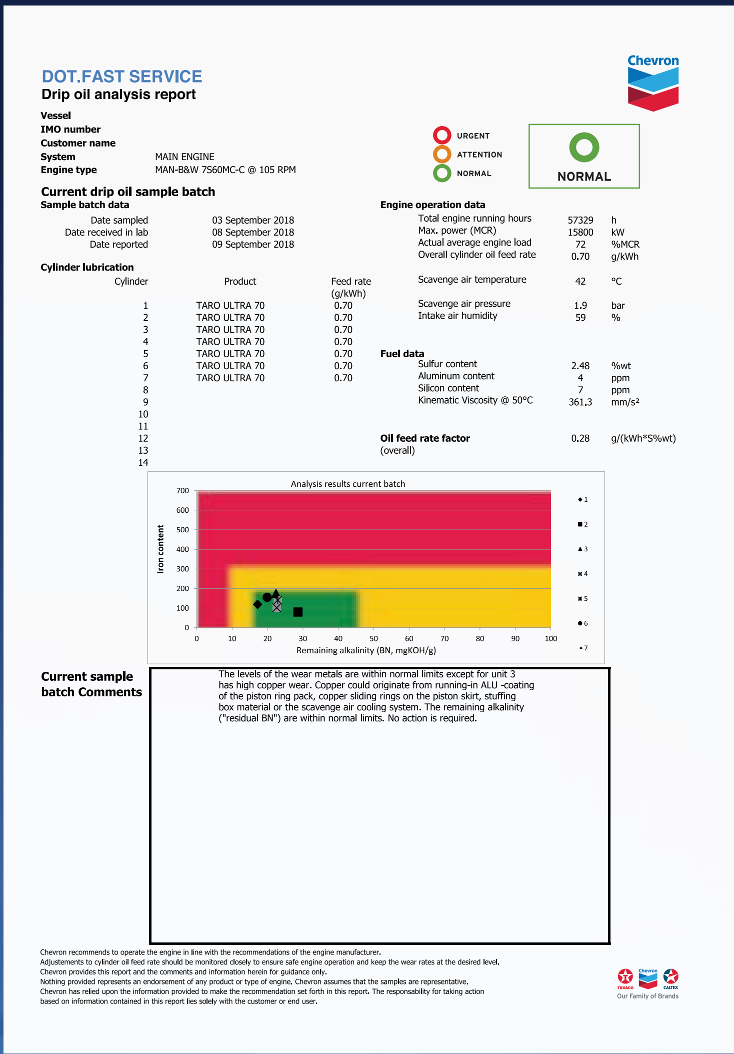
- Testing of drip oil samples via highest industry standards in two quality certified laboratories
- Comprehensive reporting with to-the-point commenting considering the full picture
- Monitoring effectiveness of fuel purification through measurement of CAT Fines
- Identifying excessive system oil leakage (for example, through stuffing box glands)
- Monitoring of piston ring groove wear
- Indication of blow-by

250 running hours

Recommended sampling frequency for ***Onboard*** Drip Oil Analysis (or each time the vessel switches to a new batch of HFO).

1,000 running hours

Recommended sampling frequency for ***Onshore*** Drip Oil Analysis.



DOT.FAST SERVICE

Drip oil analysis report

Vessel
IMO number
Customer name
System MAIN ENGINE
Engine type MAN-B&W 7S60MC-C @ 105 RPM

URGENT
ATTENTION
NORMAL

NORMAL

Current drip oil sample batch

Sample batch data

Date sampled	03 September 2018
Date received in lab	08 September 2018
Date reported	09 September 2018

Cylinder lubrication

Cylinder	Product	Feed rate (g/kWh)
1	TARO ULTRA 70	0.70
2	TARO ULTRA 70	0.70
3	TARO ULTRA 70	0.70
4	TARO ULTRA 70	0.70
5	TARO ULTRA 70	0.70
6	TARO ULTRA 70	0.70
7	TARO ULTRA 70	0.70
8		
9		
10		
11		
12		
13		
14		

Engine operation data

Total engine running hours	57329	h
Max. power (MCR)	15800	kW
Actual average engine load	72	%MCR
Overall cylinder oil feed rate	0.70	g/kWh
Scavenge air temperature	42	°C
Scavenge air pressure	1.9	bar
Intake air humidity	59	%

Fuel data

Sulfur content	2.48	%wt
Aluminum content	4	ppm
Silicon content	7	ppm
Kinematic Viscosity @ 50°C	361.3	mm/s²

Oil feed rate factor (overall) 0.28 g/(kWh*S%wt)

Current sample batch Comments

The levels of the wear metals are within normal limits except for unit 3 has high copper wear. Copper could originate from running-in ALU -coating of the piston ring pack, copper sliding rings on the piston skirt, stuffing box material or the scavenge air cooling system. The remaining alkalinity ("residual BN") are within normal limits. No action is required.

Chevron recommends to operate the engine in line with the recommendations of the engine manufacturer.
Adjustements to cylinder oil feed rate should be monitored closely to ensure safe engine operation and keep the wear rates at the desired level.
Chevron provides this report and the comments and information herein for guidance only.
Nothing provided represents an endorsement of any product or type of engine. Chevron assumes that the samples are representative.
Chevron has relied upon the information provided to make the recommendation set forth in this report. The responsability for taking action based on information contained in this report lies solely with the customer or end user.

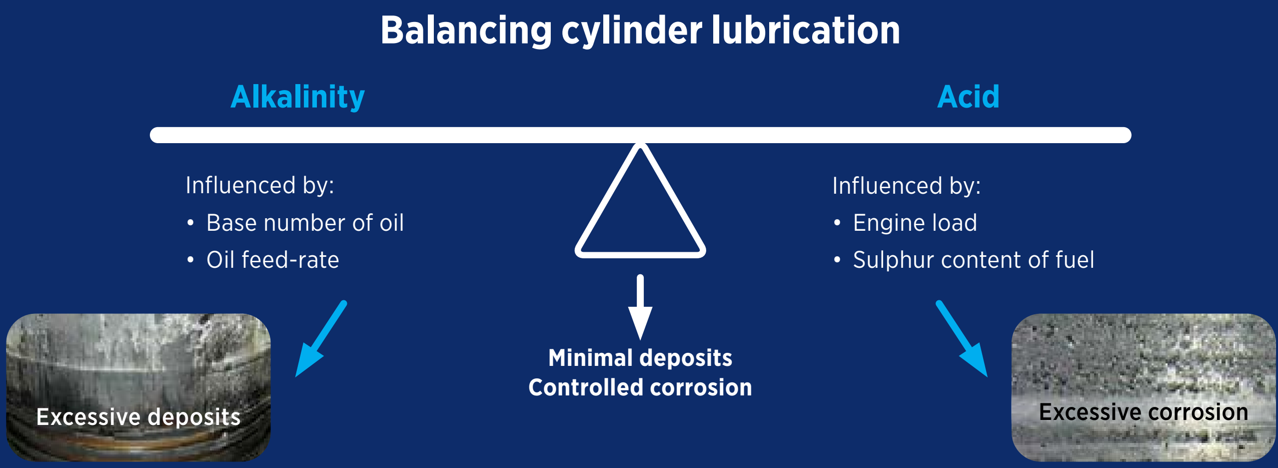
Our Family of Brands

Chevron's laboratories provide complete analysis of your samples with review and comments by technical experts.

field experience

The DOT.FAST® Service was evaluated in cooperation with operators and equipment builders in the marine and power generation industries.

In field tests onboard Wallenius Marine's M/V *Undine* and Suisse Atlantique's M/V *Général Guisan*, lubrication engineers and crew members found the DOT.FAST Drip Oil Analyzer to be both effective and easy to operate.



the sulphur/base balance

High sulphur fuel oil burns to produce oxides of sulphur (SOx) during combustion. In the presence of water, these SOx form sulphuric acid which causes corrosion in the engine; different levels of sulphur in the fuel oil contribute to varying levels of acidity.

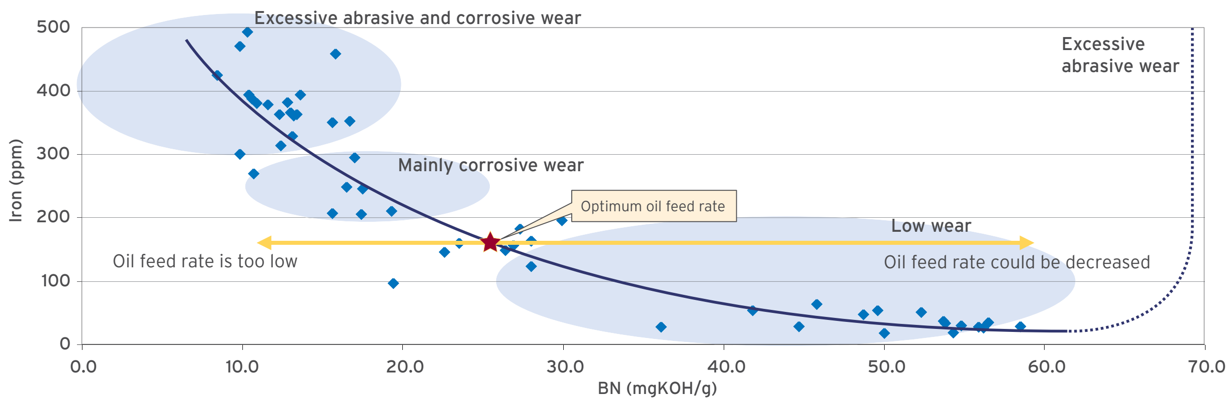
One task for the cylinder oil is to protect the engine from acidic corrosion. This is achieved by the alkalinity of the cylinder oil, defined by its base number (BN) and its feed rate. Too much alkalinity however, will result in the formation of excessive abrasive deposits on the piston crown top lands, ultimately leading to increased liner wear and scuffing.

It is important to maintain the correct sulphur/base balance. This balance can be achieved by changing to a cylinder oil with an appropriate BN, by adjusting the cylinder oil feed rate or a combination of the two. Chevron Marine Lubricants offers cylinder oils with a very wide BN range, going from 20 BN to 140 BN (Taro® Ultra 20, Taro Ultra 40, Taro Ultra 70, Taro Ultra 100, and Taro Ultra 140).

The **total iron content** measured by DOT.FAST® indicates the total wear taking place in the engine, including corrosive wear, enabling you to make any necessary adjustments.

Fe

DOT.FAST OnBoard Drip Oil Analysis provides accurate measurement of **total iron wear** including **corrosive wear**.



This graph is based on real time data and will vary from engine to engine.

Iron Content as Function of BN

onboard analysis

The DOT.FAST® Drip Oil Analyzer is unique and innovative in the industry and delivers onboard test results with laboratory accuracy. The DOT.FAST Drip Oil Analyzer comes with everything you need to prepare and test samples, including a custom-designed DispoRack and software to record, process and interpret results.

Using the Drip Oil Analyzer once every two weeks ensures effective management of your engine's lubrication. It can also be beneficial to do onboard drip oil analysis after changing to a new batch of fuel oil or to monitor the running-in process of new overhauled units.

onshore analysis

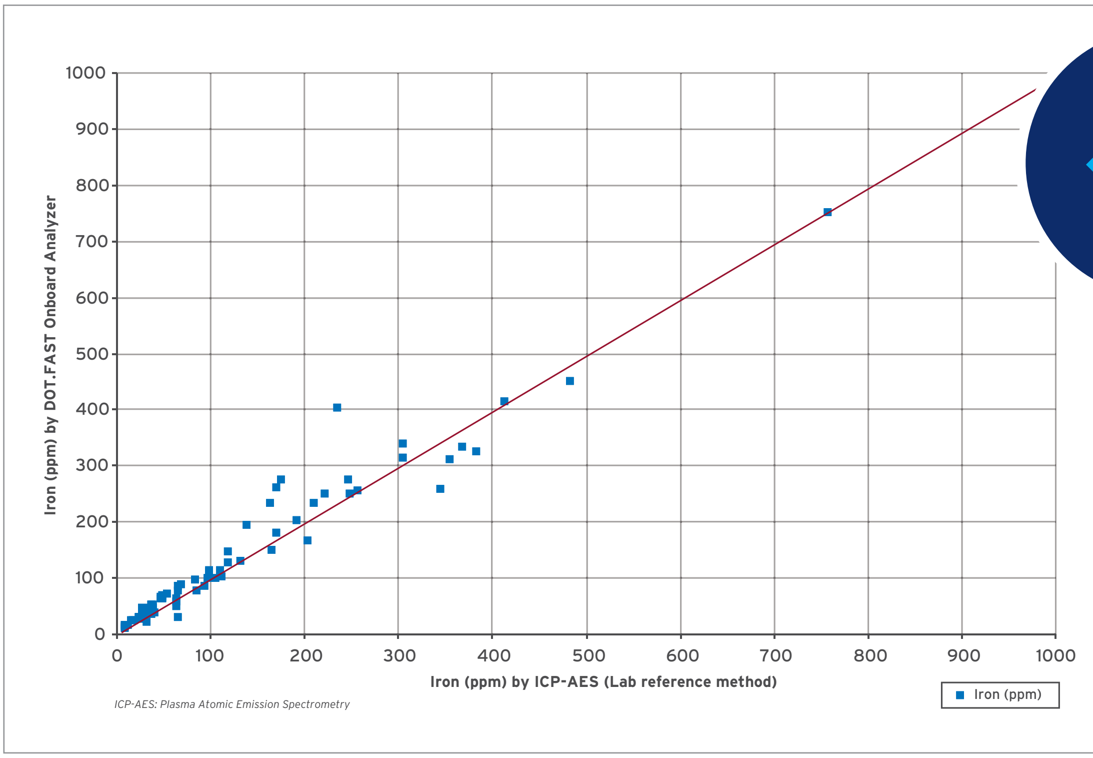
Samples sent to Chevron's laboratory are fully analyzed (base number, iron and all other elements). The results are tabulated and reviewed by technical experts.

Recommendations are reported back to the ship. Historical data is maintained and can be accessed via a password-protected Internet site.

Subscribers to the DOT.FAST Service may send a full set of samples for analysis once every two months.

Always confirm that the product selected is consistent with the original equipment manufacturer's recommendation for the equipment operating conditions and customer's maintenance practices.

Correlation Between Onboard and Onshore Analysis



Extensive testing has shown that the DOT.FAST Drip Oil Analyzer provides unbiased results compared with ICP-AES used in a laboratory setting.

4

A feed rate sweeptest is helpful in shortening the oil feed rate factor (g/kWh * S%wt) familiarization period.

sweeptest sample analysis

Performing a sweeptest is the shortest way to determine the optimal oil feed rate factor, bringing **valuable cost saving** efficiencies to your operation, and is recommended by major OEMs such as MAN Energy Solutions AS.

Analysis of sweeptest oil samples is conducted on-shore at our ISO certified laboratories, and customers receive feedback in a fully reviewed FAST™ report within 24–48 hours of receipt of the final sample. These reports indicate what the optimum oil feed rate factor (g/kWh * S%wt) is with the given cylinder oil in use. FAST sample kits contain everything you need to conduct the tests, including standard sized sample bottles, labels and pre-addressed envelopes for our laboratories.

sweeptest sample delivery

To be included with each batch of samples:

Completed DOT.FAST® engine data sheet

Download a copy from the DOT.FAST CD-ROM or from the CML website:

chevronmarineproducts.com/en_UK/lubricants-services/dotfast-drip-oil-analysis-service.html

Batches received without this sheet will not be analyzed.

One main engine system oil used sample

Required in order to calculate the amount of system oil dilution in the drip oil samples.

Fully completed FAST sample labels for each bottle

These tests will be handled separately in the laboratory.

Testing guidelines:

1. **For the cylinder oil to be evaluated, collect drip oil samples at different cylinder oil feed rates**. A typical approach is to start at 1.4 g/kWh and lower in steps of 0.2 g/kWh to the OEM minimum recommended. For every step, collect the samples after 24 running hours from every cylinder at the same time (complete batch of samples)
2. **Use FAST labels** and indicate the corresponding cylinder number on the label. Fully complete a FAST label for any system oil sump tank sample included.
3. **Always include a completed DOT.FAST engine data sheet with every batch of samples.**
4. **Send completed sweeptests to our global FAST laboratories.** Please do not sent FAST samples to the personal attention of any of our staff as this will delay processing (use addresses located on back).

5

Regular testing of the condition of your cooling water is easy with Delo® XLI and XLC cooling water treatment.

cooling water monitoring

Field and laboratory tests prove that Chevron's Delo® cooling water treatments provide maximum protection and last longer than traditional technologies in your marine or power generation systems.

Delo® XLI and XLC cooling water treatments combine excellent performance with long service life to help keep your engines running for longer. In fact, if Delo cooling water treatments are replenished regularly to compensate for leakage, the cooling water can be considered as fill for life. It is vital to test the cooling water at Chevron's recommended test frequency, so, ensure to check the Delo inhibitor/glyco concentration every week, check the chloride levels once a week and do a full FAST™ analysis of all systems on a half-yearly basis.

easy, cost-effective monitoring

Save time and money by monitoring your cooling water condition with onboard testing and FAST™ services.

Comprehensive FAST™ reports

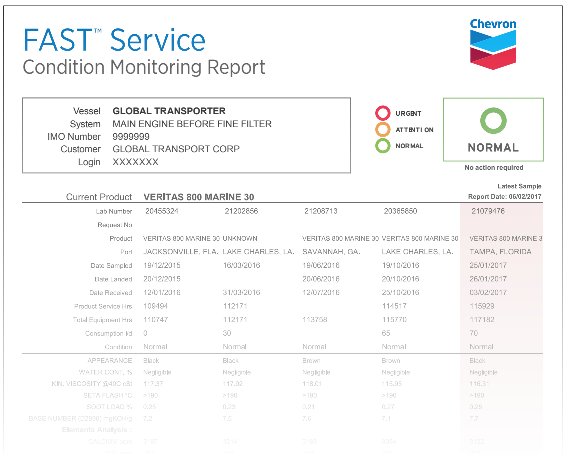
Chevron's FAST service provides in-depth onshore analysis of your cooling water samples at advanced global laboratories. We report on several parameters and elements in your cooling water samples, as part of our comprehensive equipment monitoring program.

Chloride and pH monitoring is easy

Delo XLI's Organic Acid Inhibitor Technology (OAT) corrosion inhibitor system is designed to protect cast iron, copper and other system metals at lower pH levels than conventional coolants. Acid and base indicator strips are used to easily measure pH balance. High chloride levels can significantly increase the risk of corrosion, and are also evidence of seawater contamination in the system.

For onboard testing, test strips can be used for quickly and conveniently measuring rough chloride levels in cooling water. Chevron recommends testing the Delo inhibitor cooling water treatment's concentration, pH value and chloride levels once a week.

Below, left to right: Chevron's FAST Service Condition Monitoring Report, pH and chloride test strips.



FAST™ Service
Condition Monitoring Report

Chevron

Vessel GLOBAL TRANSPORTER
System MAIN ENGINE BEFORE FINE FILTER
IMO Number 9999999
Customer GLOBAL TRANSPORT CORP
Login XXXXXXX

URGENT
ATTENTION
NORMAL

NORMAL
No action required

Current Product VERITAS 800 MARINE 30

					Latest Sample Report Date: 06/02/2017
Lab Number	20455324	21202856	21208713	20365850	21079476
Request No					
Product	VERITAS 800 MARINE 30	UNKNOWN	VERITAS 800 MARINE 30	VERITAS 800 MARINE 30	VERITAS 800 MARINE 3
Port	JACKSONVILLE, FLA.	LAKE CHARLES, LA.	SAVANNAH, GA.	LAKE CHARLES, LA.	TAMPA, FLORIDA
Date Sampled	19/12/2015	16/03/2016	19/06/2016	19/10/2016	25/01/2017
Date Landed	20/12/2015		20/06/2016	20/10/2016	26/01/2017
Date Received	12/01/2016	31/03/2016	12/07/2016	25/10/2016	03/02/2017
Product Service Hrs	109494	112171		114517	115929
Total Equipment Hrs	110747	112171	113758	115770	117182
Consumption l/d	0	30		65	70
Condition	Normal	Normal	Normal	Normal	Normal
APPEARANCE	Black	Black	Brown	Brown	Black
WATER CONT. %	Negligible	Negligible	Negligible	Negligible	Negligible
KIN. VISCOSITY @40C cSt	117.37	117.92	118.01	115.95	116.31
SETA FLASH °C	>190	>190	>190	>190	>190
SOOT LOAD %	0.25	0.23	0.21	0.27	0.25
BASE NUMBER (D2896) mgKOH/g	7.2	7.6	7.6	7.1	7.7
Elements Analysis :					
CALCIUM ppm	3187	3214	3188	3084	3122

all samples from any of the lubricant analysis services mentioned in this brochure are to be sent to the following addresses:

Inform the courier company that the receiver is ‘Warehouse Assistant’.

Chevron Marine Lubricants — FAST Program
CSGS Belgium NV
Polderdijkweg 16
B-2030 Antwerpen
Belgium
Tel. +32 (0)35458411

Couriers’ contact: Sample reception,
Tel. +32 (0)35458439

Samples landed in mainland China can be sent to our laboratory in Shanghai:

Chevron Marine Lubricants — FAST Program
SGS-CSTC Standards Technical Services Co. Ltd
88 Pugong Rd, Fengxian District,
Shanghai Chemical Industrial Park,
Shanghai 201507, China
上海市奉贤区化学工业区普工路88号（201507）

Tel: +86 (21)60887042

Couriers’ contact: Fountain Luo 罗春芳,
Tel. +86 (21)60276363

Search our YouTube channel for Chevron Marine Lubricants training videos on how to conduct safe, reliable tests and visit our website chevronmarineproducts.com for more FAST resources.

www.chevronmarineproducts.com

Always confirm that the product selected is consistent with the original equipment manufacturer’s recommendation for the equipment operating conditions and customer’s maintenance practices.

marine lubricants

FAST™

lubricant sample kit instructions

How to take good samples:

Since FAST analysis requires relatively small quantities of oil, you must exercise great care to ensure that your samples are truly representative of a particular system or piece of equipment. The following steps will assist you in taking representative samples.

- ✔ Ensure that sample containers are clean, dry and free of possible contaminants.
- ✔ Establish a sample point for each piece of machinery, preferably a point where the oil is flowing steadily.
- ✔ Always take the samples from the same sampling point.
- ✔ Take the sample when the machinery is running at operating temperature, if at all possible.
- ✔ Flush about one liter of oil from the sample point to allow for the removal of any entrapped water or debris.
- ✔ Fill the Chevron sample bottle at the sampling point.
- ✔ **Close the sample bottle tightly and wipe off any excess oil from the outside of the bottle to avoid any contamination of other items during delivery to our laboratory.**

Sampling intervals

Except for special circumstances, where there is a good reason to believe that a potential problem could exist (such as accidental contamination), the number of samples submitted for analysis per piece of equipment should be kept to a minimum and should be restricted to those that are technically necessary and economically justified. General guidelines for the sampling of propulsion machinery and auxiliary equipment are given in the table below.

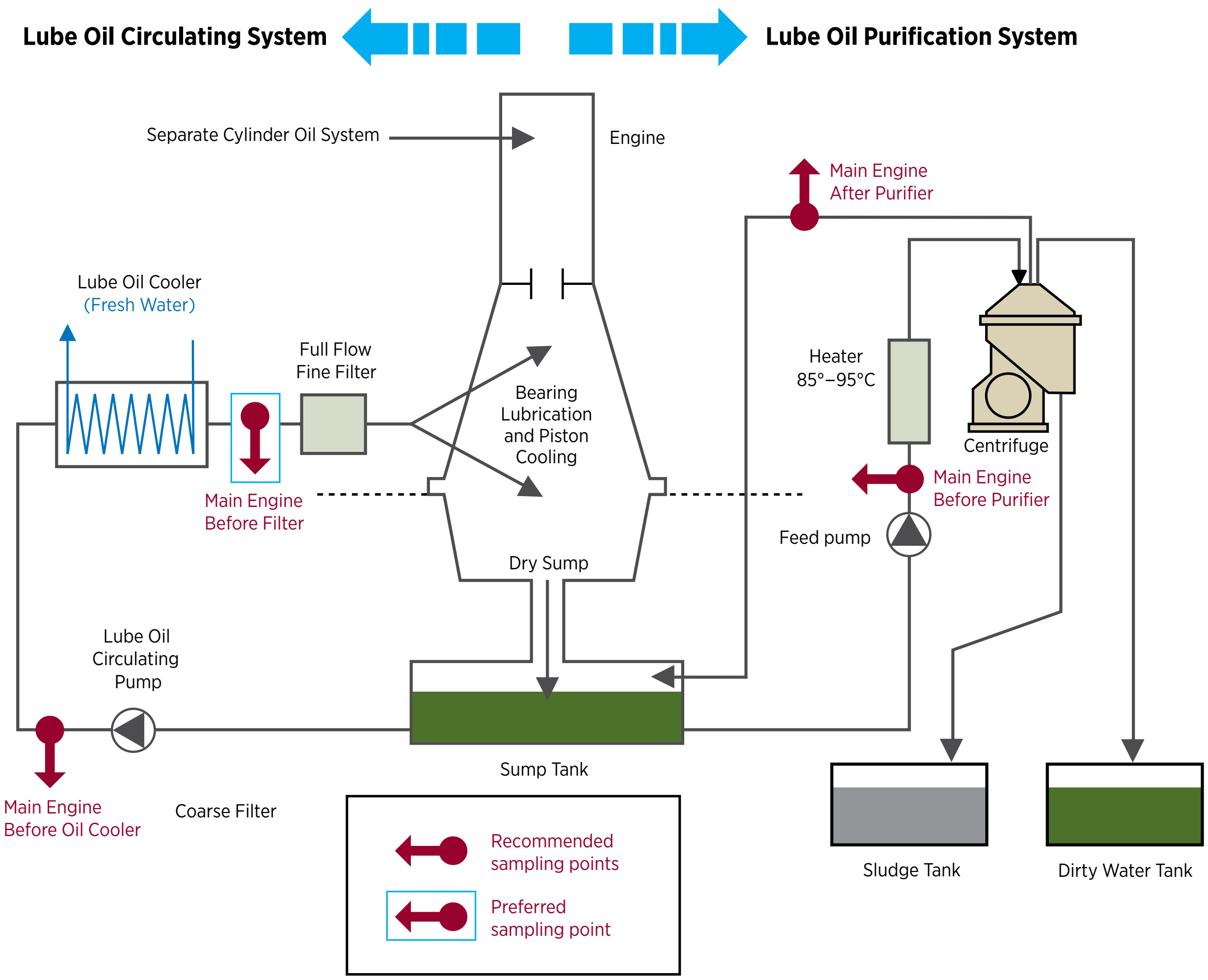
Propulsion machinery

Slow-speed engine	4–6 months
Medium-speed engine	4–6 months
Steam turbine	6–12 months
Auxiliary diesel engines	6–8 months
Stern tubes	As requested by surveyor (usually 4 samples per year)

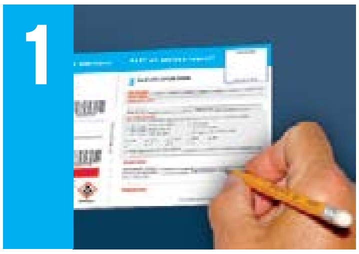
Examples of good sampling points

Main engine	Main engine before fine filter (preferred), before and after purifier, before oil coolers (discharge side of the circulating oil pump, feed pump).
Compressors	Mid-point of the crankcase or bearing return line.
Gears	Return line, before the filter.
Hydraulic systems	Return line, before the filter.
Pumps	Bearing return line.
Turbines	Bearing return line.
Storage tanks	Draw samples from both the top and near the bottom and mix together in equal portions.

Recommended Sampling Points



Sampling is as easy as…



Prepare sample and complete the information on Part 3.

Attach Part 2 to the bottle, keeping Part 1 for your records.

Send the sample bottle along with Part 3 in the sample bag provided.

1 Complete a FAST Oil Analysis Request form for each sample.

- ✔ Pay close attention that required fields are completed (IMO Number, Vessel Name, Owner/Operator, Vessel Equipment and Product Name). Failure to do so will result in sample processing delays.
- ✔ Check Chevron sample point tag or previous FAST report for consequent equipment naming.
- ✔ Close the sample bottle tightly.

2 Attach the 'Caution' portion of the form to each sample bottle.

3 Place the sample bottle(s) and FAST Oil Analysis Request form(s) in the sample bag provided and hand the completed package to the ship's agent for delivery to the laboratory.

Customers calling at China mainland ports can send samples to our FAST Chinese laboratory. All other samples should be mailed to our laboratory in Belgium. Most sample analysis will be completed within 24–48 hours of receipt, and conveniently delivered by email.

Keep Part 1 of the form on board for your record.

Send Part 3 with sample.

Attach Part 2 to sample bottle.

Attention:

- ✔ **Do not copy labels!** Each sample request must have a unique number.
- ✔ Add extra oil samples for additional testing requests.
- ✔ Add other information on FAST labels.
- ✔ **Peel off Part 2 label ONLY**. Keep backing on Parts 1 and 3 for easy handling.

marine lubricants

DOT.FAST® service

quick start guide — sampling and analysis

Step 1 | Sample the drip oil

- Sample at the scavenge air drain sampling valve during stable engine running conditions.
- Flush well before sampling.
- Collect a sample of 50–100 ml in a clean plastic container.
- Transfer that sample in a FAST sample bottle for both onshore and onboard testing and identify the bottle well.

Recommended sampling frequency:

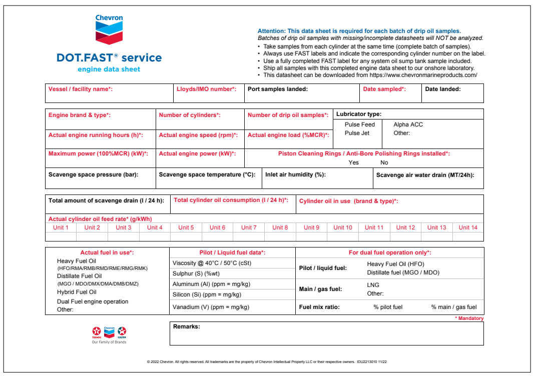
Onshore Drip Oil Analysis:
Every 2 months (~1000 running hours)

Onboard Drip Oil Analysis:
Every 2 weeks (~250 running hours)

Test frequency can be changed depending on situation, needs and experience (e.g., after using new fuels batches, after an overhaul, after a corrective action and oil feed rate adjustment, etc.).

Step 2 | Collect the data and complete the Engine Data Sheet

Note: Drip Oil samples intended for onshore analysis should always be accompanied with a complete Engine Data Sheet. The Engine Data Sheet can be found in the DOT.FAST kit, and additional copies are easily downloaded from the Chevron website at www.chevronmarineproducts.com/en_UK/lubricants-services/dot-fast.html



Chevron

DOT.FAST® service
engine data sheet

Attention: This data sheet is required for each batch of drip oil samples.
Batches of drip oil samples with missing/incomplete datasheets will NOT be analyzed.
- Take samples from each cylinder at the same time (complete batch of samples).
- Always use FAST labels and indicate the corresponding cylinder number on the label.
- Use a fully completed FAST label for any system oil sump tank sample included.
- Ship all samples with this completed engine data sheet to our onshore laboratory.
- This datasheet can be downloaded from https://www.chevronmarineproducts.com/

Vessel / facility name*:	Lloyds/IMO number*:	Port samples landed:	Date sampled*:	Date landed:

Engine brand & type*:	Number of cylinders*:	Number of drip oil samples*:	Lubricator type: Pulse Feed, Pulse Jet, Alpha ACC, Other:
Actual engine running hours (h)*:	Actual engine speed (rpm)*:	Actual engine load (%MCR)*:	
Maximum power (100%MCR) (kW)*:	Actual engine power (kW)*:	Piston Cleaning Rings / Anti-Bore Polishing Rings installed*: Yes No	
Scavenge space pressure (bar):	Scavenge space temperature (°C):	Inlet air humidity (%):	Scavenge air water drain (MT/24h):

Total amount of scavenge drain (l / 24 h):	Total cylinder oil consumption (l / 24 h)*:	Cylinder oil in use (brand & type)*:

Actual cylinder oil feed rate* (g/kWh)

Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Unit 14

Actual fuel in use*:	Pilot / Liquid fuel data*:	For dual fuel operation only*:
Heavy Fuel Oil (HFO/RMA/RMB/RMD/RME/RMG/RMK)	Viscosity @ 40°C / 50°C (cSt)	Pilot / liquid fuel: Heavy Fuel Oil (HFO), Distillate fuel (MGO / MDO)
Distillate Fuel Oil (MGO / MDO/DMX/DMA/DMB/DMZ)	Sulphur (S) (%wt)	
Hybrid Fuel Oil	Aluminum (Al) (ppm = mg/kg)	Main / gas fuel: LNG, Other:
Dual Fuel engine operation	Silicon (Si) (ppm = mg/kg)	
Other:	Vanadium (V) (ppm = mg/kg)	Fuel mix ratio: % pilot fuel % main / gas fuel

* Mandatory

Remarks:

Our Family of Brands

Step 3 | Analyze the drip oil samples using the DOT.FAST® Onboard Test Kit

3.1 Always use recommended personal protection equipment.

3.2 Set up the test equipment and samples in a clean environment.

3.3 Identify the ITUs with corresponding cylinder number. Include one extra blank ITU if zeroing the Drip Oil Analyzer.

3.4 Take the oil sample correctly with the pipette and dispense in the ITU.

3.5 Close the ITU, crush ALL four ampoules and shake well. If zeroing, use the same process for the blank ITU (e.g., crush all four ampoules and shake well).

3.6 Tap the ITU content to the bottom and rest the ITU in a sloping position.

Rest time:

BROWN:	~1 hr
BLACK:	~3 hrs
CLEAR:	~1 hr

3.7 Prepare the Drip Oil Analyzer and zero if necessary. See the DOT.FAST® Instruction Manual, Section 3.4, Steps 11 and 17–21 for details on how to zero the Drip Oil Analyzer. **Important: do not press the ZERO button with an actual sample in place**. Ensure that the cuvette is filled with clear liquid from the blank ITU (see Manual, Section 3.4, Step 20).

3.8 Place a cuvette in the DispoRack™ and attach a filter to the ITU.

3.9 Turn the ITU upside down above the cuvette and wait, allowing the liquid to separate into two layers. Then push the clear bottom layer into the cuvette until it reaches the mark.

3.10 Immediately place the cuvette in the Drip Oil Analyzer, read and record the result using the DOT.FAST® Worksheet.

3.11 Repeat for each ITU.

Note: Keep your equipment clean and free from dust. In case of spills, wipe the wet surfaces clean immediately.

Step 4 | Enter the data

Enter all test results and the recorded data from the Engine Data Sheet into the DOT.FAST Onboard Software.

Step 5 | Dispose of the waste

Dispose of used ITUs and their content according to the waste management plan required by MARPOL regulations. Empty the oil-reagent mixture from each cuvette and ITU in a suitable container that can be drained to the sludge tank. Treat and dispose the remaining plastic container as mixed waste.

For further detailed information, please refer to the DOT.FAST Instruction Manual.

For any technical inquiries about the DOT.FAST Service, please contact your local Chevron sales representative or our Technical Services Help Desk (DOT.FAST@chevron.com).

Visit www.chevronmarineproducts.com for more information and resources about the DOT.FAST Service.

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DOT.FAST® service

engine data sheet

Attention: This data sheet is required for each batch of drip oil samples.

Batches of drip oil samples with missing/incomplete datasheets will NOT be analyzed.

- Take samples from each cylinder at the same time (complete batch of samples).
- Always use FAST labels and indicate the corresponding cylinder number on the label.
- Use a fully completed FAST label for any system oil sump tank sample included.
- Ship all samples with this completed engine data sheet to our onshore laboratory.
- This datasheet can be downloaded from https://www.chevronmarineproducts.com/

Vessel / facility name*:	Lloyds/IMO number*:	Port samples landed:	Date sampled*:	Date landed:

Engine brand & type*:	Number of cylinders*:	Number of drip oil samples*:	Lubricator type: Pulse Feed, Pulse Jet, Alpha ACC, Other:
Actual engine running hours (h)*:	Actual engine speed (rpm)*:	Actual engine load (%MCR)*:	
Maximum power (100%MCR) (kW)*:	Actual engine power (kW)*:	Piston Cleaning Rings / Anti-Bore Polishing Rings installed*: Yes No	
Scavenge space pressure (bar):	Scavenge space temperature (°C):	Inlet air humidity (%):	Scavenge air water drain (MT/24h):

Total amount of scavenge drain (l / 24 h):	Total cylinder oil consumption (l / 24 h)*:	Cylinder oil in use (brand & type)*:

Actual cylinder oil feed rate* (g/kWh)

Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Unit 14

Actual fuel in use*:	Pilot / Liquid fuel data*:	For dual fuel operation only*:	
Heavy Fuel Oil (HFO/RMA/RMB/RMD/RME/RMG/RMK)	Viscosity @ 40°C / 50°C (cSt)	Pilot / liquid fuel:	Heavy Fuel Oil (HFO) Distillate fuel (MGO / MDO)
Distillate Fuel Oil (MGO / MDO/DMX/DMA/DMB/DMZ)	Sulphur (S) (%wt)		
Hybrid Fuel Oil	Aluminum (Al) (ppm = mg/kg)	Main / gas fuel:	LNG Other:
Dual Fuel engine operation	Silicon (Si) (ppm = mg/kg)		
Other:	Vanadium (V) (ppm = mg/kg)	Fuel mix ratio:	% pilot fuel % main / gas fuel

* Mandatory

Remarks:

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worksheet

DATE______________________________________ BY ______________________________________

Cylinder Unit	Iron (ppm)	BN (mg KOH/g)	Cylinder Oil Feed Rate* ❑ g/kWh ❑ g/bhph **Measured @** ❑ Actual load ❑ 100% MCR
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

*It is very important to keep record of oil feed rate differences between units, as this influences measured results.

TEXACO Chevron CALTEX
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DOT.FAST® service

quick start guide — onboard software

If the DOT.FAST® Onboard Software is **not** installed on your PC, follow Steps 1 and 2.
Otherwise proceed directly to Step 3.

Step 1 | Install the DOT.FAST Onboard Software

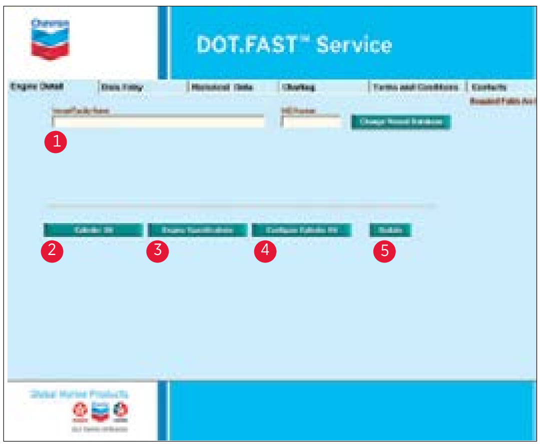
1.1 Insert the DOT.FAST CD into your CD drive. Select **INSTALL ONBOARD SOFTWARE** to launch the Setup Wizard.

1.2 Read and accept the License Agreement.

1.3 Select the directory where you want to install the program.

1.4 Click **INSTALL** and then **FINISH** to complete the installation.

Step 2 | Enter Information about your vessel/facility



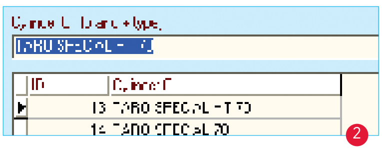
2.1 Enter the vessel/facility name and IMO number in the **Engine Detail tab**.

2.2 Click the **CYLINDER OIL** button. Enter and manage
the cylinder oils used onboard your vessel.

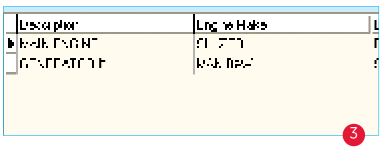
2.3 Click the **ENGINE SPECIFICATIONS** button. Enter
and manage required system details.

2.4 Click the **CONFIGURE CYLINDER OIL** button. Enter and manage cylinder oils used by each individual unit.

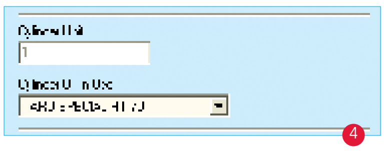
2.5 When finished, click the **UPDATE** button.



Sample from the Cylinder Oil screen.

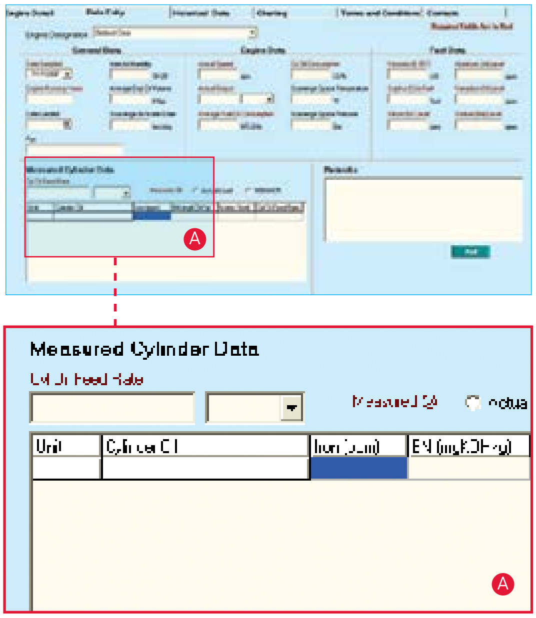


Sample from the Engine Specifications screen.



Sample from the Configure Cylinder Oil screen.

Step 3 | Enter measured results and operational data from the DOT.FAST® Worksheet and Engine Data Sheet



3.1 Open the **Data Entry tab** and choose a system from the **Engine Designation** drop-down menu.

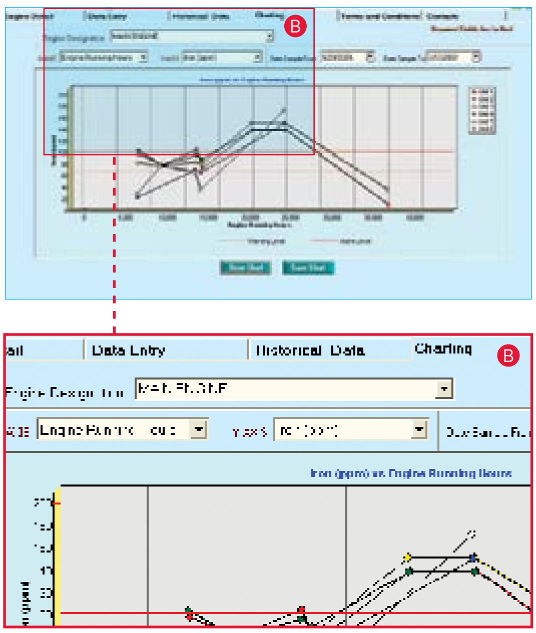
3.2 Fill in required operational data fields.

3.3 In the Measured Cylinder Data section, first enter the default oil feed rate setting for the system and choose the unit of measurement. Then enter the measured data for iron, BN, and if necessary, different oil feed rate settings for individual units.

3.4 Provide additional information in the Remarks field (e.g., unit overhaul, running-in, etc.).

3.5 Click the **ADD** button to save the data.

Step 4 | View trending charts to easily interpret the data



4.1 Open the **Charting tab** and choose a system from the Engine Designation drop-down menu.

4.2 Select trending parameters for the **X-axis** and **Y-axis** from the drop-down menus.

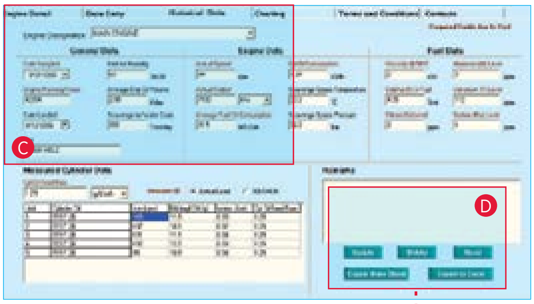
4.3 Choose a date range from the **Date Sample From** and **To** drop-down menus.

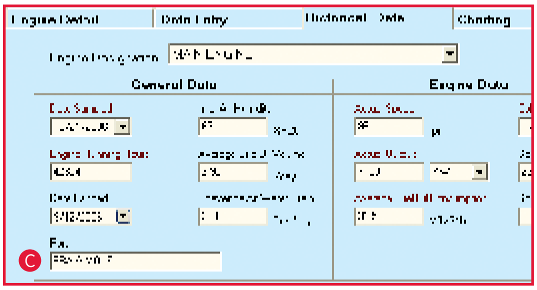
4.4 Draw the chart by clicking the **DRAW CHART** button.

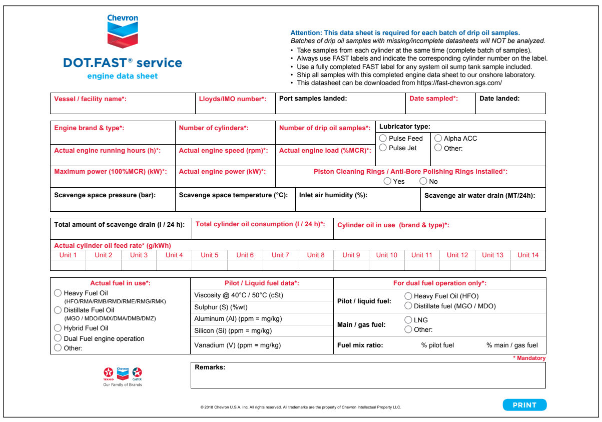
4.5 To save or print the chart, click the **SAVE CHART** button.

Note: The default alarm and warning limits for iron and BN can be changed. See the DOT.FAST Instruction Manual for more information.

Step 5 | Update or complete unfinished data sets, print an Engine Data Sheet or export the database content to Microsoft® Excel®







To update

5.1 Open the **Historical Data tab**.

5.2 Click on the **Engine Designation** drop-down menu to open the Search Engine.

5.3 Select the data set to be updated from the Search Engine.

5.4 Make any necessary changes. Click the **UPDATE** button to save the changes.

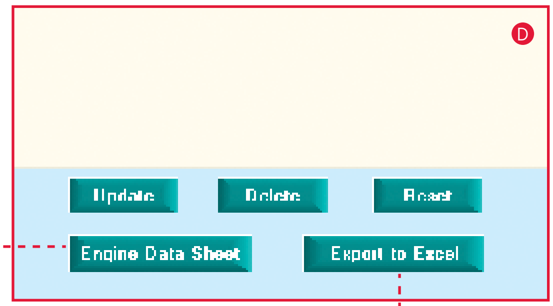
If needed, click on the **RESET** button to revert back to the initial settings or the **DELETE** button to remove the data set completely.

To print an Engine Data Sheet

5.2.1 Select a data set from the Historical Data Search Engine.

5.2.2 Click the **ENGINE DATA SHEET** button.

5.2.3 Click the **PRINTER** icon.



To export to Microsoft Excel

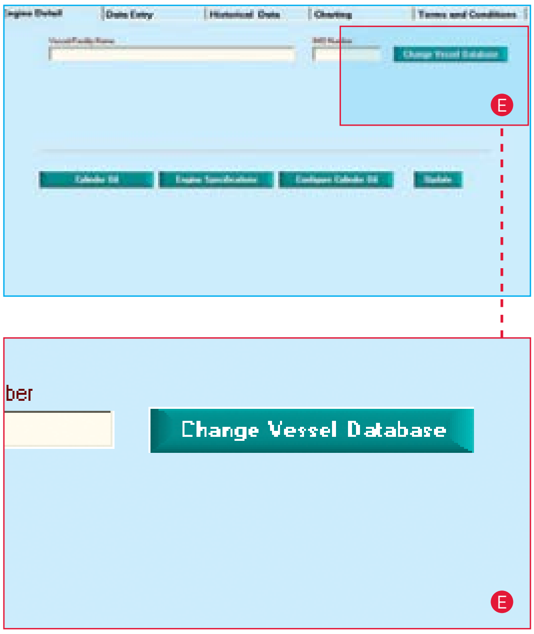
5.3.1 Select a data set from the Historical Data Search Engine.

5.3.2 Click on the **EXPORT TO EXCEL** button in the **Historical Data tab**.

5.3.3 Enter a file name.

5.3.4 Select a save location, then click **SAVE**.

Step 6 | How to share or change to another vessel/facility database



Data files can be shared and opened by other users using the DOT.FAST® Onboard Software.

To share

6.1 Open the **DATA folder** of the DOT.FAST Onboard Software.

6.2 Make a copy of the data file (*.abs) you want to share.

6.3 Send it to another user.

To read other data files

6.2.1 Copy the data file into the DATA folder of your DOT.FAST Onboard Software.

6.2.2 In the **Engine Detail tab,** click on the **CHANGE VESSEL DATABASE** button, then click on the data file you would like to open.

6.2.3 Now all of the historical data and charts in that database are available and can be fully accessed by the software.

For further detailed information, please refer to the DOT.FAST Instruction Manual.

For any technical inquiries about the DOT.FAST Service, please contact your local Chevron sales representative or our Technical Services Help Desk (DOT.FAST@chevron.com).

Visit www.chevronmarineproducts.com for more information and resources about the DOT.FAST Service.

Our Family of Brands

Chevron

marine lubricants

sweeptest sample deliveries

a DOT.FAST® service

Performing a sweeptest can help improve feed rates and bring **valuable cost saving** efficiencies to your operation.

Analysis of sweeptest oil samples is conducted on-shore at our ISO certified laboratories, customers receive feedback in a fully reviewed FAST™ report within 24–48 hours of receipt of the final sample. These reports indicate what the optimum ACC factor is with the given cylinder oil in use.

FAST sample kits contain everything you need to conduct the tests, including standard sized sample bottles, labels and pre-addressed envelopes for our global laboratories.

To be included with each batch of samples:

Completed DOT.FAST® engine data sheet

Download a copy from the DOT.FAST CD-ROM or from the CML website:

chevronmarineproducts.com/en_mp/home/lubricants-services/dot-fast/how-dotfast-works.html

Batches received without this sheet will not be analyzed.

One main engine system used oil sample

Required in order to calculate the amount of system oil dilution in the drip oil samples.

Fully completed FAST sample labels for each bottle

These tests will be handled separately in the laboratory.

Testing guidelines:

1. **Take samples from every cylinder** at the same time (complete batch of samples).
2. **Use FAST labels** and indicate the corresponding cylinder number on the label. Fully complete a FAST label for any system oil sump tank sample included.
3. **Always Include a completed DOT.FAST engine data sheet with every batch of samples.**
4. **Send completed sweeptests to our global FAST laboratories.** Please do not sent FAST samples to the personal attention of any of our staff as this will delay processing.

Inform the courier company that the receiver is ‘Warehouse Assistant’.

Chevron Marine Lubricants — FAST Program
SGS Belgium NV
Polderdijkweg 16.
B-2030 Antwerpen, Belgium

Couriers contact receptionist
Tel:+32 (0)478962712

Samples landed in mainland China can be sent to our laboratory in Shanghai:

Chevron Marine Lubricants — FAST Program
SGS-CSTC Standards Technical Services Co., Ltd
No.88 Pugong Road, Fengxian District
Shanghai Chemical Industrial Park,
Shanghai, 201507, China
上海市奉贤区化学工业区普工路88号（201507)
Tel: +86 021 6027 6372

Couriers contact
Fountain Luo 罗春芳 and Cindy Gu 顾蕾
Tel:+86 (21)60276363 / +86(21)60887042

Note that our laboratory does not run fuel samples. Providing the key parameters of the fuel are indicated on the DOT.FAST Service engine data sheet — sulfur content, and preferably also aluminum and silicon content — this is sufficient information to obtain accurate results.

Search our YouTube channel for Chevron Marine Lubricants training videos on how to conduct safe, reliable tests and visit our website chevronmarineproducts.com for more FAST resources.

Contact the DOT.FAST helpdesk with any questions at CMLtechservice@chevron.com.

Our Family of Brands

marine lubricants

customer benefit studies

customer benefit study

chevron marine lubricants | formosa plastics marine corp.

chevron Cetus® DE 100 solves compressor valve deposits build up

Chevron field engineers advice to Formosa tanker *FPMC C LORD* to switch compressor lubricant to Cetus® DE 100 cures exhaust carbon deposit build up.

Situation

Vessel *FPMC C LORD* faced issues with carbon deposits on valves when using mineral compressor oils in air compressors. Mineral lubrication is mainly used for internal lubrication of moving components but under high-temperature and high-pressure applications the lubricant can be oxidized particularly when residual oil remains in the exhaust valve and pipe. This can lead to thermal decomposition, dehydrogenation aggregation in combination with impurities and dust drawn into the intake combining and deposited on the hot valve surface eventually forming carbon deposits.

Results

Following the change to Cetus® DE 100, Formosa reported significantly improved compressor performance. The crew aboard the chemical tanker reported significant improvements in valve cleanliness and compressor performance after switching from a mineral air compressor oil.

Chevron Cetus DE 100 is a fully formulated, high-quality synthetic compressor lubricant based on diester technology to protect reciprocating air compressors against carbon deposit build up and wear. The vessel operates suction gas compressors, which operate at high temperatures. The technical superintendent noted the following benefits after the change to Cetus DE 100:

- ✔ Significant improvement in compressor performance compared to the previously used mineral air compressor oil because there was a reduction in carbon deposits.
- ✔ Clean in/outlet valves with very low carbon deposits, meaning longer running periods between maintenance.
- ✔ Reduced deposits in discharge lines and improved safety in compress air systems.
- ✔ Reduced wear of piston rings, cylinders and bearings.
- ✔ Improved equipment reliability and reduction in unscheduled downtime.

Exhaust valve deposits using mineral lubricant

Conclusion

The significant performance and maintenance improvement has lead to Formosa deciding to switch another eleven vessels to Cetus DE 100 over the following months including vessels using different air compressors, such as YANMAR, J.P. SAUER & SOHN all changing from mineral air compressor oil to synthetic Cetus DE 100. ■

Exhaust valve improved cleanliness after using Cetus DE 100

customer benefit study

chevron marine lubricants | neda maritime

taro® special HT ultra combats severe corrosion on the M/T *Seriana*

Tanker adopts Chevron's ultra-high BN Taro® Special HT Ultra to combat severe corrosion, resulting in a 30% reduction in feed rates and savings for operator Neda Maritime.

Situation

The M/T *Seriana* is a 110,000 dwt LR2 tanker operating in the Greek market under the management of Neda Maritime. Soon after her launch in 2015 the Japanese-built vessel began to experience severe corrosion in its MAN 6S60ME-C8.2 engine. Initially, a significantly higher than OEM recommended feed rate of Taro® Special HT 100 cylinder lubricant was implemented by the owners, in an effort to keep the wear rate within acceptable limits. However, wear rates were unchanged and over-lubrication resulted in liner polishing.

Understandably, Neda Maritime were concerned about the implications for the liners' lifespan and following numerous scavenging space inspections as well as repeated on board scrapedown measurement analysis, Neda turned to Chevron's Marine Field Technical Specialists who recommended switching to a higher BN cylinder lubricant, Taro® Special HT Ultra, a 140BN cylinder oil with exceptional lubricating properties. A high cylinder oil dosage, as well as being costly for operators, does not necessarily result in better engine operation, and the experts at Chevron instead analyzed the case with a focus on oil characteristics and chemistry. Initially the product was also used at a high feed rate before being gradually reduced following positive results from frequent drip oil testing using the DOT.FAST® service.

Results

Liner measurements from the M/T *Seriana* demonstrated that within a period of approximately four months, the use of Taro® Special HT Ultra had returned wear levels to normal. Ultimately, the feed rate was reduced by more than 30% and the overall engine condition is much improved. With DOT.FAST® drip oil monitoring the team at Chevron demonstrated that switching to Taro® Special HT Ultra provided both a positive technical outcome and cost savings of more than $20,000/year for this vessel alone.

"The results were impressive."

Dr. Panos Deligiannis
Tankers Technical Manager,
Neda Maritime Agency Co. Ltd.

"Severe combustion acid corrosion and short residence time in the liner call for a larger concentration of cylinder oil additives and Neda Maritime are very pleased that Chevron responded with Taro® Special HT Ultra, the use of which assisted in both reducing wear levels and increasing cost savings," said Dr. Panos Deligiannis, Tankers Technical Manager at Neda Maritime Agency Co. Ltd., "The results were impressive."

Taro® Special HT Ultra provided both a positive technical outcome and cost saving of more than
$20,000/year
for this vessel alone.

Chevron Marine Lubricants DOT.FAST® and FAST™ services provide both on-board and on-shore analysis of drip oil, giving an accurate measurement of total iron wear, including corrosive wear.

Conclusion

A key advantage of switching to a higher BN lubricant is the associated cost savings, as the higher BN can potentially decrease feed rates, and in most cases, reduce corrosion with less product injected into the cylinder. Oil analysis service DOT.FAST® is essential in demonstrating improvements in both engine condition and the associated cost saving with moving from a lower BN to a higher number cylinder lubricant such as Taro® Special HT Ultra. Chevron Marine Lubricants DOT.FAST® and FAST™ services provide both on-board and on-shore analysis of drip oil, giving an accurate measurement of total iron wear, including corrosive wear, enabling feed rate reduction whilst maintaining and in some cases improving wear rates.

As the global shipping industry heads into a lower sulphur, lower emissions future, this success story is yet another example of why a "one size fits all" approach to engine lubrication is not the solution. Chevron Marine Lubricants continue to offer a full range of six cylinder lubrication products, from our 25BN Taro® Special HT LF through to the 140BN Taro® Special HT Ultra to meet all of the needs of operators globally. ■

customer benefit study

chevron marine lubricants | AS tallink grupp

tallink's tale of LNG transformation

The choices facing ship owners opting to use LNG are not always complicated. But getting it right remains critical. Nowhere is this more evident than on Estonian ferry operator AS Tallink Grupp's fast link between Tallinn and the Finnish capital of Helsinki.

Situation

In 2017, AS Tallink Grupp took delivery of its first LNG-fueled ferry, *Megastar*, from Meyer Turku. For Tallink procurement manager Raivo Veskus, the company's decision to turn to LNG was driven by its strategy of environmental responsibility.

"The Baltic is a small sea and we are trying to play our part in keeping it clean," he says. "LNG offers high environmental benefits, with zero sulphur and particulate matter, around 25 percent less CO_2 and virtually no NO_x emissions."

The 2,800-capacity ferry is charged with making the two-hour sailing across the Gulf of FInland six times a day. Delivering nearly 18,000 people daily between these two highly interconnected hubs makes a smooth operation crucial.

The Importance of Reliability

"On such a busy service it is very important that we stick to schedule," says Raivo Veskus. "We can't afford to have reliability concerns."

Chevron is proud to play its part in ensuring that reliability. Through local distributor Lubtec, the company supplies *Megastar* with its low-ash trunk piston engine oil designed specifically for gas engines, Chevron Marine Lubricants' **HDAX 5200**. The lubricant ensures that the five Wärtsilä medium-speed, dual-fuel engines are protected and in good condition.

"Wärtsilä told us which oils were approved for these engines, and we were very happy when our choice of supplier was the same as the shipyard's," says Raivo Veskus. "We are satisfied not only with the quality of the Chevron product but also with the service from local distributor Lubtec. Service is especially important for ships that stay for only a short time at the dock."

Chevron Marine Lubricants' **HDAX 5200** is designed for engines operating continuously on LNG. This fits neatly with *Megastar's* fixed operating routine—the vessel runs only on LNG (and up to 5 percent marine diesel oil as pilot fuel) and is refueled by truck every night in Tallinn.

Continued

"The Baltic is a small sea and we are trying to play our part in keeping it clean."

Raivo Veskus, Procurement Manager, AS Tallink Grupp

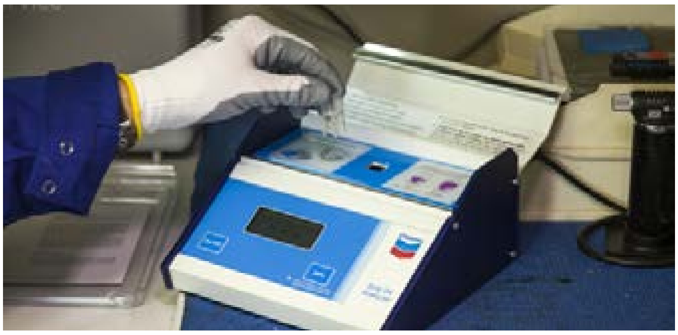
“Wärtsilä told us which oils were approved for these engines, and we were very happy when our choice of supplier was the same as the shipyard’s.”

Raivo Veskus, Procurement Manager, AS Tallink Grupp

On such a new vessel, it is important to check that engines are getting the protection they need. Tallink uses Chevron’s FAST™ analysis to check that lubrication is correct, and that no engine condition issues are emerging. Engineering staff send oil samples to Chevron’s laboratories for testing regularly, showing excellent performance characteristics.

Conclusion

Tallink’s early operations on LNG are encouraging, and the company is already preparing for the next steps. A dedicated LNG bunkering vessel will be delivered soon, and in 2022 Tallink hopes to take delivery of a second LNG-fueled ferry—a sister ship to *Megastar*. The developments mark another milestone for LNG’s rise as a marine fuel, and show once more why Chevron is building its range, its service offer, and its expertise to cater for gas-fueled engines.



FAST analysis can help protect your vessels vital assets and optimise the performance of on-board equipment.

customer benefit study

chevron marine lubricants | eletson corporation SA

discovering the convenience of online lubricant ordering

Ship owners operate under many complex constraints. Each time-saving efficiency they find helps keep them competitive. Eletson found a time-saving efficiency in Chevron's OnePort™ online lubricant procurement system.

Situation

Shipping company Eletson Corporation SA, headquartered in Piraeus, Greece, owns a fleet of thirty-six vessels, and is one of the worlds' largest owners of medium- and long-range product tankers.

Until the beginning of 2020, the company had utilized traditional email to place orders for their fleet of Chevron Marine Lubricants supplied vessels. While serving Eletson efficiently with regional customer service support, the local Chevron team wanted to help optimise operations for their customer by introducing the recently launched OnePort™ ecommerce platform.

A team from Chevron — consisting of Account Manager Aris Theodosiadis and Customer Service Representative Vassilis Zacharias — visited the Support Engineer from the Eletson Technical Department, Mr. Konstantinos Tzagkournis, at the companies' head office to explain the benefits of the new system.

"Placing orders with OnePort saves a lot of time.."

Konstantinos Tzagkournis, Support Engineer, Eletson Corporation SA

The Solution

The team from Chevron delivered a personalized demonstration illustrating how easy it is to place orders, check availability and confirm delivery — all in one place.

“I can access the platform from different devices, and can easily view important transactional information quickly.”

Konstantinos Tzagkournis, Support Engineer, Eletson Corporation SA

On seeing how easy it was to use, Mr. Tzagkournis recognized that OnePort™ would enable staff to quickly place and track orders for vital lubricants products and that this would bring efficiencies to the business.

Eletson immediately adopted the system, and after being quickly guided through the straightforward process for registration, was able to start ordering immediately.

Conclusion

Since adopting OnePort, Chevron customer Eletson has placed all orders for lubricants through the system. The company has been particularly impressed with the easy access to delivery notes (MLDRs) and invoices.

“Placing orders with OnePort saves a lot of time because it cuts down on unnecessary emails, I can access the platform from different devices, and can easily view important transactional information quickly,” said Mr. Tzagkournis.

Left to right: Mr. Konstantinos Tzagkournis with Chevron’s Vassilis Zacharias and Aris Theodosiadis.

The time-saving benefits of OnePort, combined with easy to use functions, have proved that transitioning to digital tools has valuable benefits for both the customer and supplier.

Scan this QR code to view Chevron’s OnePort™ YouTube video and learn more.

OnePort™ customer portal

Chevron

marine lubricants

iolcos hellenic maritime enterprises streamlines lubricant logistics with chevron's oneport™ online portal

Iolcos Hellenic Maritime Enterprises has streamlined lubricant procurement across its fleet of 16 bulk carriers after adopting Chevron Marine Lubricants online customer portal, OnePort™, to manage its lubricants ordering.

The Athens-based ship manager and operator, which specializes in oceangoing Panamax and post-Panamax vessels, had previously managed its ordering process by phone and email. In January 2021, the company switched to OnePort and has since processed all transactions on the system, which enable real-time online ordering as well as instant swift access to the company's order history.

OnePort effectively reduces order management time by eliminating unnecessary work from the process of lubricant procurement. The consolidation of several common supply-chain transactions such as product availability inquiries, order confirmations and delivery receipts help customers to access information quickly and in a reduced time-frame. Online ordering also helps to accelerate purchasing when offices would otherwise be closed, such as overnight or on holidays.

"We were delighted to be able to help Iolcos Hellenic Maritime Enterprises simplify its lubricants procurement with our state-of-the-art web solution," said Michael Kerimis, Account Manager, Chevron Marine Lubricants. "Besides optimizing work processes and driving efficiency, Iolcos also welcomed some of OnePort's other useful functions, such as the ability to compare prices at up to five ports simultaneously."

"The team at Chevron Marine Lubricants has done an excellent job creating the OnePort customer portal. The onboarding process managed by Vassilis Zacharias from the local customer service team was smooth. Managing orders online reduces email traffic while giving me a full overview of all transactions in one place. This has already saved me a lot of time. It is a very simple and useful tool that I am using for all of my lubes management."

Mr. Fernando Vergetis, Supply Department,
Iolcos Hellenic Maritime Enterprises Co Ltd

OnePort™
customer portal

one place for your lubrication needs

- Intuitive, time-saving user interface
- Orders linked to your recommended products
- Simple order placement
- Multiple port and price information

to find out more about oneport, click here

chevronmarineproducts.com

customer benefit study

chevron marine lubricants | asia maritime pacific

chevron expertise solves cold corrosion issues

When dry bulk shipping company Asia Maritime Pacific Shanghai turned to Chevron to help solve a cold corrosion issue on two of its ships, Chevron was able to significantly improve the operation of the main engine with its specialised approach to lubricant solutions.

Situation

Two of Asia Maritime Pacific Shanghai's sister ships, both 35,800 dwt bulk carriers, installed with MAN B&W 5S 50 ME-B Mark 9 engines, were suffering from issues related to cold corrosion. Despite trying both 70 BN and 100 BN cylinder lubricants, liner wear continued to increase and considering the cost and time issues associated with changing cylinder liners, this was not an ideal solution. In an effort to combat the corrosion problem, cylinder oil feed rates were increased, which can lead to other engine issues, as well as increasing lubrication cost. So the customer turned to the experts at Chevron.

"The vessels were still experiencing high levels of cold corrosion even with the increased feed rate. The cylinder liner was close to the wear limit, and the honing mark partly disappeared in the upper liner. Without the resistance of the honing mark, the liner surface was not able to sustain oil film," explained Mr. Michael Gu Xinjun, Fleet Manager of Asia Maritime Pacific Shanghai.

"This was a tricky problem. How to improve cylinder lubrication effectiveness was our focus, but we needed to solve not only the corrosion problem, but also how to quickly use the remaining SAE 50 viscosity, 70 BN products on-board the vessel," said Mr. Michael Gu Xinjun.

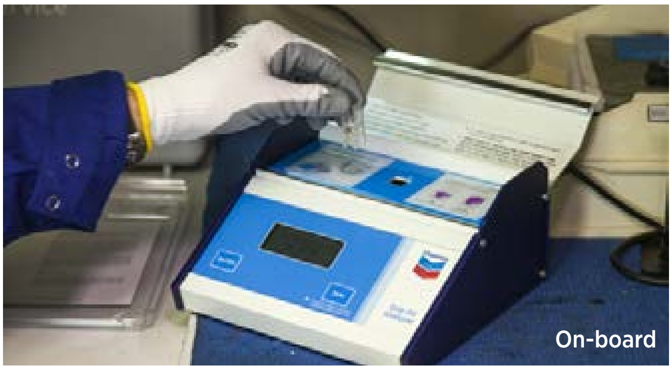
Results

Having analyzed the problem, the technical specialists at Chevron recommended the use of Taro® Special HT Ultra. By mixing the remaining cylinder lubricant — from a competitor supplier — on-board with the 140BN Taro® Special HT Ultra, Chevron was able to achieve two things. Firstly, to increase the BN from 70BN to 100BN or higher. At the same time, overall viscosity was increased to above SAE 50, improving oil adhesion and oil film thickness, which is an effective way to reduce liner wear.

Through Chevron's personalised approach, a regionally based Chevron customer service representative liaised with Asia Maritime Pacific, along with the Chevron supply team, to identify where the vessels could lift Taro® Special HT Ultra. In October and December of 2017, operator Asia Maritime Pacific was able to take product in Singapore, to begin the changeover to the higher BN cylinder lubricant.

Following a main engine inspection, Asia Maritime Pacific reports that thanks to the use of Taro® Special HT Ultra, the condition of the cylinder liners has significantly improved.

Asia Maritime Pacific reports that thanks to the use of Taro® Special HT Ultra, the condition of the cylinder liners has significantly improved.



On-board

Chevron Marine Lubricants DOT.FAST® and FAST™ services provide both on-board and on-shore analysis of drip oil, giving an accurate measurement of total iron wear, including corrosive wear.

On-shore

Conclusion

A key advantage of switching to a higher BN lubricant is the associated cost savings, as the higher BN can potentially decrease feed rates, and in most cases, reduce corrosion with less product injected into the cylinder as well as increasing the liner life through optimized lubrication. DOT.FAST oil analysis is essential for monitoring wear, and in demonstrating improvements in both engine condition and the associated cost saving with moving from a low BN to a higher base number cylinder lubricant such as Taro® Special HT Ultra. Chevron Marine Lubricants DOT.FAST® and FAST™ services provide both on-board and on-shore analysis of drip oil, giving an accurate measurement of total iron content, a view of corrosive wear and enabling feed rate reduction whilst maintaining and in most cases improving wear rates.

As shipping heads into a lower emissions future, this success story is yet another example of why a "one size fits all" approach is no longer appropriate. Chevron Marine Lubricants continue to offer a full range of cylinder lubrication products, including our 25BN Taro® Special HT LF through to the 140BN Taro® Special HT Ultra.

customer benefit study

chevron marine lubricants | sealink navigation ltd

The right oil and the right practice: ensuring trouble-free sailing on VLSFO

Sealink Navigation worked with Chevron Marine Lubricants to prepare its fleet for IMO 2020 sulphur regulations. By following engine designer recommendations, selecting an appropriate cylinder oil and introducing an effective inspection and analysis regime, Sealink was able to safely navigate the challenge.

Situation

Sealink Navigation Ltd operates a fleet of bulkers with MAN B&W electronically controlled Mk 8 & 9 engines, lubricated by Chevron Marine Lubricants. In preparing for the IMO's global sulphur cap introduced on 1 January 2020, the company had decided to comply with the new regulation by switching to very low sulphur fuel oil (VLSFO).

Sealink's fleet includes four vessels with MAN B&W MK 9 engines. The combination of a new, low-sulphur fuel with big, modern engines meant that the lubrication protocol and set-up needed to be considered very carefully. Corrosion in such engines — which operate under very high combustion pressures and temperatures — has been controlled by cylinder oil with a high base number (BN) when using high-sulphur fuel. But the use of low-sulphur fuel changes these conditions; a high BN is no longer appropriate, but engines still require protection from corrosion.

The challenge for Sealink was how to comply with the new environmental regulation and establish a new cylinder lubrication regime while ensuring that its engines would be protected.

"With DOT.FAST drip oil analysis, we can assess what's happening in the engine and adapt oil feedrate to protect the condition of the cylinder."

Evangelos Chalikias, Technical Director, Sealink Navigation Ltd

The Solution

Chevron Marine Lubricants has always maintained a very close contact with Sealink's technical department. This relationship became closer still during the transition to the low-sulphur fuel, with Chevron maintaining regular dialogue with Sealink's technical manager. In the run-up to 2020, the two companies cooperated closely to prepare the vessels and engines for the new legislation, electing to lubricate the engines with Taro® Ultra 40.

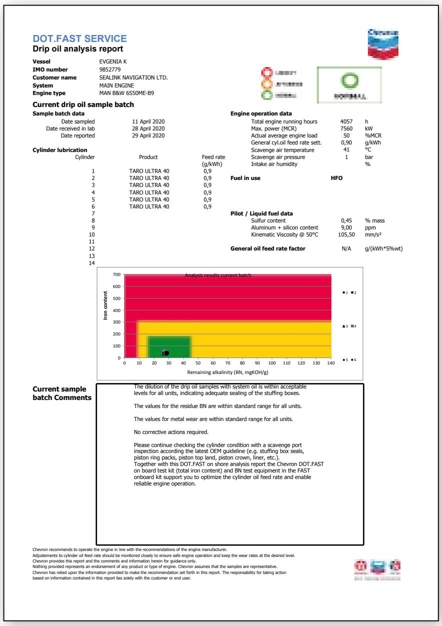
As well as choosing the appropriate cylinder oil, Sealink also implemented a new lubrication program based on advice from both Chevron and the engine manufacturer. On its MAN B&W Mk 8 & 9 engines, Sealink installed cermet-coated piston rings that help prevent scuffing while operating on low-sulphur fuels. Extra filters were fitted to prevent fuel cat fines from reaching the engines. Both measures help to prevent wear and deposits.

“With the right practices and procedures — including a regime of DOT.FAST® drip oil analysis to catch concerns early — all two-stroke marine engine designs can be operated on VLSFO trouble-free.”

Georgia Chaloulou, Technical Specialist, Chevron Marine Lubricants

A more rigorous cylinder inspection and oil analysis regime was also introduced to catch potential problems early.

This includes visual inspection of the cylinders every 150–250 hours; drip oil analysis with Chevron Marine Lubricants’ DOT.FAST® and FAST™ OnBoard kits after every fuel change; laboratory analysis every three months using Chevron’s DOT.FAST service to detect both abrasive and corrosive wear; and compatibility analysis of fuels in a laboratory before any new fuel is bunkered.



DOT.FAST SERVICE
Drip oil analysis report

Vessel	EVGENIA K
IMO number	9852779
Customer name	SEALINK NAVIGATION LTD.
System	MAIN ENGINE
Engine type	MAN B&W 6S50ME-B9

Current drip oil sample batch

Sample batch data

Date sampled	11 April 2020
Date received in lab	28 April 2020
Date reported	29 April 2020

Cylinder lubrication

Cylinder	Product	Feed rate (g/kWh)
1	TARO ULTRA 40	0,9
2	TARO ULTRA 40	0,9
3	TARO ULTRA 40	0,9
4	TARO ULTRA 40	0,9
5	TARO ULTRA 40	0,9
6	TARO ULTRA 40	0,9
7		
8		
9		
10		
11		
12		
13		
14		

Engine operation data

Total engine running hours	4057	h
Max. power (MCR)	7560	kW
Actual average engine load	50	%MCR
General cyl.oil feed rate sett.	0,90	g/kWh
Scavenge air temperature	41	°C
Scavenge air pressure	1	bar
Intake air humidity		%

Fuel in use **HFO**

Pilot / Liquid fuel data

Sulfur content	0,45	% mass
Aluminum + silicon content	9,00	ppm
Kinematic Viscosity @ 50°C	105,50	mm/s²

General oil feed rate factor N/A g/(kWh*S%wt)

Current sample batch Comments

The dilution of the drip oil samples with system oil is within acceptable levels for all units, indicating adequate sealing of the stuffing boxes.

The values for the residue BN are within standard range for all units.

The values for metal wear are within standard range for all units.

No corrective actions required.

Please continue checking the cylinder condition with a scavenge port inspection according the latest OEM guideline (e.g. stuffing box seals, piston ring packs, piston top land, piston crown, liner, etc.).
Together with this DOT.FAST on shore analysis report the Chevron DOT.FAST on board test kit (total iron content) and BN test equipment in the FAST onboard kit support you to optimize the cylinder oil feed rate and enable reliable engine operation.

Chevron recommends to operate the engine in line with the recommendations of the engine manufacturer.
Adjustements to cylinder oil feed rate should be monitored closely to ensure safe engine operation and keep the wear rates at the desired level.
Chevron provides this report and the comments and information herein for guidance only.
Nothing provided represents an endorsement of any product or type of engine. Chevron assumes that the samples are representative.
Chevron has relied upon the information provided to make the recommendation set forth in this report. The responsability for taking action based on information contained in this report lies solely with the customer or end user.

Left: Piston rings from the Evgenia K show good cleanliness and overall condition. Right: DOT.FAST report from the Evengia K indicating ‘normal’ and that no corrective action is required.

Based on this inspection program, Sealink has opted to intermittently use a lubricant with a higher base number. There have been cases where scavenge port inspection results have shown a build-up of deposits on the first piston ring land, which indicates the engine needs a bespoke solution.

Sealink technical director Evangelos Chalikias explains the process. “Once the higher BN oil is in use, we run the engine for about four days before another visual inspection is done. If the results are satisfactory, we ask the crew to change back to the original Taro Ultra 40 BN oil. If not, we run the engine for another 3–4 days before performing another inspection. With DOT.FAST drip oil analysis, we can assess what’s happening in the engine and adapt oil feedrate to protect the condition of the cylinder.”

The Result

Sealink shared photos from scavenge port inspections as well as data from liner measurements during online meetings with Chevron Marine Lubricants. These show that the vessels are operating very smoothly and without problems using Taro Ultra 40. Normal wear rates were confirmed by the DOT.FAST laboratory reports. Sealink also observed good control of piston ring land cleanliness, even when applying relatively low feed rates.

Sealink’s experience highlights that protecting high-horsepower modern engines in the low-sulphur regime requires more than changing cylinder oil. By following the advice of Chevron and MAN B&W, Sealink has been able to run its vessels using VLSFO without any sign of problems.

Crucial steps included the installation of cermet-coated piston rings and filters as specified by the engine designer as well as the introduction of a structured inspection and drip oil analysis routine.

Chevron Marine Technical Specialist Georgia Chaloulou says: “Running engines well with VLSFO is not just about choosing the right cylinder oil. With the right practices and procedures — including a regime of DOT.FAST drip oil analysis to catch concerns early — all two-stroke marine engine designs can be operated on VLSFO trouble-free. For Sealink, this translates into low operating costs and simplified operation, thus improving safety, reliability and peace of mind for their charterers.”

customer benefit study

chevron marine lubricants | asia maritime pacific shanghai

FAST and DOT.FAST annual review highlights hidden savings

Dry bulk ship operator Asia Maritime Pacific identified new opportunities to help optimise operations across its fleet, using Chevron's annual oil analysis reports to spot long-term trends in lubricant performance and equipment condition.

Situation

Asia Maritime Pacific operates a fleet of bulk carriers. The company has worked closely with Chevron Marine Lubricants for several years and is a regular user of Chevron's FAST™ and DOT.FAST® oil analysis services.

Following the shift to using very low sulfur fuel oil (VLSFO) in 2020, some of Asia Maritime Pacific's vessels encountered abnormal main engine liner wear, accompanied by distinctive red deposits on piston crowns and top edges.

Monitoring for recurrence of the issue across multiple vessels would have been a complex and time-consuming task using individual oil analysis reports. To effectively monitor for this and other opportunities to improve their operations, Asia Maritime Pacific required a more long-term perspective offering a consolidated overview of the entire fleet, and covering not just the main engine but all lubricated onboard equipment.

The Solution

Chevron Marine Lubricants recommended FAST and DOT.FAST Annual Reviews, an added service for Chevron's oil analysis customers that compiles yearly information from multiple individual reports in an easy-to-read format. Visibility of historical analysis helps operators to spot opportunities to help optimise oil use and equipment condition.

Regular FAST and DOT.FAST oil analysis reports contain vital information about how a lubricant is performing in combination with the particular equipment with which the lubricant is being used. The equipment can range from winches, to compressor valves and main engines. When any of these fail, operators can incur losses that build up over the life of a vessel, as well as stoppages that can unnecessarily impact individual voyages.

For those responsible for managing multiple vessels — such as a fleet managers and superintendents — individual reports can be time consuming to analyse, potentially resulting in a delay to corrective action being taken to resolve issues. While isolated problems are easy to spot in single reports, it can be challenging to build a big picture of any issues evolving across the fleet.

(continued)

"By performing an annual review of the fleet oil analysis data, we have found a real opportunity to reveal hidden issues."

Michael Gu Xinjun, Fleet Manager, Asia Maritime Pacific Shanghai

Chevron's FAST™ and DOT.FAST® Annual Review provides an overview of the condition of the lubricant and machinery involved. It also summarizes the overall severity of issues discovered during the analysis. Other elements of the reports include:

- ✔ Summary of fleet analysis condition
- ✔ Results by vessel, product and application
- ✔ Analysis of issues and identification of the root cause
- ✔ Recommendations
- ✔ Vessel management advice for improvement

Allied with close support from Chevron's Technical Specialists, the Annual Review is a valuable tool that can provide deeper insight on vessel, machinery and oil performance.

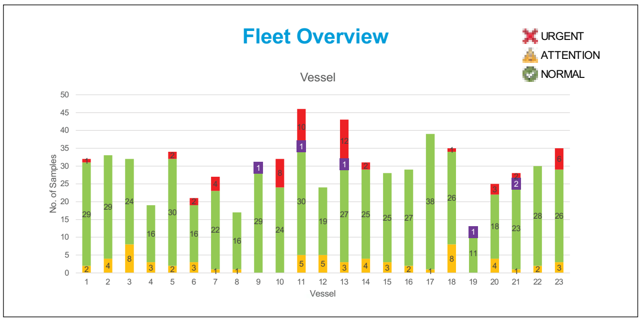
The Result

The benefits that Asia Maritime Pacific gained from the annual review go well beyond watching out for the recurrence of red deposits (although this issue was successfully avoided). Michael Gu Xinjun, Fleet Manager, Asia Maritime Pacific Shanghai, explained that the level of detail in the review — and the ability to compare across vessels and time periods — offered other opportunities for optimization.

First, the compilation of analysis reports means that Asia Maritime Pacific can spot potentially problematic trends before they turn into fully fledged problems. For example, marginally increasing wear on a specific piece of equipment could suggest that an early intervention is needed. The company is also able to use the reports to gain

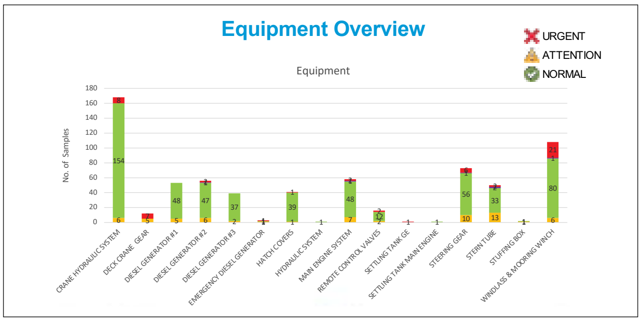
(continued)

Figure 1



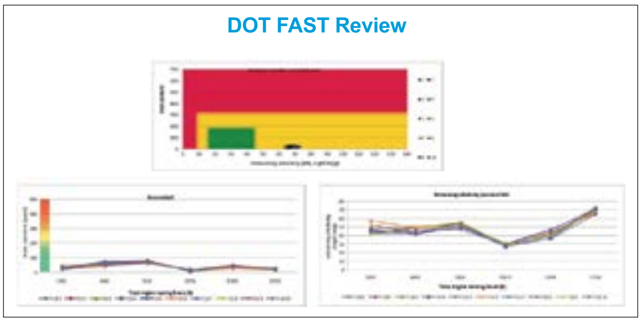
The number of samples received and the traffic light rating for each sample. The majority are green, suggesting the equipment is in good condition and being lubricated correctly. Blue indicates incomplete samples. Some vessels needed urgent attention, for example 11 and 13 may require further investigation.

Figure 2



This indicates the number of samples received across the fleet, with the blue line highlighting the equipment that has been tested the most. The traffic light system demonstrates the equipment that may merit further investigation.

Figure 3



The DOT.FAST drip oil analysis report provides insight into main engine wear and performance.

Figure 4

Vessel 1
Analysis Results — Overview

Component	Product	Sampling Interval	Attention/Urgent Reports	Date of Last Report	Last Report
DECK CRANE #1	RANDO HDZ 68	Every 12 months	0	9/3/2020	Normal
DECK CRANE #2	RANDO HDZ 68	Every 12 months	0	9/3/2020	Normal
DECK CRANE #3	RANDO HDZ 68	Every 12 months	0	9/3/2020	Normal
DECK CRANE #4	RANDO HDZ 68	Every 12 months	0	9/3/2020	Normal
DIESEL GENERATOR #1	TARO 40 XL 40	Every 12 months	1	9/3/2020	Urgent
DIESEL GENERATOR #2	TARO 40 XL 40	Every 12 months	0	9/3/2020	Normal
DIESEL GENERATOR #3	TARO 40 XL 40	Every 12 months	0	9/3/2020	Normal
HATCH COVERS	RANDO HDZ 32	Every 12 months	0	9/3/2020	Normal
MAIN ENGINE BEFORE FINE FILTER	VERITAS 800 MARINE 30	Every 12 months	0	9/3/2020	Normal
MOORING WINCH	RANDO HDZ 100	Every 12 months	1	9/3/2020	Urgent
STEERING GEAR	RANDO HDZ 68	Every 12 months	0	9/3/2020	Normal
STERN TUBE	CLARITY SYNTHETIC HYDRAULIC OIL 100	Every 12 months	0	9/3/2020	Normal
WINDLASS	RANDO HDZ 100	Every 12 months	0	9/3/2020	Normal

*Follow OEM's instructions & Depending on oil condition

Component	Product	Date Sampled	Condition	WATER CONT. %	KIN. VISCOSITY @40C cSt
DIESEL GENERATOR #1	TARO 40 XL 40	9/3/2020	Urgent	0	216,73
MOORING WINCH	RANDO HDZ 100	9/3/2020	Urgent	2,71	99,3

Detailed FAST analyses for individual vessels reveal hidden issues and provide practical solutions.

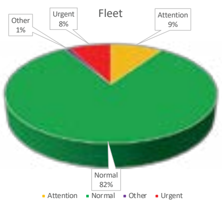
"The actions required are simple and often inexpensive to perform, while helping us to improve ship management reduces costs across the fleet."

Michael Gu Xinjun, Fleet Manager, Asia Maritime Pacific Shanghai insight into new practices, examining the performance of environmentally acceptable lubricants and particular stern tube systems, for example. Finally, the reviews provide an objective means of measuring performance so that the advantages of any changes in practice or equipment can be gauged accurately.

"By performing an annual review of the fleet oil analysis data we have found a real opportunity to reveal hidden issues," says Michael Gu Xinjun. "The actions required are simple and often inexpensive to perform, while helping us to improve ship management reduces costs across the fleet."

Figure 5

2020 Summary



Vessel	Attention	Normal	Other	Urgent	Grand Total
1	2	29		1	32
2	4	29			33
3	8	24			32
4	3	16			19
5	2	30		2	34
6	3	16		2	21
7	1	22		4	27
8	1	16			17
9		29	1		30
10		24		8	32
11	5	30	1	10	46
12	5	19			24
13	3	27	1	12	43
14	4	25		2	31
15	3	25			28
16	2	27			29
17	1	38			39
18	8	26		1	35
19		11	1		12
20	4	18		3	25
21	1	23	2	2	28
22	2	28			30
23	3	26		6	35
Grand Total	65	558	6	53	682

The annual fleet summary can reveal larger trends — both positive trends that could be reinforced, and negative trends which may warrant further investigation.

The FAST and DOT.FAST annual review is a valuable tool that can provide deeper insight on vessel, machinery and oil performance.

Figure 6

FAST™ Service
Condition Monitoring Report

Vessel : 1
IMO : —
Customer : —
System : DIESEL GENERATOR #3 Cylinders & bearings
Date Reported: 12 Jan 2021

URGENT
ATTENTION
NORMAL
NOT APPLICABLE

ATTENTION
Monitoring required

					Latest Sample
Request No	21808861	21809528	21809532	21897423	**21804421**
Product	TARO 40 XL 40(X)	TARO 40 XL 40(X)	TARO 40 XL 40(X)	TARO 40 XL 40(X)	**TARO 40 XL 40(X)**
Port	—	—	—	—	
Date Sampled	06 Oct 2019	27 Dec 2019	15 Mar 2020	04 Jul 2020	**24 Dec 2020**
Date Landed	07 Oct 2019	27 Dec 2019	16 Mar 2020	-	**-**
Date Received	23 Oct 2019	15 Jan 2020	24 Mar 2020	17 Jul 2020	**11 Jan 2021**
Product Service Hrs	3800	3957	4334	239	**-**
Total Equipment Hrs	30680	30737	31114	31402	**32094**
Consumption L/d	25	25	25	-	**25**
Condition					
APPEARANCE	Black	Black	Black	Black	**Black**
WATER CONT. (%)	Negligible	Negligible	Negligible	Negligible	**Negligible**
KIN. VISCOSITY @40°C (cSt)	170.60	170.70	164.84	141.66	**153.45**
SETA FLASH (°C)	>190	>190	>190	>190	**>190**
SOOT LOAD (%)	0.60	0.97	1.13	0.60	**1.60**
BASE NUMBER (D2896) (mgKOH/g)	33.1	31.9	31.2	38.5	**37.1**
Spectrographic Analysis					
CALCIUM (ppm)	15600	13563	12653	15183	**14996**
ZINC (ppm)	477	402	436	555	**604**
PHOSPHORUS (ppm)	452	382	404	519	**541**
BORON (ppm)	2	1	1	4	**2**
IRON (ppm)	17	15	12	11	**12**
COPPER (ppm)	2	1	1	2	**2**
LEAD (ppm)	0	4	5	0	**1**
CHROMIUM (ppm)	1	1	1	1	**1**
ALUMINIUM (ppm)	9	4	3	5	**4**
SILICON (ppm)	10	9	9	13	**12**
TIN (ppm)	0	0	0	0	**0**
NICKEL (ppm)	19	19	14	11	**14**
VANADIUM (ppm)	60	68	33	7	**10**

Latest Comments Request No :
Product given as : TARO 40 XL 40(X)

HIGH LEVEL OF SOOT. IT IS RECOMMENDED TO LOWER SOOT LEVEL BY PURIFICATION (PREFERABLY AT 95°C, AT OEM RECOMMENDED THROUGHPUT).

Please note that Chevron provides this FAST Report and the comments and information contained herein for guidance only. Nothing provided represents an endorsement of any product or type of engine. Chevron assumes that the samples are representative. Chevron has relied upon, the information provided to make the recommendation set forth in this report. Responsibility for taking action, based on information contained in this FAST Report lies solely with the customer or end user.

Reported by Marine Oil Analysis Specialist   Page 1 of 2 Page

The FAST Service Condition Monitoring Report provides comprehensive laboratory analysis of important equipment indicators, enabling intervention before breakdown can occur.

marine lubricants

aeoliki marine sees immediate benefit from chevron's oneport online portal

Marine services company Aeoliki Marine reported improved lubricant management as soon as it began using Chevron Marine Lubricants' OnePort.

Cyprus-based Aeoliki Marine Ltd provides a one-stop shop for a wide range of services, including bunkers, electronic supplies and services, vessel tracking software, and ship security alert systems. But the biggest part of its business focuses on supplying a complete range of marine lubricants, so securing those supplies simply, efficiently and quickly is vital.

When it adopted Chevron Marine Lubricants' procurement portal, OnePort™, in April 2022 to manage those supplies, it saw an immediate impact. Aeoliki Marine's Lubricants Consultant, Marios Argyros, paid tribute to its effectiveness, saying that it gives him and his team "the best option to easily submit our lubricants requests and optimize our time."

Within days of seeing a demonstration of OnePort, Argyros was up and running and, following a short guide through its straightforward registration process, was able to start placing orders. Since then, he and his team have placed all their transactions through the system — which now run into the hundreds; both invoiced orders and product availability enquiries.

Aeoliki Marine

Although based in the Mediterranean — it has a branch office in Athens as well as its Cyprus headquarters — Aeoliki Marine cooperates with both oil majors and independent lubricant suppliers to deliver products and services worldwide. So OnePort's direct communication functionality, enabling the user to contact Chevron regardless of any time zone difference, is essential.

Its clients include companies in the superyacht, offshore and commercial shipping industries, including well-known ship operators who manage more than 150 container ships and bulk carriers.

Continued

Marios Argyros

"... the best option to easily submit our lubricants requests and optimize our time."

Marios Argyros
Aeoliki Marine's Lubricants Consultant

Argyros is, therefore, acutely aware of the need for a reliable ordering system and said that in his opinion, OnePort™ "is the greatest and most complete platform in the marine lubes sector." That completeness enables it to manage Aeoliki Marine's entire lubricant order management process, providing a full overview of all of its transactions.

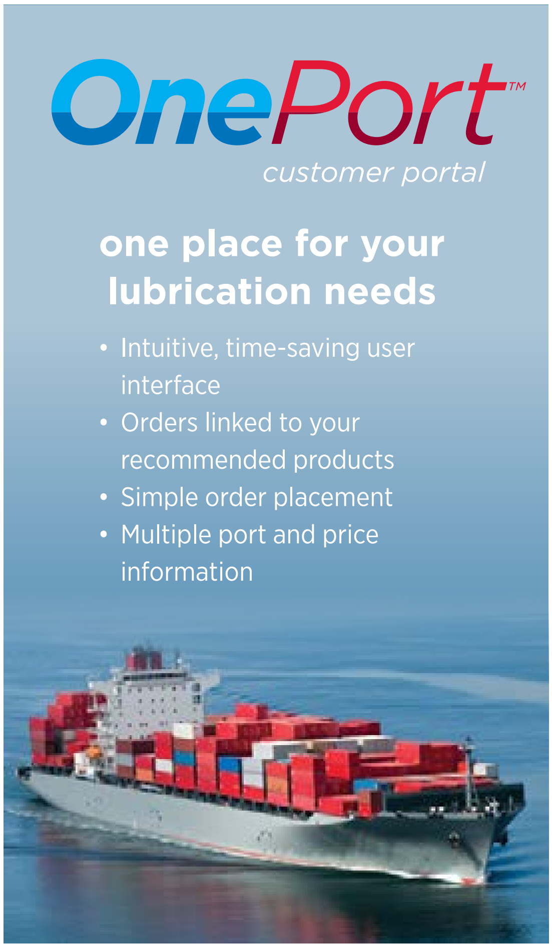
It has a number of features that help control each request and speed up the procurement process. These allow users to track delivery details — such as availability, supply possibility, notice periods and extra charges — in real time via OnePort. This makes it possible to use OnePort as the company's main order communication tool, eliminating the long email chains often associated with such transactions.

OnePort also has an easy-to-use product selection process and a spectrum of information that can be accessed in one place, including port notes, lead times and last-supplied dates of each product, along with status information for every order and enquiry.

There is also a "Lubechart Recommended" section in which recommended products can be grouped, helping minimize ordering mistakes and ensuring customers can easily find the products they require.

OnePort is accessed online so it can be operated at any time and from any location, making it possible to place orders and retrieve delivery notes (MLDRs) and invoices outside office hours.

Over the months that Aeoliki Marine Ltd has been using OnePort, the company has joined its many other users in discovering that its time-saving benefits, combined with its easy-to-use functions, prove that transitioning to digital tools has valuable benefits for both customer and supplier.



"... the greatest and most complete platform in the marine lubes sector."

Marios Argyros
Aeoliki Marine's Lubricants Consultant

to find out more about oneport, click here

marine lubricants

white papers

marine lubricants

the future of marine two-stroke engine lubrication

"Mari Innovator" — a third-generation built methanol dual-fueled MR product/chemical IMO 2/3 type tanker, delivered September 2021, built by HMD, Korea.

As shipping faces an era of new fuels and new engine designs to accommodate them, what role will cylinder lubrication play in enabling efficient and reliable engine operation?

A new era of cylinder condition

The maritime sector worldwide is heading towards an unprecedented diversity in fuel options. Having recently gone through one mass fuel switch — the International Maritime Organization's global sulphur cap introduced on 1 January 2020 (IMO sulphur cap — the shipping sector now aims to reduce greenhouse gas emissions in line with the IMO's 2050 ambition, as set out in the Initial IMO GHG Strategy[1], currently to cut emissions by at least 50% and reduce carbon intensity by at least 70% based on 2008 levels (IMO long-range carbon target).

As the IMO sulphur cap saw the emergence of very low sulphur fuel oil (VLSFO), the IMO long-range carbon target will encourage the introduction of more ship fuels. Alternatives like liquefied natural gas (LNG) and methanol are already in use and fuels such as ammonia, hydrogen and ethanol are being developed alongside lower-carbon synthetic and biomass-derived versions of conventional fuels. So-called "e-fuels", which are produced using renewable energy, are also being developed.

Like VLSFO, each of the above fuels bring specific challenges to engine and cylinder condition that can be mitigated by careful handling, specific engine design and an appropriate lubrication regime.

At the same time, engine design will continue to advance — both to accommodate different fuels and to continue advancing efficiency. With new engine designs come new cylinder condition requirements. Higher cylinder pressures or temperatures require better performing lubricants, for example, and new combustion concepts may also demand different properties from lubricating oils.

1. Please refer to Initial IMO GHG Strategy (https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx)

Pat McCloud, General Manager, Chevron Marine Lubricants says: “There are many unknowns about the future of marine fuels and engines. Chevron Marine Lubricants has a clear mission; to help its customers through that uncertainty, delivering robust and reliable lubricant performance that can help keep engines clean and operating well whatever the fuel, whatever the design.”

Cylinder condition in the age of sulphur: a quick recap

To explore how different fuels (which may come into play in the future), and engines may affect cylinder lubrication, it is worthwhile to review the changes brought about in recent years, as engine designers and ship operators adapted to emerging trends.

Over the last two decades, there has been a shift in how cylinder condition is maintained in marine two-stroke engines. One starting point is the oil price shock of the 2000s, when the price of crude oil — which had floated at around US$25 a barrel for nearly two decades until 2003 — reached a peak of US$147.02 in mid-2008.

Slow steaming

Ship owners and operators faced higher fuel bills. To cut costs, they came up with a simple solution: slow down. By operating their ship engines at lower load, they burned less fuel. According to a 2011 publication by Maersk, Slow Steaming — The Full Story, the container ship *Emma Maersk* could save 4,000 metric tons of fuel oil on a Europe-Singapore round trip by cutting speed in half, from 24 to 12 knots. At the prices of the time, that equated to a saving of up to US$2.8 million.

In the same publication referenced above, Maersk saw slow steaming as a way to cut fuel bills as well as greenhouse gas emissions. At the same time, significant changes to engine design were also being made. Previously engines had been optimised for high speeds and high engine loads. But a new era focused on fuel efficiency rather than maximal power output demanded different designs.

New engines, new challenges

The fuel efficiency of engines was challenged by the need to meet the IMO’s new (at that time) Tier II nitrous oxides (NOx) requirements and therefore keep combustion temperatures relatively low. The solution was found in longer piston strokes to enable slow engine speeds while turning bigger, more efficient propellers.

These modern engine designs improved efficiency, but another challenge emerged. There had always been potential for cold corrosion in two-stroke engines — abnormal wear caused by sulphuric acid forming and condensing on the cylinder liner and piston components. But higher pressures and longer piston strokes exacerbated the issue.

Luc Verbeeke, Senior Engineer, Chevron Marine Lubricants explains: “You need water, sulphur and a temperature below the dew point to form sulphuric acid. One way of controlling corrosion is to make sure that the cylinder liner temperature stays above the dew point to form sulphuric acids. But once you start having ultra-long strokes, it is almost impossible to have equal distribution of temperature in the liner — there will unavoidably be pockets below the dewpoint. So, when those engines started to run slower, cold corrosion started to eat the liner away.”

Solving cold corrosion

Cold corrosion caused ship operators to adapt their lubrication strategies to minimise the negative effect of sulphuric acid. The best way was to select a lubricant oil with an appropriate amount of alkaline material (indicated as base number or BN) to neutralise the sulphuric acid before it could cause damage. Generally speaking, the more sulphuric acid is formed, the higher the BN needed to prevent cold corrosion — although appetite for BN can vary significantly between engine types and operation, even at the same fuel sulphur content.

As well as highlighting the clear link between fuel sulphur and lubricant choice, another important lubricant practice was reinforced by the threat of cold corrosion: the need for regular analysis of used cylinder oil. By testing oil samples drained from the cylinder, operators could identify warning signs — iron content, for example, or conversely too little alkalinity left in the oil — and adjust lubricant and optimise feed rate or BN of cylinder oil, as required.

2020 turbulence

The link between sulphur and BN, and the need for careful monitoring of drain oil, came to the fore once again as the industry prepared for the biggest ever coordinated switch of fuels in 2020. The IMO's global sulphur cap, limiting the sulphur content in fuel to 0.50%, led to the introduction of an entirely new fuel type, very low sulphur fuel oil (VLSFO). This blend became the predominant choice for ship owners globally after January 1, 2020 (except those choosing to continue burning high-sulphur fuel with the aid of exhaust gas cleaning systems known as scrubbers).

The lower sulphur content of VLSFO meant a lower BN lubricant was needed. Simple enough, but the great fuel switch was not without issues. Being a blend, there is inherent variability in VLSFO depending on the constituent ingredients. This can make it challenging to handle. In a circular last year — Marine Lubricants Information Bulletin 17, "Scuffing and red deposits after fuel transition: causes and solutions" — Chevron identified one emerging challenge for some older engines caused by fuel properties.

To protect against scuffing and other issues, owners need to be aware of the variability in VLSFO types. They also need to monitor engine fuel combustion parameters, adjust them when needed and perform frequent port inspections. In addition, drain oil needs to be checked regularly and corrective action taken, if necessary, by adjusting lubricant BN, feed rate or both. Chevron's DOT.FAST test kit allows vessels to quickly understand what is going on within their engine and take timely preventative action.

History lessons

From cold corrosion to VLSFO, the recent past of cylinder condition highlights some useful insights as the maritime sector prepare for future fuels and engine design changes:

1) There can be no one-size-fits-all approach to cylinder lubrication: High-sulphur fuels require different oils to low-sulphur fuels and the fuels shipping uses in the future are likely to raise further, different condition challenges requiring new formulations.

2) Cylinder condition depends on the engine as much as fuel: Whether it is super-long stroke pistons exacerbating cold corrosion, or older engines struggling with the challenges of VLSFO, engine design and condition must be taken into account in cylinder lubrication.

3) Any lubrication regime for new engine designs or new fuels will require vigilant monitoring for indicators of potentially problematic cylinder condition factors.

Picking from the palette of different fuels for the future

Perhaps the greatest unknown factor in managing cylinder condition in the future is which fuels will be preferred. One authority on the subject is CIMAC, the International Council on Combustion Engines. According to Peter Müller-Baum, Secretary General of CIMAC, the four most likely candidate "net-zero" carbon fuels suitable for deep-sea shipping are green ammonia, green methanol, LNG and synthetic hydrocarbons.

Ammonia and methanol: A balancing act

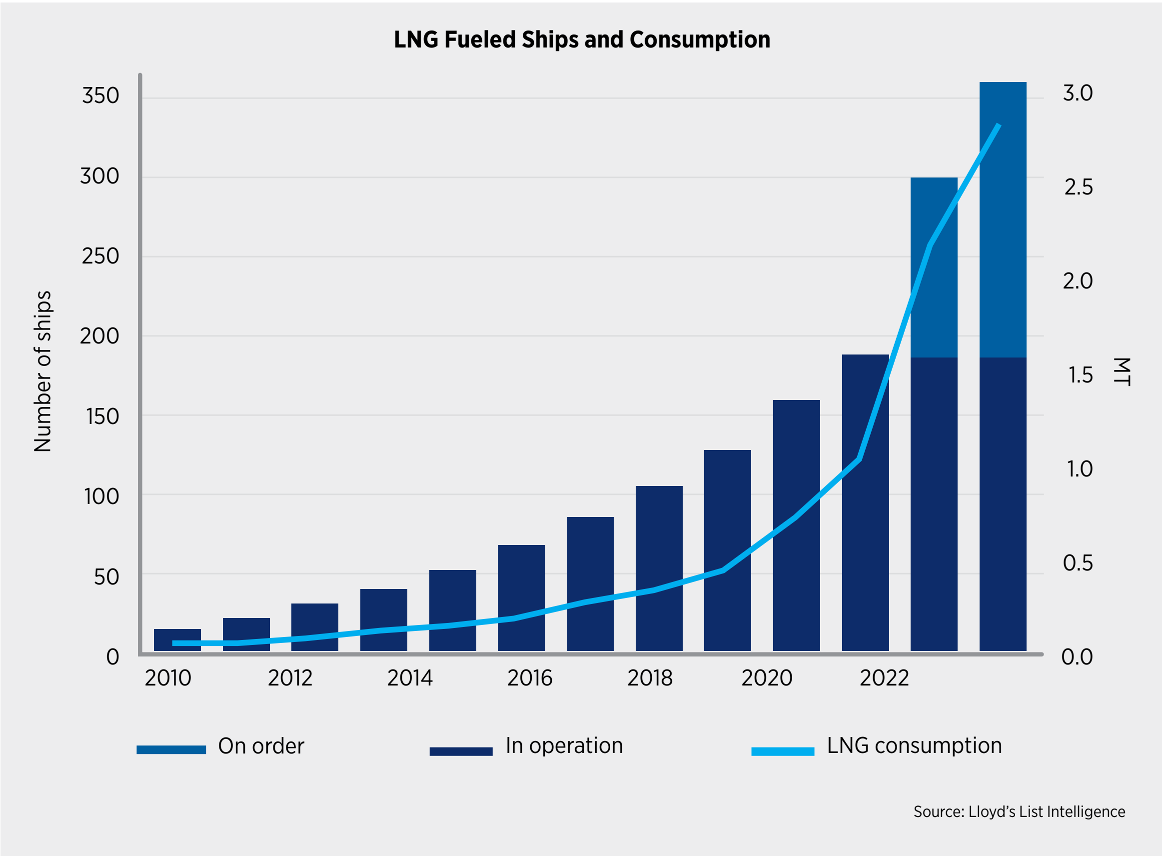
Ammonia and methanol are likely candidates because they offer cost-effective production processes. Methanol is a well-established industrial product while ammonia, which uses nitrogen rather than carbon as a carrier for hydrogen, is less expensive to make than other synthetic fuel options which use carbon.

"Ammonia will probably be cheaper than other options based on hydrogen because you don't need that extra energy to add carbon," says Müller-Baum. "That's why it is interesting. The problem is that it's highly toxic and therefore difficult to handle."

Methanol is not as hazardous, and ports and ship operators already have experience of it both as a cargo and as a fuel. Since 2016 a series of seven methanol carriers have been powered by methanol-burning MAN B&W engines lubricated by Chevron Marine Lubricants.

"Methanol is advantageous in many ways," says Müller-Baum. "On the other hand, the fuel itself will most probably be more expensive than ammonia because you need more energy to produce it."

Between ammonia and methanol, there is a trade-off between lower production costs (ammonia) and lower supply infrastructure costs (methanol). As wide availability of green ammonia or green methanol has yet to be established, it is challenging for ship owners facing investment decisions to make a choice. To make investment simpler, engine developers are promising the availability of retrofit options — meaning that ships can start operating on one fuel today before upgrading engines to run different fuels when they become available.



LNG: A realistic step to lower-carbon shipping?

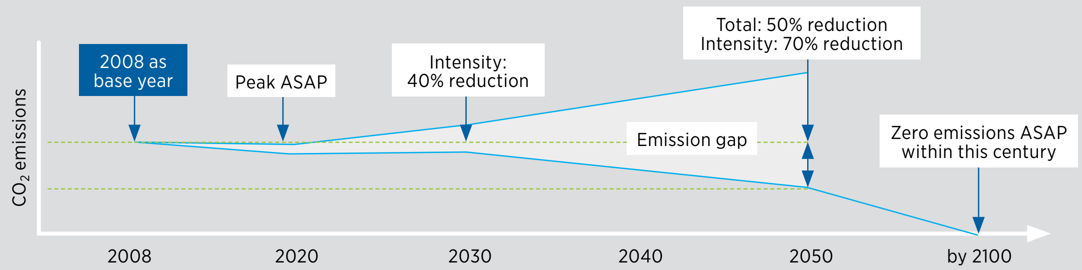
There are two other pathways that do not rely on retrofitting engines: which are LNG and synthetic hydrocarbons. Engine technologies already exist for these fuels and these technologies are widely deployed and are fully ready to burn alternative fuels as they become more available.

Fossil LNG is relatively widely used in shipping — primarily by gas carriers but increasingly by vessels in other segments. The fuel in its current form does not offer sufficient CO_2 reductions to meet IMO's 2050 target, but it does reduce some pollutants, such as sulphur oxides (SOx), nitrogen oxides (NOx), and particulate matter (PM). And its lifecycle CO_2 impact could be improved in the future if the methane molecule is synthesized, using captured carbon and renewable electricity, or biomass. These lower carbon options can initially be added to fossil LNG as drop-in fuels to cut emissions, and later — as supply increases — potentially replace fossil LNG altogether.

Even if carbon-neutral LNG is not available in the future, the engine technology it requires will be able to be retrofitted for methanol and/or ammonia fuel. These make LNG a versatile option in today's uncertain fuel market.

"That is why ship operators may look at LNG orders for the next few years, when these other fuels are still more or less a vision of the future," says Müller-Baum.

IMO strategy on CO_2 emissions



Short-term 2018–2023

- Tighter EEDI and SEEMP
- Energy-efficient indicators
- Speed reduction
- National action plans

Mid-term 2023–2030

- Energy-efficient measures for new and existing ships, using new indicators
- Carbon pricing / MBM
- Plan for low-carbon fuels

Long-term 2030+

- Development of zero-carbon fuels
- New/innovative emission-reduction mechanisms

Source: Achieving the IMO decarbonization goals, July 2020, DNV

Synthetic hydrocarbons: lower-carbon copies of today's fuels

The fourth pathway also delivers synthetic fuels akin to green ammonia, green methanol. The processes already exist to convert renewable energy and captured carbon into synthetic hydrocarbons. These hydrocarbons can be produced in any form — including the marine diesel and heavy fuel oil that ships have burned for more than a century. The synthetic versions are chemically identical, except that they will not use fossil carbon, and can then move towards the target of net-zero emissions over their production-to-use lifecycle.

Such synthetic hydrocarbons would allow ship operators to use conventional engines and fuel handling solutions. But, according to Müller-Baum, their future availability is even more uncertain than ammonia or methanol.

"Technically, it is not rocket science," Müller-Baum explains. "But it is rather energy intensive, which makes it more expensive than other options. However, if there is a huge industry producing these kinds of fuels — synthetic kerosene for aviation, for example, or synthetic gasoline for automobiles, it maybe not be so expensive to also produce fuel for shipping. But producing these fuels for shipping alone would not be profitable from today's point of view."

Shipowners cannot, sadly, afford to wait and see if synthetic hydrocarbons — or those derived from biomass — will emerge and enable their fleets to use them without changing their engines.

LNG is a slightly different case. If this hydrocarbon becomes widely available as a synthetic fuel, owners of today's gas-fueled engines will be able to switch to the new fuel. But if synthetic LNG is not available, it is likely that gas engines will be able to be retrofitted to use other new fuels more easily than conventional diesel engines. From the perspective of future fuels, LNG-fueled engines may therefore offer more flexibility even if synthetic LNG does not become available.

Future fuels and cylinder condition

Each of the four future fuels described above — ammonia, methanol, LNG and synthetic (including biofuel) hydrocarbons — has its own impact on cylinder condition. For synthetic hydrocarbons, the challenges would be similar to those accompanying use of current HSFO, marine diesel or whichever fuel is to be replicated. For LNG and methanol, there is already growing understanding of the required lubrication regime. Only ammonia remains unknown.

Gas engine growth

The first dual-fueled two-stroke ship engines were ordered in 2013. Over the preceding eight years, the gas-fueled fleet has grown to 221 vessels (excluding LNG carriers), according to DNV's Alternative Fuel Insights platform, with a further 394 vessels on order. Engine developers and lubricant suppliers including Chevron Marine Lubricants have already had plenty of experience. Much of this experience was put into CIMAC's Guideline On The Lubricating of Reciprocating Gas Engines. The general advice for two-stroke engines is:

> *When the engines are operated on gas, the resulting fuel mix (gas and pilot fuel) is generally equivalent to an ultra-low sulphur fuel as the gas contains very little, if any, sulphur, and the amount of pilot fuel is small. When the engine switches over to liquid fuel operation, the engine acts like a diesel engine, and it may be subject to cold corrosion. Some general advice can be given for operation on gas:*
>
> - *Use cylinder oils with good deposit control to avoid deposit build up.*
> - *Cylinder oil feed rates should be kept as low as possible.*
> - *Lubricant oil quills or injectors must be kept in good working order to maintain correct oil dosing and distribution.*
> - *Drains (scavenge air, water mist catcher, receiver, and piston underside) must be kept clean and fully operational.*
> - *Cylinder condition should be monitored, and action should be taken based on observations. As wear is generally low, actions to address deposit build-up should be the priority.*

MAN Energy Solutions and WinGD engines operated on LNG are treated similarly to ultra-low sulphur fuel oils with a sulphur content of 0.10% or lower.

First movers on methanol

Another widely discussed fuel, methanol, has been used as fuel on a series of seven methanol carrying tankers for more than five years now. The engines are lubricated by Chevron Marine Lubricants, which documented early experience in a dedicated whitepaper "Methanol and marine: lubricants in a lower sulphur, lower emissions future".

Marinvest's MAN ME-LGIM engines have been lubricated with Chevron Marine Lubricants oil since 2016. In a recent Chevron Marine Lubricants webinar, Marinvest technical director Frederik Stubner explained how the company had initially been concerned about the effect that prolonged dual fuel operations would have on cylinder liner and piston ring wear. Regular scrapedown oil analysis using Chevron's DOT.FAST® service and frequent in-situ liner measurements were used to monitor cylinder condition. The ship operator reported that cylinders appear much cleaner when burning methanol than conventional liquid fuels.

Engine developer approaches: MAN Energy Solutions

For MAN Energy Solutions, many of the future fuels are already in service. The company already has two-stroke marine engines operating on LNG, methanol, ethane and LPG. According to Julia Svensson, Research Engineer, MAN Energy Solutions, lubrication requirements remain consistent across these fuels.

"In all cases [except the forthcoming low-pressure ME-GA dual-fuel LNG engine] our engines use the Diesel process, so the concept of what is needed from the lubricant is similar. For all low-sulphur fuels the recommendations are essentially the same as for 0.10% and <0.50% sulphur fuels."

Methanol engine from MAN Energy Solutions

MAN ES also recommends cermet piston ring coating for all engines running on low-sulphur fuels, in order to increase the margin against damage to the piston rings and cylinder liners. Svensson also notes that lubrication recommendations can change as MAN ES learns more about how engines operate with these new fuels, and as engines get updated.

In the past two years, MAN ES has introduced a new approval structure for lubricants that places a greater demand on cleanliness for products used with their newer engines (Mk 9 and above). These new Category II requirements, which will be discussed in more depth in the following chapters, will naturally apply to all of the new engines running on LNG, methanol and other low-sulphur alternative fuels.

MAN ES also notes the distinction between fuels currently in use and another future fuel candidate — ammonia. An ammonia engine is under development and is expected to be available commercially by 2024. It is too early to describe cylinder condition concept or lubrication requirements for this new engine type.

Engine developer approaches: WinGD

WinGD designs two-stroke engines that include a low-pressure, Otto-cycle dual-fuel engine capable of running on LNG and fuel oil. This engine concept in particular offers the potential for future fuel flexibility, although its Diesel-process engines will also be candidates for running on liquid future fuels.

WinGD currently validates lubricants for its dual-fuel engines under two categories: those that have passed a validation test in the field on gas mode (known as 'DF validation'), demonstrating "a good ability to keep the piston running components clean .. at optimised low feed rates"; and those that have passed a field validation test in liquid mode and are allowed for gas operation "based on their performance" (known as 'general usage').

According to Roger Mäder, Head of Tribology, WinGD, the current tribology concept works for both liquid and gaseous fuels. However, detailed lubricant requirements cannot be confirmed until more testing of future fuels have been carried out.

"If a fuel contains something that can be aggressive to the material of the cylinder liner or other components it can damage it. So, we need to have a countermeasure to protect these components."

Roger Mäder, Head of Tribology, WinGD

"First actions are the testing of future fuels at WinGD facilities," says Mäder. "Then the continuous testing and validation of cylinder lubricants is important — not just the validation but also follow up together with oil companies about how they behave in the field."

New fuel types might have different combustion concepts as well as different fuel properties and different combustion by-products.

"If a fuel contains something that can be aggressive to the material of the cylinder liner or other components it can damage it. So, we need to have a countermeasure to protect these components. Smart material combinations are important, as well as how you neutralise acids and how lubricants react with these fuels."

Future engines and cylinder condition

The impact of new fuels is just one element of future cylinder condition. Arguably more important is the impact of engine advances to further increase fuel efficiency.

Fuel efficiency will help ship operators minimise emissions until lower-carbon fuels are widely available. And once running on those fuels, which could come at a significant premium compared to today's fuels, efficient engines will help to keep costs manageable.

The major avenue for increasing fuel efficiency in two-stroke engines is through increasing combustion pressure. This can have an impact on cylinder cleanliness if the lubricant is not sufficiently resistant to higher temperatures. For future cylinder oils, increasing thermal stability and reducing the potential for forming deposits in cylinders will be crucial.

A new level of cylinder cleanliness

MAN ES has attempted to address the problems of cylinder cleanliness in new engine designs by setting more demanding lubrication requirements, explains Julia Svensson.

"During the past few years when engine development has been fast and we have been pushing out different engines with increasing pressure, we saw that some of the cylinder lubes were not up to the task. For these engines with high pressures and small clearances, the lubrication needs to keep the engine clean so that deposits are not obstructing anything, and the engine can really perform."

After removing no objection letters for some low-BN oils because they were not providing the expected cleanability, MAN ES introduced its Category II. Eventually, a list will show the lubricants granted the Category II status which are applicable for all engines and recommended for MAN engines Mk 9 and above. Cylinder oils granted this status must have excellent overall performance, with special focus on cleaning ability.

Minimising deposits

Luc Verbeeke, Senior Engineer, Chevron Marine Lubricants, explains that there are high BN products that can be used with MAN ES's modern engines — Chevron Marine Lubricants' Taro Ultra 100 and Taro Ultra 140 both have Category II approval — but a Category II low-BN oil would be the ideal solution to match fuels with low sulphur content. Fortunately, a new low-BN cylinder oil, Taro Ultra Advanced 40, will become available in the second half of 2022. MAN ES has approved this 40 BN oil as a Category II lubricant suitable for its Mk 9 and later engines. In the interim, MAN ES recommends intermittent switching between 40 BN and 100 BN oils, when needed, to ensure cleanliness.The search for greater cleanliness at low-BN is not limited to MAN diesel engines. For Otto-cycle engines such as WinGD's dual-fuel LNG engines, there is an added impetus in finding low-alkaline yet low ash solutions.

Luc Verbeeke, further stated that the Otto-cycle concept of compressing a fuel-air mix and then igniting it — as opposed to the Diesel process of igniting fuel as it is injected — means that lower deposits are even more important.

"Because you are igniting a mix with a pilot fuel, of course, any other sort of ignition will also ignite the mixture — say a glowing piece of deposit on the piston crown. This means you can get uncontrolled combustion. The calcium carbonate or metals in general from cylinder oil additives will not help you at all. So, we believe that lower ash products are required."

"Deposit formation can be an issue if an oil is overheated, or thermal stability is exceeded. Especially for fuels with low sulphur, you don't have a lot of acid formation, so you don't need a lot of BN but you still want to have clean components and therefore high detergency. This has been a trick to have a low ash product but with high detergency."

Protecting engines with after-treatment

According to Luc Verbeeke, lower ash products will be needed not just for low-pressure Otto engines, but for future low-pressure engine designs using other fuels. There will also be a need among engines using exhaust gas after-treatment such as selective catalytic reduction (SCR) and particulate filters to lower emissions such as NOx and particulate matter, respectively. After-treatment is likely to become a more important element of many marine engines — whether to remove sulphur, to lower NOx (selective catalytic reduction or exhaust gas recirculation), to reduce methane slip or to minimise particulate emissions (diesel particulate filters) in line with potential future regulation.

The presence of after-treatment in the post-combustion chain means that engines will have to work harder to expel exhaust, which could lead to less complete scavenging. This means more combustion by-products would

likely remain in the engine cylinder. If those by-products include ash from the metallic elements in lubricants, this could lead to more deposits in the cylinder. Even if ash deposits are not problematic in the cylinder, the fouling that ash can cause along the post-combustion chain means that it should be minimised, especially where after-treatment is deployed.

Requirements for future cylinder lubrication

It is clear that fuels will not be the only factor to influence cylinder condition in the future.

Many of the candidate fuels have already been in operation on two-stroke low-speed engines using the Diesel and Otto process, and the lubrication requirements for Diesel engines to date appear similar for all low-sulphur fuels. This of course may be updated as further experience is gained and may be entirely different as other fuels emerge — for example ammonia.

As Otto-cycle engines emerge to burn fuels beyond LNG, and as exhaust after-treatment becomes more widely used, lower ash cylinder oils may be needed to keep engine cylinders and the post-combustion chain clean from deposits that can contribute to sub-optimal combustion.

As well as developing engines for different fuels, such as methanol, ammonia, hydrogen, biodiesel and any other potential candidates, the general advance of engine design will continue to focus on improving fuel efficiency. This will be driven by higher temperatures and pressures in the cylinder, putting lubricant under increasing stress. This more demanding environment is reflected in MAN ES's Category II requirements as well as in WinGD's requirement for lower-ash yet high detergency products and a separate 'DF validation' process.

> **"As a pioneer of cylinder lubrication for the different fuels .. as well as an early developer of low-ash marine oils, Chevron Marine Lubricants is well placed to meet the needs of users of future marine engines."**
>
> **Pat McCloud**, General Manager, Chevron Marine Lubricants

But amid all these emerging requirements, the basic reason for lubricating cylinders in the first place should not be ignored. Julia Svensson from MAN ES puts it clearly.

"Sometimes we forget what the obvious things a lubricant is supposed to do: to lubricate the piston and liner; to reduce the friction, introduce wear protection and minimise the risk of seizures; to neutralise acids if any and take care of oxidation products; to keep cylinder components clean to ensure the free movement of the rings; and to prevent excessive deposit build-up. These have always been the requirements. It is still true and it is not anything new."

Satisfying these challenging future development demands will be Chevron Marine Lubricants' mission, says General Manager Pat McCloud.

"As a pioneer of cylinder lubrication for the different fuels — such as fuel oil, LNG, methanol, ammonia and biodiesel — as well as an early developer of low-ash marine oils, Chevron Marine Lubricants is well placed to meet the needs of users of future marine engines," he says. "Combined with our efforts in making global supply ever easier, these investments will ensure that our customers are well served to operate their engines safely and reliably today and into the future."

solutions for your journey

marine lubricants

taking the temperature of the 2020 fuel sulphur switch

As shipping moves further toward a future powered by cleaner fuels, the introduction of IMO's global sulphur cap on 1 January 2020 offers some valuable lessons about how to ensure the safe and reliable operation of main engines.

Alongside everything else that an unprecedented period of uncertainty has thrown at shipping, 2020 started with the biggest-ever shakeup of the marine fuels market. A majority of internationally trading ships switched to very low-sulphur fuel oil (VLSFO), with a sulphur content of 0.50% m/m or lower, in compliance with IMO's MARPOL Annex VI sulphur regulations. The remainder either continued to burn high-sulphur fuel but with exhaust gases funneled through cleaning systems (or 'scrubbers') to reduce their sulphur emissions, or adopted other low or no-sulphur fuels such as liquefied natural gas (LNG) or methanol.

Prior to the fuel change, there was industry-wide concern about how new fuels could affect ship operations. One major question was whether ship operators would be able to successfully adjust their fuel handling and engine operations — including adopting new cylinder lubrication products and practices — to manage use of the new VLSFO blends. Several months after the switch, Chevron Marine Lubricants assesses how the industry dealt with these issues.

Taking the temperature of the 2020 fuel sulphur change is particularly important considering the challenges shipping will face in the future. As the industry explores options for meeting IMO's greenhouse gas emission reduction ambitions — most crucially the aim of cutting emissions by 50% by 2050 compared to 2008 levels — more new fuels will come into play. According to DNV GL, 30–40% of the global fleet's energy demand will need to be met by carbon-neutral fuels to achieve this target.

"Using new fuels — whether it is today's VLSFOs or the carbon-neutral fuels of tomorrow — requires careful planning as well as a rigorous monitoring programme to avoid engine issues," says Ian Thurloway, Brand, Marketing & Business Development Manager for Chevron Marine Lubricants. "As ship owners and operators look towards 2050, the lessons of the great sulphur switch are far too valuable to ignore."

A turning point for marine fuel

Such a wide-ranging change inevitably led to concerns as 2020 approached. The most fundamental were about price and availability: would VLSFO be widely available and priced competitively compared to the high-sulphur heavy fuel oil (HSFO) that scrubber-equipped vessels could continue to use?

In the end, these fears about VLSFO were not realised. As oil majors and refiners announced their VLSFO plans in the run-up to 2020, worries about availability diminished and (barring a few isolated incidents) lack of compliant fuel has caused little disruption. Meanwhile the low oil price throughout the first half of the year has meant that the relative cost of fuels has been less critical than was imagined in 2019.

There were also concerns beyond price and availability. It was widely anticipated that the VLSFO blends, produced specifically to meet the new sulphur regulations, would have very different characteristics not just to traditional fuels but also to each other. This would mean operational challenges relating to the variable properties of the new fuels and how they should be handled.

Preparing for the switch meant cleaning fuel tanks so that residual high-sulphur fuel would not inadvertently make vessels non-compliant. Fuel tanks would need to be arranged so that specific batches of fuel could be segregated if needed. Fuel supply lines had to be able to chill or heat fuels to the viscosity requirements of engines. And fuel purification and filtration had to be bolstered to protect engines from damaging contaminants either inherent in the new fuels (such as cat fines) or resulting from the accidental combination of incompatible fuels.

"Cylinder units that could have run for another six months or a year on HSFO did not survive the tougher conditions with the new fuels."

Luc Verbeeke, Senior Engineer,
Chevron Marine Lubricants

Another crucial consideration was cylinder lubrication. Whichever fuel is used, cylinder oil is critical to ensure that engines run safely and reliably. Low-sulphur fuels need oils with a lower base number (BN) that require different management to those used for HSFO. But beyond the base number, the new VLSFO blends were a relatively unknown quantity. If the individual fuels were not stable or if ships bunkered different blends that were incompatible, asphaltene precipitation could cause sludge to build in the fuel supply system which could lead to deposits in the engine, potentially affecting performance and reducing time between planned maintenance. Effective lubrication could help protect against potential deposits.

Taking stock of 2020

According to Luc Verbeeke, Senior Engineer, Chevron Marine Lubricants, despite the daunting challenges it appears as though the switch went smoothly for most ship operators.

"The large majority have made the transition well and were adequately prepared," he says. "Most of our customers switched from HSFO to VLSFO. We did see OEMs report a temporary spike in scuffing issues on engine cylinders. This was not unexpected, and the majority of issues are more related to housekeeping — such as handling fuels properly and following OEM advice — than fuel quality or cylinder lubrication."

There have also been some important learnings about VLSFO itself. As late as December 2019, the consensus was that the marine fuels market would feature myriad VLSFOs with a widely varying range of fuel quality. The reality has been somewhat better for operators. In fact, by Luc Verbeeke's analysis, VLSFO has in general turned out to be a high-quality product with a greater energy content and faster combustion than traditional HSFO.

"You could say that customers get more value for money from VLSFOs," he says. "But that has still created some challenges. While newer ships do not have a problem using these fuels, engines already closer to an overhaul did struggle sometimes. Cylinder units that could have run for another six months or a year on HSFO did not survive the tougher conditions with the new fuels."

The reason for the difficulties in older engines was the calculated carbon aromaticity index (CCAI), which measures the ignition qualities of fuels. Most VLSFOs have a CCAI score of 820 or below, significantly lower (and therefore with more energy content) than a typical HSFO with a score of 850 or higher. Combustion analysis by Chevron Marine Lubricants identified that ship operators will need to keep their engines generally in better shape to burn these fuels, and that lubricant monitoring services will play a vital part in this process.

Another lesson has been about the impact of some methods of tank cleaning on engine running. In the period leading up to 2020, several operators cleaned their fuel tanks by using fuel additives or diesel oil that flushed high-sulphur waste through the fuel system — effectively using their engines as an incinerator to burn off the waste.

“Some of these engines failed pretty quickly and this will potentially also have a longer-term effect,” says Luc Verbeeke. “I think this will become clear in future overhauls. All the cat fines and sludge that were in the tank were put through the engine.”

Combined with incorrect fuel handling, these challenges with older engines and the impact of flushing waste material through engines account for most scuffing incidents. The fact that reports of scuffing have since declined to usual levels suggests that the industry has now come to terms with the procedures it needs to operate safely and reliably with VLSFO.

Most issues that have arisen in the use of VLSFO have very little to do with the quality of the fuel itself. This is clear because the number of issues reported would not have declined if the problem was with fuels — and cylinder oils — that are still being used. As well being a relief for fuel purchasers, that fact also vindicates the cylinder lubrication strategy advocated by Chevron Marine Lubricants.

Example of a piston with scuffing and deposits. Photo courtesy of Chevron Marine Lubricants, 2020

Managing the shift to low-BN oils

In the run-up to the sulphur cap, Chevron Marine Lubricants renewed its range of cylinder oils to cover the entire spectrum of fuels that would be used after 2020 — from near-zero sulphur fuels such as LNG or methanol to HSFO with a sulphur content possibly even higher than 3.5%. The Taro Ultra range was formulated to offer flexibility and to ensure global supply. It was rolled out across Chevron Marine Lubricants' existing supply network of over 573 ports during 2019 to ensure readiness to meet the demands of the post-2020 landscape.

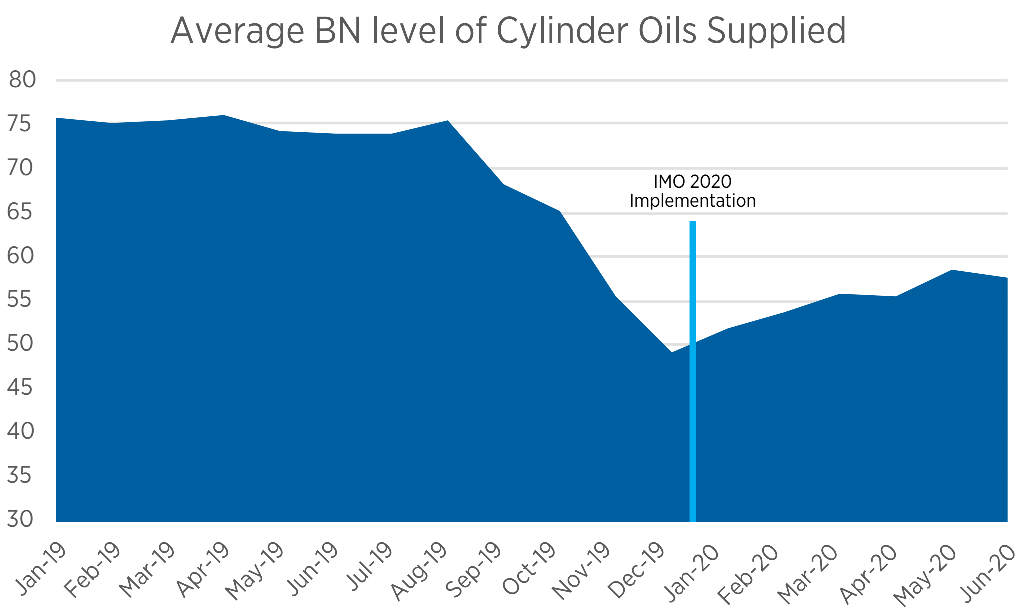
The BN40 product Taro Ultra 40 is an example of that flexibility. It was rigorously tested with VLSFO blends and is also suitable for intermittent operations that vary between the use of LSFO, blends and distillates — such as when switching fuels when sailing through SECAs. This removes the use of multiple cylinder oils, reducing on-board complexity.

In the run-up to the end of December, Chevron Marine Lubricants took a survey of customers' plans for the fuel switch. This was designed to help manage the changing lubrication requirements and BN levels; the move from high- to low-BN product in general represented a complex shift in the supply chain of lubricants.

"We were quite surprised how late a lot of the industry left the switch," says Ian Thurloway. "Some did change over as early as September to gain more experience before the regulation came into effect. But we noted a very late run on low-BN product in December."

For Chevron, ensuring supply and availability of products was a huge priority. The global switch to lower BN oil meant dramatically different product was needed across the world. According to Simon Chung, Team Lead — Global Marine Product & Technology Support, Chevron Marine Lubricants, it was a question of getting the right products in place in the right package for customers. But swings in demand made the big transition even more problematic.

"Earlier in the year we saw volumes of high-BN marine cylinder oils drop off because ship operators did not want to be left with excess stock," he explains. "The volume didn't pick up again until very late in the year, and then it was for low-BN oils. So, there was a lot of uncertainty in demand and the shift in product meant that we also had to plan for several different scenarios, as well as helping customer manage their transition."



VLSFO, ECA and scrubber operation data included. Chevron Marine Lubricants, 2020.

Monitoring the new regime

Another critical element of managing the transition with ship operators was to reinforce the importance of testing drip oil. While lower sulphur in fuels may mean fewer harmful emissions, the loss of lubricity that sulphur brings can also make engine operations more challenging. And with little experience using 0.50% sulphur fuels, operators needed to verify that they were taking the right steps to safeguard their engines.

As Luc Verbeeke explains, "In the traditional high-sulphur world there was a buffer zone against engine damage. As you reduce feedrates, you enter first a corrosive wear zone before reaching the more damaging adhesive/abrasive wear. The engine operates best in the corrosive wear zone if you manage that. But with sulphur levels

in fuels coming down, that safety margin has become much smaller and you can end up getting to the damaging adhesive/abrasive wear much faster — potentially towards the sudden severe wear that affects the engine immediately and cannot be recovered."

Total iron levels remain important for indicating when engines are in a corrosive regime, but the magnetic particles are also needed to alert ship operators to abrasive wear. Chevron's DOT.FAST® service uses an onboard test that looks at total iron. The onshore laboratory service goes further, using inductively coupled plasma (ICP) mass spectrometry to identify not only total iron, but also a particle quantification (PQ) analysis to detect magnetic particles.

"The DOT.FAST laboratory analyses now provide a reading of both total iron and magnetic iron," explains Luc Verbeeke. "If you see total iron increasing without magnetic particles rising, you know you have corrosion. But if you see magnetic particles also rising, you have adhesive/abrasive wear."

Looking beyond 2020 fuels

This monitoring and analysis will be critical as the industry adapts to even more fuel changes in the future. The amount of sulphur in marine fuels is likely to decrease further in response to future regulations, reducing the safety barrier between normal engine operation and damaging cylinder wear. But there is much more than sulphur on the future fuel agenda.

Total iron levels remain important for indicating when engines are in a corrosive regime, but the magnetic particles are also needed to alert ship operators to abrasive wear.

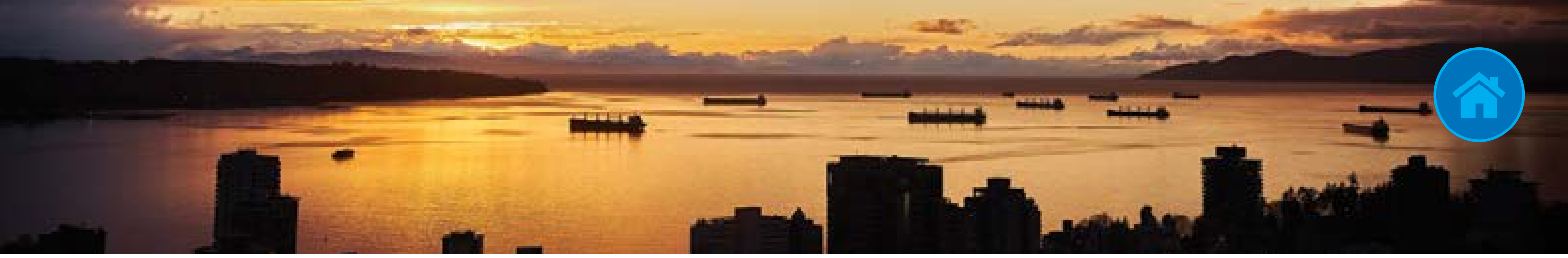
"Looking beyond 2020 there are still a lot of big changes to come," says Simon Chung. "IMO has further regulations on the horizon, OEMs are still looking at certifications and approvals as well as other engine designs and fuels. Therefore, the picture will likely only become more complex. We are continuously looking at our product range and making sure we address any gaps that emerge."

Having navigated the sulphur cap, IMO is now turning its attention to other areas. In the longer term, this means decarbonisation in line with its target of reducing greenhouse gas emissions per transport work by 40% by 2030, then reducing total greenhouse gas (GHG) emissions by 50% by 2050 (based on 2008 levels). More immediately, other emission reductions will take the focus — namely particulate matter and nitrogen oxides (NOx). Luc Verbeeke expects that the IMO's hitherto limited Tier III NOx regime will be expanded rapidly.

"The first NOx regime was in place in the US in 2016 and we now expect several other parts of the world to follow shortly," he says. "It will be adopted in the North Sea and Baltic Sea in 2021. So today when you build a new ship you could say that you will avoid the US, although this would be limiting and reduce vessel flexibility. But can you afford to say you will avoid the US and Europe for the lifetime of your vessel?"

From the cylinder lubrication perspective, lower NOx limits will require changes from the oils generally used today. Most vessels are likely to meet Tier III NOx by means of exhaust gas aftertreatment — either selective catalytic reduction (SCR) or exhaust gas recirculation (EGR). When using these devices, maintaining engine efficiency is critical to make sure that emissions limits can be maintained while engines run smoothly and efficiently. Cylinder lubricants can contribute to this efficiency by altering factors such as ash formation — which can have a detrimental impact on aftertreatment — and viscosity.

When it comes to decarbonisation, any contributions to efficiency that cylinder lubricants can provide will be useful as ship operators look towards IMO's 2030 target. This target — essentially reducing the GHG emissions of each ship by 40%, although specific regulations have yet to be formulated — will also need to be met by ships already in service.



Future fuels for 2050

Meeting the 2030 target may not require a change of fuel, but the more ambitious 2050 target certainly will. To reduce GHG emissions by half compared to 2008 levels after 42 years of growth in shipping volumes is a daunting task. Some observers believe it is a task that the internal combustion engine is unable to achieve. But a range of new carbon-neutral fuels stand against that viewpoint.

"Ship propulsion will not likely change radically by 2050," says Luc Verbeeke. "It has now been proven that ship engines can run on a wide range of new fuels including the e-fuels like methanol and ammonia that are produced by renewable electricity. We see a lot of projects investigating how to store excess electricity as e-fuels and some of these make sense as shipping fuels. We believe that the diesel engine will still have a role, although the fuels will have to change."

The range of carbon-neutral fuels currently under consideration by the shipping industry includes ammonia, methanol and synthetic LNG. Each of these will bring specific challenges to maintaining engine condition. Chevron Marine Lubricants already has a wealth of experience in two of these areas.

The company has been lubricating the methanol-fuelled two-stroke engines of Marinvest Shipping for more than four years now, supplying 40BN product with positive feedback. And it has long experience in lubricating dual-fuel LNG engines on the gas carrier fleet and across a growing number of merchant vessels.

Ammonia as a marine fuel has yet to emerge, although it has strong potential and is currently the subject of several engine and vessel pilot projects. Chevron is monitoring these developments and assessing the impact and requirements this fuel will place on cylinder lubrication.

Conclusion

As the industry heads into a future of new fuels, the switch to low-sulphur fuels at the beginning of 2020 provides a useful indicator of what might come.

Perhaps the clearest observation is that the most frequent issues may not be attributable to inherent quality problems with the new fuels themselves. It is the correct handling of the fuels, good preparation for any new regime and the adherence to OEM guidance that most often safeguard engines from damage while optimizing performance. While it is too early to assess the characteristics of many future fuels, these factors will remain crucial.

It is also apparent that cylinder lubrication will need to continue to evolve in line with the shifting marine fuel landscape. As the IMO has mandated reduced sulphur content, cylinder lubricants have been reformulated to cope with new, lower sulphur fuels. Future regulations — whether governing particulate matter or ultimately the use of carbon-based fuels — will see an even more diverse range of fuels and fuel characteristics come into play. Cylinder lubricants will have to address these new characteristics and the challenges they pose for engines.

Finally, any new regime will need to be monitored carefully to ensure engines are not subjected to unacceptable wear. Low-sulphur fuel running reduces the safety margin between normal operation and abrasive/adhesive damage, and it is likely that new fuels will add other challenges. Regular and detailed drip oil analysis — able to measure magnetic and non-magnetic iron — will be essential to provide a clear picture of what is happening inside the engine. Onboard and onshore testing with these capabilities such as that deployed by Chevron's DOT.FAST service will help to spot issues before they become problems and inform ship operators how to adapt and optimize cylinder lubrication.

The switch to low-sulphur fuels has been largely successful, supported by good preparation from ship operators, strong support from OEMs, fuel and lubricant providers and careful monitoring of operations using the new fuels. With similar care there is every reason to believe that the shipping industry can also navigate the fuel changes that lie ahead.

Chevron

marine lubricants

lubricating dual-fuel auxiliary engines: a practical approach

As an increasingly diverse marine fuels market adds complexity for ship operations, owners are looking for simplified solutions to optimise engine performance. Chevron Marine Lubricants' recent work with dual-fuel four-stroke engines highlights a practical approach to these challenges.

Dual-fuel LNG engines are being installed on more and more vessels, driven by an expanding fleet of LNG carriers as well as the rise of LNG-powered propulsion in other vessel segments. Along with emissions benefits in gas mode, these engines provide fuel flexibility, with the ability to run on either LNG or fuel oil dependent on availability. That flexibility means that lubrication requirements for the same engine can change depending on how the fuel is used.

"In dual-fuel auxiliary engines — as with all engines — there is no one-size-fits-all solution," says Ian Thurloway, Brand, Marketing & Business Development Manager for Chevron Marine Lubricants. "Lubrication is usually dictated by the fuel used and its operating profile. The flexibility of dual-fuel engines means that this can be a more challenging environment than other applications."

The rise of LNG as marine fuel

The use of LNG engines has increased dramatically in the past decade. Initially deployed on gas carriers, the engines are now being installed on merchant vessels; according to DNV GL's Alternative Fuels Insight[1], the gas-fueled fleet (excluding LNG carriers) grew from just 21 vessels in 2010 to 168 in 2019. It is expected to more than double by 2022. Meanwhile, the gas carrier fleet — as well as the number of offshore facilities including floating storage regasification units (FSRU) and floating LNG (FLNG) installations — is also set to expand as demand for LNG around the world rises.

The growth of LNG as a marine fuel coincides with increasing global production of natural gas and the emergence of environmental legislation in the shipping sector. The fuel was initially pioneered in small Norwegian ferries to

1. https://afi.dnvgl.com/Statistics?repId=1

reduce harmful nitrogen oxide (NOx) emissions and was also touted as a means of complying with fuel sulphur (SOx) limits when IMO introduced sulphur emission control areas (ECAs) in January 2015.

LNG is an attractive option for shipowners looking to comply with IMO's global sulphur cap. LNG is currently one of the few readily available fuels which can offer lower carbon dioxide emissions, meaning that it is being considered by some ship owners and operators as a step in the path to decarbonising shipping, in line with IMO's greenhouse gas emission reduction strategy.

Dual-fuel engines mean that operators have the versatility to switch between LNG and residual or distillate fuels, for example if LNG is unavailable or is only required in a specific area such as an ECA or in port. It is a particularly practical option while global LNG bunkering infrastructure is being developed, or when a ship's trading pattern means that it does not necessarily have fixed bunkering locations.

The challenge of lubricating four-stroke, dual-fuel engines

Around three quarters of ships using LNG as fuel have dual-fuel, four-stroke engines. When running continuously on LNG these engines require an oil formulated to minimise ash deposits, which can adversely affect the performance of gas engines by encouraging premature ignition or pre-ignition. However, these oils will not always be appropriate when dual-fuel engines are operating on residual or distillate fuels.

"The challenge for some operators is that they may not know what fuel their vessels will use on a long-term basis," explains Chevron Marine Lubricants marine technical service engineer Rik Truijens. "They could shift from operation on gas to using marine diesel oil, right up to full operation on heavy fuel oil. This means operators also face uncertainty about which lubricant they should be using with which fuel."

Like two-stroke engines, four-stroke engines require lubricating oil to ensure smooth running and engine cleanliness. But while two-stroke engines have separate lubrication systems for the cylinders and the crankcase, four-stroke engines have a common sump serving both cylinders and crankcase. Rather than two oils (cylinder oil and system oil), four-stroke engines are therefore lubricated by a single trunk piston engine oil (TPEO).

Another important difference between lubricating two-stroke and four-stroke engines is how the oil is replenished. While fresh cylinder oil for two-stroke engines is injected into the cylinders continuously, in four-stroke engines trunk piston oil is recirculated from the sump, so only needs to be topped up.

The recirculating of oil in four-stroke engines has two important implications. First, it means that contaminants from fuel and/or engine wear can accumulate in the sump, making the oils' ability to handle these contaminants particularly important. Secondly, it can make fuel switching more complicated. While two-stroke engines can simply switch the lubricant they are injecting into cylinders to match the new fuel type, in four-stroke engines the entire reservoir of oil in the sump needs to be replaced. Ideally, operators need a practical approach to lubrication that will prevent this costly and time-consuming task.

"If you choose a gas engine oil, then you will need to change the sump as soon as the engine runs for any length of time on distillate fuels, because the oil will not be able to handle those contaminants," says Truijens. "Likewise, oil designed for gas operation will not cope with prolonged use of residual fuel."

Different oils for different fuels

There are many reasons why different fuels need different lubricating oils. A major factor is sulphur content. The higher the level of sulphur in a fuel, the greater the risk of acidic corrosion in the engine. To counter this, lubricants include alkaline material, quantified by their base number (BN). More sulphur in fuel requires greater alkalinity (i.e., a higher BN) in an engine oil.

However, if the alkalinity in oil is too high for the fuel sulphur level, ash deposits can be formed in engines. This is a particular challenge in gas engines, where the ash embers can settle on pistons and potentially cause pre-ignition of gas fuel — also known as 'knocking' — with a negative impact on engine performance.

According to lubrication advice from many leading dual-fuel four-stroke engine OEMs, engines running constantly on LNG should be lubricated with a low-ash engine oil. These low ash oils — such as Chevron Marine's HDAX 5200 —

help to ensure that the formation of deposits on the piston and ring belt remain under control. Reliable oxidation and nitration resistance can also reduce build-up of insoluble contaminants and promotes long oil and filter service life.

For dual-fuel engines running primarily on distillate fuels — including marine gas oil and marine diesel oil — alternating with LNG, more alkalinity is needed in a lubricating oil to handle the sulphur present in these fuels. To achieve the right balance between oil alkalinity and detergency, while helping protect valves from excessive wear and keep the engine clean, Chevron Marine Delo 1000 Marine 40 can provide the solution. The selected additives in the oil promote engine cleanliness and replenishment intervals can be extended with the use of separation and filtration.

Even more protection is needed for dual-fuel engines running mainly on residual fuels such as heavy fuel oil. Residual fuels typically contain asphaltenes which can drop out of solution and form sludgy deposits. For continuous operation on this type of fuel, alternated with natural gas and/or distillate fuel, a lubricating oil designed to handle these asphaltene contaminants is needed, such as the Chevron Marine Taro DP and XL series.

Many residual fuels have a high sulphur content and therefore require lubricant oils with a high BN, with enough alkalinity reserve to help protect the engine from corrosion. Chevron Marine Taro DP and XL are available in a range of BN levels, allowing operators to select the level they require. Chevron Marine recommends that operators determine the required BN through used oil analysis. It is Chevron Marine's experience that, in case of operation on residual fuels, the best results are obtained with Taro DP and XL maintaining the BN in the sump around 25, with a minimum of 20.

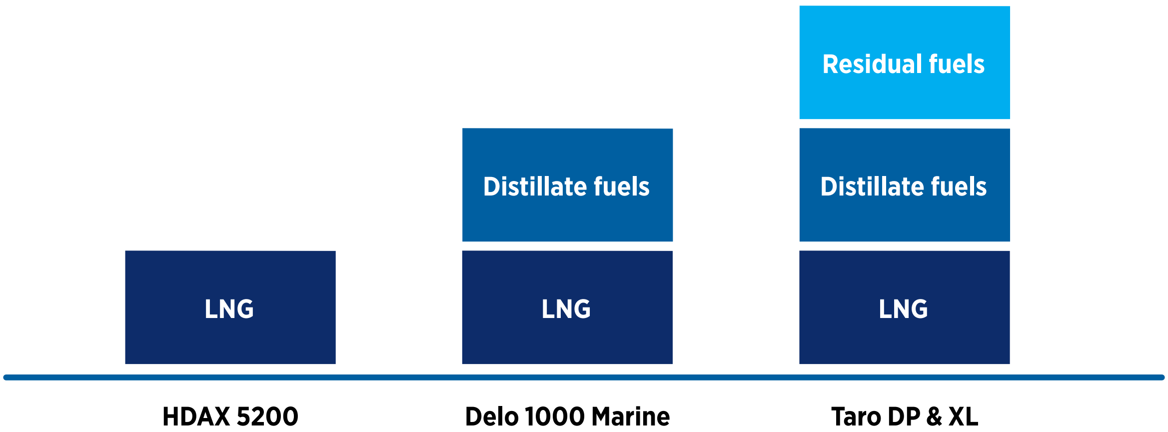
The advice above highlights the different types of trunk piston engine oils used with LNG, distillates and residual fuels. Get it wrong and there can be both operational and financial consequences — increased topping up of engine oil due to contaminants in the sump; the cost and time of replacing the entire sump; or, in extreme cases, engine damage.

Real-world lubrication challenges

On vessels in service, sometimes operating cases are not quite so clear-cut. Some dual-fuel engines might operate on an unpredictable mix of all three fuel types, bunkering either residual or distillate fuels where they can and using LNG as it is available or allowed. With such a varied operating profile, it would not be feasible or economical to switch the lubricating oil in the sump to the optimum product for each different type of fuel. Instead, Chevron Marine has identified a more realistic way to manage the lubrication of dual-fuel auxiliary engines.

"A practical approach can be to assess up front what type of fuel will be applied predominantly, then select the lubricating oil according to which fuel has the most potential contaminants," explains Rik Truijens. "This means residual fuel, followed by distillate fuels and then LNG."

In Chevron Marine's portfolio, the selection — depending on the fuel used by the vessel with the highest potential for contaminants — would be between:



This approach allows for practical protection of the engines without switching oil every time a new fuel is used. Thanks to Chevron Marine's investment in developing a wide and flexible portfolio of trunk engine piston oils, the approach can be further simplified.

Chevron Marine's Taro DP and XL series of trunk piston engine oils for medium-speed engines comprise four products designed specifically to handle contamination of the sump with asphaltenes originating from residual fuel. But according to Rik Truijens, it also offers the ideal platform for lubricating all cases of dual-fuel auxiliary engine use.

"If we use a gas engine oil, as soon as the engine runs for a long time on distillates, we will need to change the sump because of contaminants and oil degradation," he says. "Likewise, for residual fuel with oil meant for distillates, you could experience issues with asphaltenes and corrosive wear."

A practical approach to multi-fuel lubrication

Initially using Taro 20 DP is the ideal solution for total flexibility. From this base, all three fuels can be used. The oil is designed for residual fuels but is also acceptable for gas operation with pilot fuel and for distillate fuels — at BN 20 its alkalinity is high enough to adequately neutralise acids and help prevent corrosion. Although the ash content is higher than HDAX 5200 and Delo 1000, it is within acceptable limits.

The Taro DP and XL series is fully compatible across the different BN products. This means that when starting with BN 20 (Taro 20 DP), the sump can be topped up with BN 30 oil or BN 40 oil to replenish the BN level depending on the requirements of the fuel in use. For example, if mainly using low-sulphur (<0.5%) residual fuel — such as the new very low sulphur fuel oil (VLSFO) blends coming to market with IMO's 2020 global sulphur cap — an operator could top up the sump with Taro 30 DP to reach the required BN 25. If using a traditional high-sulphur residual fuel, topping up with the higher BN Taro 40 XL 40 would help to replenish the more rapid depletion of BN from the sump oil.

Using this strategy, operators of dual-fuel engines that could burn any type of fuel alternating between distillate, residual and LNG with pilot fuel can apply Taro DP and XL lubricants only, adjusting the sump oil to counteract BN depletion by topping up with the appropriate grade of engine oil.

If alternating distillate and residual fuel with LNG, this strategy would entail the following recommendations depending on the primary fuel.

	FUEL QUALITY		
Residual VLSFO		Chevron Marine Taro DP & XL	Maintain sump around BN 20 by topping up with Taro 20 DP Maintain sump around BN 25 by topping up with Taro 30 DP
Distillate		Chevron Marine Delo 1000 Marine	Maintain sump around BN 20 by topping up with Taro 20 DP
LNG + Pilot		Chevron Marine HDAX 5200	Maintain sump around BN 20 by topping up with Taro 20 DP

Keeping an eye on oil condition

In order to maintain the correct alkalinity in the sump and to ensure that the oil is handling other contaminants adequately, regular monitoring of the engine oil is essential. Chevron Marine's FAST analysis program provides reliable results within 48 hours via its online service. Laboratories in Ghent and Shanghai test several critical variables — including BN, iron and wear metal content, viscosity, insoluble materials and acid number — and deliver actionable recommendations that can help to extend the service life of oil.

"As always with lubrication, we believe that there is no single approach to lubrication needs," explains Ian Thurloway. "The precise needs of each engine will depend on factors including the operating profile and the fuel chemistry. Monitoring with FAST enables early detection of potential issues and provides recommendations for the necessary adjustments, which prevent downtime and limit the potential for costly damage to occur."

Fleet-wide clarity and flexibility

The result of this approach is flexibility, clarity and uniformity for operators, helping to reduce the different engine lubricants required across their gas-fueled fleets. Where vessels can be certain that they will only be using distillate fuels with LNG, they are still using the Chevron Marine Delo 1000 oil, designed for distillates. Where residual fuels are in play, the strategy of maximising flexibility by using Chevron Marine Taro 20 DP 40 as a base ensures that engines are protected whether they are running on LNG, distillates or residual fuel.

Thurloway concludes: "The challenge of lubricating dual-fuel auxiliary engines is just one example of how the widening marine fuel mix is adding complexity to ship operators' lubrication choices. Chevron Marine's work in developing a practical strategy — and the flexibility offered by deploying the Taro DP and XL range — highlight the way Chevron Marine is providing solutions to help ship operators navigate these challenges."

we've got you covered

marine lubricants

the 2020 global sulphur cap and the role of cylinder oil lubricants

The impending onset of the Global Sulphur Cap 2020 is catalysing a monumental shift in the types of fuel being bunkered by the international shipping fleet away from predominantly heavy sulphur fuel oil (HSFO) to a wider variety of fuel options.

With an entry into force date of January 1, 2020, stricter fuel sulphur content restrictions imposed on the global fleet has put the industry on the verge of what will be the most significant period of change in the past decades. Under the new rules, ships must burn fuels with a sulphur content of no more than 0.50% m/m or a maximum equivalent emission output. This is a significant drop from the current limit of 3.50% which has been in effect since January 1, 2012.

Owners and operators must switch their vessels to use lower sulphur fuels or alternatives to meet the IMO legislation. Those wishing to continue to use HSFO must equip their vessels with emissions abatement technology that 'scrubs' the sulphur from exhaust gas to achieve an equivalent method of compliance to those burning a compliant low sulphur fuel. <0.5% low sulphur fuel oil (LSFO) is expected to be the predominant compliance option to meet IMO legislation requirements post-2020.

Regardless of the compliance route chosen, bunkering low sulphur fuel alternatives—versus installation of scrubbers on board—impacts cylinder oil lubricant use. The use of one type of fuel oil by the majority of the global fleet accompanied by one type of lubricant will soon become a thing of the past. In the post-2020 industry, the role of the cylinder oil lubricant will become ever more crucial in protecting the engine.

Ian Thurloway, Brand and Marketing Manager for Chevron Marine Lubricants, says: "We expect the implementation of IMO 2020 legislation to result in the use of a wider range of marine fuels, from distillates and low sulphur residual fuels, to new blends and other innovations appearing on the market. It's widely expected that well over 90% of vessels in the global fleet will switch to using compliant fuels, with the remaining percentage continuing to burn HSFO with scrubber technology installed on board."

New fuels, new challenges

HSFO has been the go-to fuel for ocean-going ships since the conversion of the fleet from coal to oil in the early 20th century. However, the entry into force of MARPOL Annex VI in 2005 marked the beginning of a sea-change in the traditional, HSFO-favoured fuel landscape, initially sparked by the enforcement of a global sulphur cap of 4.50% m/m, later lowered to 3.50% in 2012.

The establishment of Emission Control Areas (ECAs) pushed owners and operators sailing ships in these designated zones towards using fuels with a lower sulphur content due to the stricter limits on permissible sulphur content being enforced.

The first ECA was created in Europe in 2005, requiring all ships sailing in the Baltic Sea area and the North Sea area to use fuels with a maximum sulphur content of 1.50% m/m. In 2011, this cap on sulphur was further reduced to 1.00% m/m and in 2012 a new ECA in North America was established. Since 2015, ships sailing in ECAs have faced the strictest fuel sulphur contents cap of 0.10%.

China has governed its own equivalent of an ECA since April 2016 wherein ships berthing at a total of 11 regional ports must use fuel with a maximum sulphur content of 0.50%. Since July 1, 2015, Hong Kong has enforced a requirement for all vessels to switch to fuel not exceeding 0.50% sulphur content while at berth. The port of Sydney, Australia has also imposed a 0.10% fuel sulphur content limit for cruise ships berthing at the port since October 2015.

Therefore, a great number of vessels navigating within areas hosting existing sulphur content restrictions are well versed in the practice of switching from a high sulphur fuel oil to a low sulphur fuel oil or alternatives, and mastering the associated cylinder oil lubrication requirements.

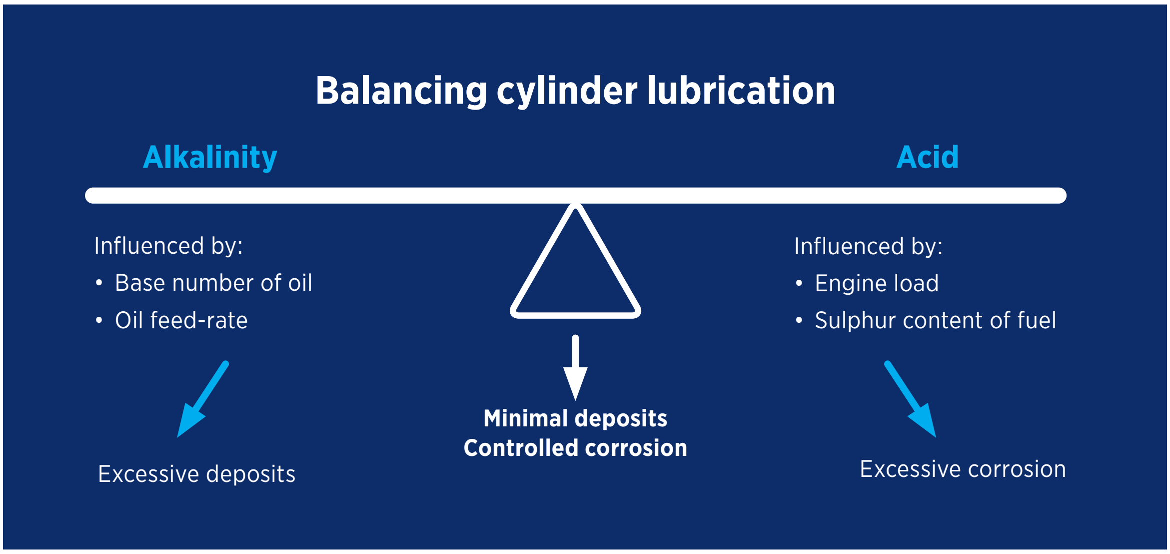
However, for the rest of the global fleet the arrival of the Global Sulphur Cap will still create seismic change, and the adoption of either compliance option will result in momentous changes being undertaken by the owner or operator.

Sulphur emissions and 2020 are only part of the story. The IMO is also looking at ways to further reduce ship emissions, including greenhouse gases (GHGs). New international regulations set by the IMO to reduce CO_2 emissions require a reduction in the total annual GHG emissions produced by shipping by at least 50% by 2050 compared to 2008, while, at the same time, pursuing efforts towards phasing them out entirely. This will promote the use of fuel alternatives to oil-based bunkers, and ultra-low sulphur and CO_2 emission fuel types such as methanol, liquefied natural gas (LNG), liquefied petroleum gas (LPG), and ethane will become increasingly attractive options for compliance.

The role of lubricants in a sulphur-constrained industry

Lubrication is the lifeblood of an engine, the dominant function of cylinder oil being to protect the engine from acidic corrosion. This is achieved by balancing the alkalinity of the cylinder oil, defined by its base number (BN) and its feed rate. Sulphur-containing fuel oils produce oxides of sulphur (SOx) during combustion. In the presence of water, SOx forms sulphuric acid which causes a corrosive environment in the engine. Therefore, the differing sulphur content in fuels is what governs the varying levels of acidity and risk of corrosion in the engine cylinder.

The role of a cylinder oil's BN is pivotal in controlling the acidic/alkalinity balance in the engine cylinder. Too little alkalinity can put an engine at risk from cold corrosion, whereas too much alkalinity can result in the formation of excessive abrasive deposits on the piston crown top lands, ultimately leading to increased liner wear and scuffing. It is crucial to maintain the correct sulphur/BN balance by using cylinder oil with an appropriate BN, by adjusting the cylinder oil feed rate, or a combination of the two (see illustration on page 3).



Using alternative fuel types to HSFO has a direct impact on engine lubrication and cylinder lubrication, as the BN of the lubricant must be matched to the sulphur content of the fuel and operating conditions within the engine.

"Under the rules of the Global Sulphur Cap, fuels with <0.50% sulphur content will drive demand towards lower BN cylinder oils, whereas use of HSFO with sulphur content potentially higher than 3.50%, coupled with the use of scrubber technology, will drive the demand for higher BN cylinder oils," says Luc Verbeeke, Senior Engineer, Chevron Marine Lubricants.

2020: are you ready?

The post-2020 fuel landscape poses different challenges for cylinder oil lubricant use to those previously faced by equipment manufacturers (OEMs).

Previously the use of cylinder oils based on a 70BN chemistry have been favoured. However, changes in engine machinery, operational profiles and the types of fuel used have posed greater corrosive risk in the engine cylinders in the past decade.

The operational profiles of engines have changed over the past 10–15 years from vessels running at high speed, high load to running at low speed, low load. Feed rates have reduced, and lubrications system have become more efficient. This has created a significant impact on optimal cylinder oil use and in some cases with lower liner surface temperatures, allowing cold corrosion to form. More recently, 100–140 BN cylinder oils have been needed to protect newer engines against cold corrosion under part-load conditions for those burning higher sulphur fuels.

"The BN level of the lubricant must be matched, and the correct feed rate applied to meet the fuel sulphur level content. As a general rule, the lower the fuels sulphur content, the lower the BN level required.

"Moving away from the use of a 70 BN lubricant to other cylinder lubricant BN levels could be perceived as challenging, akin to making the change to using a different type of fuel. However, in reality, this isn't the case when handled correctly," says Luc Verbeeke.

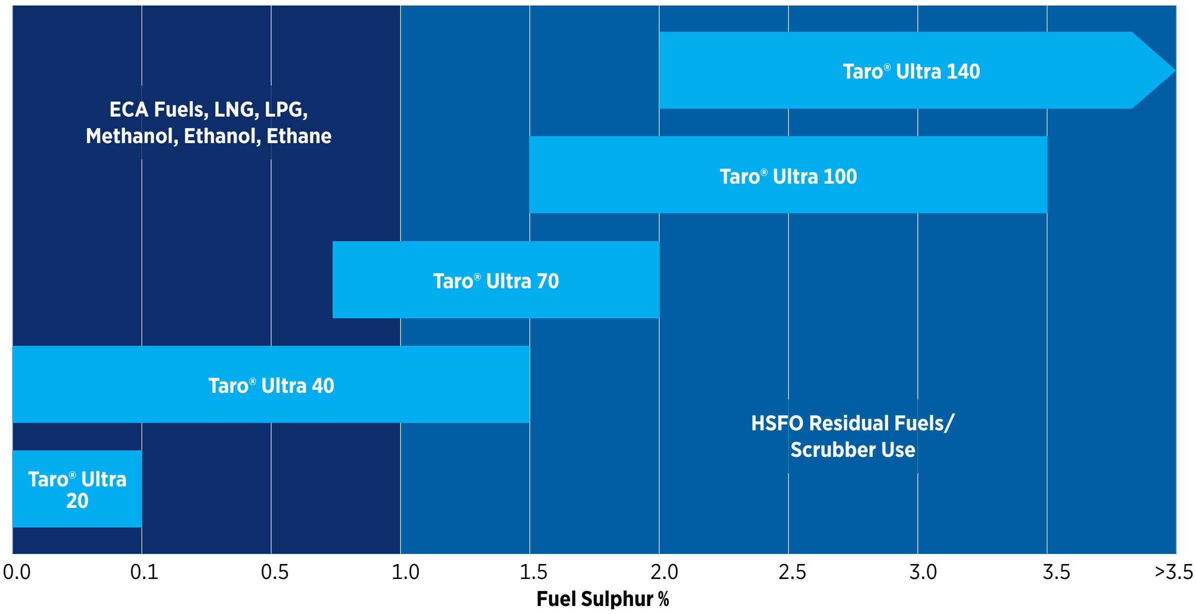
When changing over to a different cylinder oil product, the existing cylinder oil lubricant stock on board should be reduced as much as possible, allowing the empty tank to be re-filled with the new cylinder oil product matched to the compliant fuel of choice. However, if this is not possible, you can blend down to next level of BN by combining the existing cylinder oil with a lower BN cylinder oil product. Mixing two-cylinder oil products together and conducting monitoring via used oil analysis will help ensure the BN level remains optimal.

Once the Global Sulphur Cap regulations come into play, changes to the bunker supply chain will take effect. This will possibly result in HSFO blends bunkered for use by vessels equipped with scrubber technology potentially operating continuously on a higher sulphur content than 3.5% m/m and experiencing more severe corrosion issues.

Therefore, continued HSFO use does not necessarily mean continued use of current cylinder oil products without further consideration. If you use a HSFO with a higher sulphur content than that currently bunkered, you could risk an increased corrosive regime occurring in the engine unless you increase the cylinder oil BN or the feed rates. There is significant risk associated with using a too low BN cylinder oil with a high sulphur content fuel. If the BN level of the lubricant is too low and the feed rate is not optimised, then an engine will be experiencing severe corrosive wear. Optimising feed rate is essential for any ship changing fuels or cylinder oil lubricants. It is not always possible to operate an engine at or close to the OEM's minimum feed rate without entering a corrosive regime, although this may be overcome with a move to a higher BN cylinder lubricant providing additional neutralization and enabling the engine to operate on an optimized feed rate. This can often not only reduce engine wear, but also reduce the overall cost of operation.

Over-lubrication can also have a detrimental effect, impacting liner surface condition and reducing the oil film effectiveness. In ships continuing to burn HSFO or moving to a compliant fuel, used oil analysis should always be conducted to ascertain the optimal feed rate to minimise corrosive and abrasive wear. If corrosion does start to occur, then a switch to a higher BN or a feed rate adjustment may be required.

"For intermittent operations that vary between the use of LSFO, blends and distillates when voyaging between the open ocean and emission control areas, the use of a 40 BN single grade product is recommended by Chevron Marine Lubricants. This removes the use of multiple cylinder oils, reducing on-board complexity," says Luc Verbeeke.



Fuel strategy	Optimum Lubricant
Up to 3.5%, or even higher HSFO with scrubber	100–140 BN
Distillates	20 BN
LNG	20 BN
Intermittent use of LSFO and distillates	40 BN
Ultra-low sulphur alternatives	20 BN
Methanol	40 BN

New challenges, new lubricants

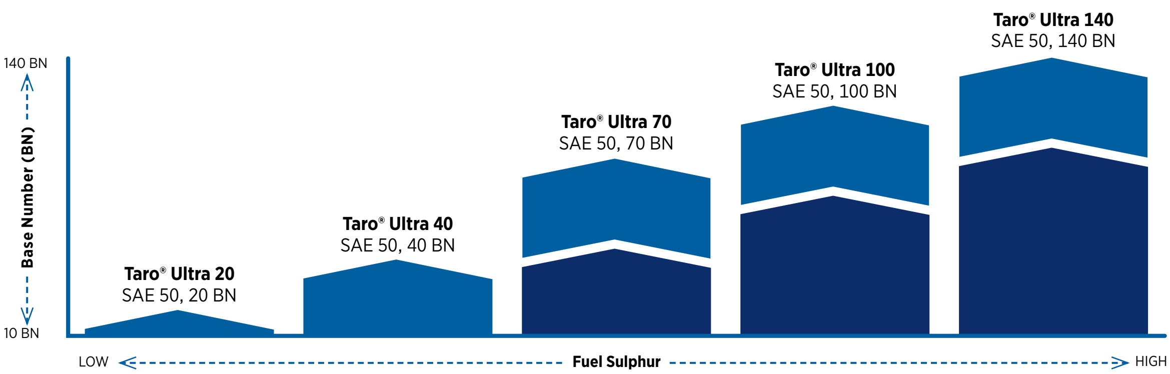
“The ‘one size fits all’ approach is not something we have ever adopted at Chevron, and going forward, our experience in this customised approach is even more imperative,” added Ian Thurloway.

Choosing the right cylinder oil with the correct BN and feed rate can be particularly challenging for ship owners navigating the shift to bunkering different types of fuel.

To support the operation of vessels in an emissions-constrained era now and in the future, Chevron Marine Lubricants developed the Taro® Ultra range of cylinder oil lubricants.

Taro® Ultra 20	Taro® Ultra 40	Taro® Ultra 70	Taro® Ultra 100	Taro® Ultra 140
High performance 20 BN SAE 50 cylinder oil for large cross-head diesel engines operating on fuels with <0.1% wt in sulphur content such as distillate, LNG, and LPG	High performance 40 BN SAE 50 cylinder oil for engines operating on LSFO, LNG, methanol & distillate fuel, including 0.5% wt fuel blends with sulphur content and intermittent ECA use providing all round lubricant flexibility and performance	High performance 70 BN SAE 50 cylinder oil for a wide range of fuels, or for vessels operating on 0.5% wt fuels with high levels of cold corrosion	High performance 100 BN SAE 50 cylinder oil, the optimal choice for many new built vessels and for vessels fitted with scrubber, operating on fuels with sulphur content above 1.5% wt	High performance 140 BN SAE 50 cylinder oil developed to help combat cold corrosion and allow for operation with high sulphur fuel and scrubber at lowest cylinder oil feed rate possible

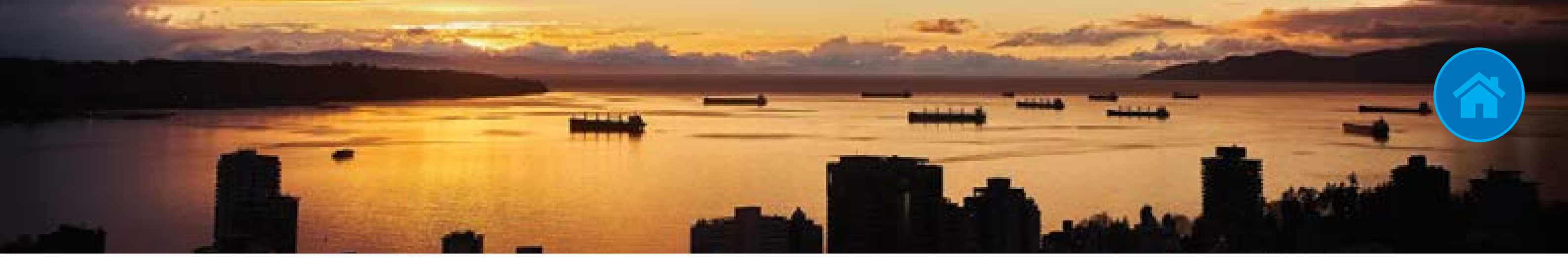
The Taro Ultra range covers virtually all fuel options and combinations, comprising products from 20 BN to 140 BN. By applying years of experience gathered developing high performance lubricating oils, Chevron Marine Lubricants has created each Taro Ultra Cylinder oil product with a formulation that specifically supports an industry facing multi-fuel use post 2020.



“Chevron Marine Lubricants has further strengthened the supply chain capability for our cylinder oil lubricant products to help provide ultimate global availability and flexibility to cope with demand changes in 2020 in line with fuel availability,” says Ian Thurloway.

Development of the Taro Ultra range started in 2016 and the resulting cylinder oils have undergone extensive in field testing with OEMs, and in a wide range of engine types. This field testing amounts to over 65,000 hours of operational time, with all products in the Taro Ultra range tested with a multitude of fuel types and across all applications, including the most severe and demanding operations. Chevron Marine Lubricants has also tested Taro Ultra 40 BN product with 0.5% compliant LSFO fuel blends which are anticipated to be widely used in early 2020.

Enabling Chevron Marine Lubricant customers to make an easy transition between lubricant products prior to and post-2020, the Taro Ultra portfolio replaces the existing Taro Special HT range and is fully compatible and miscible with existing products. Therefore, if you have a Taro Special HT cylinder oil product remaining in your tank, adding a Taro Ultra product will be perfectly acceptable.



“The Taro Ultra 40 BN cylinder oil is multipurpose and is intended for use with different fuels of varying sulphur content between 0.1% to 0.5% m/m. This means it is a good candidate for those switching to using LSFO and distillates as well as other low sulphur options such as LNG,” says Luc Verbeeke.

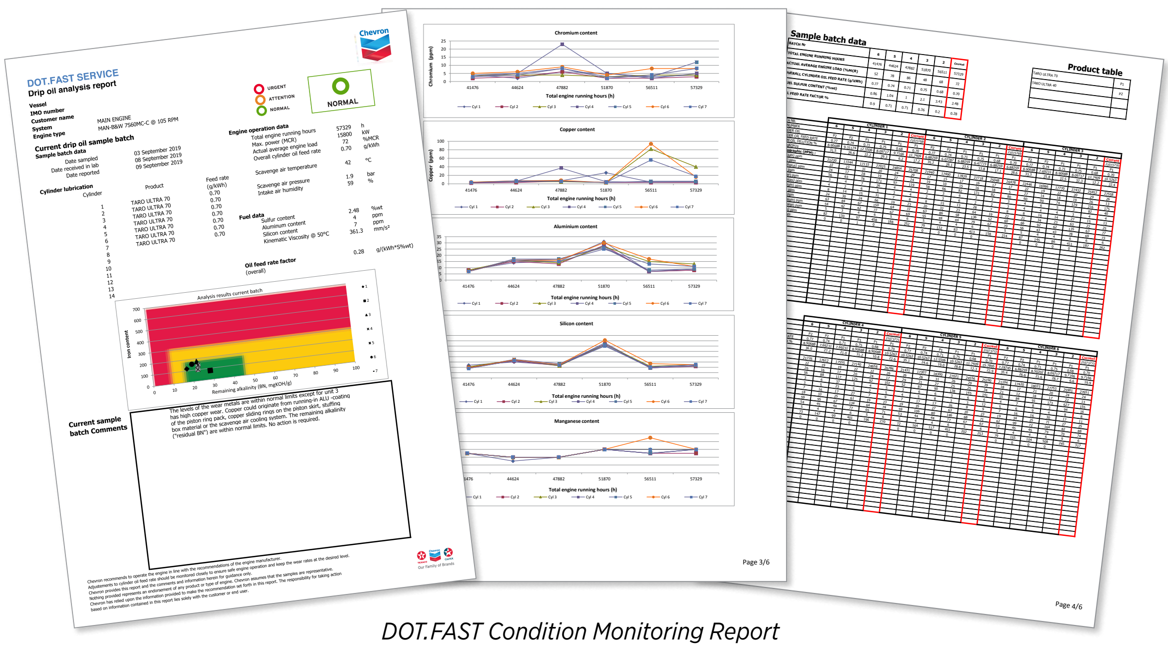
The Taro Ultra range is being rolled out across Chevron Marine Lubricants’ existing supply network of over 700 ports during 2019 to ensure readiness to meet the demands of the post-2020 landscape.

The role of oil analysis

Chevron Marine Lubricants recommends that operators use **drip oil analysis** onboard monitoring to manage in-service operations, important in the transition to using different fuel types and cylinder lubricants, due to the criticality of maintaining correct sulphur/base number balance. Drip oil analysis is an efficient and reliable way to accurately monitor changes that indicate BN levels or feed rates require adjustment in order to maintain optimal engine lubrication. This type of analysis allows crews to quickly understand what is going on within an engine, and subsequently take immediate action on identified issues.

Drip oil analysis is the process of analysing unburned cylinder oil that has passed through the combustion chamber and passed the pistons and liners in the main engine. It is an effective way to monitor corrosive and abrasive engine wear. Recommended by all major OEMs today, drip oil analysis helps operators with a range of optimisation requirements, such as guarding against excessive cylinder oil feed rates while optimising cylinder lubrication at different engine operating modes. Monitoring of drip oil samples reduces costs for operators, by allowing preventative measures to be taken to protect valuable assets, and minimising engine down-time.

Chevron’s DOT.FAST® program can indicate areas for improvement in feed rate settings and engine hardware. The total iron content measured indicates the total corrosive and abrasive wear occurring in the engine, enabling crew to make any necessary adjustments to feed rate and BN. DOT.FAST onboard analysis delivers immediate feedback on cylinder running conditions and provides an early indication of elevated levels of both abrasive and corrosive engine wear. At the same time, it helps optimise the cylinder oil feed rate and minimise the build-up of abrasive deposits, cylinder oil consumption, engine fouling, and the risk of scuffing.



DOT.FAST Condition Monitoring Report

“DOT.FAST onboard analysis is a critical service that tells the user immediately whether to adjust the cylinder oil feed rate up or down accordingly. There is no need to wait for shore analysis, allowing prompt action,” says Ian Thurloway.

The onshore analysis component of the DOT.FAST service sees samples sent to Chevron’s laboratory fully analysed for base number, iron, and all other elements. The results are tabulated and reviewed by technical experts, and recommendations are reported back to the ship. Using onshore analysis ensures the testing of drip oil samples to the highest industry standards in a quality certified laboratory and provides comprehensive reporting with to-the-point commentary. Additional benefits include monitoring the effectiveness of onboard (heavy) fuel purification procedures through measurement of CAT Fines (Al+Si).

Future-proofed protection

Cylinder oil lubricants will play an increasingly important role as shipping navigates its way into a lower sulphur, lower emissions future. Failure to ensure that the correct cylinder lubricant is used can have a serious effect on your operation.

“As an industry leader with one of the best supply networks in the world and a full range of products to meet the diverse range of needs of both today and tomorrow, Chevron remains committed to providing reliable solutions for the marine fuels of the future. To meet the uncertain demands of 2020, Chevron’s global supply network has been further strengthened to provide a robust, flexible and agile model to ensure supply in a changing landscape. From ship visits, to FAST and DOT.FAST fluid analysis, Chevron’s world-class technical support team holds the expertise to help your 2020 transition. 2020 — we’ve got you covered,” concluded Ian Thurloway.

marine lubricants

methanol and marine lubricants in a lower sulphur, lower emissions future

The drivers for alternative bunker fuels and why shipping is set to witness its most significant period of change in recent memory

Gone are the days when the majority of fleets operate with just one fuel and one cylinder lubrication oil. A combination of new and upcoming environmental legislation aimed at reducing ship emissions, along with vessel and engine optimizations to accommodate shifting commercial realities, means that ship engines today witness a far more complex range of operating conditions than ever before.

This is just the beginning of what is set to be the most significant period of industry change in recent memory, as both cost and environmental pressures push owners and operators to explore a diverse new range of alternative bunker fuels. Understanding the impact for shipping as it heads into a lower sulphur, lower emissions future has been critical for leading lubricants supplier Chevron in their development of new products to meet the challenges of today and tomorrow.

But having the right products is only part of the picture. Partnering with a forward-thinking supplier that provides industry leading support services is critical if owners and operators are to successfully join the pioneers in adopting future marine fuels.

Sulphur regulations: the road to 2020 and beyond

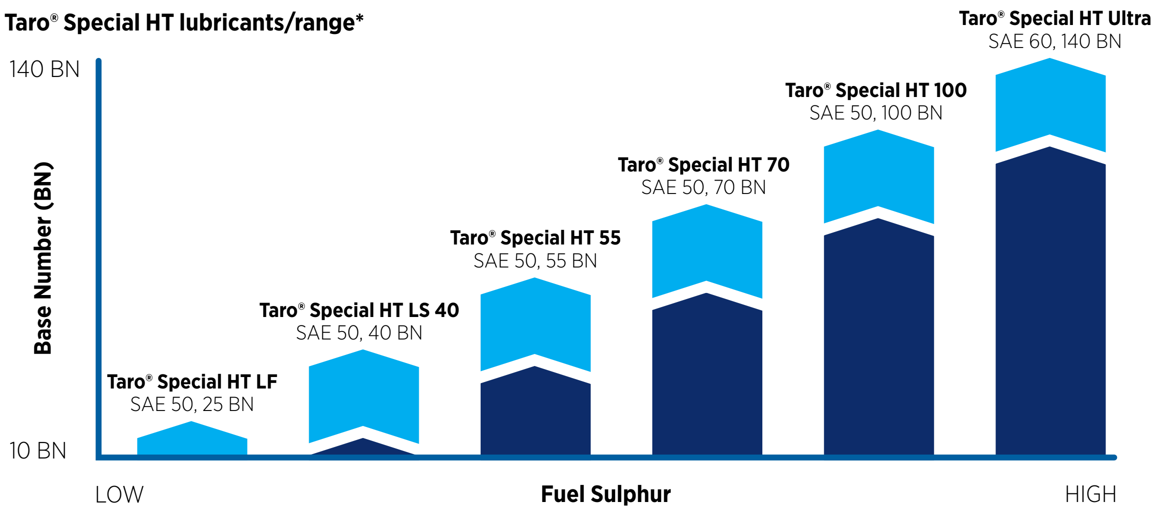
Ships have been burning oil bunkers for many decades now, but it was the entry into force of MARPOL Annex VI in 2005 that marked the beginning of what is set to be a sea-change for the sector. Since 2005 we have seen the introduction of emission control areas (ECAs), initially in Europe, then followed in 2012 by North America. In 2015 the sulphur content of bunker fuel being burned in these zones was capped at 0.10% by weight. Alongside this, countries such as China have introduced at-berth fuel regulations, limiting fuel to a maximum sulphur content of 0.50%. This means that vessels today already need to burn a range of fuels to meet these requirements.

However, the most notable change on shipping's horizon will come on January 1, 2020 when the global sulphur cap on marine fuel lowers to 0.50%. The realities of oil refining mean the industry's preferred bunker fuel of today, high sulphur heavy fuel oil (HFO), will only be able to be burned by those who install scrubbers, so they can achieve an equivalent method of compliance to those burning a compliant low sulphur fuel. In 2020 the vast majority of vessels are expected to switch to using Marine Gas Oil (MGO) or compliant blended fuels.

New fuels and lubricants for new challenges

Sulphur emissions and 2020 are only part of the story and the IMO is working on ways to tackle other ship emissions such as greenhouse gases (GHGs). With this in mind, industry innovators are looking beyond oil-based bunkers to a range of new, alternative bunker fuels that includes methanol, liquified natural gas (LNG), liquified petroleum gas (LPG), and ethane. Many of the vessels using these alternative fuels are dual-fueled, meaning the engines can run either on a higher sulphur conventional fuel or on a virtually zero sulphur content alternative fuel, resulting in more extreme operating conditions within the engine.

This highlights how a "one size fits all" approach to both fuels and lubricants is clearly no longer sufficient, and without proper guidance choosing the right cylinder oil with the correct BN and feed rate can be particularly challenging. Understanding this has been key to the development of Chevron's full range of cylinder lubricant oils — this agile approach is why it is the industry leader when it comes to lubricating engines burning the full array of alternative fuels. Chevron's Taro® cylinder lubricants range[1] from 25BN to 140BN covers virtually all fuel options and combinations.



Taro®[1] Special cylinder lubricants range, solutions for the majority of operations running today.

"When it comes to lubricating the engines of alternatively fueled vessels, Chevron is one of the true pioneers," says Chevron Marine Lubricants Account Manager, Bert Van Cleemput. "If we look at methanol-fueled vessels, today there are seven vessels operating with two-stroke methanol dual-fuel engines and Chevron is lubricating four of them. We are also lubricating the world's only four-stroke methanol dual-fuel vessel, *Stena Germanica*, which has been running on methanol since March 2015. For dual-fuel methanol two-stroke slow speed engines, we recommend Taro® Special HT LF[2], a high-performance 25 BN SAE 50-cylinder lubricant."

* *Taro® Special HT has been replaced by the Taro® Ultra range.*

1. *The Taro® Ultra 20BN to 140BN portfolio replaces the Taro® Special HT portfolio and is fully compatible and miscible.*
2. *Taro® Ultra 20 replaces Taro® Special HT LF and is fully compatible and miscible.*

A new generation: ocean-going methanol dual-fuel ships

Following their delivery in 2016, M/T *Mari Jone* and M/T *Mari Boyle* became two of the world's first ocean-going methanol dual-fuel ships. This project is the product of a collaboration between several leading industry innovators, including:

- Waterfront Shipping, a wholly owned subsidiary of Methanex Corporation and a global marine transportation company specializing in the safe, responsible and reliable transport of bulk chemicals and clean petroleum products to major international markets in North America, Asia Pacific, Europe and Latin America;

- Vancouver, Canada-based Methanex Corporation, the world's largest producer and supplier of methanol to major international markets in North America, Asia Pacific, Europe and South America;

- Private ship manager and investment group Marinvest Shipping AB;

- MAN Diesel & Turbo, the world's leading provider of large-bore diesel engines and turbomachinery;

- Chevron Marine Lubricants, part of Chevron Corporation, one of the world's largest integrated energy companies and a leader in providing marine lubrication solutions for alternatively fueled vessels.

Ship manager Marinvest are co-owners of the M/T *Mari Jone* and M/T *Mari Boyle* along with Waterfront Shipping who are also the charterers of the vessels.

The ME-LGI methanol dual-fuel engines aboard the vessels, developed by MAN Diesel & Turbo, allow for operation on methanol, heavy fuel oil (HFO), marine diesel oil (MDO) or marine gas oil (MGO). The vessels already have a combined 7,000 hours of operation using methanol bunkers.

Benefits of methanol fuel
Using methanol as a marine fuel is a relatively new idea, even within the context of alternative fuels, but it is easy to understand the attraction of its emerging use as a bunker fuel.

"Methanol is a clean-burning, cost-effective marine fuel, that meets the shipping industry's increasingly stringent emissions regulations," says Jason Chesko, Senior Manager, Global Market Development, Methanex.

Pure methanol was first isolated in 1661 and has been shipped globally for over 100 years. Today, methanol is one of the top five chemical commodities shipped around the world each year, and as it is already found in many of the world's seaports, its use as a marine fuel is not subject to the same availability and infrastructure concerns surrounding the viability of some other alternative marine fuels.

Methanol is widely used as a feedstock in the manufacture of a range of other chemicals and products such as plastics and paints. To meet International Methanol Producers and Consumers Association (IMPCA) specifications, the quality is both high (99.9% pure) and uniform. It is particularly attractive in the context of IMO 2020 and other expected future regulations as methanol is free from sulphur, and burning it in a diesel engine only requires the use of a very small amount of pilot fuel — typically around five percent of either HFO or a marine distillate such as MGO or MDO. The result is that compared to burning traditional bunkers using methanol as a marine fuel reduces the emissions of SOx by 99%, bringing them well within current and future global and ECA standards. At the same time, nitrogen oxides are reduced by up to 60% and particulate matter is reduced by 95%.

Methanex has production facilities in six countries around the world. Methanol can be produced from natural gas, and renewable sources such as municipal waste, biomass and recycled carbon dioxide. On an industrial scale, methanol is predominantly produced from natural gas by reforming the gas with steam and then converting and distilling the resulting synthesized gas mixture to create pure methanol. The result is a clear, liquid, organic chemical that is water soluble and readily biodegradable. The production process puts the CO^2 footprint for methanol bunkers on a par with diesel, but new ways to produce methanol are also being developed. For example,

a plant in Iceland produces methanol from recycled CO^2, and reports it releases 90% less CO^2 than the use of a comparable amount of energy from fossil fuels.

Energy density is one area where methanol is outperformed by oil-based fuels, and Chesko says vessels would need to burn a little more than twice the amount of methanol to produce the energy equivalent of MGO. While this can lead to considerations over the size of fuel tanks, methanol is a biodegradable liquid and in some vessels it can be stored in the ballast tanks to alleviate some of the issues around space. It also means that if spilled in water, it quickly and completely dilutes to non-toxic levels. On a calorific equivalent basis, methanol bunkers are currently priced at similar levels to MGO.

Under normal operating conditions methanol is a liquid fuel, so it is easier to work with compared to some other alternative fuels and has very similar onboard handling characteristics to diesel. As it is a low flashpoint fuel, methanol fueled vessels must incorporate certain design requirements such as the use of double wall piping to the engine, but even so, the premium for upgrading a newbuild vessel to a dual-fuel methanol capable vessel is typically less than five percent.

ME-LGI methanol dual-fuel two stroke engine vessels
The ME-LGI methanol dual-fuel engine developed by MAN Diesel & Turbo allows for operation on methanol, heavy fuel oil (HFO), marine diesel oil (MDO), or marine gas oil (MGO). Firing the engine with methanol requires the use of a small amount of pilot fuel, typically five percent of either HFO or MGO.

"It's a completely new fuel injection system on these methanol engines," notes Johan Kaltoft, Senior Project Manager, Diesel Research Centre, Marine Low Speed, Research & Development at MAN Diesel & Turbo.

The engines are configured with two injectors each for fuel oil and methanol. It is the injectors that are the limiting factor when it comes to the variety of fuels that can be used by multi-fueled vessels, rather than the number of different fuels a vessel is able to practically carry.

"LNG, for example, is a common rail injection so the pressure build-up is in the supply system. Methanol has a booster injection valve, so the pressure build-up is on the engine. The fact that these injection systems are different for each fuel limits as to what is going on in the engine, and at the moment that limit is two," explains Kaltoft.

Under regular operation for M/T *Mari Jone* and M/T *Mari Boyle*, the methanol is transferred by means of the Framo deep well pump system from a dedicated slop tank which also acts as methanol fuel storage tank to the 79m3 methanol day service tank. From there, methanol is transferred via double wall piping to the engine at 10 bar low pressure using a separate fuel supply system. The methanol is used at ambient temperature, and a heat exchanger is available if required.

Methanol bunkering
Bunkering operations for the M/T *Mari Jone* and M/T *Mari Boyle* are straightforward. Firstly, there is no incremental cost or complexity due to the fact they are methanol bunkers because the vessels are already loading cargoes of methanol. Any methanol to be used as fuel is separated from the cargo and diverted to the slop tank, which is used as the fuel tank. This is then recorded in the oil record book as fuel, separate from the cargo record book. This methanol will then always be a fuel and cannot be sold as a cargo.

For other methanol fueled vessels such as the cruise ferry *Stena Germanica*, also lubricated by Chevron, methanol bunkers are delivered by truck. For larger applications a diesel bunker barge can easily be converted for methanol bunkering.

Real world vessel operation with methanol bunkers
The M/T *Mari Jone* and M/T *Mari Boyle*, two of seven of the world's first generation of methanol fueled ships, now operate in a diverse range of global markets. They typically load methanol cargoes in New Zealand, Geismar in Louisiana, and Point Lisas in Trinidad. They also make calls in China, Korea, Australia, the US Gulf, Chile and Peru, and could also see operation in Europe.

Loading bunkers in such a wide range of ports means that the sulphur content of the HFO they burn alone varies from 1.8% to 3.5%. But by their very nature the dual-fuel methanol engines are subject to an even wider range of sulphur conditions: they could be burning 95% methanol, which has zero sulphur, along with either a low sulphur or high sulphur pilot fuel; they could be burning a 0.10% sulphur distillate fuel for ECA compliance; they could be burning up to a 3.5% maximum sulphur heavy fuel oil; or they could be burning a mix of 70% methanol along with either a high or low sulphur oil product.

"This makes it very tricky to know to which level to limit the cylinder oil to the liners, and what the BN of the cylinder lubricant has to be. In fact, one of the biggest concerns when we ordered the engines early on was the effect that dual-fuel operation has on the liners, and it is something no-one could really answer," says Fredrik Stubner, Director Ship Management, Marinvest Shipping AB.

To meet this challenge, Marinvest turned to Chevron Marine Lubricants for not only their range of cylinder lubricants, but also their DOT.FAST® service to help with optimising the lubrication of the engines. DOT.FAST® provides both onboard and onshore analysis of drip oil giving an accurate measurement of total iron wear, including corrosive wear. Combining both the onboard DOT.FAST® Drip Oil Analyzer for total iron wear and a BN tester, it is the most effective service in the market today.

The role of used oil analysis

Analysis of unburned cylinder oil that has passed through the combustion chamber and passed the pistons and liners in the main engine is an effective way to monitor engine wear. It is recommended by all major OEMs today, and helps operators with a range of optimization requirements, such as guarding against excessive cylinder oil consumption and optimizing cylinder lubrication at different engine operating modes. Monitoring of used oil samples reduces costs for operators, by allowing preventative measures to be taken to protect valuable assets, and minimizing engine down time.

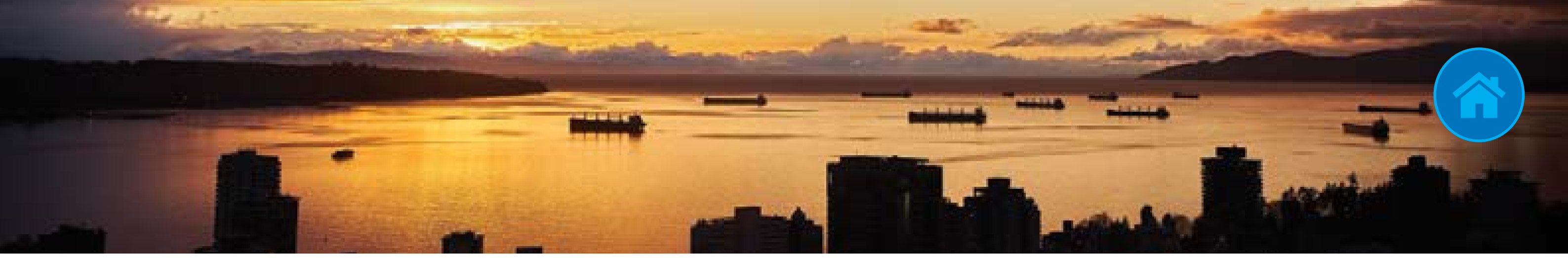
Chevron Account Manager Bert Van Cleemput has worked closely with Marinvest on creating a lubrication package for these pioneering vessels, and attributes the success of the project to the DOT.FAST® program, which early on indicated areas for improvement in feed rate settings and engine hardware.

"When we look at optimizing the feed rates and lubrication of two-stroke engines, the two main parameters are BN and Fe. For onboard analysis, the DOT.FAST® Drip Oil Analyzer is unique and innovative in the industry, delivering laboratory accurate test results right on the vessel. The DOT.FAST® Drip Oil Analyzer comes with everything required to prepare and test samples, including a custom-designed DispoRack™ and software to record, process and interpret results.

"DOT.FAST® onboard analysis delivers immediate feedback on cylinder running conditions, and provides an early indication of elevated levels of both abrasive and corrosive engine wear. At the same time, it helps optimize the cylinder oil feed rate and minimise the build-up of abrasive deposits, cylinder oil consumption, engine fouling, and the risk of scuffing."

With the onshore analysis component of the DOT.FAST® service, samples sent to Chevron's laboratory are fully analyzed for base number, iron, and all other elements. The results are tabulated and reviewed by technical experts, and recommendations are reported back to the ship. Using onshore analysis ensures the testing of drip oil samples to the highest industry standards in a quality certified laboratory, and provides comprehensive reporting with to-the-point commentary. Additional benefits include monitoring the effectiveness of onboard (heavy) fuel purification procedures through measurement of CAT Fines (Al+Si).

"DOT.FAST® from Chevron is a critical service in order to control and optimize the reliable lubrication of the engine. It allows us to see on a daily basis the iron content and the TBN number of the breakdown oil. It tells us immediately whether to adjust the cylinder oil feed rate up or down accordingly. There is no need to wait for shore analysis that would mean you lose time and miss the opportunity to act promptly to avoid excessive wear on the piston rings," says Stubner.



As an extra precaution against cylinder wear, and to safeguard against human error with cylinder oil selection, the vessels are also set to employ MAN's Automated Cylinder Oil Mixing (ACOM) system to ensure the right cylinder oil dosage is utilized at all times. For new engines being delivered this system is now standard.

"Having the ACOM system will help us a lot as normally when we are talking about zero sulphur fuel you want a low BN cylinder oil, like Taro® Special HT LF[3], but in our case we can use methanol along with high sulphur fuel oil where a 140 BN oil might be better. We perform a fuel analysis on all bunkers prior to their use and then input this data into the ACOM system, this then blends the cylinder oils to create the perfect BN mix," explains Stubner.

Industry pioneers

Being among the first to operate with a new fuel will always bring with it unique challenges. In the case of M/T *Mari Jone* and M/T *Mari Boyle*, meeting these challenges has been possible through high levels of support from Marinvest, Waterfront Shipping, a dedicated team at MAN in Copenhagen, and the forward-thinking expertise and strong relationship building skills of Chevron's team of account managers and technical experts.

"The engines were designed and produced in just ten months. There was testing with one cylinder in Copenhagen at first for a few hours, and it worked, so it was then tested in Japan as well as Korea. Once the engine was built it was tested for a number of hours, but our crew onboard our ships were really the first to do it on a long-term basis. It's then you learn things — what has to be improved, what has to be changed, and so on. We feed that back to MAN in Copenhagen, that feeds back to us and we try it out," says Stubner.

"Of course, there is the potential for extra costs and complexities with such a project, such as requiring a dedicated crew, dealing with a prototype engine, and working with a new type of fuel. But was this difficult? I would say no. I am happy to say that it worked very well. It is a challenge only because it is new. When you tackle that hurdle it becomes quite ordinary and normal procedure," Stubner continued.

Future fuels and lubricants

Methanol is just one out of a range of potential alternative marine fuels that — along with LNG, LPG and ethane, among others — is set to play an increasingly important role as shipping navigates its way into a lower sulphur, lower emissions future.

Ian Thurloway, Brand and Marketing Manager for Chevron Marine Lubricants notes: "We expect the implementation of IMO 2020 legislation to result in the use of a wider range of marine fuels, from distillates and low sulphur residual fuels, to new blends and other innovations appearing on the market. Chevron Marine Lubricants is well placed to meet the challenges posed by these changes and working closely with early adopters of alternative fuels such as Waterfront Shipping, Methanex and Marinvest is an example of our commitment to the new low emissions landscape of today and the future. We are proud to supply not only the largest fleet of methanol fueled vessels with our Taro® lubricants with great success, but also the majority of LNG dual-fuel propelled two-stroke vessels operating today."

Chevron's range of Taro®[4] cylinder lubricants from 25BN to ultra-high 140BN covers fuels with virtually any sulphur content ranging from <0.1% to the high sulphur HFOs. Taro® Special HT 100 has just received OEM approval for intermittent steaming in and out of ECA zones with no need to change the cylinder lubricant[1].

As an industry leader with one of the best supply networks in the world and a full range of products to meet the diverse range of needs of both today and tomorrow, Chevron remains committed to providing reliable solutions for the marine fuels of the future.

3. *Taro® Ultra 20 replaces Taro® Special HT LF and is fully compatible and miscible.*
4. *The Taro® Ultra 20BN to 140BN portfolio replaces the Taro® Special HT portfolio and is fully compatible and miscible.*

Chevron

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marine lubricants

product data sheets

marine lubricants

Taro® Ultra 20

Description

Taro® Ultra 20 is a 20 Base Number (BN) cylinder lubricant designed for lubricating the latest generation two-stroke marine engines operating at high mechanical and thermal loads under all operating conditions on low sulphur fuels (<0.1% sulphur), including those in continuous operation within Emissions Control Area (ECA) zones and LNG operation. Taro Ultra 20 is blended with highly refined base oils and carefully selected additives to provide excellent ring and liner wear protection andpiston cleanliness in slow-speed crosshead diesel engines.

Typical Characteristics

SAE Viscosity Grade	50
MPID	**219033**
Base number, mg KOH/g (ASTM D2896)	20
Density at 15°C, kg/l (ASTM D4052)	0.90
Flash point, COC, °C (ASTM D92)	180 min
Pour point, °C (ASTM D97)	–12
Kinematic Viscosity at 100°C, mm^2/s (ASTM D445)	19.0

Recommended Applications

Taro Ultra 20 is recommended for lubricating the cylinders of large low-speed marine diesel engines continuously using low sulphur fuel (<0.1% sulphur), under all loads and operating conditions, including those in continuous operation within Emissions Control Area (ECA) zones. Running on low sulphur fuel (<0.1% sulphur) requires the reduction of base introducedinto the cylinder.

Taro Ultra 20 is approved by WinGD (formerly Wärtsilä) for use in the latest generation engine designs, including WinGD dual fuel engines operating with gas fuels. Taro Ultra 20 should be used in accordance with OEM guidelines and recommendations.

Performance Benefits

1. Engine Protection

Protects against excessive cylinder liner and piston ring wear, thus allowing prolonged service intervals.

2. Engine Cleanliness

Prevents ring sticking and minimizes deposit formation on the pistons and throughout the combustion chamber exhaust areas.

3. Storage Stability

Stable at ambient temperatures and during long-term storage.

4. Compatibility

Miscible and compatible with diesel cylinder lubricants generally known to the international marine trade.

Our Family of Brands

Disclaimer. Data provided in this PDS is based on standard tests under laboratory conditions and is indicative only. Minor variations which do not affect product performance are expected in normal manufacturing. This product should not be used for any purpose other than those expressly set out in this PDS. The user has sole responsibility for verifying that this product is suitable for the user's intended application. Recommendations differ between engine manufacturersso always consult your manual. Neither Chevron nor its subsidiaries make any warranty or representation as to the accuracy or completeness of this PDS and neither Chevron nor its subsidiaries accept liability for any loss or damage suffered as a result of the use of this product other than in accordance with the termsof this PDS. (September 2020)

marine lubricants

Taro® Ultra 40

Description

Taro® Ultra is new range of cylinder lubricants specifically designed to cope with the demands and required flexibility for IMO 2020. Taro Ultra cylinder lubricants have been fully field tested using a wide variety of fuels expected to be available post IMO 2020 implementation and are approved by major OEMs.

Taro Ultra 40 is a 40 Base Number (BN) cylinder lubricant designed for lubricating the latest generation two-stroke marine engines running on low sulphur fuels under all loads and operating conditions. Taro Ultra 40 is blended with highly refined base oils and carefully selected additives to provide excellent ring and liner wear protection and piston cleanliness in slow-speed crosshead diesel engines.

Typical Characteristics

SAE Viscosity Grade	**50**
MPID	**219034**
Base number, mg KOH/g (ASTM D2896)	40
Density at 15°C, kg/l (ASTM D4052)	0.92
Flash point, COC, °C (ASTM D92)	180 min
Pour point, °C (ASTM D97)	–15
Kinematic Viscosity at 100°C, mm^2/s (ASTM D445)	19.0

Recommended Applications

Taro Ultra 40 is recommended for lubricating the cylinders of large low-speed marine diesel engines using:
* Continuous operation on Very Low Sulphur Fuel (VLSFO) and Ultra Low Sulphur Fuel (ULSFO), under all loads and operating conditions. Running on low sulphur fuel requires the reduction of BN introduced into the cylinder. This can be achieved by optimizing the oil federate. Taro Ultra 40 should be used in accordance with OEM guidelines and recommendations.
* ACOM (automated cylinder oil mixing) system that mixes Taro Ultra 40 and Taro Ultra 140 to the BN requested depending on sulphur content of the bunkered fuel.

Taro Ultra 40 Is Approved For:

- ☑ **MAN Energy Solutions**
- ☑ **WinGD (formerly Wärtsilä)**
- ☑ **Japan Engine Corporation (formerly Mitsubishi/Kobe Diesel)**
- ☑ **ACOM (automated cylinder oil mixing) according to MAN approval**

Performance Benefits

1. Engine Protection

Protects against excessive cylinder liner and piston ring wear, thus allowing prolonged service intervals.

2. Engine Cleanliness

Prevents ring sticking and minimizes deposit formation on the pistons and throughout the combustion chamber exhaust areas.

3. Storage Stability

Stable at ambient temperatures and during long-term storage.

4. Compatibility

Miscible and compatible with diesel cylinder lubricants generally known to the international marine trade.

Taro® Ultra Advanced 40

Description

Taro® Ultra Advanced 40 is the latest addition to Chevron Marine Lubricants' range of cylinder oils meeting the highest performance standards. Taro Ultra Advanced 40 is designed to provide improved marine engine protection over previous generation of low Base Number (BN) formulations.

Taro Ultra Advanced 40 is a high performance, 40 Base Number (BN) cylinder lubricant specially formulated to:

- Offer enhanced piston and piston ring pack cleanliness and liner wear protection as a result of high dispersant and detergent effectiveness, at moderate BN level
- Protect the latest engine designs operating on fuels with sulfur content of 0,5% and lower from wear and corrosion
- Further extend thermal stability
- Improve scavenge space and exhaust track cleanliness by having significantly lower sulfated ash content than existing MAN ES Category II 100 and 140 BN lubricants
- Avoid alternating between high and low BN cylinder oils to improve piston cleanliness, simplifying operations

Taro Ultra Advanced 40 is blended with highly refined base oils and carefully selected additives to help provide strong ring and liner wear protection and piston cleanliness in large bore low speed crosshead engines.

Typical Characteristics

SAE Viscosity Grade	**50**
MPID	**219040**
Base number, mg KOH/g (ASTM D2896)	40
Density at 15°C, kg/l (ASTM D4052)	0.92
Flash point, COC, °C (ASTM D92)	220 min
Pour point, °C (ASTM D97)	–15
Kinematic Viscosity at 100°C, mm^2/s (ASTM D445)	19.0

Recommended Applications

Taro Ultra Advanced 40 is recommended for cylinder lubrication of the latest generation large low-speed marine diesel engines equipped with exhaust abatement technologies operating with a range of low and up to zero sulphur fuels including VLSFO, ULSFO, LNG and methanol. Taro Ultra Advanced 40 should be used in accordance with OEM guidelines and recommendations.

Taro Ultra Advanced 40 is Approved For:

☑ **MAN Energy Solutions (Category II cylinder oils)**

Performance Benefits

1. Engine Protection

Designed to keep pistons clean at moderate BN and oil ash level, eliminating the need to alternate with cylinder oils of higher and lower BN to help maintain cleanliness. Anti-seizure properties help minimize the risk of scuffing and increase thermal stability to minimize the deposit build up. Formulated to prevent ring sticking. Designed to help protect against corrosive wear for a range of low and zero sulphur fuels including VLSFO, ULSFO, LNG and methanol.

2. Engine Exhaust Cleanliness

Operation with a lower sulfated ash lubricant can help reduce accumulation of oil ash in scavenge space, on exhaust valves, turbocharger and other components in the exhaust system such as economizer and critical exhaust gas after treatment systems as SCR, EGR, DPF.

3. Storage Stability

Stable at ambient temperatures and during long-term storage.

4. Compatibility

Miscible and compatible with diesel cylinder lubricants commonly used in the international marine trade.

Chevron

marine lubricants

Taro® Ultra 70

Description

Taro® Ultra is new range of cylinder lubricants specifically designed to cope with the demands and required flexibility for IMO 2020. Taro Ultra cylinder lubricants have been fully field tested using a wide variety of fuels expected to be available post IMO 2020 implementation and are approved by major OEMs.

Taro Ultra 70 is a 70 Base Number (BN) cylinder lubricant designed for lubricating two-stroke marine engines running on low sulphur fuels with corrosive operating conditions, or older mild corrosive engines equipped with exhaust abatement technologies using heavy fuel oil. Taro Ultra 70 is blended with highly refined base oils and carefully selected additives to provide excellent ring and liner wear protection and piston cleanliness in slow-speed crosshead diesel engines.

Typical Characteristics

SAE Viscosity Grade	50
MPID	**219035**
Base number, mg KOH/g (ASTM D2896)	70
Density at 15°C, kg/l (ASTM D4052)	0.93
Flash point, COC, °C (ASTM D92)	180 min
Pour point, °C (ASTM D97)	–15
Kinematic Viscosity at 100°C, mm^2/s (ASTM D445)	19.0

Recommended Applications

Taro Ultra 70 is recommended for lubricating the cylinders of large low-speed marine diesel engines running on low sulphur fuels but corrosive operating conditions or older mild corrosive engines equipped with exhaust abatement technologies using heavy fuel oil. Taro Ultra 70 should be used in accordance with OEM guidelines and recommendations.

Taro Ultra 70 Is Approved For:

- ☑ **MAN Energy Solutions**
- ☑ **WinGD (formerly Wärtsilä)**
- ☑ **Japan Engine Corporation (formerly Mitsubishi/Kobe Diesel)**

Performance Benefits

1. Engine Protection
Effective acid neutralization ensures protection against excessive cylinder liner and piston ring wear resulting from the use of high sulphur heavy fuel oils, thus extending cylinder liner and piston ring life.

2. Engine Cleanliness
Prevents ring sticking and minimizes deposit formation on the pistons and throughout the combustion chamber exhaust areas.

3. Storage Stability
Stable at ambient temperatures & during long-term storage.

4. Compatibility
Miscible and compatible with diesel cylinder lubricants generally known to the international marine trade.

5. Operating cost
If oil feedrate is above minimum recommended by OEM, there is potential to move to a higher base number formulation to provide the same level of alkalinity and corrosion protection but at lower feedrates, therefore reducing operating cost.

marine lubricants

Taro® Ultra 100

Description

Taro® Ultra is new range of cylinder lubricants specifically designed to cope with the demands and required flexibility for IMO 2020. Taro Ultra cylinder lubricants have been fully field tested using a wide variety of fuels expected to be available post IMO 2020 implementation and are approved by major OEMs.

Taro Ultra 100 is a 100 Base Number (BN) cylinder lubricant specially formulated to combat the effects of cold corrosion in two-stroke marine engines equipped with exhaust abatement technologies running on heavy fuel oil, under all loads and operating conditions. Taro Ultra 100 is blended with highly refined base oils and carefully selected additives to provide excellent ring and liner wear protection and piston cleanliness in slow-speed crosshead diesel engines.

Typical Characteristics

SAE Viscosity Grade	**50**
MPID	**219036**
Base number, mg KOH/g (ASTM D2896)	100
Density at 15°C, kg/l (ASTM D4052)	0.95
Flash point, COC, °C (ASTM D92)	180 min
Pour point, °C (ASTM D97)	–15
Kinematic Viscosity at 100°C, mm^2/s (ASTM D445)	19.0

Recommended Applications

Taro Ultra 100 is recommended for lubricating the cylinders of the latest generation large low-speed marine diesel engines equipped with exhaust abatement technologies operating with heavy fuel oil, under all loads and corrosive operating conditions. Taro Ultra 100 should be used in accordance with OEM guidelines and recommendations.

Taro Ultra 100 Is Approved For:

- ☑ **MAN Energy Solutions**
- ☑ **WinGD (formerly Wärtsilä)**
- ☑ **Japan Engine Corporation (formerly Mitsubishi/Kobe Diesel)**

Performance Benefits

1. Engine Protection

Effective acid neutralization ensures protection against excessive cylinder liner and piston ring wear resulting from the use of high sulphur heavy fuel oils, thus extending cylinder liner and piston ring life.

2. Engine Cleanliness

Prevents ring sticking and minimizes deposit formation on the pistons and throughout the combustion chamber exhaust areas.

3. Storage Stability

Stable at ambient temperatures and during long-term storage.

4. Compatibility

Miscible and compatible with diesel cylinder lubricants generally known to the international marine trade.

5. Operating cost

If oil feedrate is above minimum recommended by OEM, there is potential to move to a higher base number formulation to provide the same level of alkalinity and corrosion protection but at lower feedrates, therefore reducing operating cost.

Chevron
marine lubricants

Taro® Ultra 140

Description

Taro® Ultra is new range of cylinder lubricants specifically designed to cope with the demands and required flexibility for IMO 2020. Taro Ultra cylinder lubricants have been fully field tested using a wide variety of fuels expected to be available post IMO 2020 implementation and are approved by major.

Taro Ultra 140 is a 140 Base Number (BN) cylinder oil specially formulated for use in high corrosion environments. As an ultra-high base number cylinder lubricant, this product is created for the latest type of highly efficient two-stroke engines which have an increased tendency to develop cold corrosion inside the cylinder than the older, less efficient installations. Taro Ultra 140 provides the same level of alkalinity and corrosion protection as Taro Ultra 100 at lower feedrates, therefore helping to reduce operating costs. Taro Ultra 140 a is blended with highly refined base oils and carefully selected additives to provide excellent ring and liner wear protection and piston cleanliness in slow-speed crosshead diesel engines.

Typical Characteristics

SAE Viscosity Grade	50
MPID	**219037**
Base number, mg KOH/g (ASTM D2896)	140
Density at 15°C, kg/l (ASTM D4052)	0.98
Flash point, COC, °C (ASTM D92)	180 min
Pour point, °C (ASTM D97)	–15
Kinematic Viscosity at 100°C, mm^2/s (ASTM D445)	19.0

Recommended Applications

Taro Ultra 140 is recommended for lubricating the cylinders of the latest generation large low-speed marine diesel engines equipped with exhaust abatement technologies operating with heavy fuel oil, under all loads and very corrosive operating conditions. The base number of Taro Ultra 140 makes this product ideal for use in engine types and under operating conditions which are sensitive to cold corrosion in the cylinder. Taro Ultra 140 should be used in accordance with OEM guidelines and recommendations.

Taro Ultra 140 Is Approved For:

- ☑ **MAN Energy Solutions**

Performance Benefits

1. Engine Protection

Effective acid neutralization ensures protection against excessive cylinder liner and piston ring wear resulting from the use of high sulphur heavy fuel oils, thus extending cylinder liner and piston ring life.

2. Engine Cleanliness

Prevents ring sticking and minimizes deposit formation on the pistons and throughout the combustion chamber exhaust areas.

3. Storage Stability

Stable at ambient temperatures and during long-term storage.

4. Compatibility

Miscible and compatible with diesel cylinder lubricants generally known to the international marine trade.

5. Operating cost

Ultra-high base number formulation provides the same level of alkalinity and corrosion protection at lower feedrates, reducing operating cost.

marine lubricants

Veritas® 800 Marine 30

Description

Veritas® 800 Marine 30 is a crankcase lubricant for two-stroke marine engines. Veritas 800 Marine is blended with highly refined base oils and carefully selected additives to provide very good anti-corrosion and anti-foam properties. The combination of detergency and the exceptional oxidation stability provides clean piston interiors and crankcase. Veritas 800 Marine 30 is formulated with the appropriate level of alkalinity to neutralize acidic combustion products that can enter the crankcase.

Typical Characteristics

SAE Viscosity Grade	30
MPID	**219100**
Base number, mg KOH/g (ASTM D2896)	5.6
Density at 15°C, kg/l (ASTM D4052)	0.89
Flash point, COC, °C (ASTM D92)	180 min
Pour point, °C (ASTM D97)	–18
Kinematic Viscosity at 40°C, mm²/s (ASTM D445)	111.0
Kinematic Viscosity at 100°C, mm²/s (ASTM D445)	11.9
Viscosity Index	95
FZG test (A/8.3/90), failure load stage (CEC-L-07-95)	11

Recommended Applications

Veritas 800 Marine 30 is recommended for the crankcase lubrication of large low-speed marine diesel engines operating with all fuel types and under all loads and operating conditions. Veritas 800 Marine 30 should be used in accordance with OEM guidelines and recommendations.

Veritas 800 Marine 30 Is Approved For:

- ☑ **MAN Energy Solutions**
- ☑ **WinGD (formerly Wärtsilä)**
- ☑ **Japan Engine Corporation (Mitsubishi)**

Performance Benefits

1. Engine Protection

Helps to protect bearings and white metals in the engine lubrication systems against corrosive wear from acidic combustion by-products.

2. Engine Cleanliness

Helps to ensure clean crankcases, piston interiors and lubricating oil lines.

3. Smooth Operation

Can prevent the formation of foam and ensures smooth operation of pumps with a continuous oil feed to all engineparts.

4. Easy Purification

Effective water and contaminants handling.

Disclaimer. Data provided in this PDS is based on standard tests under laboratory conditions and is indicative only. Minor variations which do not affect product performance are expected in normal manufacturing. This product should not be used for any purpose other than those expressly set out in this PDS. The user has sole responsibility for verifying that this product is suitable for the user's intended application. Recommendations differ between engine manufacturers so always consult your manual. Neither Chevron nor its subsidiaries make any warranty or representation as to the accuracy or completeness of this PDS and neither Chevron nor its subsidiaries accept liability for any loss or damage suffered as a result of the use of this product other than in accordance with the terms of this PDS. (September 2020)

marine lubricants

Delo® 710 LE SAE 20W-40

Regional equivalent: Delo 6170 CFO SAE 40

Description

Delo® 710 LE SAE 20W-40 is an industry leading, ultra-high-performance diesel engine oil for use in EMD and GE engines in railroad, marine and power generation applications. It is formulated specifically for engines using Low Sulphur and Ultra Low Sulphur Fuels and new low emission engines.

Delo 710 LE SAE 20W-40 uses premium quality base oils that are very pure, with extremely low levels of sulphur, nitrogen and aromatics to enhance oxidation resistance. It employs newly developed dispersants, detergents and oxidation inhibitors to promote outstanding oil life and minimal ash content.

Typical Characteristics

MPID	219370
Kinematic viscosity at 100°C, mm^2/s	15.50
Flash Point	230

Recommended Applications

Delo 710 LE SAE 20W-40 is recommended for diesel engines using Low Sulphur and Ultra Low Sulphur Fuels; with or without exhaust after treatment; where Zn-free oils are required in applications such as Railroad, Marine, Offshore Drilling and Production, Stationary Power Generation. Sporadic use in combination with high sulphur fuel is only allowed when a strong used oil analysis program is possible. Close monitoring of the base number is essential.

Delo 710 LE SAE 20W-40 Is Approved For:

- ☑ **Electro-Motive Diesel** LMOA Generation 5
- ☑ **General Electric** LMOA Generation 4 Long Life, LMOA Generation 6

marine lubricants

Performance Benefits

1. Good Oxidation Stability
Good oxidation stability, soot dispersancy and base retention for long oil life with newly designed low consumption power assemblies

2. Promotes Oil Consumption Reduction
SAE 20W-40 helps provide a 15–25% oil consumption reduction versus single grade engine oils.

3. Offers Protection Against Wearing
Designed to offer high performance wear protection in railroad, marine and power generation applications, helping reduce costs.

4. Promotes Engine Cleanliness
Advanced keep-clean formulation promotes optimumengine cleanliness with reduced maintenance downtime.

5. Reduces Deposits
Helps reduce exhaust system and turbocharger deposits,contributing to increased uptime and system efficiency.

6. Zinc Free
Zinc free, non-chlorinated.

Our Family of Brands

Delo® 1000 Marine

Description

Delo® 1000 Marine lubricants are high-performance diesel engine oils for medium-speed trunk piston diesel engines. Delo 1000 Marine lubricants are blended with highly refined base oils and carefully selected additives. They have very good viscosity control when used in severe high-temperature service, and their great BN retention characteristics prevent corrosive wear over long periods of operation. The unique detergent and dispersant additive system provides piston cleanliness and soot handling. This results in extreme reduction of both "hot" (piston lands and grooves, piston undercrown, purifier preheaters) and "cold" (crankcase, cambox, rocker area, fuel pumps, purifier bowl) deposits. Delo 1000 Marine lubricants provide a highdegree of water tolerance and have good water separation.

Typical Characteristics

SAE Viscosity Grade	30	40
MPID	**219201**	**219200**
Base number, mg KOH/g (ASTM D2896)	12	12
Density at 15°C, kg/l (ASTM D4052)	0.89	0.89
Flash point, COC, °C (ASTM D92)	180 min	180 min
Pour point, °C (ASTM D97)	–18	–18
Kinematic Viscosity at 40°C, mm²/s (ASTM D445)	102.0	135.0
Kinematic Viscosity at 100°C, mm²/s (ASTM D445)	11.6	14.2
Viscosity Index	100	100
FZG test (A/8.3/90), failure load stage (CEC-L-07-95)	12	12

Recommended Applications

Delo 1000 Marine lubricants are recommended for medium-speed trunk piston diesel engines burning distillate and low sulfur fuels. The good load carrying capacity of Delo 1000 Marine lubricants also makes these suitable for use in engine reduction gears and other applications where EP properties are required. Delo 1000 Marine should be used in accordance with OEM guidelines and recommendations.

Delo 1000 Marine Lubricants Are Approved For:

- ☑ **MAN Energy Solutions**
- ☑ **Wärtsilä and MaK (Caterpillar)**
- ☑ **Rolls Royce Bergen**
- ☑ **Daihatsu**
- ☑ **Hyundai Himsen**
- ☑ **Yanmar**

marine lubricants

Performance Benefits

1. Engine Protection

Controls cylinder liner wear effectively and helps to protect bearings from corrosion. High performance, anti-wear additives provide protection against wear for cams, camshaft and bearings. Delo® 1000 Marine lubricants also promote a high degree of water tolerance and anti-foam protection.

2. Engine Cleanliness

Helps to ensure clean crankcases, piston interiors and lubricating oil lines.

3. Easy Purification

Effective water and contaminants handling.

4. Smooth Operation

Helps to provide minimum maintenance and downtime, long engine life and economical operating costs.

Our Family of Brands

marine lubricants

Delo® SHP

Description

Delo® SHP lubricants are high-performance diesel engine oils for medium- and high-speed trunk piston diesel engines withor without oil purifiers. Delo SHP lubricants are blended with highly refined base oils and carefully selected additives. Delo SHP lubricants have very good viscosity control when used in severe high-temperature service, and their BN retention characteristics help to prevent corrosive wear over long periods of operation. The unique detergent and dispersant additive system promote piston cleanliness, liner lacquer control and first-rate soot handling. This results in extreme reduction of both "hot" (piston lands and grooves, piston undercrown, purifier preheaters) and "cold" (crankcase, cambox, rocker area,fuel pumps, purifier bowl) deposits. Delo SHP lubricants help to provide a high degree of water tolerance and have good water separation.

Typical Characteristics

SAE Viscosity Grade	30	40
MPID	**219203**	**219206**
Base number, mg KOH/g (ASTM D2896)	12	12
Density at 15°C, kg/l (ASTM D4052)	0.89	0.89
Flash point, COC, °C (ASTM D92)	180 min	180 min
Pour point, °C (ASTM D97)	–15	–18
Kinematic Viscosity at 40°C, mm²/s (ASTM D445)	104.0	135.0
Kinematic Viscosity at 100°C, mm²/s (ASTM D445)	11.8	14.0
Viscosity Index	100	100
FZG test (A/8.3/90), failure load stage (CEC-L-07-95)	12	12

Recommended Applications

Delo SHP lubricants are recommended for medium- and high-speed trunk piston diesel engines burning distillate and low sulfur fuels. Delo SHP can be used in diesel engines with or without oil purifiers and particularly suited for engines sensitiveto liner lacquering. The good load carrying capacity of Delo SHP lubricants also makes these suitable for use in engine reduction gears and other applications where EP properties are required. Delo SHP should be used in accordance with OEMguidelines and recommendations.

Delo SHP Lubricants Are Approved For:

- ☑ **MAN Energy Solutions**
- ☑ **Wärtsilä Marine – Deutz SBVM628**
- ☑ **MaK (Caterpillar)**
- ☑ **Rolls Royce Bergen**
- ☑ **Daihatsu**
- ☑ **Hyundai Himsen**
- ☑ **Yanmar**

Delo SHP Lubricants Are Suitable For Use In:

- ☑ **MTU** Type 2

Performance Benefits

1. Engine Protection

Controls cylinder liner wear effectively and helps to protect bearings from corrosion. High performance, anti-wear additives help to provide protection against wear for cams, camshaft and bearings. Delo® SHP lubricants also provide a high degree of water tolerance and anti-foam protection. It can also help protect against liner lacquer formulation.

2. Engine Cleanliness

Helps to ensure clean crankcases, piston interiors and lubricating oil lines.

3. Easy Purification

Effective water and contaminants handling.

4. Smooth Operation

Helps to provide minimum maintenance and downtime, long engine life and economical operating costs in applications with or without oil purifiers.

Taro® DP and XL Series

Description

Taro® DP and XL series lubricants are high-performance diesel engine oils for medium-speed trunk piston diesel engines. Taro DP and XL series are blended with highly refined base oils and carefully selected additives. Taro DP and XL series lubricants have very good viscosity control when used in severe high-temperature service, and the BN retention characteristics helps to prevent corrosive wear over long periods of operation. The unique detergent and dispersant additive system promotes piston cleanliness as well as control of fuel contaminants. This results in extreme reduction of both "hot" (piston lands and grooves, piston undercrown, purifier preheaters) and "cold" (crankcase, cambox, rocker area, fuel pumps, purifier bowl) deposits. Taro DP and XL series lubricants provide a high degree of water tolerance and have good water separation.

Typical Characteristics

	Taro 20 DP 30/40 (X)*	Taro 30 DP 30/40 (X)*	Taro 40 XL 40 (X)*	Taro 50 XL 40 (X)*
SAE Viscosity Grade	**30/40**	**30/40**	**40**	**40**
MPID	**219230/219240**	**219231/219241**	**219243**	**219244**
Base number, mg KOH/g (ASTM D2896)	20	30	40	50
Density at 15°C, kg/l (ASTM D4052)	0.90	0.91	0.90	0.91
Flash point, COC, °C (ASTM D92)	180 min	180 min	180 min	180 min
Pour point, °C (ASTM D97)	–12	–12	–12	–12
Kinematic Viscosity at 40°C, mm²/s (ASTM D445)	94.0/135.0	94.0/135.0	135.0	135.0
FZG test (A/8.3/90), failure load stage (CEC-L-07-95)	12	12	12	12

* Depending on the port designated, products may be delivered with or without the (X) identifier — e.g., Taro 20 DP 30X or Taro 20 DP 30 — however, the product typical test data both with or without the (X) identifier are miscible and fully compatible.

Recommended Applications

Taro DP and XL series lubricants are recommended for medium-speed trunk piston diesel engines burning residual or marine diesel fuels. Taro DP and XL series should be used in accordance with OEM guidelines and recommendations. The good load carrying capacity of Taro DP and XL series lubricants also makes these suitable for use in engine reduction gears and otherapplications where EP properties are required.

Taro DP and XL Series Lubricants Are Approved For:

- ☑ **MAN Energy Solutions**
- ☑ **Wärtsilä and MaK**
- ☑ **(Caterpillar)Rolls Royce Bergen**
- ☑ **Daihatsu**
- ☑ **Hyundai Himsen**
- ☑ **Yanmar**

Performance Benefits

1. Engine Protection

Controls cylinder liner wear effectively and helps to protect bearings from corrosion. High performance, anti-wear additives can provide protection against wear for cams, camshaft and bearings. Taro® DP and XL series lubricants also promotes a high degree of water toleranceand anti-foam protection.

2. Engine Cleanliness

Helps to ensure clean crankcases, piston interiors and lubricating oil lines.

3. Easy Purification

Effective water and contaminants handling.

4. Smooth Operation

Helps to provide minimum maintenance and downtime, long engine life and economical operating costs.

Delo® 100 Motor Oil SAE 40

Regional equivalent: Ursa Extra Duty SAE 40

Description

Delo® 100 Motor Oil SAE 40 is a heavy duty monograde engine oil specifically formulated for heavy duty two-stroke diesel engines (Detroit Diesel) operating in both on- and off-highway service. These low ash engines have special lubricating needswhich no ordinary diesel crankcase engine oil could satisfy.

Delo 100 Motor Oil SAE 40 is formulated with proven solvent refined base stocks and a carefully balanced system of detergents, inhibitors and anti-wear additives.

Typical Characteristics

MPID	219932
Characteristic	SAE 40
Density at 15°C, kg/l	0.90
Kinematic viscosity at 40°C, mm^2/s	131.0
Kinematic viscosity at 100°C, mm^2/s	14.5
Viscosity Index	109
Pour point, °C	–24
Flash point COC, °C	270
Total Base Number, mg KOH/g	7.3
Sulphated Ash, %wt	0.8

Recommended Applications

Delo 100 Motor Oil SAE 40 is recommended for use in older two- and four-stroke diesel engines in farm machinery, construction equipment, marine, and other off-highway applications where the SAE 40 grade is specified by the OEM. Delo100 Motor Oil SAE 40 utilizes reliable technology to help provide robust performance in older engines burning ultra-low sulphur diesel fuels. Delo 100 Motor Oil SAE 40 may also be used in industrial applications such as: gear drives, pump chains,or where a detergent type engine oil is required.

Delo 100 Motor Oil SAE 40 Meets The Requirements Of:

- ☑ **Detroit Diesel** Two-stroke Series 71, 92 and 149
- ☑ **API** CF-2, CF

Performance Benefits

1. High Temperature Deposit Control
Helps to protect against high temperature oxidation andoil thickening in older engines.

2. Special Extreme Pressure Anti-Wear Properties
Good control of deposits and wear optimize the engineoverhaul intervals.

3. Protection Against Rust, Corrosion, Varnish & Sludge
Helps keep oil screens, filters, and rings clean and free forprolonged periods.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. To obtain a SDS for this product, visit chevronmarineproducts.com.

Chevron

marine lubricants

Delo® 400 SAE 40

Regional equivalents: Delo Silver SAE 40, Ursa LA 3 SAE 40, Ursa Heavy Duty SAE 40

Description

Delo 400 SAE 40 oil is a mixed-fleet motor oil recommended for older four-stroke gasoline and diesel engines. Delo 400 SAE 40 heavy duty motor oil is a premium quality engine oil. It is formulated utilizing advanced additive technology which helps provide outstanding engine protection for four-stroke diesel engines requiring a monograde engine oil.

Typical Characteristics

MPID	219338
Density at 15°C, kg/l	0.89
Kinematic viscosity at 100°C, mm^2/s	14.7
Pour point, °C	-24
Total Base Number, mg KOH/g	10.1
Sulphated Ash, %wt	1.5

Recommended Applications

Delo 400 SAE 40 monograde oil is a mixed-fleet motor oil recommended for older four-stroke gasoline and diesel engines that require a monograde engine oil. Delo 400 SAE 40 oil is formulated for exceptional performance in older engines usingboth normal, high, and low sulfur diesel fuels.

Delo 400 SAE 40 is not recommended for use in DDC two-stroke engines.

Delo 400 SAE 40 Is Approved For:

- **MAN Truck & Bus** M 3275-2
- **MTU** Category 2

Delo 400 SAE 40 Meets The Requirements Of:

- **API** CF
- **API** SJ
- **Daimler** MB-Approval 228.2
- **Detroit Diesel** DDC/MTU Category 2
- **MAN Truck & Bus** 270

Performance Benefits

1. Controlled Oil Costs

Minimal crownland deposits and good oxidation stabilitymay help minimize oil consumption.

2.Long Engine Life

Good control of deposits and wear can optimize the engine overhaul intervals.

3.Exceptional Engine Cleanliness

High detergency provides good deposit and sludge control in the piston ring belt area.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. Toobtain a SDS for this product, visit chevronmarineproducts.com.

marine lubricants

Delo® 400 MGX SAE 15W-40

Regional equivalents: Delo 400 LE SAE 15W-40, Ursa Ultra LE SAE 15W-40

Description

Delo® 400 MGX SAE 15W-40 is a premium performance low SAPS technology heavy duty diesel engine lubricant, specifically formulated for on-highway and off-highway applications. It aims to provide protection for new low emission diesel engines with Selective Catalytic Reduction (SCR), Diesel Particulate Filter (DPF) and Exhaust Gas Recirculation (EGR). Additionally, it is designed for mixed fleets of on-highway and off-highway diesel engines and meets the performance requirements of a wide range of naturally aspirated and turbocharged four-stroke diesel engines. This product is formulated using advanced additive technology to help provide protection for on-highway and off-highway applications burning high or low sulphur diesel fuels.

Delo 400 MGX SAE 15W-40 is formulated using advanced low SAPS additive technology which helps to provide engine protection for diesel engines meeting Euro IV, V and Euro VI emission requirements and for 2007 and 2010 EPA exhaust particulate emissions standards for on highway diesel trucks, using Ultra Low Sulphur Diesel (ULSD).

Delo 400 MGX SAE 15W-40 is based upon ISOSYN® technology, which uses premium base oils with high viscosity index in combination with an optimal blend of latest technology in dispersant, detergent, oxidation inhibition, anti-wear, corrosion inhibition, viscosity improver, and de-foaming additives to give a product which rivals synthetic lubricants in critical enginetests.

Typical Characteristics

MPID	235105
Density at 15°C, kg/l	0.88
Kinematic viscosity at 100°C, mm^2/s	14.6
Pour point, °C	–36
Flash point COC, °C	228
Total Base Number, mg KOH/g	9.6
Sulphated Ash, %wt	1.0

Recommended Applications

Delo 400 MGW SAE 15W-40 is a mixed fleet motor oil recommended for four-stroke naturally aspirated and turbocharged diesel engines but may also be used in four-stroke gasoline engines. This product is recommended for diesel engines meeting Euro I through VI emissions requirements. It can be used in new advanced engines equipped with features like four- valve heads, supercharging, turbocharging, direct injection, shorter piston crowns, higher power density, intercooling, full electronic management of fuel and emission systems, Exhaust Gas Recirculation (EGR), exhaust particulate filters (DPF) and for most engines fitted with SCR NOx reduction systems. It is also recommended for use in older engines as well as today'smost modern low emission designs. It is formulated for exceptional performance with Ultra Low Sulphur Diesel but also withhigh, normal and low sulphur diesel fuels (10–5000 ppm sulphur).

Delo 400 MGW SAE 15W-40 is ideal for mixed commercial fleets, farm machinery, construction equipment, marine and otheroff-highway applications.

marine lubricants

Delo 400 MGX SAE 15W-40 Is Approved For:

- **Cummins** CES 20081
- **Detroit Diesel** DDC93K218
- **Daimler** MB-Approval 228.31
- **DEUTZ** DQC III-10 LA
- **Mack** EO-O Premium Plus
- **MAN** M3575
- **MTU** Oil Category 2.1
- **Renault** RLD-3
- **Volvo** VDS-4

Delo 400 MGX SAE 15W-40 Meets The Requirements Of:

- **ACEA** E9-12
- **API** CI-4, CI-4+, CJ-4
- **Ford** WSS-M2C171-E
- **JASO** DH-2
- **Caterpillar** ECF-3
- **Off-highway, construction or marine applications** which will require API CJ-4 and CI-4

Performance Benefits

1. Smooth Lock-Ups
Specially tuned friction characteristics, ensuring smooth shifting and lock-ups.

2. Good Fluid Lifetime
The friction durability helps make sure that this performance is retained throughout the fluid lifetime.

3. High Viscosity Index
High Viscosity Index means that the oil will retain sufficient viscosity for effective lubrication even at high operating temperatures.

4. Functions In Cold Weather
The low-temperature fluidity helps to provide transmission protection during cold weather start-up.

5. Prevents Harmful Sludge
The good oxidation stability helps to prevent formation ofharmful sludge, lacquer or deposits.

6. Prevents Loss Of Fluid
Compatible with a wide variety of elastomer materials,preventing loss of fluid due to seal deterioration.

7. Corrosion Protection
Can prevent corrosion of automatic transmission fluid coolers.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. Toobtain a SDS for this product, visit chevronmarineproducts.com.

Our Family of Brands

Delo® Gold Ultra SAE 15W-40

Regional equivalents: Ursa Marine 15W-40, Delo 400 Multi-grade SAE 15W-40,
Ursa Super TD SAE 15W-40, Delo Gold Ultra E SAE 15W-40

Description

Delo® Gold Ultra SAE 15W-40 is a high-quality, heavy-duty diesel crankcase lubricant. Manufactured from high-quality base oils and compounded with additives, Delo Gold Ultra SAE 15W-40 provides good lubrication for turbo-charged, high-speed diesel engines under severe operating conditions. It contains detergent/dispersant, antioxidation and anti-wear additives, and meets the API service classification CI-4.

Typical Characteristics

MPID	219933
Density at 15°C, kg/l	0.88
Kinematic viscosity at 40°C, mm²/s	115.0
Kinematic viscosity at 100°C, mm²/s	15.2
Viscosity Index	138
Pour point, °C	–39
Flash point COC, °C	230
Total Base Number, mg KOH/g	10.2

Recommended Applications

Delo Gold Ultra SAE 15W-40 is recommended for use in heavy-duty (turbo-charged), high-speed diesel engines operating under very severe conditions where an API CI-4 type oil is required. This grade is especially recommended for emergency equipment onboard seagoing vessels such as lifeboat engines and motor-driven fire pumps and emergency compressors.

Delo Gold Ultra SAE 15W-40 Is Approved For:

- ☑ **Daimler** MB-Approval 228.3
- ☑ **Detroit Diesel** 93K215
- ☑ **Deutz** DQC III-10

Delo Gold Ultra SAE 15W-40 Meets The Requirements Of:

- ☑ **API** CI-4/SL
- ☑ **Caterpillar** ECF-1-a
- ☑ **JASO** DH-1
- ☑ **MAN Truck & Bus** M 3275-1
- ☑ **MTU** Category 2

Performance Benefits

1. Oxidation Stability & Deposit Control
Minimal crownland deposits and good oxidation stabilitymay help minimize oil consumption.

2. Corrosion Protection
Good control of deposits and wear may optimize the engine overhaul intervals.

3. Anti-Wear Properties
High detergency can provide good deposit and sludge control in the piston ring belt area.

4. Minimizing Operating Costs
Can prevent unscheduled downtime by providing efficient dispersion of soot particles. The protection against soot related wear and deposit can also prevent excessive viscosity increase and filter plugging.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. Toobtain a SDS for this product, visit chevronmarineproducts.com.

Delo® 400 XSP SAE 5W-40

Regional equivalents: Ursa Ultra X SAE 10W-40, Delo 400 LE Synthetic SAE 5W-40

Description

Delo® 400 XSP SAE 5W-40 is a mixed-fleet engine oil recommended for naturally aspirated and turbocharged four-stroke diesel engines and four-stroke gasoline engines. It helps keep piston rings clean and free for optimum combustion pressureand minimal wear.

A high level of ashless dispersants keeps fuel soot in suspension and helps to avoid filter plugging, cylinder head sludge, abrasive wear, viscosity increases, and oil gelation. These problems could cause excessive engine wear and bearing failure, without warning. Optimized additive chemistries combined with synthetic base stocks control oxidation, sludge, and unduethickening between oil drains. A de-foaming additive helps prevent air entrapment.

Typical Characteristics

MPID	TBD
Density at 15°C, kg/l	0.85
Kinematic viscosity at 40°C, mm^2/s	96.0
Kinematic viscosity at 100°C, mm^2/s	15.4
Viscosity Index	170
Pour Point, °C	-46
Flash Point COC, °C	223
Total Base Number, mg KOH/g	10
Sulfated Ash, %wt	1.0

Recommended Applications

Delo 400 XSP SAE 5W-40 with ISOSYN Advanced Technology is a mixed-fleet motor oil, recommended for naturally aspirated and turbocharged four-stroke diesel and gasoline engines in which the API CK-4, API SN or API SN PLUS service categoriesand SAE 5W-40 viscosity grade is recommended.

Delo 400 XSP SAE 5W-40 specifically formulated for all applications including 2017 greenhouse gas (GHG 17) compliant diesel engines with lower CO^2 emissions and improved fuel economy, in addition to EPA 2010 compliant low emission diesel engines with Selective Catalytic Reduction (SCR), Diesel Particulate Filter (DPF) and Exhaust Gas Recirculation (EGR) systems. It is fully compatible with previous engine models and previous API Oil Service Categories.

Delo 400 XSP SAE 5W-40 Is Approved For:

- ☑ **DEUTZ** DQC III-10 LA
- ☑ **Mack Trucks (Volvo)** EOS 4.5
- ☑ **Renault Trucks (Volvo)** RLD-4
- ☑ **API** CH-4, CI-4 Plus, CJ-4

Delo 400 XSP SAE 5W-40 Meets The Requirements Of:

- ☑ **Cummins** CES 20086
- ☑ **MAN Truck & Bus** M 3575

Performance Benefits

1. Low Viscosity Synthetic Base Stock

Promotes consistent cold engine starting for gasoline anddiesel engines operating in sub-zero temperatures.

2. Minimized Operating Costs

Good soot dispersancy and wear control protect the cylinders, pistons, rings, and valve train components against wear and corrosion, promoting optimum service life and minimal maintenance. Contributes to maximum vehicle utilization and minimal downtime.

3. Good Emission Control System Life

Promotes optimum Diesel Particulate Filter (DPF) life for minimal downtime and cleaning, thus helping to minimizemaintenance costs.

4. Managed Inventory Costs

Compatible with previous API Oil Service Categories. Suitable for use in gasoline engines and naturally aspirated or turbocharged electronically controlled/low emission diesel engines. One oil that meets the engine performance requirements of most North American and European engine manufacturers. One oil that allows users with a wide mix of engine brands to enjoy simplified inventory and dispensing systems that help save money, space and handling time.

Our Family of Brands

Clarity® Synthetic Hydraulic Oil AW

Description

Clarity® Synthetic Hydraulic Oil AW is designed to help protect both mobile and stationary hydraulic equipment in industrial applications, as well as in environmentally sensitive areas. Clarity Synthetic Hydraulic Oil AW is formulated with synthetic base stock and an ash less, zinc-free additive system that provides oxidation stability, water separability, foam suppression, and helps protect against wear, rust and corrosion. Clarity Synthetic Hydraulic Oil AW is designed to meet or exceed the performance requirements of conventional anti-wear hydraulic oils, especially in severe, high-output applications such as axial piston pumps, while providing an additional level of safety in case of leaks or incidental discharge to the environment.

Typical Characteristics

ISO Viscosity Grade	**32**	**46**	**68**
MPID	**219601**	**219603**	**219609**
Kinematic viscosity at 40°C, mm^2/s	32.5	46.5	68.5
Kinematic viscosity at 100°C, mm^2/s	7.0	9.3	11.8
Viscosity Index	183	183	162
Pour point, °C	–45	–42	–42
Flash point COC, °C	220	225	240
Copper Corrosion, 3h/150°C	1B	1B	1B
FZG, Pass Stage, DIN 51354	**11**	>12	>12

Recommended Applications

Clarity Synthetic Hydraulic Oil AW is designed for use in mobile and stationary hydraulic vane, piston, and gear type pumps. The anti-wear performance of Clarity Synthetic Hydraulic Oil AW makes it especially suited for high performance industrial applications utilizing axial piston pumps where pressures may exceed 5,000 psi. It has a viscosity index much higher than typical conventional anti-wear hydraulic oils, provides optimal flow at low temperatures, and good oil film protection at high operating temperatures. Clarity Synthetic Hydraulic Oil AW is well suited for applications situated in environmentally sensitive areas. The ISO 32 and ISO 46 formulations of this product have good low-temperature pumpability properties that extend to temperatures as low as –30°C (–22°F).

Clarity® Synthetic Hydraulic Oils AW are not compatible with zinc/calcium containing fluids, and OEM recommended lubricant change-out procedures including drain and flush requirements need to be adhered to.

Clarity Synthetic Hydraulic Oils AW Meet The Requirements Of:

- ☑ **DIN 51524-3** (HVLP, 2006, Part 3)
- ☑ **ISO** (11158 L-HV), **ASTM** (D6158, HV)
- ☑ **Eaton Vickers** (35VQ25A, M-2950-S, I-286-S),
- ☑ **Cincinnati Machine** P-68 (ISO 32). P-70 (ISO 46), P-69 (ISO 68)
- ☑ **Bosch-Rexroth** (former specification RE 90220-01)
- ☑ **Frank Mohn**
- ☑ **Framo hydraulic cargo pumping** (ISO 46)
- ☑ **Arburg** (ISO 46)
- ☑ **Krauss Maffei Kunststofftechnik (ISO 46)**
- ☑ **McGregor Hatch Cover Systems** (VG 32)

Performance Benefits

1. Premium Performance

Ashless formulation provides wear protection, rust and corrosion protection, hydrolytic stability, water separability, foam inhibition, and filterability.

2. Long Oil Life

Ability of the synthetic base stock to withstand oxidation at high operating temperatures results in maximum service life for the oil.

3. Wear Protection at Start-up

Minimum change in viscosity over wide operating temperatures due to high viscosity index. Multi-viscosity performance minimizes the need to change viscosity grades for seasonal changes.

4. Environmental Sensitivity

Very low acute aquatic toxicity to both fish and invertebrates based on tests of water accommodated fractions. Ashless formulation facilitates conventional recycling programs.

5. Low Temperature Pumpability

The ISO 32 and ISO 46 formulations are specifically developed to ensure good low temperature fluidity for lowtemperature operations as low as –30°C (–22°F).

6. Zinc-free

Suited for applications involving yellow metals found in axial piston pumps.

marine lubricants

Clarity® Hydraulic Oil AW 100

Description

Clarity® Hydraulic Oil AW 100 is a high performance hydraulic oil designed with premium base oil technology in combination with an advanced zinc-free ashless additive system. It offers robust oxidation stability, water separation, foam suppression with dependable wear, rust and corrosion protection to both mobile and stationary hydraulic vane, piston and gear-type pumps operating in industrial applications and in environmentally sensitive areas. It is well-suited to applications where yellow metals are present in hydraulic systems. Clarity Hydraulic Oil AW 100 is a shear-stable high VI hydraulic oil designedto improve equipment efficiency and increase the operating temperature range.

Typical Characteristics

ISO Viscosity Grade	**100**
MPID	**219611**
Kinematic viscosity at 40°C, mm^2/s	100.0
Kinematic viscosity at 100°C, mm^2/s	13.8
Viscosity Index	145
Pour point, °C	-40
Flash point COC, °C	266
Copper Corrosion, 3h/150°C	1B

Recommended Applications

Clarity Hydraulic Oil AW 100 is designed to give reliable protection in mobile and stationary hydraulic vane, piston and gear-type pumps operating in high performance industrial applications as well as in environmentally sensitive areas. Many hydraulic systems are required to operate in environmentally sensitive areas where leaks or spills of hydraulic fluid may result in contamination of the soil or nearby waterways. Unlike Clarity Hydraulic Oil AW 100, conventional anti-wear hydraulic oils are formulated with metal-containing performance additives which can persist in the environment. Clarity Hydraulic Oil AW 100 is designed to meet or exceed the performance requirements of conventional anti-wear hydraulic oils, especially in severe, high-output applications such as axial piston pumps. The anti-wear performance of this oil makes it especially suited for high performance applications utilising axial piston pumps where pressures may exceed 5,000 psi. Clarity Hydraulic Oil AW 100 has offered good performance in applications involving servo-valves using multi-metal components.

Clarity Hydraulic Oil AW 100 Is Approved For:

- ☑ **Blohm+Voss** Stern tube applications
- ☑ **Wärtsilä-Japan** Stern tube applications

Clarity Hydraulic Oil AW 100 Meets The Requirements Of:

- ☑ **DIN 51524-2** (HLP)
- ☑ **DIN 51524-3** (HVLP)
- ☑ **ASTM** (D6158, HV)
- ☑ **ISO** (11158 L-HV)
- ☑ **Eaton Vickers** (M-2950-S, I-286-S)

Performance Benefits

1. Premium Performance

High performance ashless formulation is designed to meet or exceed major vane, piston and gear pump manufacturers' requirements for viscosity, rust and corrosion protection, hydrolytic stability, water separability, foam inhibition,and filterability.

2. Long Oil Life

Offers robust oxidation stability and longer service life than conventional zinc-based anti-wear or vegetable oil-based hydraulic oils.

3. Wear Protection

Reliable anti-wear formulation helps optimise wear protection in high efficiency, high speed, high temperatureand high output equipment.

4. Environmental Sensitivity

Designed for low toxicity, biodegradable[1] performance and has very low acute aquatic toxicity to both fish and invertebrates based on tests of water accommodated fractions. Ashless formulation facilitates conventional recycling programs.

5. Zinc-free

Zinc-free, ashless design helps protect in applications where yellow metals are present in piston pumps.

1. As determined by OECD 301D (Closed Bottle Biodegradability Test), Chevron Clarity Hydraulic Oil AW 100 was shown to be inherently biodegradable. This test is normally run for 28 days. After completing this test period, Chevron Clarity Hydraulic Oil AW 100 was 38% degraded. Degradation of 20–59% after 28 days in OECD 301D is evidence that a product is inherently biodegradable. Chevron Clarity Hydraulic Oil AW 100 did not meet the criteria for readily biodegradable,which is a degradation of >60% after 28 days in OECD 301D.

marine lubricants

Hydraulic Oil 5606

Regional equivalent: Hydraulic Oil 5606A

Description

Hydraulic Oil 5606 is a high performance general purpose red-dyed hydraulic oil specially developed for a range of general purpose severe service industrial applications. It has a mineral base oil formulation with a robust additive system offering good low temperature fluidity; robust wear protection, oxidation and corrosion resistance with dependable shear stability. Hydraulic Oil 5606 contains a passivator and offers good anti-foam performance, making it suitable for a range of general purpose industrial hydraulic applications.

Typical Characteristics

MPID	219390
Density at 15°C, kg/l	0.87
Kinematic viscosity at 40°C, mm^2/s	15.0
Kinematic viscosity at 100°C, mm^2/s	5.5
Viscosity Index	300+
Pour point, °C	–63
Flash point COC, °C	82

Recommended Applications

Hydraulic Oil 5606 is formulated for use in systems where clean oil is required; for example, in autopilots and robotics. It can used under a variety of weather conditions. Additionally, it can be used in severe operation conditions over a broad temperature range and is especially suitable for low temperature applications.

Hydraulic oil 5606 should not be used in systems where natural rubber elastomers are present.

Hydraulic Oil 5606 Meets The Requirements Of:

- ☑ **DIN** 51524 Part III
- ☑ **U.S. Military Specification** MIL H 5606 G
- ☑ **U.S. Military Specification** MIL-PRF-5606 H

Chevron marine lubricants

Performance Benefits

1. High Viscosity Index
Designed with a high viscosity index (VI) to offer flexibility of use across a wide range of environmental and operating temperatures.

2. General Purpose Use
Specially developed for flexible general-purpose use, across a range of severe industrial applications, reducing inventory costs.

3. Low Operating Temperatures
Offers reliable fluidity and system protection in low environmental and operating temperatures, and as system start-up.

4. Wear and Corrosion Protection
Formulated for protection against system wear, corrosion and oxidation, helping reduce downtime.

5. Seal and Paint Flexibility
Can be used with a combination with generally available seals and paints, helping improve service uptimes.

Rando® HDZ

Description

Rando® HDZ oils are high-viscosity, high-performance, anti-wear hydraulic oils, formulated specifically to cater to the widely varying operating temperatures in the marine environment. These oils are blended from high-viscosity index lubricating oilstocks and several specially selected additives designed to give robust protection to hydraulic pumps. Rando HDZ meets therequirements of major hydraulic equipment manufacturers for rust and oxidation inhibited hydraulic fluids, as well as for EPor anti-wear hydraulic fluids.

Typical Characteristics

ISO Viscosity Grade	15	22	32	46	68	100
MPID	**219300**	**219383**	**219301**	**219302**	**219303**	**219304**
Kinematic viscosity at 40°C, mm^2/s	15.0	22.0	32.0	46.0	68.0	100.0
Kinematic viscosity at 100°C, mm^2/s	3.9	5.0	6.3	8.2	11.0	14.2
Density at 15°C, kg/l	0.88	0.95	0.87	0.87	0.88	0.88
Viscosity Index	155	165	151	154	150	139
Pour point, °C	–60	–48	–48	–47	–42	–36
Flash point, °C	144	188	220	216	222	236
Copper Corrosion, 3h/150°C	1A	1A	1A	1A	1A	1A
Foam Seq. II (after blowing), ml	10	10	10	10	10	10
Foam Seq. II (after 10′ standing), ml	0	0	0	0	0	0

Recommended Applications

Rando® HDZ oils are recommended for use in all shipboard hydraulic machinery and specifically for hydraulic equipment used under extreme operating temperatures such as deck machinery. The multi-viscosity feature promotes even and continuouspower transmission over a wide temperature range with a minimum of shudder, and maximum accuracy.

Rando HDZ Oils Are Approved For:

- ☑ **Fives Cincinnati** (formerly MAG Cincinnati, Cin Machine, Cin Milacron) P-68 (ISO 32), P-70 (ISO 46), P-69 (ISO 68)
- ☑ **Besensoni** crane (ISO 46)
- ☑ **Japan IBUKI** horn (ISO 32)
- ☑ **Alfa Laval** (ISO 32)
- ☑ **Sibre** (ISO 32, 46 & 68)
- ☑ **Parker Hannifin (Denison)** HFO (ISO 32, 46, 68)

Rando HDZ Oils Meet The Requirements Of:

- **Arburg** (ISO 46), ASTM D6158, HV (ISO 15, 22, 32, 46, 68, 100)
- **Bosch Rexroth** former specification RE 90220-01 (ISO 32, 46, 68)
- **US Steel** 127, 136 DIN 51524-3, HVLP (ISO 15, 22, 32, 46, 68, 100)
- **Frank Mohn, Framo** hydraulic cargo pumping (ISO 46), ISO 11158 L-HV (ISO 15, 22, 32, 46, 68, 100), JCMAS HK-1 (ISO 32, 46)
- **Turblex** compessor (ISO 46)
- **Rehfuss** gear (ISO 15 & 32)
- **Eaton-Vickers** I-286-S, M-2950-S, 35VQ25A (ISO 32, 46, 68)
- **Sauer Bibus** geared pump (ISO 46 & 68)
- **Dieckow** pumps (ISO 46 & 68)
- **Europa** regulateur, governor (ISO 68 & 100)
- **Bremivi** planetary gear (ISO 32)
- **Bremivi** winches (ISO 46)
- **Goizper** pumps (ISO 32 & 46)
- **Hatlapa** deck machinery (ISO 46, 68 & 100)
- **Mariner** deck machinery (ISO 32 & 46)
- **GEA Westfalia** belt driven purifier (ISO 46)
- **Manabe Zoki** deck machinery (ISO 46 & 68)
- **MarFlex** pumps (ISO 32 & 46)

Performance Benefits

1. Anti-Wear and EP Properties

Extends the life of hydraulic pump and motor parts in heavy-duty service and helps protect against destructive wear under overload conditions.

2. Ultra-High Viscosity Index

Contains a specially selected high shear-stable viscosity index improver, which gives the lubricant a superior operating temperature window, even under high shear-rate conditions. Rando HDZ oils provide real "crossgrading" benefits and stay in grade, even when subjected to the shearing condition of high-speed, high-pressure hydraulicsystems in severe service.

3. Low Pour Point

Remains liquid at low operating temperatures.

4. Oxidation Stability

High oxidation stability helps ensure long life and prevent accumulation of sludge and deposits.

5. Corrosion Protection

Helps protect against rusting of close-fitting hydraulic system parts and prevents the regeneration of abrasive rust and corrosion.

6. Water Resistance

Water-separation characteristics assure speedy removal ofwater from leaks and condensation.

7. Foam Resistant

Combined with selected foam inhibitors, resists foaming, thus preventing accumulation of surface foam at high-oil circulation rates.

8. Filterability

Rando HDZ oils show good filterability properties even in the presence of water. They passed the AFNOR NFE 48 dryand wet filterability tests.

Chevron

marine lubricants

Meropa®

Description

Meropa® lubricants are premium-quality gear lubricants that have been specially developed to meet the demanding load-carrying requirements of gear manufacturers. Meropa lubricants are manufactured from high-quality base oils and have low pour points. They contain an additive combination that enhances oiliness, extreme pressure, and anti-wear properties. Meropa lubricants have a high oxidation, thermal, and hydrolytic stability, good water-separating characteristics, good air release and anti-foam properties, which helps to protect against metal corrosion and rusting.

Typical Characteristics

ISO Viscosity Grade	68	100	150	220	320	460	680
MPID	219506	219510	219515	219522	219532	219546	219568
Kinematic Viscosity at 40°C, mm²/s	68.0	100.0	150.0	220.0	320.0	460.0	680.0
Kinematic Viscosity at 100°C, mm²/s	8.8	11.4	14.9	19.2	24.3	30.0	36.5
Viscosity Index	100	100	100	100	100	100	95
Flash Point, °C	200	200	215	215	215	215	240
Pour point, °C	–15	–15	–15	–15	–15	–15	–10
Density, 15°C, Kg/l	0.88	0.88	0.89	0.89	0.90	0.90	0.90
FZG load stage, A/8.3/90	>12	>12	>12	>12	>12	>12	>12

Recommended Applications

Meropa lubricants are recommended for a wide variety of industrial and mobile equipment. Typical applications include enclosed gear systems, chain drives, sprockets, plain and anti-friction bearings, slide guides, and flexible couplings. They are particularly recommended for enclosed gear drives and speed reducers, ranging from fractional kilowatt gear motors tolarge, high power units on metal rolling mills, cement mills, and mine hoists.

Meropa lubricants are also suitable for industrial hypoid-type gears and are also recommended for use in transmission gear cases and worm drive axles on automotive, construction and mining equipment. Additionally, they are suitable for bath, splash and circulation applications. Other specific applications for Meropa are in marine gearing such as main propulsion, centrifuges, and deck machinery including winches, windlasses, cranes, turning gears, pumps, elevators and rudder carriers.

Meropa Is Approved For:

- ☑ **GROB**
- ☑ **SMS Group** SN 180-2 (ISO 100, 150, 220, 320, 460, 680)
- ☑ **ZF** TE ML 04H (ISO 100/150)
- ☑ **ZF** TE ML 04F (ISO 220)
- ☑ **SEW Eurodrive** (planetary gear ISO 150, 220, 320, 460 & 680)
- ☑ **Tanktek** (towing system ISO 220)
- ☑ **Börger Pumps** (ISO 68, 220)
- ☑ **Bremivi** (planetary gear ISO 150, 220 & 320)
- ☑ **VHI** (deck machinery ISO 150)
- ☑ **Mariner** (deck machinery ISO 150)

Meropa Meets The Requirements Of:

- **DIN** 51517/3 CLP (ISO 68, 100, 220, 320, 680)
- **US Steel** 224 (ISO 68, 100, 220, 320, 460, 680)
- **AGMA** 9005-E02-EP (ISO 68)
- **AGMA** 9005-E02-R&O (ISO 100, 220, 320, 460, 680)
- **Fives Cincinnati** P-63 (ISO 460), P-59 (ISO 320), P-63 (ISO 68), P-76 (ISO 100), P-74 (ISO 220), P-77 (ISO 150)
- **ISO** 12925-1 CKC/CKD (ISO 68, 100, 220, 320, 460, 680)
- **Zollern** (rope winch ISO 220)
- **Rehfuss** (ISO 100, 220 & 460)
- **Bremivi** (winches ISO 150)
- **ATEK** (bevel gear ISO 68, 100, 150, 220, 320, 460 & 680)
- **Graessner MS** (gear ISO 60, 100, 150 & 220)

Meropa Is Suitable For Use In:

- **Thrusters and propulsion systems** ABB Azipod, Brunvoll, Kawasaki, KTE, Schottel, SKF Blohm & Voss, Thrustmaster, Wartsila Cedervall, Wartsila UK
- **Centrifuges** Alfa Laval, Mitsubishi Kakoki, Samgong, Gea Westfalia
- **Various cranes** ACTA, BLM, Danish Crane, DMC, MHI, Sekigahara, TTS, Wuhan, Zhenjiang Marine
- **Davits and winches** A-Tech, Brohl, Davit International, DMC, Fukushima, Hatecke, Hatlapa, IHI, Kawasaki, TTS, MHI,Ned Deck Marine, Samgong, Schat-Harding, Shin Myung, Zhenjiang Marine, Zollern, Rolls-Royce Marine (RRM)

Performance Benefits

1. Load-Carrying Capacity
Offers extremely high load-carrying capacity, has good anti-wear properties, and cushions shock loads.

2. Thermal and Oxidation Stability
Intends to keep sludge formation and frequent cleaning in circulation systems to a minimum, thus often reducing expensive downtime. Recommended for continuous service for temperatures between 120–130°C.

3. Hydrolytic Stability
Aims to prevent sludge formation when in contact with water and retains compounding level for prolonged periods of time even in the presence of water.

4. Water Separation
Assures speedy separation of water in circulating systems.

5. Non-Foaming Characteristics
Readily dissipates foam under the most unfavorable conditions, such as violent agitation in the gear case.

6. Air Release Properties
Promotes fast release of entrained air bubbles which maybe formed by frequently rotating gear components.

7. Rust Preventing Properties
Helps to prevent the rusting of gears and bearings in thepresence of water.

8. Non-Corrosive to Copper and Copper Alloys
Aims to minimize wear-rates of copper alloys used in worm gears and bearings.

marine lubricants

Meropa® EliteSyn WS

Description

Meropa® EliteSyn WS is a synthetic industrial gear lubricant range showing superior performance under demanding operating conditions. It is based on water soluble polyalkylene glycols, thus providing great micro-pitting and EP performance. Furthermore, the product shows good thermal stability and corrosion protection.

Typical Characteristics

ISO Viscosity Grade	150	220	460	680
MPID	**219421**	**219414**	**219423**	**219424**
Kinematic Viscosity at 40°C, mm^2/s	159.0	230.0	470.0	690.0
Kinematic Viscosity at 100°C, mm^2/s	30.0	42.0	79.0	114.0
Viscosity Index	230	235	252	263
Flash Point, COC °C	>290	>290	>290	>290
Pour point, °C	–42	–42	–36	–36
Density, 15°C, Kg/l	1.05	1.06	1.07	1.07
FE8 bearing roller wear, <30 mg	Pass	Pass	Pass	Pass
FZG load stage, A/8.3/90	>14	>14	>14	>14
FZG micro-pitting, 90°C damage load stage	>10 High	>10 High	>10 High	>10 High

Recommended Applications

Meropa EliteSyn WS is an industrial gear oil range applicable with the following different gear designs: helical, bevel helical,planetary and worm gears, and marine gear units. The product is also suitable for the use of different applications, like: fill for life — disposable gearboxes, textile lubricants, chain and conveyor lubricants, kiln and oven lubricants, sliding bearings and roller bearings in high load/EP applications.

Meropa EliteSyn WS Is Approved For:

- ☑ **Flender** BA T 7300 A+B (revision 16)

Meropa EliteSyn WS Meets The Requirements Of:

- ☑ **DIN** 51517 part 3
- ☑ **David Brown** Type G lubricants
- ☑ **ISO 12925-1** CKPG

Meropa EliteSyn WS Is Suitable For Use In:

- ☑ **Macgregor-Cargotec** deck cranes
- ☑ **Smag-Peiner** crane grabs

Performance Benefits

1. Protects Under Harsh Conditions

Formulated to provide reliable micro-pitting resistanceand component protection under demanding conditions.

2. Offers Component Protection

Designed to offer robust EP performance, which aims toimprove component protection and system uptime.

3. High Thermal Stability

High thermal stability helps improve oil service life andmaintenance intervals, often reducing downtime.

4. Offers Oxidation Protection

Reliable oxidation resistance often offers optimum keep-clean system protection.

5. System Reliability

Low sludge and deposit formation helps maintain systemreliability.

6. Corrosion Protection

Good corrosion protection assists in keeping maintenancecosts down.

PRODUCT MAINTENANCE AND HANDLING

Compatibility With Metals

There is a incompatibility between PAGs and Al due to the high polarity of Polyglycol with regard to lubricated "tribo components" (friction partners steel to Al material) like bearing cages or worm gear drives and therefore the combination is not advised.

But Al-gearboxes — which have no bearing or sliding surfaces in direct contact with a steel shaft — are uncritical and can therefore be used with Meropa® EliteSyn WS.

The product is not miscible with mineral oils and should preferably not be mixed with other polyglycol based lubricants, in order to preserve the premium properties ofMeropa EliteSyn WS.

Mixing Meropa EliteSyn WS and other PAG-based gear oils could result in a change in appearance. Please note that possible haziness has no influence on the performance ofMeropa EliteSyn WS.

Meropa EliteSyn WS does not affect common seal and gasket materials. The use of Nitrile Rubber (NBR), Fluoro- Silicone or Vinyl-Methyl Polysiloxane (Q) is recommendedfor high temperature applications.

The product is not compatible with polyurethane-based elastomers, leather, cork, asbestos, paper and board.

It is recommended to use Meropa EliteSyn WS in gearboxes where the internal surface is unpainted or coated with resistant materials, for example a resistant two-pack epoxy formulation.

Service Considerations

Unlike mineral oil based lubricants which break down and form deposits at high temperatures, the polyalkyene glycol (“PAG”) base fluid of Meropa EliteSyn WS tends to decompose to fluid components or volatile products, retaining its lubricating properties as long as any fluid film remains. The mixed polyalkylene glycol moleculesin Meropa EliteSyn WS are also polar in nature, providing a solvent action on polar oxidation compounds which minimizes separation of insoluble sludges and deposits, helping to keep the lubrication system and machine surfaces clean.

PAGs are hygroscopic in nature, and under normal operating conditions Meropa EliteSyn WS can be expected to contain about 2000 ppm of water. Importantly, this is not free water, which can lead to loss of lubricating oil film and corrosion. With Meropa EliteSyn WS, by contrast, absorbed water is hydrogen-bonded to the PAG moleculesand does not interfere with oil film retention.

marine lubricants

FLUSH PROCEDURE

Warning: These products must never be mixed with mineral oil or PAO-based products.

The following procedure should be adhered to when changing from mineral oil or other type PAG based gear lubricant to Meropa EliteSyn WS:

Let the system run until the oil in service is warm. Drain as much as possible and pay attention to reservoirs, lines,etc., where oil may be trapped. Clean the system from residual sludge.

Flush the system with a minimum quantity of Meropa EliteSyn WS by operating under no load and drain the system while the fluid is warm. Repeat if necessary.

Seals that have been exposed to other oils may shrink when they are exposed to Meropa EliteSyn WS. Therefore,they should always be inspected. Often, careful inspectionof the system for leaks can be sufficient, but it may be advantageous to replace the seals.

In case seals are deteriorated, they must be replaced.

It is recommended to inspect the lubricant after one or two days in use to make sure that it is free of extraneous materials. Contamination with significant quantities of other lubricants can, in some cases, lead to sludge formation, foaming and other problems.

Our Family of Brands

marine lubricants

Meropa® MG

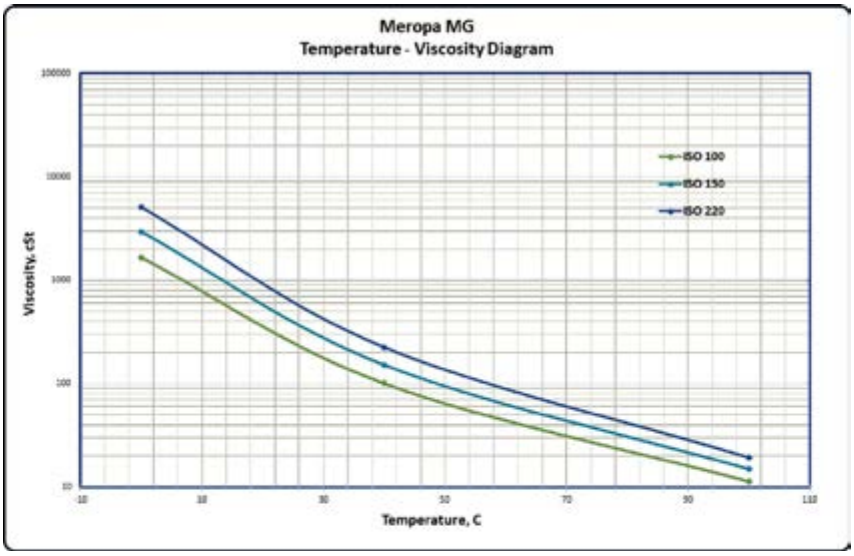
Description

Meropa® MG gear oils are premium high-performance gear oils, offering long lubricant life, corrosion protection, good wear protection with high load carr ying capacity and robust micro-pitting wear protection. They are designed for use in industrialand marine clutched gear systems, where extreme load and shock load protection is required.

Typical Characteristics

ISO Grade	100	150	220
MPID	**219493**	**219494**	**219495**
AGMA Grade	3EP	4EP	5EP
Density at 15°C, kg/l (ASTM D4052)	0.89	0.90	0.90
Viscosity, Kinematic at 40°C	100.0	150.0	220.0
Viscosity, Kinematic at 100°C	11.3	14.8	19.0
Viscosity Index	99	98	97
Flash Point, °C	234	254	268
Pour Point, °C	–24	–25	–26
Foam Properties Sequence I-III, D892			
Tendency, mL	<50	<50	<50
Stability, mL	0	0	0
Copper Corrosion, D130 (3 hr at 100°C)	1B	1B	1B
Rust Test, D665B	PASS	PASS	PASS
FAG FE-8 (D7.5-80/80-80), DIN 51819-3 Roller Weight Loss, (mg)	1.0	1.0	1.0
FZG Pass Stage, ASTM D5182	>12	>13	>12
FZG Micro-pitting, FVA 54, failure load stage	10/High	10/High	10/High

Minor variations in product typical test data are to be expected in normal manufacturing.
Meropa MG gear oils have the typical sulfur-phosphorus odor characteristic of industrial gear oils. A ventilated environment is recommended during use.



Recommended Applications

Meropa® MG gear oils are designed to ensure optimal performance in RENK and Flender/Siemens clutched gear boxes extensively used in marine vessels. The advanced formulation is balanced to provide extreme pressure protection, while providing protection against yellow metal corrosion. The robust chemistry is compatible with multiple types of sealant and paint coatings and helps to minimize the possibility of leaking seals and paint blistering on the inside of the gearbox. Competitive products with over-aggressive chemistries may attack the paint coatings and cause filter plugging.

Meropa MG Is Approved For:

- ☑ **Ortlinghaus** clutch test
- ☑ **RENK Augsburg**
- ☑ **RENK Rheine**
- ☑ **Flender**
- ☑ **Reintjes**
- ☑ **Brunvoll**

Meropa MG Meets The Requirements Of:

- ☑ **AGMA** 9005-F16 AS
- ☑ **DIN** 51517-3 (CLP)
- ☑ **ISO 6743-6 CKC** ISO-L-CKC
- ☑ **ISO 12925-1** CKC/D
- ☑ **Fives Cincinnati** ISO 100–220
- ☑ **US Steel** 224
- ☑ **Zollern** (rope winch ISO 220)
- ☑ **Bremivi** (winch ISO 220)

Meropa MG Is Suitable For Use In:

- ☑ Marine vessels using clutched gear boxes
- ☑ Industrial enclosed gearing where an AGMA EP lubricant is specified
- ☑ Industrial enclosed gearing where DIN 51517 (CLP) lubricant is specified
- ☑ Bath, splash, circulating, or spray mist lubrication as applicable to the proper viscosity grade
- ☑ Marine gearboxes requiring an extreme pressure lubricant

Performance Benefits

1. Provides Thermal And Oxidative Stability

The thermal and oxidative stability of Meropa MG minimizes deposit formation and can extend bearing and gear life. Good resistance to oil degradation at high temperatures, resulting in extended oil life and long drainintervals.

2. Rust And Corrosion Protection

Meropa MG offers rust and corrosion protection over longservice periods.

3. Extended Gear And Bearing Life

Particularly effective in enclosed gear drives operating under extreme load, speed, and temperature conditions.

4. Less Wear

Ensures optimum wear protection with reduced maintenance and increased system uptime.

5. Provides micro-pitting resistance

Delivers reliable micro-pitting and wear protection with reduced maintenance and increased system uptime.

6. Keeps Components Clean

The advanced additive technology helps to prevent varnish and sludge and keeps the components clean. Clean components can contribute to long lubricant and equipment life.

7. Water Separation

Good demulsibility and corrosion protection for trouble-free operation in applications where water contaminationis unavoidable.

Meropa® Synthetic EP 150

Regional equivalent: Pinnacle® EP 150

Description

Meropa® Synthetic EP 150 is a premium performance, synthetic EP gear oil and circulating oil designed for use in a wide range of industrial equipment operating under severe conditions, such as heavy and/or shock loading and elevated temperatures, where short service life with conventional lubricants can be expected. It is formulated with a combination of poly-alpha- olefin and synthetic ester base fluids as well as selected additives to provide good EP performance and wear protection, increased thermal/oxidation stability and protection against corrosion and rust.

Typical Characteristics

MPID	219826
Kinematic Viscosity at 40°C, mm²/s	150.0
Kinematic Viscosity at 100°C, mm²/s	18.8
Viscosity Index	150
Flash Point, COC,°C	244
Pour point, °C	-48
Density at 15°C, Kg/l	0.85
FZG Damaged Load, A/16.6/90	>12
FZG Damaged Load, A/8.3/90	>12

Meropa Synthetic EP 150 Is Approved For:

- ☑ **GROB**
- ☑ **ZF** TE-ML 04H

Meropa Synthetic EP 150 Meets The Requirements Of:

- ☑ **ANSI/AGMA** Standard 9005-EO2-EP
- ☑ **DIN** 51517-3 (CLP)
- ☑ **US Steel** Specification No. 224
- ☑ **Fives Cincinnati** P-77
- ☑ **Bremivi** planetary gear & winch

Meropa Synthetic EP 150 Is Suitable For Use In:

- ☑ All types of gear systems in mobile and stationary industrial equipment where an EP lubricant is specified, including spur, bevel and worm gears.
- ☑ Plain and anti-friction bearings subjected to heavy-duty operating conditions.
- ☑ Circulating oil systems where an EP lubricant is required.
- ☑ Outdoor machinery exposed to wide ambient temperature conditions, such as crane, hoist and winch gearboxes.
- ☑ Speed reducers, chain drives, sprockets and flexible couplings.
- ☑ Bath, splash, circulating and spray lubrication systems.

Performance Benefits

1. Minimizes Unscheduled Maintenance

Good thermal and oxidation stability provides resistance to deposit formation, maintaining a cleaner gear/ circulating oil system.

2. Extends Equipment Life in Severe Service

Special EP additive helps provide protection against wear of bearing and gear surfaces during heavy-duty operation. Effective rust and corrosion inhibitors helps with protecting majority of system components.

3. Trouble-Free Operation

Good air and water separation characteristics reduce the risk of surface wear caused by loss of lubricating oil film. Compatibility with all conventional seal materials and mineral-type circulating oils helps to eliminate operationalproblems if changing oil types.

4. Long Lubricant Life

Improved thermal and oxidation stability assists with providing longer service life under adverse conditions than is possible with conventional mineral oils.

marine lubricants

Meropa® Synthetic WM 320

Description

Meropa® Synthetic WM 320 is formulated with synthetic hydrocarbons and a reliable sulphur-phosphorus Extreme Pressure additive package which is designed to minimize wear of enclosed industrial gears operated under heavy loads and shock conditions. It provides good foam resistance and water separating characteristics which make it ideal for circulating systems with incidental water contamination. The non-corrosive formula aims to protect gear and bear materials such as steel, copper, bronze, babbitt or cadmium-nickel. Meropa Synthetic WM 320 has good oxidative and thermal stability for long service life. The naturally high VI and low pour point provide improved performance and lower viscous drag losses at low operating temperatures compared to conventional industrial gear oils. It has been specially designed to provide high micro-pitting protection.

Typical Characteristics

MPID	219956
Kinematic Viscosity at 40°C, mm^2/s	320.0
Kinematic Viscosity at 100°C, mm^2/s	35.4
Viscosity Index	156
Flash Point, °C	240
Pour point, °C (ASTM D97)	–48
Density, 15°C, Kg/l	0.85
FZG Damaged Load, A/8.3/90	>12

Recommended Applications

Meropa Synthetic WM 320 is Chevron's primary recommendation for the lubrication of industrial gear systems. Meropa Synthetic WM 320 is recommended for the lubrication of heavily loaded enclosed industrial gear drives and reducers, spur, bevel, helical, worm and industrial hypoid gear cases, open pit and underground mining equipment, cement mills, ball mills, rolling mills, crushers, shakers, hoists, conveyors, kilns, winches, machine tools, skip lines and marine equipment. Meropa Synthetic WM 320 is successfully used for wind turbine applications.

Meropa Synthetic WM 320 Is Approved For:

- ☑ **Moventas** Wind Turbine Gearboxes

Meropa Synthetic WM 320 Meets The Requirements Of:

- ☑ **ANSI/AGMA** Standard 9005-EO2-EP
- ☑ **US Steel** Specification No. 224
- ☑ **DIN** 51517/3 CLP

Performance Benefits

1. Minimizes Wear
Extreme pressure properties to minimize wear.

2. Long Service Life
Oxidative and thermal stability promote long service life.

3. Rust and Corrosion Protection
Helps to protect against rust and corrosion.

4. High and Low Operating Temperature
Wide ambient operating temperature range due to thehigh VI and low pour point.

5. Good Demulsibility
Good demulsibility for rapid water separation.

6. Foam Resistant
Has foam resistant qualities.

7. Micro-Pitting Protection
High micro-pitting protection.

Meropa® WG 460

Regional equivalent: Cylinder Oil W 460

Description

Meropa® WG 460 is a proven performance, high viscosity industrial gear and steam cylinder oil, with low carbon residue, compounded with selected fatty oils and combined with rust and foam inhibitors. It is formulated for steam cylinder and valve lubrication, where the steam is wet or of poor quality.

Typical Characteristics

MPID	219548
Kinematic Viscosity at 40°C, mm^2/s	439.0
Kinematic Viscosity at 100°C, mm^2/s	30.0
Viscosity Index	97
Flash Point, °C	284
Pour point, °C (ASTM D97)	–9

Recommended Applications

Meropa WG 460 is recommended for use on heavily loaded industrial worm gear sets, low speed heavily loaded spur and helical gears, low speed or high temperature bearings and steam cylinder and valve lubrication where the seam is wet or of poor quality (see service consideration below).

Meropa WG 460 Is Approved For:

- ☑ **Certified/licensed by NSF** as lubricants where there is no possibility of food contact (H2) in and around food processing areas (applicable for Europe, plus theregional equivalent Cylinder Oil WG 460)

Meropa WG 460 Meets The Requirements Of:

- ☑ **ANSI/AGMA** Standard 9005-EO2-CP (in Europe, plus the regional equivalent Cylinder Oil WG 460)

Meropa WG 460 Is Suitable For Use In:

- ☑ **Ariel and other types of gas compressors** cylinder lubrication

marine lubricants

Performance Benefits

1. Helps to Promote Gear Longevity
High oil film strength and viscosity offers protection against worm gear, steam cylinder and valve surface wear, rust and corrosion.

2. Robust Protection Over Surfaces
Reliable steam and condensate separation and good atomization properties helps to ensure oil offers robust protection over surfaces.

3. Smooth Lubricant Delivery
Dependable anti-foam performance promotes smooth lubricant delivery to vulnerable working surfaces.

4. Good Oxidation Stability
Good oxidation and thermal stability helps resist oil breakdown and promotes improved performance with extended oil service life.

Our Family of Brands

Pinnacle® Marine Gear 220

Description

Pinnacle® Marine Gear 220 is a fully formulated, quality synthetic gear lubricant based on a mixture of polyalphaolefins anddiesters. It offers oxidation stability at elevated temperatures, extended oil drain life and good wear protection.

Typical Characteristics

MPID	219401
Kinematic Viscosity at 40°C, mm^2/s	220.0
Kinematic Viscosity at 100°C, mm^2/s	22.7
Viscosity Index	115
Flash Point, °C	250
Pour point, °C (ASTM D97)	-45
Density, 15°C, Kg/l	0.89
FZG failure load stage, A/8.3/90	>12
FZG grey staining test, failure load stage	>10

Recommended Applications

Pinnacle Marine Gear 220 is recommended not only for lubricating plain and roller bearings, but also open and closed gears at high temperatures. It can be applied by bath, splash or circulation systems, and is specially targeted for the lubrication ofpurifier gears and reduction gears.

Pinnacle Marine Gear 220 Is Approved For:

- ☑ **Börger Pumps**

Pinnacle Marine Gear 220 Meets The Requirements Of:

- ☑ **Various types of reduction gears** Rolls-Royce Marine, Lohman-Stolterfoht Zollern Rope Winch, Ateck Bevel Gear, Kongsberg Winches
- ☑ **Elevators** Ushio, Hyundai Elevator

Pinnacle Marine Gear 220 Is Suitable For Use In:

- ☑ **Centrifuges** Alfa Laval, Westflia, Mitsubishi Kakoki
- ☑ **Inert gas blowers** Robushi, Aalborg, Air products
- ☑ **Several deck applications** where mineral gear oils cannot be used because of too high/low operating temperatures,or if extended drain intervals are required

Performance Benefits

1. Thermal and Oxidation Stability

Synthetic hydrocarbon base oils help to provide oxidationand thermal stability.

2. Bearing and Gear Protection

Bearing and gear protection combined with good copper compatibility at elevated temperatures were shown in the FZG test. Helps to protect against the formation of micro-pitting as a result of fatigue stress, as tested in the FZG grey staining test.

3. Compatibility

Compatible with most mineral oil-based EP and R&O gear lubricants, as well as with most PAO-based synthetic EP and R&O gear lubricants.

4. Low Friction

Unique low friction coefficient promotes improved gear efficiency, energy savings, less friction, less wear, and lower operating temperatures compared to conventional mineral oils.

5. Extended Drain Intervals

Aims to provide longer lubricant life, less maintenance costs, and less used oil disposal.

marine lubricants

Capella® A 68

Description

Capella® A is a premium synthetic compressor oil specifically designed for the lubrication of ammonia refrigeration compressors operating at high discharge temperatures in systems with extremely low evaporator temperatures. Capella® Ais formulated from specially synthesized polyalphaolefin (PAO) base fluids.

Typical Characteristics

ISO Viscosity Grade	**68**
MPID	**219415**
Density 15°C, kg/l	0.83
Flash Point, °C	260
Pour Point, °C	–57
Viscosity, kinematic	
mm^2/s @ 40°C	68.7
mm^2/s @ 100°C	10.6
Viscosity Index	143
Acid No., mg KOH/g	0.01

Recommended Applications

Lubrication of compressors in refrigeration and air-conditioning systems filled with ammonia, especially where the minimum evaporator temperatures are down to –60°C. The product is particularly suited for reciprocating and screw ammonia compressors operating at discharge temperatures exceeding 100°C.

Capella A 68 Is Approved For:

- **ABB Stal Refrigeration AB**
- **Sabroe**
- **Broedrene Gram**

Capella A 68 Meets The Requirements Of:

- **DIN** 51503
- **British Standard** 2626/1992

Performance Benefits

1. Efficient, Trouble-free Operation

Extremely low pour point and freon floc point (below –50°C) help enable fluidity without wax or deposit formation at very low minimum evaporator temperature, even with low solvency of the lubricating oil in the refrigerant. This further contributes to evaporator efficiency and cleanliness of the flow lines.

Synthetic polyalphaolefin base fluid provides a very low pour point (–57°C) and less oil thickening even at extremely low temperatures. This helps make the product suitable for operation at the very low evaporator temperatures typical in modern ammonia refrigeration systems, where in addition the solvency of the lubricating oil in the refrigerant is very low. Further, the low oil volatility of the synthetic polyalphaolefin base fluid reduces oil consumption and limits the amount of lubricant carry-over to the evaporator, which results in increased heat transfer efficiency. Additive free formulation prevents production of sludge caused by ammonia soap formation.

Low moisture content helps prevent icing in refrigeration expansion valves and deliver maximum corrosion protection.

2. Minimum Downtime

Synthetic polyalphaolefin base fluid provides excellent thermal and chemical stability in the presence of ammonia, avoiding the formation of gum, varnish and sludge deposits.

3. Lower Maintenance Costs

Ultra high viscosity index of synthetic polyalphaolefin base fluid helps provide highest oil viscosity at elevated operating temperatures and maintain fluid film strength for greatest protection against compressor wear.

4. Easier Cold Start-up

Ultra high viscosity index of synthetic polyalphaolefin base fluid helps provide lower viscosity at cold temperatures, reducing cold start-up power requirements.

marine lubricants

Capella® HFC

Description

Capella® HFC is a premium-grade, fully synthetic oil for the lubrication of compressors used in refrigeration and air conditioning systems. Capella HFC is blended exclusively with specially selected polyolesters. It has a high viscosity index ensuring a good lubricity over a wide temperature range.

Typical Characteristics

	Capella HFC 32	Capella HFC 55	Capella HFC 100
ISO Viscosity Grade	**32**	**46/68**	**100**
MPID	**219405**	**219411**	**219404**
Density 15°C, kg/l	1.00	1.01	0.97
Flash Point, COC, °C	>240	>270	>260
Pour Point, °C	-57	–51	-30
Viscosity, kinematic			
mm^2/s @ 40°C	32.0	53.0	100.0
mm^2/s @ 100°C	5.7	8.4	11.4
Viscosity Index	119	132	100
Acid No., mg KOH/g	0.03	0.03	0.03

Recommended Applications

Capella HFC lubricants have been developed in cooperation with major refrigerant compressor manufacturers worldwide, specifically for use with chlorine-free hydrofluorocarbon (HFC) refrigerants, such as R134a, R404a, R410a or R507, etc. The product series are especially suited for the first-fill and retrofit lubrication of refrigeration compressors in provision andindustrial refrigeration plants, as well as in air-conditioning systems and heat pump equipment.

Capella HFC grades are not recommended for use in ammonia refrigerating systems, where Capella WF or Capella A are recommended instead.

Note: Capella HFC lubricants readily absorb moisture from the ambient air, which can cause system performance problems.Capella HFC packages should be kept sealed until time of use and should not be reused once opened.

Capella HFC Meets The Requirements Of:

- ☑ **DIN** 51503-1 Groups KC, KD, KE

Capella HFC Is Recommended For Use In:

- ☑ **Bitzer**
- ☑ **Bock**
- ☑ **Dorin**
- ☑ **GEA**
- ☑ **Grasso**
- ☑ **Sabro**
- ☑ **ABB Stal Refrigeration AB**
- ☑ **Sulzer**
- ☑ **Ushio Reinetsu**
- ☑ **Carrier**
- ☑ **York**

Performance Benefits

1. Efficient, Trouble-free Operation

Exhibits excellent oil-refrigerant miscibility properties with HFC-refrigerants over a wide range of operating temperatures, which helps ensure adequate lubrication of the compressor bearings and to facilitate oil return from the refrigeration system.

2. Minimum Downtime

Provides excellent thermal and chemical stability in the presence of hydrofluorocarbon (HFC) refrigerants. Demonstrated excellent compressor cleanliness with absence of any copper transfer in numerous compressor tests.

3. Lower Maintenance Costs

High resistance to oxidation, even at high operating temperatures, which helps guarantee a long service life. Provides excellent lubricity, even in the presence of refrigerants.

marine lubricants

Capella® Low Temp AB 68

Formerly known as Refrigeration Oil Low Temp

Description

Capella® Low Temp AB is a synthetic refrigeration compressor oil based on alkylbenzene components of the branched type. The product is recommended for use with ammonia (R717) and systems using older chlorofluoro- and hydrochlorofluorocarbon (CFCs & HCFCs — freon) refrigerants. It is suitable for a wide temperature range, including installations with very low evaporating temperatures, where mineral based products do not perform adequately.

Typical Characteristics

ISO Viscosity Grade	**68**
MPID	**219828**
Density 15°C, kg/l	0.87
Flash Point, °C	190
Pour Point, °C	42
Viscosity, kinematic	
mm^2/s @ 40°C	68.0
Floc point (R50), °C	58
Floc point (R12), °C	<–73

Recommended Applications

Capella Low Temp AB can be applied in screw and piston compressors in refrigeration and air-conditioning systems filled with ammonia (R717) and systems using older CFC (chlorofluorocarbon, such as R12 and R502) and HCFC (hydrochlorofluorocarbon, such as R22) refrigerants.

Capella Low Temp AB is particularly recommended in case of high compressor discharge temperatures and/or very low evaporator temperatures — temperatures below –35°C with R22, –25°C for R502.

For systems containing hydrofluorocarbon (HFC) refrigerants such as R134a, R404a, R507, etc., Capella HFC is recommended instead.

Capella Low Temp AB Is Approved For:

- ☑ **Bock** R22 (CFC) and R717 (ammonia)
- ☑ **Howden Compressors** R717 (ammonia)
- ☑ **Mycom (Mayekawa)** R717 (ammonia)
- ☑ **Sabroe** R717 (ammonia)

Capella Low Temp AB Is Suitable For Use In:

- ☑ **Bitzer***
- ☑ **Carrier***
- ☑ **Thermoking***
- ☑ **Dorin*, Danfoss*** Tamrotor Marine Compressor
- ☑ **Necchi/ERC***

* approved under former name Refrigeration Oil Low Temp 68

Performance Benefits

1. Wide operating temperature window

Compared to mineral based refrigerating oils Capella Low Temp AB deploys higher thermal stability and lower volatility, which makes the product the better choice in case of high compressor discharge temperatures. At the same time, the low pour point and very low floc points enable lower minimum evaporator temperature over mineral based refrigerants.

2. Extended lifetime and lower maintenance cost

The thermal stability and lower volatility over mineral based refrigerating oils result in longer service life and reduced lubricant carry-over to the evaporator, where the higher solvency promotes improved system cleanliness. The formulation is free of additives which prevents the production of sludge caused by ammonia soap formation, critical for ammonia refrigeration systems.

3. Optimum lubrication

The product is miscible with CFC and HCFC refrigerants and maintains lubricity. It is formulated to protect cast ironand remains stable in the presence of CFC and HCFC as well as with ammonia.

Capella® WF 32, 68

Description

Capella® WF is a high-quality essentially wax-free oil for the lubrication of compressors used in refrigeration and air-conditioning systems. The product series are recommended for use with ammonia, carbon dioxide and halogenated refrigerants.

Capella WF is manufactured from naphthenic base oils selected to meet refrigeration compressor manufacturers' requirements. The product series offers particularly good low temperature properties and high stability, minimizing varnishand sludge formation over extended operating periods.

Capella WF is dehydrated and packaged to resist moisture.

Typical Characteristics

ISO Viscosity Grade	32	68
MPID	**219356**	**219354**
Density 15°C, kg/l	0.91	0.91
Flash Point, °C	168	179
Pour Point, °C	–39	–33
Viscosity, kinematic		
mm^2/s @ 40°C	30.0	64.0
mm^2/s @ 100°C	4.4	6.5
Viscosity Index	6	13
Acid No., mg KOH/g	0.03	0.03
Floc point, °C	–50	–50

Recommended Applications

Refrigeration compressor oil recommended for use with ammonia, carbon dioxide and chlorofluoro- and hydrochlorofluoro carbons (CFCs & HCFCs —freon) as well as sulfur dioxide and ethylene chloride refrigerants.

Capella WF product series delivers very low freon floc and pour point performance and offers chemically stable performance in presence of ammonia and fluorinated hydrocarbons. For this they make an excellent choice for ammonia systems with the minimum evaporator temperature as low as –50°C (provided evaporator hot flush capability), and fluorinated hydrocarbon refrigerants with minimum evaporator temperatures of –45°C (R12), –35°C (R22) and –25°C (R502) respectively.

For ammonia systems with minimum evaporator temperatures of –60°C, Capella A is recommended.

For systems containing hydrofluoro carbon (HFC) refrigerants such as R134a, R404a, R507, etc., Capella HFC is recommended.

marine lubricants

Capella WF Meets The Requirements Of:

- **DIN** 51503
- **British Standard** BS 2626:1992 type A

Capella WF Is Recommended For Use In:

- **Bitzer**
- **Bock**
- **Carrier**
- **DWM Copeland Dorin**
- **Broedrene GramGrasso**
- **Heinrich Huppman**
- **J & E Hall**
- **Kelvinator**
- **Linde**
- **Matsushita**
- **Mc Quay**
- **Mycom** NH3 – screw & piston
- **Robert BoschSabroe**
- **ABB Stal Refrigeration ABSullair**
- **Sulzer Tecumsec**
- **Trane**
- **York**

Performance Benefits

1. Efficient, Trouble-free Operation

Extremely low pour point and freon floc point (below –50°C) enable fluidity without wax or deposit formation at very low minimum evaporator temperature, even with low solvency of the lubricating oil in the refrigerant. This further contributes to evaporator efficiency and cleanliness of the flow lines.

Low moisture content helps prevent icing in refrigeration expansion valves and delivers maximum corrosion protection.

2.Minimum Downtime

Robust thermal and oxidation stability protect against in- service oil thickening and minimize formation of harmful gum, varnish and sludge in the system, helping to ensure extended drain intervals.

3.Lower Maintenance Costs

Reliable lubricity helps protect against vulnerable component wear, reducing maintenance downtime and costs. The product is further compatible with a wide range of refrigerants, helping reduce inventories and potential misapplications.

Our Family of Brands

Cetus® DE 100

Description

Cetus® DE 100 is a premium performance, synthetic compressor oil based on diester technology. This offers outstanding thermal and oxidative stability with an effective oil film to protect loaded parts against corrosion and wear, even in case of high discharge temperatures and pressures. This advanced formulation also offers good low temperature performance and energy saving properties.

Typical Characteristics

ISO Viscosity Grade	**100**
MPID	**219400**
Density 15°C, kg/l	0.96
Flash Point, °C	252
Pour Point, °C	-39
Viscosity, kinematic	
mm^2/s @ 40°C	96.0
mm^2/s @ 100°C	10.1
Viscosity Index	92

Recommended Applications

Cetus DE 100 is recommended for stationary and portable reciprocating compressors, as well as for rotary screw and rotary vane compressors. The product is also suitable for the lubrication of anti-friction bearing assemblies operating under high temperature conditions (e.g. fans, blowers & process pumps). Cetus DE 100 can be used in compressors with the following gases: process air, benzene, butadiene, carbon dioxide (dry), carbon monoxide, ethylene, furnace (crack) gas, helium, hydrocarbon gases, hydrogen, inert gases, methane, natural gas, nitrogen, propane, sulphur hexafluoride and synthesis gas.

Cetus DE 100 can be used in contact with the following seals, paints and plastics: Viton®, High nitrile Buna N®, Teflon®, epoxy paint, oil-resistant alkyd, nylon, Delrin®, Celcon®. Cetus DE 100 is compatible with conventional non-detergent petroleum oils, although mixing will reduce the performance of the product.

The product should not be used with: neoprene, SBR rubber, low nitrile Buna N®, acrylic paint, lacquer, polystyrene, PVC, ABS and galvanized components. Cetus DE 100 is not recommended for use in breathing air compressors.

Cetus DE 100 Is Approved For:

- ☑ **Hamworthy**
- ☑ **Matsubara**
- ☑ **Sperre Tanabe**
- ☑ **Yanmar Deno**
- ☑
- ☑

Cetus DE 100 Meets The Requirements Of:

- ☑ **ISO 6743-3** ISO-L-DAB & ISO-L-DAJ

Cetus DE 100 Is Suitable For Use In:

- ☑ **Hatlapa Sauer &**
- ☑ **Sohn**

marine lubricants

Performance Benefits

1. Efficient, Trouble-free Operation

The good oxidation stability of the formulated oil helps to resist oil degradation, even in newer, more efficient compressors with higher output. In addition to the low sludge and varnish and the low carbon deposit formation tendency on the valves and pistons in reciprocating compressors, the high solvency of the product aids to keep the compressor parts clean. This results in minimal compressor maintenance and cleaner discharge lines, filters and air vessels.

2. Long Life

The advanced formulation with higher oil film strength minimizes oil carry over and promotes reduced oil consumption. The advanced thermal and oxidative stability permits oil drain intervals to be extended beyondthose achieved with conventional lubricants.

3. Rust Protection

Effective corrosion inhibition helps to protect against rust caused by moisture entering the system, particularly during shutdown and intermittent operation.

4. Anti-Foam and Air Release Properties

Helps to prevent accumulation of surface foam in the crankcase and promotes adequate lubrication of the compressor components.

5. Increased Safety Margins

High flash and fire points over conventional lubricants in combination with cleaner compressor operation reduces the risk of fire and explosions in discharge systems.

Chevron

marine lubricants

Cetus® PAG

Formerly known as LPG Compressor Oil

Description

Cetus® PAG is a synthetic compressor oil based on polyalkylene glycol. It is designed for use in reciprocating compressors for chemical and hydro-carbon gases, including natural gases such as LNG and LPG. Because the solubility of these gases inCetus PAG is low, the oil maintains its viscosity, unlike mineral oil base lubricants which will dilute.

Typical Characteristics

MPID	219827
Density 15°C, kg/l	1.06
Flash Point, °C	260
Pour Point, °C	–30
Viscosity, kinematic	
mm^2/s @ 40°C	185.0
mm^2/s @ 100°C	35.0
Viscosity Index	238

Recommended Applications

Cetus PAG is recommended for lubrication of the cylinders and/or crankcase bearings of reciprocating compressors for multiple gases, including natural gases such as: methane and ethane; petroleum gases such as propane and butane; hydrocarbon chemical gases such as ethylene, propylene and butylene; and chemical gases such as ammonia, butadiene, vinylchloride and dry inert gases.

Cetus PAG easily mixes with water, therefore contact with humid air should be avoided.

Cetus PAG contains polyalkylene glycols and is not compatible with mineral oil or other synthetic fluids. When changing toor from Cetus PAG, the oil system should be completely drained and thoroughly flushed.

Cetus PAG does not affect common seal and gasket materials such as butyl, nitrile, neoprene, fluoro-elastomers (e.g. Viton)and fluoro-silicones. Ordinary industrial paints soften in the presence of this oil. Two-pack epoxy formulations are normallyresistant.

Cetus PAG Is Approved For:

- ☑ **Howden Compressors**
- ☑ **Linde AG**
- ☑ **Burckhardt Compression AG** K- & Laby type compressors

Cetus PAG Meets The Requirements Of:

- ☑ **EPA** VGP 2013 EAL
- ☑ **Burckhardt** Lubricating Oil Specification (VSB) 1001301

Performance Benefits

1. Low solubility of multiple gases

The solubility of above-mentioned gases is much lower in Cetus PAG than in mineral based lubricants. Therefore, the viscosity drop of the lubricant in service is minimal. Oil film thickness, anti-wear and anti-foam performance of the formulation are maintained, and proper wear protection can be guaranteed, even at low cylinder feed rates.

2. Moisture tolerance

Cetus PAG will easily mix with water, for which the gases should be dry. The product tolerates up to 4%wt water before hazing at 80°C however, and has been evaluated for corrosion resistance with 2.5%wt water content.

3. Extended lubricant life

The robust formulation offers reliable, extended lubricant service life.

4. Reducing inventory

Formulated to resist dimerization of butadiene and to prevent the generation of solid deposits. Switching to mineral based compressor oil is no longer required in this case, which can help to reduce inventory and operational complexity.

Cetus® PAO 46, 68

Description

Cetus® PAO oils are synthetic compressor lubricants formulated with the highest-quality polyalphaolefin PAO base fluid. The PAO base fluid provides thermal and oxidation stability, high viscosity index, low pour point and good hydrolytic stability. Ahigh-performance additive package further enhances these qualities. The products are designed to meet the requirements of compact, high output rotary air compressors where mineral products are not effective any longer and make an ideal choice for large diesel engine turbocharger applications as well.

Typical Characteristics

ISO Viscosity Grade	46	68
MPID	**219403**	**219402**
Density 15°C, kg/l	0.84	0.85
Flash Point, °C	232	240
Pour Point, °C	–46	–47
Viscosity, kinematic		
mm2/s @ 40°C	46.0	68.0
mm2/s @ 100°C	8.1	10.4
Viscosity Index	150	140
Rust test, distilled seawater	Pass	Pass
Copper Corrosion, 3h, 100°C	1b	1b
Air release @ 50 °C, min	6	9

Recommended Applications

Cetus PAO 46 and Cetus PAO 68 have specifically been designed for the lubrication of oil-injected screw and rotary sliding vane air compressors operating at high discharge temperatures (>100°C) and high discharge pressures (>15 bar).

The products are also recommended for application in other types of compressors such as single and multistage reciprocating and centrifugal compressors where ISO VG 46 respectively 68 grades are required, especially in the where continuous high temperature operation is in use with discharge temperatures up to 200°C.

The products are also suitable for applications where a synthetic bearing and circulating oil is needed, such as turbochargers in low and medium speed diesel engines with separate lubricating oil circuit for the bearings. Cetus PAO 68 for example is approved by ABB for VTR turbochargers and fulfils the requirements for a 5,000-hour drain interval and for a low-friction lubricating oil.

Cetus PAO products are not recommended for use in breathing air compressors.

Cetus PAO Products Are Approved For:

- ☑ **Alup Kompressoren**
- ☑ **Donghwa Pneutec**
- ☑ **Nanjing** compressors
- ☑ **Sauer** compressors
- ☑ **Shung Shin**
- ☑ **Tanabe Pneumatic Machinery**
- ☑ **ABB** VTR.4 Turbochargers – 5000 h drain interval (ISO VG 68)
- ☑ **Deno** compressors
- ☑ **GEA Wesfalia** purifier

Cetus PAO Products Meet The Requirements Of:

- **DIN** 51506 VDL
- **Hatlapa**
- **TMC** Tamrotor Marine Compressor
- **Cryostar**

Performance Benefits

1. Good Thermal and Oxidation Stability

The robust oxidation stability promotes high temperature performance and protection, even in case of high output oil flooded screw air compressors. In this type of compressor, the lubricant is not only subject to the high temperatures resulting from the compression but also mixed with air. This promotes oil oxidation, where a standard mineral based lubricant cannot always offer satisfactory drain interval any longer. Cetus PAO continues to offer extended drain potential.

The thermal stability further enables a low carbon deposit formation tendency, maintaining compressor performance and keeping discharge lines and air vessels clean, even under severe operating conditions.

2. Long Machinery Life and Maximum Compressor Efficiency

The high viscosity index and load carrying capacity help to maintain effective lubrication and minimize wear on highly loaded parts, at both low and high operating temperatures. An effective inhibitor system further provides excellent rust and corrosion protection.

3. Anti-Foam and Air Release Properties

The air release properties and very low foam tendency aid performance in oil rotary air compressor and turbocharger applications.

4. Low Evaporation Loss

The low evaporation rate helps to reduce oil carryover and guarantees minimum oil consumption.

Chevron

marine lubricants

Compressor Oil EP VDL 100

Description

Compressor Oil EP VDL 100 is a mineral compressor lubricant, meeting DIN 51506 class VDL specifications and exhibiting high load-carrying capacity and strong aging resistance. Compressor Oil EP VDL 100 is blended from selected high-quality paraffinic base oils, supported with a well-balanced additive package to provide reliable oxidation resistance, corrosion protection and extreme pressure performance.

Typical Characteristics

ISO Viscosity Grade	100
MPID	**219320**
Density 15°C, kg/l	0.89
Flash Point, °C	248
Pour Point, °C	–12
Viscosity, kinematic	
mm^2/s @ 40°C	100.0
mm^2/s @ 100°C	11.3
Viscosity Index	97
Acid No., mgKOH/g	0.1
Rust test, distilled seawater	Pass
Copper Corrosion, 3h, 100°C	1a
Air release @ 50 °C, min	15

Recommended Applications

Compressor Oil EP VDL 100 is recommended for stationary and portable air compressors, operating at compression temperatures up to 220°C, including compressors with oil-lubricated pressure space such as single and multistage reciprocating compressors. Subject to specific OEM recommendations, Compressor Oil EP VDL 100 can also be applied forcompression of dry hydrogen or nitrogen.

Compressor oil EP VDL 100 is not recommended for use in breathing air compressors.

Compressor Oil EP VDL 100 Meets The Requirements Of:

- **DIN** 51506 VDL
- **SMS Group** SN180-2

Compressor Oil EP VDL 100 Is Recommended By:

- **DongHwa Pneutec**
- **Hatlapa** V-Line, W-type and L-type
- **Howden Compressors**
- **Sauer Compressors**
- **Sperre**
- **Tanabe**
- **Hamworthy**

Performance Benefits

1. Efficient, Trouble-free Operation

The high temperature oxidation stability of the product resists oil breakdown at high discharge temperatures. This contributes to a low carbon deposit formation tendency on valves and pistons in reciprocating compressors, maintaining compressor performance and keeping discharge lines and air vessels clean, even under severe operating conditions.

2. Rust Protection

Effective corrosion inhibition protects against rust caused by moisture entering the system, particularly during shutdown and intermittent operation.

3. Anti-Foam and Air Release Properties

Prevents accumulation of surface foam in the crankcase and guarantees adequate lubrication of the compressor components.

4. Low Evaporation Loss

The oil's low evaporation rate guarantees minimum consumption.

Coupling Grease

Description

Coupling Grease is a dark brown, tacky lithium grease specifically designed for lubrication of industrial flexible couplings. Formulated with a special polymer thickener, EP additives and corrosion and oxidation inhibitors.

The rotating action of a coupling has a centrifuge effect on the grease inside. If the lubricant used is a general-purpose grease in which the thickener is of higher density than the oil, the thickener and the oil may separate. This phenomenon is quite different from oil separation caused by 'bleeding' of the oil out of the grease. 'Bleeding' takes place slowly and involvesonly a portion of the oil in the grease. Centrifugal separation can be very rapid and result in substantial separation of oil andthickener.

One problem with separation of the oil and thickener is that the oil will tend to leak out of the coupling. A much greater problem however, is that the thickener which is separated out is moved by centrifugal force to the outer part of the grease reservoir against the torque transmission elements (e.g., the gear teeth in a geared flexible coupling). The thickener coats the transmission elements and keeps the oil component of the grease from lubricating them. This situation worsens with frequent relubrication and leads to component wear.

Coupling Grease is manufactured using a special thickener system which is exceptionally resistant to separation from the oil. As a result, Coupling Grease can resist separation, even under the high centrifugal forces encountered in couplings. Thisensures reliable coupling lubrication over long periods, even during high speed operation.

Typical Characteristics

NLGI Grade	**1**
MPID	**219575**
Dropping Point, °C	190
Oil Viscosity,	
mm^2/s @ 40°C	885.0
mm^2/s @ 100°C	41.0
Penetration, Worked @ 25°C	330
Timken OK Load, kg	18
Four Ball Weld, kg	315
Centrifugal Oil Separation 24h, vol %	<3

Recommended Applications

Correct application of the lubricant is crucial to successful operation of flexible couplings. Due to its tacky nature, Coupling Grease should be packed by hand into newly installed couplings to ensure complete coating of all moving elements. After assembly, and at relubrication, the coupling should be filled in accordance with manufacturer's instructions.

Operating temperature : –10°C to 120°C with temperature peaks up to 160°C.

Coupling Grease Meets The Requirements Of:

- ☑ **DIN** 51502 KP 0/1 K-30
- ☑ **ISO 6743-9** ISO-L-XCCIB 0/1
- ☑ **AGMA** CG-1, CG-2 and CG-3

Performance Benefits

1. Maintains Continuous Lubrication

Lithium/polymer thickener system effectively resists oil separation and maintains continuous lubrication of coupling elements under conditions of high speed and high centrifugal force.

2. Protects Metal Surfaces

High viscosity base fluids and EP additives provide reliable film strength and help protect contacting surfaces, minimizing wear under heavy and/or shock loads, or where shaft misalignment may be high.

3. Enhances Service Life

Superior resistance to oil separation and oxidation allows extended relubrication intervals relative to conventional greases.

4. Improves Equipment Life

Effective rust and corrosion inhibitors help protect coupling components in wet conditions.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. Toobtain an SDS for this product visit chevronmarineproducts.com.

marine lubricants

Delo® Starplex® EP2

Equivalent products: Starplex 2 in Brazil and Starplex EP2 in Europe

Description

Delo® Starplex® EP is a premium, multi-purpose EP automotive wheel bearing and chassis grease containing an ISO 220 mineral base oil, a lithium complex thickener, EP additives, rust and oxidation inhibitors and tackiness additives. It is dark red in colour. Delo Starplex EP has a very high dropping point, which enables effective lubrication at temperatures beyondthose possible for conventional lithium soap greases.

Typical Characteristics

NLGI Grade	2
MPID	**219951**
Dropping Point, °C	230+
Oil Viscosity,	
mm^2/s @ 40°C	220.0
mm^2/s @ 100°C	21.0
Penetration, Worked @ 25°C	280
Thickener	
(Lithium Complex), m %	11
Timken OK Load, kg	20
Ball, weld point kg	315
Corrosion Preventive Properties	pass
Water Washout, %	2.2

Recommended Applications

Extended service life at elevated temperatures required frequent lubrication to prevent oxidative degradation of the mineralbase occurring. Delo Starplex EP is not recommended for constant-velocity joints of front wheel drive vehicles.

Operating temperature : –35°C to 140°C, with temperature peaks up to 180°C.

Delo Starplex EP Meets The Requirements Of:

- ☑ **NLGI 2 - NLGI** GC/LB
- ☑ **NLGI 2 - DIN 51502** KP 2 N-30
- ☑ **NLGI 2 - ISO 6743-9** ISO-L-XCDHB 2
- ☑ **NLGI 3 - DIN 51825** KP 3 P-20
- ☑ **NLGI 3 - ISO 6743-9** ISO-L-XBDEB 3

Delo Starplex EP Is Recommended For Use In:

- ☑ **Automotive wheel bearings**
- ☑ **Chassis lubrication**
- ☑ **Highway and off-highway applications**
- ☑ **Construction equipment**
- ☑ **Agricultural tractor**
- ☑ **Heavy-duty transport**
- ☑ **General industrial greasing**
- ☑ **Marine application**

Performance Benefits

1. Saves Maintenance Costs

The effective EP additive helps protect against bearing wear under severe conditions and shock loading. Rust andcorrosion inhibitors help protect metal surfaces, even in conditions of severe water exposure.

2.Minimizes Downtime

High dropping point minimizes leakage from bearings at elevated temperatures and oxidation resistance ensures long grease life. Natural water resistance of the lithium complex thickener, combined with the additional tackinessadditive, prevents water washout.

3.Minimizes Inventory Costs

Multi-purpose capability allows use in a wide range of automotive and industrial applications, reducing the number of different greases required and eliminating product misapplication.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. Toobtain an SDS for this product visit chevronmarineproducts.com.

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marine lubricants

Molytex® EP 2

Equivalent products: Moly Grease EP 2 in America and Multifak® Moly EP 2 in Asia

Description

Molytex® EP 2 is a high performance extreme pressure multi-purpose lithium grease, formulated with a sheer stable lithium-12-hydroxy-stearate soap. Molytex EP 2 contains solid lubricant MoS_2 to contribute to good lubricity, high load carrying capability and assist seizure prevention under high load conditions. It is also formulated to help protect against corrosion, oxidation, softening in service, and offer robust assistance to water washout.

Molytex EP 2 increases the life of propeller shafts by up to 30%, when compared with a standard lithium EP grease and is especially developed for use in constant-velocity joints. Molytex EP 2 has been successfully used in constant velocity joints (CV-joints) in front wheel drive automobiles, universal joints (U-joints) and for chassis lubrication. The presence of Moly helps provide added shock protection. It is formulated to perform well in high load conditions and temperature extremes and help provide resistance to rust and water washout.

Typical Characteristics

NLGI Grade	2
MPID	**219573**
Type of soap	Lithium
Colour	Dark Grey
Concentration MoS_2, %wt	3
Penetration worked, 60x, mm/10	280
Dropping Point, °C	210
Base Oil Viscosity at 40°C, mm2/s	200.0
Base Oil Viscosity at 100°C, mm^2/s	15.0
Emcor corrosion test, distilled, stage	0-0
Copper Corrosion, 24 hrs at 100°C	1B
Four Ball Wear, method E Scar diameter, mm	0.4
Four Ball Weld Load, N	>3600

Recommended Applications

Molytex EP 2 is a multi-purpose grease suitable for wide range of applications. It can be applied to lubrication points found on dozers, scrapers, earthmovers, cranes, shovels, rollers, combines and cotton pickers. These lubrication points include most types of antifriction bearing arrangements from plain sleeve-types, to rolling element bearings, as well as bushings and other sliding surface or pivot points.

Working Temperature: –25°C up to 120°C with re-lubrication up to 140°C.

Molytex EP 2 Meets The Requirements Of:

- **DIN 51502** KPF2K-20
- **ISO 6743-9** L-XCCEB 2

Performance Benefits

1. Protects Metal Surfaces
Effective EP additive and molybdenum disulfide solid film lubricant protect against component wear under high load conditions and/or shock loading. Rust and corrosion inhibitors protect metal surfaces in wet operating conditions. Even if insufficient grease is used, some molybdenum disulfide tends to stay in place and protect metal surfaces.

2. Enhances Service Life
Excellent oxidation resistance ensures enhanced grease service life.

3. Ease of Application
NLGI 2 grade provide suitable flow properties for grease pump application systems.

4. Reduces Complexity
Multipurpose capability allows use in a wide range of heavy-duty automotive and industrial applications, reducing the number of different greases required and eliminating product misapplication.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. Toobtain an SDS for this product visit chevronmarineproducts.com.

marine lubricants

Multifak® EP

Description

Multifak® EP is a multi-purpose EP grease containing highly refined mineral base oils, lithium thickener, extreme pressure (EP) additives and rust and oxidation inhibitors. Suitable as a multi-purpose automotive grease for general purpose applications.

Typical Characteristics

NLGI Grade	0	1	2	3
MPID	**219572**	**219589**	**219571**	**219577**
Dropping Point, °C	180	195	195	205
Oil Viscosity,				
mm^2/s @ 40°C	208.0	208.0	208.0	208.0
mm^2/s @ 100°C	18.2	18.2	18.2	18.2
Penetration, Worked @ 25°C	370	325	280	235
Thickener (Lithium), m %	4	6	7.5	10
Timken OK Load, kg	18	18	18	18

Recommended Applications

Industrial plain and rolling element bearings, general plant lubrication, centralized lubrication systems (NLGI 0 & 1), construction equipment bearings, earthmoving, quarrying and mining, agricultural equipment, automotive wheel bearings, chassis grease point lubrication and marine applications.

Working temperature : –30°C up to 120°C, with relubrication up to 140°C.

Multifak EP Is Approved For:

- **Masada**
- **SEW Eurodrive** planetary gear motor (NLGI 2)
- **VHI** deck machinery (NLGI 2)
- **Alfa Laval Tofteford** (NLGI 2)
- **Heisin pumps** (NLGI 2)
- **Manabe Zoki** deck machinery (NLGI 2)

Multifak EP Meets The Requirements Of:

- **NLGI 0 - DIN 51502** KPOK-30
- **NLGI 0 - ISO 6743-9** ISO-L-XCCEB 0
- **NLGI 1 - DIN 51502** KP1K-30
- **NLGI 2 - Bloom** winch
- **NLGI 1 - ISO 6743-9** L-XCCEB 1
- **NLGI 2 - Zollem** rope Winch
- **NLGI 2 - NLGI LB**
- **NLGI 2 - DIN 51502** KP2K-30
- **NLGI 2 - ISO 6743-9** L-XCDEB 2
- **NLGI 2 - Kongsberg** winch
- **NLGI 3 - DIN 51502** KP3K-30
- **NLGI 3 - ISO 6743-9** L-XCCEB 3

Performance Benefits

1. Protects Metal Surfaces
The effective EP additive helps protect against component wear under high load conditions. Rust and corrosion inhibitors help protect metal surfaces.

2. Resist Oxidation
Formulated with antioxidants to resist oxidation and enhance grease service life.

3. Good Pumpability
Good pumpability characteristics of the lithium thickener provide suitable flow properties for grease pump application systems (NLGI 2).

4. Reduces Complexity
Multi-purpose capability allows use in a wide range of industrial and automotive applications, helping to reduce the number of different greases required and eliminate product misapplication.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. To obtain an SDS for this product visit chevronmarineproducts.com.

marine lubricants

Novatex® EP 2

Description

Novatex® EP 2 is a proven performance water resistant extreme pressure calcium-12-hydroxystearate grease, formulated in combination with a high viscosity mineral base oil. It offers protection through robust extreme pressure, anti-wear and anti-corrosion additives, with calcium soap to assist in reliable water resistance.

Typical Characteristics

NLGI Grade	**2**
MPID	**219500**
Type of soap	Calcium anhydrous
Colour	Light yellow
Penetration worked, 60x, mm/10	280
Dropping Point, °C	>140
Base Oil Viscosity at 40°C, mm^2/s	250.0
Base Oil Viscosity at 100°C, mm^2/s	14.0
Emcor corrosion test, distilled, stage	0-0
Copper Corrosion, 24 hrs at 100°C	1B
Four Ball Wear, method E Scar diameter, mm	0.4
Four Ball Weld Load, N	>3600

Recommended Applications

Novatex EP 2 is specifically recommended for the lubrication of plain and roller bearings of steel and paper mill equipment, which operate at temperatures up to 120°C. Use at temperatures above 120°C are not recommended because beyond the specified maximum temperature Novatex EP 2 does not reconstitute on cooling. However, Novatex EP 2 is also recommended for other industrial applications where an extreme pressure grease having robust water resistance is required. It is particularly good under heavy water-washing conditions where extreme pressure properties must be maintained.

Operating temperature : –30°C up to 110°C, with relubrication up to 120°C.

Novatex EP 2 Is Approved For:

- ☑ **Hoesch Rothe Erde**

Novatex EP 2 Meets The Requirements Of:

- ☑ POM, HDPE, Perbunan and Viton and all plastic parts used by Hoesh Rothe Erde up to 70°C
- ☑ The seals (Perbunan, Viton) have been tested for 168h at 70°C, the distance keepers (POM, HDPE) 24 weeks at 70°C
- ☑ **DIN 51502** KP2K-30
- ☑ **ISO 6743-9** L-XCCIB 2

Performance Benefits

1. Protects Metal Surfaces

The effective EP additive helps protect against component wear under high load conditions. Rust and corrosion inhibitors help protect metal surfaces.

2. Resist Oxidation

Formulated with antioxidants to resist oxidation and enhance grease service life.

3. Robust Water Resistance

Good adhesive properties and effective resistance to water wash out minimize loss of lubricant in service.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. Toobtain an SDS for this product visit chevronmarineproducts.com.

marine lubricants

Rust Proof Compound L

Description

Rust Proof Compound L is a soft film rust preventive for relatively long-term protection of iron and steel components. Formulated from a high melting point petrolatum and a special rust inhibitor system with penetrating and water displacing capabilities. Rustproof Compound L® contains a petroleum solvent to make application easier.

Typical Characteristics

Grade	L
MPID	**219574**
Colour	Dark Brown
Flash Point, COC, °C	85
Penetration, Undisturbed @ 25°C	280
Solvent Content, m %	20

Recommended Applications

Application of Rust Proof Compound L can be used over rust, scale, paint or other rust proofing materials. However, it will be easier to apply, and long-term protection will be obtained if heavy rust and other deposits are removed prior to application. Rust Proof Compound L should not be heated above 55°C. If the required consistency cannot be obtained by heating, it can be thinned with Stoddard Solvent to any consistency for easy application. It can be applied via brush, drip or spray.

Rust Proof Compound L can be used on but not limited to the following; undercoating of vehicles, transformer casing, bridges and floating bridge pontoons, storage vessels (non-food), non-potable water tanks, ballast tanks, gas holders, hoisting equipment, farm implements, and iron and steel exposed to atmospheric conditions before, during and after manufacturing into finished parts.

Spraying of Rust Proof Compound L can be accomplished with conventional pressure-feed, air-atomizing spray equipment. Where indoor spraying is to be performed, the use of airless spraying equipment is recommended in well ventilated area. Rust Proof Compound L is not suitable for use on surfaces carrying pedestrian or vehicular traffic.

Performance Benefits

1. Superior Long-term Rust Protection

Petrolatum and special additive system form a non-hardening, self-sealing film to protect surfaces against the elements. Good water displacing capabilities helps ensure that the protective film is also waterproof. The

special rustinhibitor system ensures maximum protection against corrosive attack. Good penetrating characteristics ensure difficult-to-reach seams and crevices receive effective corrosion protection.

2.Requires Minimum Surface Preparation

Ability to penetrate existing flaky or heavy rust means that little or no preliminary cleaning of metal surfaces is required before application. This penetrating ability makes existing rust easier to remove.

3. Self-sealing Film

Self-sealing properties of the protective film minimizes the need for touch-ups when film damage occurs through scratches or brush marks.

4. Easy Removal

Soft protective film is readily soluble in petroleum solvent to enable easy removal when required.

marine lubricants

SRI Grease

Description

SRI Grease is a specially formulated grease containing a highly refined paraffinic base oil, synthetic polyurea ashless organic thickener and high-performance rust and oxidation inhibitors, for the lubrication of anti-friction ball, needle and roller bearings operating at speeds up to and above 10,000 rpm, operating at higher temperatures, or where water or salt watermay penetrate bearings.

Typical Characteristics

NLGI Grade	**2**
MPID	**219586**
Corrosion Preventive Properties, D1743	Pass
Dropping Point, °C	243
Oil Viscosity,	
mm^2/s @ 40°C	116.0
mm^2/s @ 100°C	12.3
Penetration, Worked @ 25°C	280
Thickener (Polyurea), m %	8

Recommended Applications

SRI Grease can be used in temperatures ranging from –20 to 140°C for continuous service. However, for short term exposuretemperatures should not exceed 150°C.

Applications can include high speed bearings operating under high or low temperature conditions, unsealed bearings where there is the likelihood of fresh or salt water getting into the bearings, sealed-for-life bearings, industrial ball and roller bearings, electric motor, fan, and air-conditioning unit bearings, automotive alternator, generator and starter motor bearings, water pump bearings and boat trailer wheel bearings.

Operating temperature: -20°C up to 140°C, with short peaks up to 150°C.

SRI Grease Meets The Requirements Of:

- ☑ **DIN 51502** KU2-20+140M+100
- ☑ **ISO 6743-9** L-XBDFA2L-XBDFA2

Performance Benefits

1. Enhanced Oxidation Stability

Synthetic polyurea thickener is stable at elevated temperatures. Coupled with a high dropping point, highly refined base oil and anti-oxidant components, this enables extended operation periods at high temperatures.

2.Protects Metal Surfaces

Special rust and corrosion inhibitors provide protection to metal surfaces in wet conditions, even in a salt water environment. Passes Bearing Rust Test, ASTM D1743- 73 with 5% synthetic sea water. Good oxidation stability prevents the formation of corrosive oxidation by-products.

3.Superior Resistance to Water Washout

Synthetic polyurea thickener has inherent water resistance.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. To obtain an SDS for this product visit chevronmarineproducts.com.

marine lubricants

Starplex® EP 3

Description

Starplex® EP 3 Starplex EP 3 is a high performance long-service multipurpose lead-free grease, formulated for long-term service in roller-and ball-bearing applications, operating at high temperatures and under high loads.

With a wide operating temperature range, Starplex EP 3 is formulated with mineral base stocks with temperature resistant lithium complex soap thickener, combined with EP additives and wear, corrosion and oxidation inhibitors. Starplex EP 3 offers good mechanical stability and is suited to bearing lubrication under conditions where strong vibrations are present.

Typical Characteristics

NLGI Grade	**3**
MPID	**219952**
Colour	Brown
Texture	Smooth
Soap type	Lithium Complex
Penetration worked, mm/10	220–250
Dropping Point, °C	>250
Base oil type	Mineral
Base oil viscosity at 40°C, mm^2/s	115.0
Copper corrosion, 24h/100°C	1
Emcor distilled water	0/0
Four ball weld load, N	2800
Four Ball Wear, mm	0.3
Water resistance static	1–90

Recommended Applications

Starplex EP 3 grease is used for lubricating machines and components which are subjected to high thermal and mechanical loads over a long service life. It has been tested in applications involving extreme pressures, vibrations and impact stress, wet conditions, dust, and in the presence of plastic seals. This product largely covers the applications of conventional lithium, sodium and calcium greases, as well as of aluminum and calcium complex greases.

Starplex EP 3 can be a substitute for various grease types, therefore reducing the number of greases that must be kept in storage. Operating temperature: –20°C up to 150°C with frequent re-lubrication up to 200°C for a short period of time.

Starplex EP 3 Meets The Requirements Of:

- ☑ **DIN 51825** KP 3 P-20
- ☑ **ISO 6743-9** ISO-L-XBDEB3

Starplex EP 3 Is Recommended For Use In:

- Automobile wheel bearings and generators
- Clutch thrust bearings
- Brake cylinders
- Fan bearings
- Electric motors
- Kiln cars
- Rollers in drying plants
- Paper machines
- Washing and dish washing machines
- Special do-it-yourself machines
- Household appliances

Performance Benefits

1. Wide Temperature Range Application

Formulated to promote long-term lubrication performancein wide temperature conditions and reliable thermal performance contributes robust protection under hightemperature conditions.

2. Long Bearing Service Life

Mechanical stability helps maintain lubrication performance in bearings which are subject to strong vibrations. High pressure load capacity promotes long-term wear resistance.

3. Protects Metal Surfaces

Assists long-term corrosion protection where moisture, water or aggressive atmospheres are present.

4. Improves Equipment Life

Good sealing characteristics help protect lubrication points from dust, dirt and water. Tough, adhesive oil film performance aids long-term component protection.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. Toobtain an SDS for this product visit chevronmarineproducts.com.

marine lubricants

Texclad®

Description

Texclad® is a high performance calcium grease that contains adhesive open gear grease based on a water-stabilized calcium thickener and high viscosity mineral oils. It contains graphite and molybdenum disulfide additives to offer reliable protection in heavy duty operations. The formula is a smooth and buttery texture and is black in colour.

Typical Characteristics

NLGI Grade	**2**
MPID	**219570**
Dropping Point, °C	88
Graphite, m %	22
Molybdenum Disulfide, m %	3
Oil Viscosity,	
mm^2/s @ 40°C	875.0
mm^2/s @ 100°C	36.5
Penetration, Worked @ 25°C	280
Thickener (Calcium), m %	9

Recommended Applications

Texclad can be used continuously in temperatures ranging –10 to 60°C. It can also be exposed to; gears in construction, mining and industrial equipment, dipper sticks on excavating shovels, automotive fifth wheels (tractor-trailer turntables), steel girth gears (girth tires) on rotary kilns and crushing mills, sugar mill plain bearings, when fluid lubricants have shown atendency to leak and marine wire ropes.

Operating temperature : –10°C up to 60°C.

Texclad Is Approved For:

- ☑ **Masada**

Texclad Meets The Requirements Of:

- ☑ **DIN 51502** MF 2 C-10
- ☑ **DIN 51502** KF 2 C-10
- ☑ **ISO 6743-9** L-XAAIB 2

Performance Benefits

1. Effective Water Resistance

Good adhesive properties and effective resistance to water wash out minimize loss of lubricant in service.

2. Protect Metal Surfaces

High load-carrying capacity and anti-wear additives extend gear tooth life in heavy duty service. Resistance to flaking at low temperatures maintains surface protection.

3. Solid Film Protection

Graphite and molybdenum disulfide provide solid-film protection in event of loss or degradation of the fluid lubricant.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. To obtain an SDS for this product visit chevronmarineproducts.com.

marine lubricants

Ulti-Plex® Synthetic EP

Description

Ulti-Plex® is a high performance, high temperature industrial and automotive EP grease specially formulated from an ISO 320 synthetic base oil, lithium complex thickener, EP additives, a tackiness agent and special corrosion and oxidation inhibitors. For EP ball and roller bearing applications, especially in continuous high temperature service up to 230° where conventional greases tend to harden, or low temperature conditions down to –30°C where conventional greases are no longer pumpable.

Typical Characteristics

NLGI Grade	1.5
MPID	**219412**
Dropping Point, °C	280
Oil Viscosity,	
mm²/s @ 40°C	405.0
mm²/s @ 100°C	41.0
Penetration, Worked @ 25°C	–315
Viscosity Index	150
Thickener (Lithium Complex), m %	13
Timken OK Load, kg	23

Recommended Applications

Due to the heavy base oil viscosity and adhesive properties of Ulti-Plex, it is recommended that a heavy follower plate be used in air-driven grease pumps. Depending on pipe sizing and distance, pumping rates will be lower than for conventional greases of the same NLGI grade. It may be necessary to use Ulti-Plex where pumpability is a primary requirement.

Application can include: pulp and paper applications (high temperature felt roll bearings, lime kilns, sludge press bearings, pulp refiner bearings and pump and exhaust fan bearings), steel industry applications (roll bearings, conveyor bearings, furnace and coiler grease points and pump and exhaust fan bearings), mining industry (conveyor bearings, pins and bushings on buckets and loaders, shaker screens and crushers) and marine (deck equipment, shaft bearings, crane and windlass winches, water exposed bushings, wire ropes).

Operating temperature: –30°C up to 230°C.

Ulti-Plex Synthetic EP Meets The Requirements Of:

- **DIN 51502** KPHC2N-30
- **ISO 6743-9** L-XCDEB 2

Performance Benefits

1. Long Bearing Service Life

Combination of a lithium complex thickener, oxidation inhibitor, and synthetic base oil helps provide resistance to hardening in service. EP additives provide good wear protection under heavy and/or shock loads. Effective rustand corrosion inhibitors help protect metal surfaces in wetconditions.

2. Wide Temperature Range Application

The high viscosity index synthetic base oil resists thickening at low temperatures and enables use over a wide temperature range. The oxidation stability of the base fluid components enables operation in continuous high temperature environments.

3. Protects Against Equipment Failure

High viscosity index synthetic base oil and tackiness additive maintain oil viscosity and provide adhesive properties which help prevent oil leakage in high speed and high temperature conditions.

4. Superior Water Resistance

Lithium complex thickener and tackiness additive produces good resistance to water washout.

Environment, Health And Safety

Information is available on this product in the Safety Data Sheet (SDS) and Customer Safety Guide. Customers are encouraged to review this information, follow precautions and comply with laws and regulations concerning product use and disposal. To obtain an SDS for this product visit chevronmarineproducts.com.

Our Family of Brands

marine lubricants

Clarity® Synthetic EA Gear Oil 100

Description

Clarity® Synthetic EA Gear Oil 100 is a readily biodegradable high-performance gear oil that meets EPA Vessel General Permit (VGP 2013) requirements for environmentally acceptable lubricants. It is designed to give maximum protection in industrial gear applications on vessels and in environmentally sensitive areas.

Clarity Synthetic EA Gear Oil 100 is formulated with synthetic base stock and an ashless, zinc-free additive system that can provide good oxidation stability, water separability, foam suppression, and protection against wear, rust and corrosion. It isa high VI synthetic product which allows for operation over a wide temperature range.

Typical Characteristics

MPID	**803121**
VG 100	
Kinematic Viscosity at 40°C, mm²/s	100.0
Kinematic Viscosity at 100°C, mm²/s	18.0
Viscosity Index	199
Flash point, COC, °C	185
Pour Point, °C	39
Copper Corrosion 3hrs/100°C	1B
Rust test, distilled water	PASS
Rust test, salt water	PASS
Water separability at 82°C	<3 ml emulsion at 30 minutes
Foam Seq I, ml	50/0
Foam Seq II, ml	50/0
Foam Seq III, ml	50/0
FZG, load failure stage	>12
Timken OK Load, lb	>60
Elastomer Compatibility	
Buna-N (100°C, 168 hrs)	Pass
Viton (150°C, 168 hrs)	Pass
Biodegradability, %	>60
Aquatic Toxicity	
Fathead minnow, OECD 203, mg/L	>1000
Daphnia magna, OECD 202, mg/L	>130
Algae, OECD 201, mg/L	>120
Bioaccumulation	NEGATIVE

marine lubricants

Recommended Applications

This lubricant is readily biodegradable, non-bio accumulative, and minimally toxic. In the event of a spill, the product biodegrades by more than 60% within 28 days, minimizing the impact to the environment. Clarity® Synthetic EA Gear Oil 100 is designed to give maximum protection in marine gear equipment used on vessels and in environmentally sensitive areas.

Clarity Synthetic EA Gear Oil 100 Is Approved For:

- ☑ **Aegir**
- ☑ **AGMA** EP 9005-E02
- ☑ **Berg**
- ☑ **Blohm+Voss**
- ☑ **Cincinnati Milacron** P-76
- ☑ **David Brown** S1.53.101
- ☑ **DIN** 51517 (Part 3)
- ☑ **IHC Merwede**
- ☑ **James Walker**
- ☑ **Kamewa**
- ☑ **Kemel**
- ☑ **Ortlinghaus**
- ☑ **Schottel**
- ☑ **Wärtsilä**

Clarity Synthetic EA Gear Oil 100 is miscible with common mineral based gear oils, however, following good practice, in-service oils should be completely drained to avoid any risk of additive incompatibility and ensure that the full performance benefits are achieved. Do not use in high pressure systems near flames, sparks, and hot surfaces. Use only in well ventilated areas. Keep container closed.

Performance Benefits

1. Environmentally Acceptable

Meets the requirements of the EPA Vessel General Permit (VGP 2013) for biodegradation, low toxicity and low bioaccumulation.

2. Premium Performance

Ashless formulation helps to provide protection against wear of industrial gears, as well as rust and corrosion protection, water separability, foam inhibition, EP protection and shear stability.

3. Long Oil Life

Good ability of the synthetic base stock to withstand oxidation at high operating temperatures results in maximum service life for the oil relative to vegetable-based readily biodegradable products.

4. Low Temperature Pumpability

Specifically developed with high viscosity index to help ensure good fluidity for low operating temperatures.

Our Family of Brands

Clarity® Synthetic EA Grease 0

Description

Clarity® Synthetic EA Grease 0 is a premium performance environmentally acceptable lubricant (EAL) grease formulated for the lubrication of heavily loaded bearings in wet and corrosive environments, even at low temperatures, and offers dependable adhesion and water resistance.

Clarity Synthetic EA Grease 0 is an anhydrous calcium thickened grease based on biodegradable synthetic esters, and contains antioxidants, corrosion inhibitors and extreme pressure (EP) and anti-wear (AW) additives.

Typical Characteristics

NLGI grade	ASTM D217	0
MPID	**219019**	
Texture		Smooth
Thickener type		Anhydrous Calcium
Base oil Type		Synthetic ester
Base Oil viscosity at 40°C, mm^2/s	ASTM D7152	460
Base Oil viscosity at 100°C, mm^2/s	ASTM D7152	50
Dropping Point, °C	IP 396	186
Density at 15°C, kg/l	IP 530	0.930

marine lubricants

Recommended Applications

Clarity Synthetic EA Grease 0 is a premium performance environmentally acceptable lubricant (EAL) grease suitable for a range of marine on-deck applications, including slides, hinges, submerged pumps, propeller caps, in marine applications requiring an NLGI 0 EAL grease.

Clarity Synthetic EA Grease 0 serves as a universal grease for forestry, agricultural and construction vehicles, and is pumpable in most modern centralised lubrication systems.

Clarity Synthetic EA Grease is also recommended for the lubrication of:

- Highly loaded plain and rolling bearings, slideways and other elements of construction and farm machinery
- Machine tools
- Wheel flanges
- Threaded spindles
- Gear drives
- Applications where a biodegradable grease NLGI 0 is required, and is suitable for applications where risk of contamination of soil, water or channels can occur

Clarity Synthetic EA Grease 0 is approved for:

- Hanil Industry
- Yoowon Korea
- 3 K Industry
- Dongtal
- Jiangsu China Empire Offshore

Clarity Synthetic EA Grease 0 meets the requirements of:

- ☑ **ISO 12924** L-XD(F)BIB0
- ☑ **DIN 51502** KPE0G-40
- ☑ **Operating temperature** -40°C up to 100°C with short peaks up to 110°C
- ☑ **2013 VGP** Compliance
- ☑ **SS** 155470

Maintaining a clean work environment is critical when equipment greasing is performed. Grease fittings should be wiped clean prior to grease injection to prevent contaminants from entering the equipment. Bearing housings should be maintained one-third to one-half full of grease. Over-greasing should be avoided as excessive heat build-up can result. Periodic relubrication via grease gun or centralised system should be supplemented by complete cleaning and packing with fresh grease on an appropriate schedule. Always follow OEM recommendations.

Performance Benefits

1. Wide range of applications

Developed to contribute to efficient protection of a range of on-deck marine applications requiring NLGI 0 EAL grease

2. Environmentally acceptable lubricant

Designed to meet the biodegradability, renewability, toxicity, bioaccumulability and biomagnification properties

3. Water-resistance adhesion

Aids robust adhesion and water resistance

4. Corrosion resistance

Formulated to contribute to corrosion protection across a range of on-deck applications

5. Good pumpability

Offers pumpability in many centralised lubrication systems

marine lubricants

Clarity® Synthetic EA Hydraulic Oil 100

Description

Clarity® Synthetic EA Hydraulic Oil 100 is an ash free readily biodegradable high performance hydraulic oil that meets EPA Vessel General Permit (VGP 2013) requirements for environmentally acceptable lubricants. It is designed to give maximumprotection in hydraulic equipment used on vessels and in environmentally sensitive areas.

Clarity Synthetic EA Hydraulic Oil 100 is designed to give maximum protection in hydraulic equipment used in vessels and in both mobile and stationary hydraulic pumps in high-performance industrial applications. It is formulated with synthetic base stock and an ashless, zinc-free additive system that can provide good oxidation stability, water separability, foam suppression, and protection against wear, rust and corrosion. Clarity Synthetic EA Hydraulic Oil 100 is a high VI synthetic product which allows for operation over a wide temperature range.

Typical Characteristics

MPID	219013
Viscosity, Kinematic cSt at 40°C	100.0
Viscosity, Kinematic cSt at 100°C	18.8
Viscosity Index	210
Flash Point, °C	193
Pour Point, °C	48
Copper Corrosion	1b
Rust Test, Synthetic Sea Water	PASS
FZG, Fail Load Stage	12
Elastomer Compatibility	
Buton-N, Viton, Polyurethane	PASS
Biodegradability, OECD 301B, % in 28 days	>60
Aquatic Toxicity	
Fathead minnow, OECD 203, mg/L	>10.000
Daphina magna, OECD 202, mg/L	>120
Algae, OECD 201, mg/L	>10.000
Bioaccumulation	Negative

Recommended Applications

Clarity Synthetic EA Hydraulic Oil 100 is designed to give maximum protection in hydraulic equipment used on vessels andin environmentally sensitive areas. This lubricant is readily biodegradable, non-bio accumulative, and minimally toxic. In the event of a spill, the product biodegrades by more than 60% within 28 days, minimizing the impact to the environment.

Clarity Synthetic EA Hydraulic Oil 100 Is Approved For:

- ☑ **SKF**
- ☑ **Wärtsilä**
- ☑ **B&V**
- ☑ **Kobleco**

Clarity Synthetic EA Hydraulic Oil Is Recommended For Use In:

☑ **Blohm+Voss**	☑ **HEPR** in mobile and stationary hydraulic vane-pistongear-type pumps

Clarity® Synthetic EA Hydraulic Oil 100 is miscible with common mineral based hydraulic oils, however, following good practice, in-service oils should be completely drained to avoid any risk of additive incompatibility and ensure that the full performance benefits are achieved. Do not use in high pressure systems near flames, sparks, and hot surfaces. Use only in well ventilated areas. Keep container closed.

Performance Benefits

1. Environmentally Acceptable

Meets the requirements of the EPA Vessel General Permit (VGP 2013) for biodegradation, low toxicity and low bioaccumulation.

2. Zinc-Free

Suited for applications involving yellow metals found in axial piston pumps.

3. Long Oil Life

Good ability of the synthetic base stock to withstand oxidation at high operating temperatures can result in maximum service life for the oil relative to vegetable-based readily biodegradable products.

4. Low Temperature Pumpability

Specifically developed with high viscosity index to help ensure good fluidity for low operating temperatures.

5. Premium Performance

Ashless formulation helps to provide good protection against wear of hydraulic pumps, as well as rust and corrosion protection, hydrolytic stability, water separability, foam inhibition, and filterability.

1000 THF

Description

1000 THF is a high quality, multifunctional tractor hydraulic fluid, specially formulated for use in transmissions, final drives, wet brakes, and hydraulic systems of tractors and other equipment employing a common fluid reservoir. It is also a great choice for wet brake transaxles in off-road equipment. This type of fluid is also referred to as Universal Tractor Transmission Oil (UTTO). It is formulated using highly refined base oils, a viscosity index improver, oxidation and corrosion inhibitors, anti-wear and film strength additives, an antifoaming agent, and a pour point depressant. Its distinctive orange colour allows for easy product identification and leak detection.

1000 THF replaces the former product Textran TDH Premium.

Typical Characteristics

MPID	219920
Density at 15°C, kg/l	0.87
Flash point COC, °C	235
Pour point, °C	–42
Kinematic viscosity at 40°C, mm^2/s	59.0
Kinematic viscosity at 100°C, mm^2/s	9.3
Viscosity Index	145

Recommended Applications

1000 THF meets the needs of modern tractors for a multi-functional lubricant. It is designed for many uses, such as lubrication of the transmission and final drive, and also serves as a hydraulic fluid to operate power steering units, brakes, implements, and attachments. It is formulated to suppress brake “chatter” and excessive brake facing wear. It offers smooth operation of clutch packs and wet brakes, offers good shifting action, aims to provide exceptional rust and corrosion protection for vital parts, and minimizes leakage because of good compatibility with seals, O-rings, and packing materials.

It helps prevent sludge and varnish formation, helps to protect metal surfaces against scuffing and wear, and provides good lubrication for spur, helical, and spiral bevel final drive gears. 1000 THF is compatible with equipment manufacturer's proprietary fluids and other fluids of this type.

1000 THF Is Approved For:

- ☑ **Volvo** 97303 [WB 101]
- ☑ **ZF** TE-ML 03E / TE-ML 05F / TE-ML 17E / TE-ML 21F

1000 THF Is Suitable For Use In:

- ☑ **Deck cranes/deck machinery applications**
  Hydralift/TTS, Norsafe

1000 THF Meets The Requirements Of:

- **ABB Dodge** Controlled start-up transmissions
- **Non-hypoid API GL-4 applications** (under low-speed high-torque conditions)
- **Hitachi** Mid-sized wheel loader axle applications, transfer case and hydraulics
- **AGCO** improved power fluid 821XL
- **Case Corporation** JIC-143/JIC-145/MS 1206/ MS 1207/MS 1209/MS 1210 (TCH)
- **Case New Holland** MAT 3505/MAT 3525
- **Caterpillar** TO-2
- **Ford New Holland** ESN-M2C134-D/FNHA-2-C-201
- **International Harvester** B6
- **John Deere** JDM J20C **Kubota** UDT
- **Massey Ferguson** M1135/M1141/M1143/M1145
- **Minneapolis-Moline** Q-1722/Q-1766/Q-1766B
- **Oliver** Q-1705
- **Renk Doromat** 874A/874B
- **White Farm Equipment** Q-1826

Performance Benefits

1. Long Equipment Life

Special additives help to protect metal surfaces against scuffing and wear even under severe operating conditions,which helps to maximize equipment life.

2. Smooth Operation

Formulated to suppress brake "chatter" and transmission "slip" for quiet and efficient action of brakes and transmission.

3. Low Inventory Cost

One fluid does the job of a full range of tractor hydraulic systems. It can be used to replace multiple products and free up shelf space too.

4. Reliable Operation

Formulation helps keep metal parts clean and free of varnish and sludge deposits that could result in prematurebreakdown.

5. Minimizing Weather And Storage Concerns

Aims to protect against rust and corrosion of highly finished precision parts when operating in humid conditions and during seasonal shutdown periods.

6. Minimal Downtime

Good compatibility with seals, O-rings, and packing materials maintains their good condition and helps to keep leakage at a minimum.

Delo® Gear EP-5 SAE 80W-90

Regional equivalents: Geartex® EP-C SAE 80W-90, Geartex EP-5 SAE 80W-90,
Multigear® EP-5 80W-90, Thuban® GL-5 EP 80W-90, Gear Oil GL-5 SAE 80W-90

Description

Delo® Gear EP-5 SAE 80W-90 is an automotive gear lubricant suitable for API GL-5 applications. It is formulated with mineral base oils in combination with a high performance additive system.

Typical Characteristics

MPID	219941
Density at 15°C, kg/l	0.89
Flash point COC, °C	212
Pour point, °C	-33
Kinematic viscosity at 40°C, mm^2/s	135.0
Kinematic viscosity at 100°C, mm^2/s	14.3
Viscosity Index	101

Recommended Applications

Delo Gear EP-5 SAE 80W-90 is designed for use in automotive hypoid drive axles, steering systems, non-synchronized transmissions and transaxles which require a fluid with API GL-5 performance. Operating temperatures of above 100°C will lead to a significant reduction in the fluid service life. Peak operating temperatures should not exceed 120°C. Note that Daimler axle oil specifications include a minimum viscosity requirement that is not met by Delo Gear EP-5 SAE 80W-90.

The friction characteristics of Delo Gear EP-5 SAE 80W-90 make it generally unsuitable for use in synchronized manual transmissions and transaxles, and it should not be used in these applications unless a GL-5 fluid is specifically recommended.

Delo Gear EP-5 SAE 80W-90 And Regional Equivalents Meet The Requirements Of:

- **Volvo 97321** Delo Gear EP-5 SAE 80W-90, MultiGear EP-5 SAE 80W-90, Gear Oil GL-5 SAE 80W-90
- **Volvo 97310-90** Geartex EP-C SAE 80W-90, Geartex EP-5 SAE 80W-90
- **ZF TE-ML 05A** Multigear EP-5 80W-90
- **ZF TE-ML 12M** MultiGear EP-5 SAE 80W-90
- **ZF TE-ML 16B** Geartex EP-5 SAE 80W-90, MultiGear EP-5 SAE 80W-90
- **ZF TE-ML 17B** Geartex EP-5 SAE 80W-90, MultiGear EP-5 SAE 80W-90
- **ZF TE-ML 19B** Geartex EP-5 SAE 80W-90, MultiGear EP-5 SAE 80W-90
- **ZF TE-ML 21A** Geartex EP-5 SAE 80W-90, MultiGear EP-5 SAE 80W-90
- **ZF TE-ML 07A** Geartex EP-C SAE 80W-90, Geartex EP-5 SAE 80W-90
- **Bosch TE-ML 08** Geartex EP-C SAE 80W-90, Geartex EP-5 SAE 80W-90
- **US Military MIL-L-2105D** Geartex EP-C SAE 80W-90, Geartex EP-5 SAE 80W-90
- **API** GL-5

Delo Gear EP-5 SAE 80W-90 Is Suitable For Use In:

- **Deck cranes** Liebherr
- **Non-synchronized reduction gearboxes and propeller shaft gearboxes of life saving equipment** Hyundai Life Boat, Fassmer, Hatecke, Beihai, Mansei, Norsafe, Yamaha, Tohatsu

Performance Benefits

1. Protection Against Wear And Tear
High performance additives provide EP protection, protecting components against scuffing and wear.

2. Premium Stability
Premium shear stability, ensuring that the viscosity is retained throughout the fluid lifetime.

3. Fast Circulation In Cold Weather
Good low-temperature fluidity, superior to a standard SAE 90 product, allowing fast circulation during cold weather start-up.

4. Prevents Thickening Of Oil
Reliable oxidation stability, preventing oil thickening during service and formation of harmful varnish and deposits.

5. Prevents Loss Of Fluid
Compatible with a wide variety of elastomer materials, preventing loss of fluid due to seal deterioration.

6. Rust Protection
Good rust protection.

7. Foam Resistance
Good resistance to foaming.

Havoline® ATF III-H

Regional equivalents: Texamatic® 7045E, Texamatic 1888, Automatic Transmission Fluid MD-3

Description

Havoline® ATF III-H is a proven performance Automatic Transmission Fluid formulated for applications that call for the former GM DEXRON®-III H, MERCON® and Allison C-4 fluids. It is formulated with high performance mineral base oils and a specially balanced additive combination to provide exceptional oxidation resistance, extended oil life and good wear protection.

Typical Characteristics

MPID	219957
Density at 15°C, kg/l	0.86
Kinematic viscosity at 40°C, mm²/s	34.1
Kinematic viscosity at 100°C, mm²/s	7.0
Viscosity Index	171
Pour Point °C	-50
Colour	RED

Recommended Applications

Havoline ATF III-H is designed for use in automatic transmissions that require a GM DEXRON®-III H type fluid. Although this specification has been made technically obsolete by GM itself, many equipment manufacturers continue to recommend fluids of this type. It can be used in transmissions that require a Ford MERCON® fluid. The product is not recommended for transmissions that require a Ford MERCON® V fluid (this is a separate specification to MERCON®). Due to fundamental differences in frictional properties, it should not be used in applications that require a Ford M2C33-F/G fluid.

Havoline ATF III-H is also suitable for use in power steering systems that require a mineral-type Power Steering Fluid. It should not be used in steering or active suspension systems that call for specific semi-synthetic or synthetic fluids, as the response speed may not be sufficiently fast. Havoline ATF III-H may also be used as a wide temperature range anti-wear hydraulic fluid for mobile, industrial and marine applications. The viscosity corresponds to ISO VG 32.

Havoline ATF III-H And Regional Equivalents Are Approved For:

- ☑ **MAN Truck & Bus** 339 Typ V1 (Texamatic 7045E)
- ☑ **Voith** H55.6335.3X (Texamatic 7045E/Texamatic 1888)

Havoline ATF III-H And Regional Equivalents Meet The Requirements Of:

- ☑ **Allison** C-4
- ☑ **Ford** Mercon
- ☑ **GM** DEXRON-III H (DEXRON IIIG for regional equivalent Texamatic 7045E)

Havoline ATF III-H Is Suitable For Use In:

- ☑ **Deck cranes/deck machinery applications** MacGregor/Cargotec
- ☑ **Automatic reduction gearboxes of life boats and other high speed diesel engines** Hyundai Life Boat, Fassmer, Hatecke, Beihai, Norsafe, Schat-Harding, Sabb, Steyr

Performance Benefits

1. Smooth Lock-Ups
Specially tuned friction characteristics, helping to ensure smooth shifting and lock-ups.

2. Good Fluid Lifetime
Good friction durability, making sure that this performanceis retained throughout the fluid lifetime.

3. Effective Lubrication At High Temperatures
High Viscosity Index, meaning that the oil will retain sufficient viscosity for effective lubrication even at high operating temperatures.

4. Low-Temperature Fluidity
Great low-temperature fluidity, providing transmission protection during cold weather start-up.

5. Prevents Harmful Sludge
Good oxidation stability, preventing formation of harmfulsludge, lacquer or deposits.

6. Protects Against Corrosion
Helps prevent corrosion of automatic transmission fluidcoolers.

Havoline® Outboard 2T

Regional equivalents: MOTEX 2T OUTBOARD, Havoline 2-Cycle Engine Oil TC-W3, Super Outboard 3, TC-W3

Description

Havoline® Outboard 2T is an efficient premium performance, two-stroke marine outboard oil, formulated with an ashless additive system. It is pre-diluted with a high flashpoint low aromatic solvent which aids easy mixing with gasoline across a wide temperature range.

Typical Characteristics

MPID	219821
Density at 15°C, kg/l	0.87
Kinematic viscosity at 40°C, mm²/s	54.0
Kinematic viscosity at 100°C, mm²/s	8.7
Viscosity Index	138
Pour point, max °C	–39
Flash point COC, °C	134
Total Base Number, mg KOH/g	5.7
Sulphated Ash, %wt	<0.01

Recommended Applications

Havoline Outboard 2T is recommended for water-cooled two-cycle outboard engines and personal water craft applications. It is formulated for use at most engine manufacturers fuel/oil ratios and is well suited for use in oil-injected engines as well as in engines where the oil is mixed with gasoline. It is miscible with gasoline, even at low temperatures.

Havoline Outboard 2T Meet The Requirements Of:

- ☑ **NMMA** TCW-3

Performance Benefits

1. High Power Output
Highly refined mineral oil and ashless additives offer piston cleanliness and help maintain engine performance.

2. Keep-Clean Performance
Formulated to offer protection against ring sticking thus, maintaining combustion efficiency and power output.

3. Reduced Maintenance Costs
Robust additive system helps protect against wear under high speed, peak performance operation.

4. High Power Output
Highly refined mineral oil and ashless additives offer piston cleanliness and help maintain engine performance.

5. Optimum Spark Plug Life
Ashless additive system helps reduce spark plug fouling under a wide range of operating conditions.

HDAX® 5200 Low Ash Gas Engine Oil SAE 40

Description

HDAX® 5200 Low Ash Gas Engine Oil SAE 40 is an advanced performance, premium quality, bright stock free engine oil. It is formulated with premium base oil technology and an additive package containing ash less dispersant, oxidation inhibitors,metallic detergents and a metallic anti wear agent.

HDAX 5200 Low Ash Gas Engine Oil SAE 40 provides great oxidation and nitration resistance, which minimizes the build-up of insoluble particles and helps to provide long oil and filter life. Additionally, it gives protection against ring and liner scuffing and wear. It also minimizes valve recession in four-stroke engines and provides admirable piston and ring belt deposit control and effectively protect against the formation and build-up of engine sludge.

Typical Characteristics

MPID	219910
Density at 15°C, kg/l	0.88
Kinematic viscosity at 100°C, mm^2/s	13.5
Pour Point, °C	–33
Total Base Number, mg KOH/g	4.2
Sulfated Ash, %wt	0.5

Recommended Applications

HDAX 5200 Low Ash Gas Engine Oil SAE 40 is recommended for four-stroke and selected two-stroke stationary engines fuelled by natural gas. It is formulated to meet catalyst compatibility requirements and are especially suited for installationsrequiring low phosphorus oil to prevent exhaust catalyst poisoning. HDAX 5200 Low Ash Gas Engine Oil SAE 40 is suitablefor use with fuels containing low levels of sulphur.

HDAX 5200 Low Ash Gas Engine Oil SAE 40 Is Approved For:

- **Caterpillar** CG gas engines
- **GE Jenbacher** Type 2/3 Class A, Class S Fuel
- **GE Jenbacher** Type 4A Class A, Class S Fuel
- **GE Jenbacher** Type 4B Class A, Class B, Class C,Class S Fuel
- **GE Jenbacher** Type 4CS, Class A Fuel
- **GE Jenbacher** Type 6FJ Class A, Class B, Class C, Class S Fuel
- **GE Jenbacher** Type 6CE Class A, Class S Fuel
- **GE Jenbacher** Type 6HK Class S
- **MWM** Gas engines
- **Wärtsilä** Natural gas
- **Waukesha** 220GL
- **Waukesha** COGEN Application
- **Indonesia Lemigas** NPT Number

Performance Benefits

1. Cost Effective
Low maintenance cost and long engine life.

2. Low Wear
Helps to provide protection against piston, ring, and liner scuffing, scoring, and wear.

3. Valve Protection
The level and type of ash producing additives in the oils help to provide minimum valve recession with low levels of combustion chamber deposits to minimize the potential for preignition and spark plug fouling.

4. Clean Pistons
Aims to provide piston cleanliness to help prevent ringsticking and maintain clean, varnish-free piston skirts.

5. Clean Crankcases and Top Decks
Minimizes the formation of crankcase and valve cover/topdeck sludge.

6. Catalyst Compatibility
Formulated to be compatible with exhaust emissions reduction systems.

marine lubricants

HDAX® 9700 SAE 40

Description

HDAX® 9700 is a premium performance, uniquely designed engine oil recommended for dual fuel, medium-speed, four-stroke cycle trunk piston engines burning natural gas with diesel pilot fuel ignition and up to 100 percent low sulfur diesel fuel (<1000 ppm sulfur).

HDAX 9700 is a premium dual fuel gas engine oil with proven field service experience in dual fuel engines operating with diesel pilot ignition natural gas mode and up to 100 percent diesel mode for extended operational periods. It offers reliable deposit control, corrosion resistance and wear protection. The formulation is designed to control ash accumulation in combustion chambers and exhaust after treatment while providing sufficient alkalinity to protect against acidic corrosion.

Typical Characteristics

MPID	219911
Density at 15°C, kg/l	0.87
Kinematic viscosity at 40°C, mm²/s	117.0
Kinematic viscosity at 100°C, mm²/s	13.4
Viscosity Index	110
Pour Point, °C	–36
Flash Point COC, °C	268
Total Base Number, mg KOH/g	5.8
Sulfated Ash, %wt	0.7

Recommended Applications

HDAX 9700 is recommended for dual fuel, natural gas/ultra low sulfur diesel medium-speed trunk piston engines in coastal marine, inland marine, railroad and power generation applications. These high output engines may be turbocharged and equipped with exhaust catalysts systems. Always confirm that the product selected is consistent with the original equipment manufacturer's recommendation for the equipment operating conditions and customer's maintenance practice.

HDAX 9700 Is Approved For:

☑ **MAN Energy Solutions**

Performance Benefits

1. Smooth Engine Operation

Fit for purpose formulation suitable for use with wide range of fuels, allowing switching from gas to diesel without need to change oil.

2. Long Oil Life

A combination of premium base oils and high performance additives offer excellent oxidation and nitration resistance over extended oil life. Used oil analysis is recommended for establishing and maintaining oil service intervals.

3. Clean Pistons

Very low combustion chamber and piston deposits help protect liners from scoring and extend engine top-end maintenance cycles.

Texatherm® 32 & 46

Description

Texatherm® is a heat transfer fluid formulated to meet the requirements of hot circulating systems operating at temperatures of up to 320°C. Based on highly refined paraffinic base oils with inherently good thermal stability, Texatherm contains selected additives which help to enhance oxidation stability, protect against rusting or corrosion of steel and copper, and prevent air entrainment and foaming.

Typical Characteristics

ISO Viscosity Grade	32	46
MPID		
Density at 15°C, kg/l	0.86	0.86
Density at 100°C, kg/l	0.80	0.80
Density at 200°C, kg/l	0.73	0.73
Density at 300°C, kg/l	0.67	0.67
Pour point, °C	–15	–15
Flash point COC, °C	220	235
Oxidation (ASTM D943), hrs to TAN = 2.0 mg KOH/g	3500	3500
Rust test, synthetic seawater	PASS	PASS
Kinematic viscosity at 0°C, mm^2/s	313.0	545.0
Kinematic viscosity at 40°C, mm^2/s	32.0	46.0
Kinematic viscosity at 100°C, mm^2/s	5.5	6.9
Viscosity Index	106	105
Copper corrosion, 3h at 100°C	1a	1a
Water by Karl Fischer, mg/kg	<50	<50
TAN, mg/KOH/g	0.08	0.1
Air release ag 50°C, min.	2.3	2.3
Foam Seq II, after blowing, ml	0	0
Foam Seq II, after 10 minutes, ml	0	0

Recommended Applications

Texatherm is recommended for use as a heat transfer fluid in temperatures ranging from –15°C to a maximum bulk temperature of 288°C. The maximum recommended film temperature is 316°C (the film or skin temperature is the temperature of the oilfilm that it in direct contact with the internal wall of the heat exchangers tubes in the heater).

Suitable For Open Or Closed Heat Transfer Systems With Forced Circulation Operating Under The Following Conditions:

- ☑ **Maximum bulk oil temperature** 288°C
- ☑ **Maximum film temperature on heater surfaces** 316°C
- ☑ **Maximum temperature of oil surface in contact with air in open system** 107°C

Texatherm 32 Is Approved For:

- GESAB

Performance Benefits

1. Thermal and Oxidation Stability

Exhibits good thermal and oxidation stability, allowing operation at high temperatures for extended periods.

2. Heat Transmission

Maximum heat transmission to the process vessel or equipment allows the use of smaller circulating system pumps, valves and heating coils.

3. High Thermal Conductivity

High thermal conductivity and low viscosity at the relevant operating temperatures helps to ensure high heat transferrates with limited pumping energy.

4. Low Vapor Pressure

Low vapor pressures at the elevated temperatures minimize evaporation, vapor lock and cavitation, and eliminates the need to high-pressure piping and equipment.

5. Low Temperature Operation

Low temperature fluidity assists rapid system start-up.

GST® Premium 32

Local equivalent GST Advantage RO 32

Description

GST® Premium 32 is formulated with premium base oil technology designed to meet the critical demands of HPS (Mitsubishi Hitachi Power Systems), formerly MHI (Mitsubishi Heavy Industries), non-geared gas and steam turbines requiring a MS04- MA-CL002 product. It is suitable for use in gas and steam turbines where extreme temperatures are experienced and requirecirculation systems with high temperature stability.

GST Premium turbine oil combines highly refined group II base stocks and an additive package designed to minimize the formation of deposits in reservoirs, high temperature bearings and other hot areas of the turbine.

Typical Characteristics

MPID	219345
Flash Point, °C	224
Pour Point, °C	–14
Kinematic viscosity at 40°C, mm2/s	31.5
Kinematic viscosity at 100°C, mm2/s	5.4
Viscosity Index	105
Copper Corrosion	1b
Oxidation Stability, TOST life, hrs. to 2.0 Acid No.	1.4
RPVOT, mins	10,000
Total Oxidation Product (TOP), m %	1,500

Recommended Applications

GST Premium 32 is formulated to meet the critical demands of non-geared gas, steam and hydroelectric turbine bearing lubrication and R&O service in marine reduction gears. They are additionally suitable for industrial severe service requiring an R&O, ISO 32 circulating oil with extended service capability.

GST Premium 32 Is Approved For:

- **Siemens** TLV 901304 and TLV 901305
- **Mitsubishi Hitachi** Power Systems MS04-MACL002
- **Siemens** TLV 901304 and TLV 901305

GST Premium 32 Meets The Requirements Of:

- **ANSI/AGMA** 9005-F16 R&O,
- **ASTM D4304** Type I / Type III (non-geared turbines)
- **British Standard** 489:1999
- **DIN** 51515/1 and 51515/2
- **General Electric** (GEK-32568k, GEK-28143b, GEK-27070 and GEK-46506e)
- **ISO** 8068 L-TGA
- **MAN Energy Solutions 10000494596**
- **Solar Turbine** ES 9-224 Class II
- **GE/Alstom** HTGD 90117 (for non-geared turbines)
- **Mitsubishi Hitachi Power Systems** MS04-MACL002

Performance Benefits

1. Exceptional Oxidation and Thermal Stability

Provides long service life at severe temperatures with minimal Deposit Formation as dictated by the stringent MHPS MS04-MA-CL001 / CL002 specification. Formulated with premium base oil technology and an ashless, zinc- free formulation.

2. Rust and Corrosion Protection

Helps ensure minimum viscosity change when variations in temperature occur.

3. High Viscosity Index

Aims to protect against corrosion or rusting of costly precision parts.

4. Minimum Foaming

Helps prevent sump overflow or erratic governor operation.

5. Fast Air Release

Helps to minimize possibility of pump cavitation in systems with high circulation rates and lesser residence time.

6. Rapid Water Separation

Facilitates water removal.

7. Hydraulic Fluid Service

For systems requiring an ISO 32 viscosity oil and pressures not exceeding 1000 psi.

8. Air Compressor Lubricant

For systems requiring an ISO 32 viscosity R&O oil.

marine lubricants

Regal® R&O

Description

Regal® R&O is a premium-quality rust- and oxidation-inhibited turbine oil. It is manufactured from highly refined paraffinic base oils. It contains oxidation, corrosion, and foam inhibitors. The oil has good water separating properties, high oxidationstability, first-rate anti-corrosion properties, and low carbon forming tendency.

Typical Characteristics

ISO Viscosity Grade	32	46	68	100	320
MPID	**219342**	**219343**	**219341**	**219344**	**219940**
Density at 15°C, kg/l	0.88	0.87	0.86	0.88	0.89
Kinematic viscosity at 40°C, mm^2/s	30.4	43.7	64.6	95.0	43.7
Kinematic viscosity at 100°C, mm^2/s	5.2	6.5	8.4	10.8	6.5
Viscosity Index	100	98	99	97	98
Pour point, °C	–15	–15	–15	–15	–15
Flash point COC, °C	220	224	245	215	252
Oxidation (ASTM D 943), hrs to TAN = 2.0 mg KOH/g	3000+	3000+	3000+	5500+	1800+
Rust test, synthetic seawater	PASS	PASS	PASS	PASS	PASS
FZG, Pass Stage, DIN 51354	10	10	10	10	—
Air release @ 50°C, mins	2.1	2.0	3.0	10	—

Recommended Applications

Regal R&O is recommended primarily for use in marine turbines of all types. These include steam, hydraulic and gas turbines. Regal R&O also provides good performance in hydraulic machinery, circulating oil systems, all applications where a high- quality, stable lubricant with good water-separating characteristics is required and non-heavy duty hydraulic systems where OEM recommends R&O type oils (for heavy duty hydraulic systems, customers should consider Rando HDZ hydraulicoil). These products can also be used as a general-purpose machine oil for shop use when R&O type oil is needed or is recommended. The multifunctional characteristics of Regal R&O type oils may allow them to replace other special applicationlubricants, which can result in reduced inventory and operating cost.

Regal R&O Meets The Requirements Of:

- ☑ **Alstom** HTGD 90117
- ☑ **ASTM** D4304
- ☑ **British Standard** 489
- ☑ **DIN** 51515

Regal R&O Is Approved For:

- ☑ **Heisin Pumps** (VG 68)
- ☑ **Regulateur Europa** (VG 68 & VG 100)
- ☑ **IMI Norgen** (VG 46)

Performance Benefits

1. Oxidation Stability

Aims to provide long service life free from deposits, sludge, and acidic oxidation products, thus avoiding sticking valves, and ensuring good bearing protection.

2. Rust Protection

Aims to protect against corrosion or rusting of costly precision parts.

3. Water Separation

Assists with speedy removal of contaminating water fromleaks and condensation.

4. Foam Inhibited

With an effective surface-foam suppressant, it often resists foaming which can generally ensure smooth functioning of governors and minimizes the risk of sump overflow.

5. Air Release Properties

A balanced combination of inhibitors prevents air locking of oil circulating pumps due to entrained air. This often provides smooth and trouble-free operation of lubricatingoil systems.

6. Potential inventory savings

Rust and oxidation inhibited formulation has multipurpose capability in a wide range of industrial applications for which this type of product is recommended, helping to simplify oil inventories and reduce the possibility of usingthe wrong lubricant.

marine lubricants

Regal® SGT 22

Description

Regal® SGT 22 is designed for use in modified aviation type gas turbines in non-aviation stationary applications suchas industrial power generation and marine service. Regal SGT 22 is formulated with synthetic polyol ester base fluids in combination with an advanced additive design offering high temperature system protection and oxidation resistance.

Typical Characteristics

MPID	219420
Acid No., mg KOH/g	0.16
Pour point, °C	–57
Flash point COC, °C	270
Kinematic viscosity at –40°C, mm2/s	9,468.0
Kinematic viscosity at 40°C, mm2/s	25.6
Kinematic viscosity at 100°C, mm2/s	5.12

Recommended Applications

Regal SGT 22 is recommended for aero derivative gas turbines exposed to severe operating environments in non-aviation applications such as industrial power generation, gas transmission and marine propulsion.

Regal SGT 22 Is Approved For:

- **U.S. Military Specification** MIL-PRF-23699G, Class STD
- **General Electric** LM Series Aeroderivitive Turbines
- **Siemens** (Allison) 501K
- **Siemens** (Rolls Royce) Avon, Olympus, Tyne and Spey models
- **Siemens** (Rolls Royce) RB 211 Gas Turbines

Regal SGT 22 Meets The Requirements Of:

- **Turbomeca Makila TL**

Regal® SGT 22 is compatible with other lubricants approved under MIL-PRF-23699G. Regal SGT 22 is compatible with metals, paints, coatings and elastomers such as Viton, Teflon, fluorosilicone, and not to be used in aircraft service Buna N (NBR).

Regal SGT 22 is not recommended for gas turbines that require MIL-PRF-23699F, Class C/I (Corrosion Inhibiting) or HTS (High Thermal Stability). Regal SGT 22 is not to be used in aircraft service.

Performance Benefits

1. Long Service Life

Good oxidation and thermal stability of the synthetic ester base fluid and special additive system helps resist oil breakdown under severe high temperature and high load conditions. The low volatility of the synthetic polyolester helps minimize evaporative losses.

2. Minimal Maintenance and Downtime

Minimal coking tendency of the synthetic ester base fluid and additive system helps minimize deposit formation on bearings and other areas exposed to the heat of the hot gases. High load carrying capacity helps ensure protection against wear. The oil is compatible with normal engine and accessory metallic construction materials and elastomeric sealing compounds.

3. All-Temperature Performance

Viscosity-temperature characteristics of the synthetic ester help promote low temperature fluidity to facilitate starting at low temperatures, while helping to ensure that an effective lubricant film is available under the most severe, high temperature conditions to protect.

Delo® XLC Antifreeze/Coolant – Concentrate

Regional equivalents: Havoline Xtended Life Coolant – Concentrate

Description

Delo® XLC Antifreeze/Coolant – Concentrate (Delo XLC) is a non-nitrited cooling fluid and corrosion inhibitor for combustion engines and heat transfer systems. Delo XLC is an ethylene glycol-based fluid that helps to provide maintenance-free protection against freezing, boiling and corrosion. With patented silicate-free aliphatic acid technology, Delo XLC encourages long-life corrosion protection for all engine metals, including aluminum and ferrous alloys. During extensive fleet testing Delo XLC has proven to provide protection for at least 32.000 hours in stationary engines.

Typical Characteristics

MPID	219900	
Ash content, mass %, ASTM D 1119	1.1	
Nitrate, amine, phosphate, borate, silicate	Nil	
Colour	Orange	
Density at 20°C, kg/l, ASTM D 1122	1.11	
Equilibrium boiling point, °C, ASTM D 1120	172	
Reserve alkalinity (pH 5.5), ASTM D 1121	6.2	
Shelf life of the concentrated product stored in original and unopened containers at the recommended temperature window	8 Years	
	50% Dilution	**33% Dilution**
pH, ASTM D 1287	—	8.3
Foaming properties at 25°C, break time, sec., ASTM D 1881	5	—
Freeze protection, °C	–37	20
Effect on non-metals, GME 60 255	None	None
Staining characteristics, ASTM D 1882	—	None
Hard water stability, VW PV 1426	No precipitate	—

Recommended Applications

Delo XLC provides long-life freeze and corrosion protection. To ensure good corrosion protection it is recommended to use at least 33 volume percent of Delo XLC in solution. Delo XLC may be used in engines manufactured from cast iron, aluminum or a combination of the two metals, and in cooling systems made of aluminum or copper alloys. Delo XLC is compatible with most other ethylene glycol-based cooling water treatments. The use of soft water is preferred for dilution, though lab testing has shown that acceptable corrosion results are still obtained with water of 20°dH, containing not up to 500 ppm chlorides and 500 ppm sulphates.

Delo XLC Is Approved For:

- ☑ **Deutz/MWM** 0199-2091
- ☑ **MAN Diesel** D36 5600 **WinGD**
- ☑ **(formerly Wärtsilä)Rolls-**
- ☑ **Royce** 2.13.01
- ☑ **Wärtsilä Finland** 32-9011
- ☑ **Caterpillar-MaK** A4.05.09.02

Delo XLC Is Suitable For Use In:

- ☑ **Deutz** Stationary Diesel Engines
- ☑ **GE – Jenbacher** Stationary Natural Gas Engines
- ☑ **MTU** 2000/4000 Diesel Engines
- ☑ **Wärtsilä** Stationary Diesel Engines
- ☑ **European HD OEMs** requiring both phosphate-free and nitrite-free formulations
- ☑ **Japanese HD OEMs** requiring silicate-free formulations

Delo XLC Meets The Requirements Of:

- **ASTM** 3306
- **ASTM** D6210
- **DAF** 74002
- **Detroit Diesel** DFS93K217
- **MAN** 324 Type SNF
- **Mercedes Benz** 325.3 under DBL 7700.30
- **MTU** MTL 5048
- **TMC** RP 364

Performance Benefits

1. Corrosion Protection

Provides long-life protection against most forms of corrosion on the majority of all metals including the aluminum heat transfer surfaces contained in modern engines.

2. Cavitation Protection

Offers cavitation protection without using nitrite or nitrite-based supplemental coolant additives (SCAs).

3. Seal Compatibility

Has no adverse effect on rubber hoses and gasket materials as shown in testing a wide range of seal materials.

4. Heat Transfer Efficiency

The carboxylic acid inhibitor forms a targeted mono-molecular protective layer on metal surfaces, thus helping to provide efficient heat transfer.

5. Economics

Corrosion protection and low additive depletion often results in in less maintenance and repair costs.

Chevron

marine lubricants

Delo® XLI Corrosion Inhibitor – Concentrate

Regional equivalents: Havoline XLI

Description

Delo® XLI Corrosion Inhibitor – Concentrate (Delo XLI) is a water-based, low toxicity, readily biodegradable, nitrite-free carboxylate inhibitor package. Based on patented Organic Additive Technology (OAT), Delo XLI provides long-life corrosion protection in aqueous solutions for all engine metals, including aluminum, iron, copper and solder alloys. Mixed with the appro- priate amount of water, Delo XLI is recommended as a cooling water treatment. Delo XLI has been proven to provide effective protection for at least 32,000 hours in marine and stationary applications. It is compatible with glycol-based engine coolants.

Typical Characteristics

MPID	219900
Nitrate, amine, phosphate, borate, silicate	Nil
Colour	Green
Specific gravity, 20°C, kg/l, ASTM D 1122	1.06 Typical
pH, ASTM D 1287	9.4 Typical
Storage stability	12 months if stored in non-opaque containers 36 months if stored in opaque containers
Modified ASTM D1384 glassware corrosion tests	PASS (XLI 5% solution)
	5% Dilution
Specific gravity, 20°C, kg/l, ASTM D 1122	1.00 Typical
pH, ASTM D 1287	8.1 Typical
Effect on non-metals, GME 60 255	No Effect
Hard water stability, VW PV 1426	No Precipitate

Recommended Applications

Delo XLI can be used as an engine cooling water treatment, a flushing fluid, or a hot test fluid for new engine blocks. It isis recommended for cooling water treatment operating below 100°C. For marine application the dosage may vary from 6.0–7.5% but a minimum of 5% volume of Delo XLI in water should be used. As an engine cooling water treatment, Delo XLI provides long-life corrosion protection. If Delo XLI is replenished regularly to compensate for leakage, the cooling water can be considered as fill for life. The use of soft water is preferred for dilution, though lab testing has shown that acceptable corrosion results are still obtained with water of 20°dH, containing not up to 500 ppm chlorides and 500 ppm sulphates.

Delo® XLI Is Suitable For Use In:

- ☑ **Detroit Diesel**
- ☑ **Deutz** TR0199-99-2091
- ☑ **GEC Alsthom Ruston**
- ☑ **Liebherr** MD 1-36-130 (DCA)
- ☑ **MaK**
- ☑ **MAN** 248
- ☑ **MAN Energy Solutions** 2-stroke engines (operating with cooling water temperature below 100°C)
- ☑ **MAN Energy Solutions** 4-stroke engines
- ☑ **MB** 312.0
- ☑ **MTU** 2000 & 4000 series engines
- ☑ **MWM**
- ☑ **Newman-Haas Racing**
- ☑ **Scania** TI 2-98 0813 TB
- ☑ **Ulstein Bergen**
- ☑ **Wärtsilä** 32-9011 and ZBS0503
- ☑ **Yanmar**
- ☑ **Hyundai-Himsen**

Performance Benefits

1. Environment

Delo XLI is based on low toxicity inhibitors and is readily biodegradable. The extended service life characteristic of this product reduces waste due to less frequent fluid disposal. The toxicological and environmental properties of Delo XLI were evaluated by an independent laboratory.

The results are listed below:

- LD50 >2000 mg/kg
  (Oral toxicity according to OECD Guideline No. 401)
- LC50 >1000 mg/l
  (Fish toxicity according to OECD Guideline No. 203)
- Biodegradability: 92% (18 days)
  (Test according to OECD Guideline No. 301E)

2. Corrosion Protection

Provides long-life protection against most forms of corrosion on the majority of metals including the aluminum heat transfer surfaces contained in modern engines.

3. Cavitation Protection

Offers cavitation protection without using nitrite or nitrite-based supplemental coolant additives (SCAs).

4. Seal Compatibility

Has no adverse effect on rubber hoses and gasket materials as shown in testing a wide range of seal materials.

5. Heat Transfer Efficiency

The carboxylic acid inhibitor inhibitor forms a targeted mono-molecular protective layer on metal surfaces, thus providing efficient heat transfer.

6. Economics

Long life corrosion protection and low additive depletion often result in less maintenance and repair costs.

marine lubricants

MCLA

Description

MCLA is an additive package for marine cylinder lubricants.

Typical Characteristics

MPID	219858
Density at 15°C, kg/l, ASTM D4052	1.18
Kinematic viscosity at 100°C, mm^2/s, ASTM D445	86.0
Flash Point COC, °C, ASTM D93	200
Base Number, mg KOH/g, ASTM D2896	400

Recommended Applications

The base number (BN) of the marine cylinder lubricant produced with MCLA should align with the sulphur content of the fuel used. It is important that the additive is mixed with a proper feedstock, to ensure it performs efficiently.

Performance Benefits

1. Wear Protection

Ensures protection against excessive cylinder liner and piston ring wear resulting from the use of bunker fuels containing various levels of sulphur.

2. Detergent/Dispersant Properties

Helps to prevent ring sticking and minimizes deposit formation throughout the combustion chamber exhaust areas.

3. Good Lubrication Properties

Maintains an oil film under severe, high load conditions, therefore reducing frictional wear and preventing scuffingof liners, pistons and rings.

4. Storage Stability

Completely stable at various ambient temperatures and during long-term storage.

5. Compatibility

Miscible and compatible with alkaline diesel cylinder lubricants generally known to the international marine trade.

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lubricant storage, stability, and estimated shelf life

Most lubricating oils and greases deteriorate with time. However, good storage practices promote sufficient stock turnover so that lubricants are used before performance loss occurs.

Storage conditions

The storage environment greatly affects the shelf life of lubricants and greases. The conditions to monitor are:

Temperature: High heat (greater than 45°C) and extreme cold (less than –20°C) can affect lubricant stability. Heat increases the rate of oil oxidation, which can lead to deposit formation and viscosity increase. Cold temperatures can cause wax and possible sediment formation. Additionally, alternating product exposure to heat and cold may draw air into drums, which may result in moisture contamination. A temperature range of –20°C to 45°C is acceptable for storing most lubricating oils and greases. Ideally, the storage temperature range should be from 0°C to 25°C.

Light: Exposure to light can change the color and appearance of lubricants. To prevent this change, keep lubricants in their original metal or plastic containers.

Water: Some lubricant additives may react with water, forming insoluble matter. Water can also promote microbial growth at the oil/water interface. Store lubricants in a dry location, preferably indoors.

Particulate Contamination: Do not store drums and pails in areas where there is a high level of airborne particles. This is especially important when storing a partially used container.

Atmospheric Contamination: Oxygen and carbon dioxide can react with lubricants and affect their viscosity and consistency. Keep lubricant containers sealed until the product is needed.

Storage conditions affecting grease

Grease properties may change during storage depending on thickener type, its concentration, the base fluids and the additives used. One condition that commonly affects greases is:

Oil Separation: Oil naturally separates from most grease. Temperatures in excess of 45°C can accelerate oil separation. If grease is removed from drums or pails, the surface of the remaining grease should be smoothed to prevent oil separation into the cavity.

Recommended storage conditions and practices

- Store lubricating oils and greases in a cool, dry indoor area where airborne particles are at a minimum. Indoor storage also prevents label deterioration and the container from weathering. The ideal storage temperature range is from 0°C to 25°C.
- If drums must be stored outside, apply one of the following options:
  - Store drums on their side or "blocked" into a tilted position, with drum bungs at the three and nine o'clock positions, to allow water to run off.
  - Place a plastic cover on top of the drum to keep the top protected from dust and water.
  - Use other equivalent methods to prevent the ingress of water or dust.

Refrigeration oils and brake fluids are highly sensitive to water contamination and must not be stored outside. Always store grease upright to prevent oil separation.

- When necessary, bring grease to satisfactory dispensing temperature just before it is used.
- Rotate the inventory. Check the container fill date and use the oldest container first.
- Keep containers tightly covered or closed to avoid contamination.
- Wipe off the tops and edges of containers before opening them to avoid contamination.
- Use clean tools and equipment when pumping or handling lubricants and grease.

Products exceeding the estimated shelf life

A product in an unopened container, which is beyond the estimated shelf life, may still be suitable for service.

The product should be tested and evaluated against the original product specifications. Thoroughly mix the container to ensure a uniform, representative sample is taken for testing. If the product's test results fall within the original specifications, it should be suitable for use. Following testing, if the product is not consumed within a year, the product should be marked for reclamation or disposal.

As a final note, the user should validate the product's performance claims against the equipment manufacturer's recent specifications. Equipment designs and specifications can change over time, making an old product obsolete for use with new equipment. Call your local Chevron supplier if there are questions concerning specification obsolescence. ■

Estimated shelf life of base oils, lubricating oils, and greases

Product	Years
Base Oils	5+
Lubricating Oils (mineral or synthetic)	5
Greases (mineral or synthetic)	3
Coolants (general)	5
Known Exceptions:	
Rust Preventatives	2
Open Gear Lubricants	2

marine lubricants information bulletin 2

what about water?

Chevron's FAST™ Service is a comprehensive equipment condition monitoring program which reports the condition of oil in service and plots the trends of important properties, including presence of water.

The used oil report, issued by Chevron's laboratory, lists the test results obtained and includes comments and recommendations on the suitability of the oil for continued service. Each used oil sample is tested for water presence.

Testing the oil

The water content of used lubricating oils can be measured in a number of ways. A simple test for water is the "crackle test." A few drops of oil are placed on an electric hot plate. If the oil starts to bubble and spatter, water is present. This test can detect as little as 0.1% water in the oil. However, the test does not indicate the exact amount of water in the oil.

A rapid and accurate test method for the quantitative measurement of the water content in oil is based on the chemical reaction of water with calcium hydride. The reaction releases a small amount of hydrogen gas, which is captured in a container. The pressure increase in the container is measured and then converted to the amount of water present in the oil sample. Many onboard test kits for water determination are based on this principle.

Test method ASTM D-95 is based on a different principle. For this test, equal volumes of oil sample and diluent solvent are subjected to a distillation test. The water and solvent vapors are condensed in a cooler and the condensed liquid is collected in a trap. The water separates from the solvent at the bottom of the trap because of its higher density. At the end of the test, the total volume of water collected in the trap is recorded and converted to the water content in the oil.

Another well-known test method, which determines very low quantities of water, is ASTM D-6304-04a, or the Karl Fischer method. This procedure can detect water levels as low as 10 mg/kg (ppm). The method is based on a chemical reaction of the water with the Karl Fischer reagent.

Finally, a number of laboratory test methods are based on the use of a centrifuge to separate the water from oil samples.

Origin of water contamination

The water contamination of fresh and used lubricating oils may originate from various sources. Lube oil storage tanks are continuously breathing because of differences between day and night temperatures. During the night, when temperatures are lower than in the daytime, ambient air containing a certain amount of water vapor is drawn into the tank's vapor space. Some of the water vapor will condense on the tank walls. As a result, a significant amount of water may collect at the bottom of a storage tank over time.

Inside a ship, temperatures are more stable because the surrounding seawater temperatures do not greatly vary and engine room temperatures are stable. Condensation has a smaller impact in this case. In-board and double-bottom tanks, however, usually de-aerate toward the deck and seawater can enter through the venting pipes. Therefore, tank vents should be shielded in heavy weather to prevent the ingress of rain or seawater. It is important to regularly check for the presence of water. If a significant amount of water is detected, it should be removed.

In some equipment, free water and/or water vapor is unavoidably generated during operation. Air compressors are very prone to water contamination, because during compression, the water vapor present in the air condenses under certain unfavorable operating conditions. Regular removal of condensed water is of utmost importance to protect the equipment.

Diesel engines produce water vapor during fuel combustion. Under adverse operating conditions this water vapor, and the moisture from humid combustion air, may condense in the crankcase and mix with the oil. Large quantities of water sometimes enter the crankcase from leaking cooling systems.

Another well-known problem area is stern tube seals. Even though most systems are equipped with gravity tanks or pressurized systems, which should keep any water out, it is very common to see water ingress in stern tube systems. Damaged seals usually cause this problem; however, a pumping effect caused by wear grooves in the shaft bushing can also allow water to enter the system.

Why all this attention to water?

Water is the most common contaminant present in used lubricant oil samples. Excessive water contamination over a prolonged period of time eventually leads to equipment failure from the following problems:

- Sludge formation in the oil, followed by possible oil line plugging
- Reaction of the lubricant additives with water that impairs the effectiveness of the additives, which, in extreme cases, may result in precipitation of the additives
- Rusting and corrosion leading to high wear and bearing failures
- Impaired lubrication film from water or steam pockets in heavily loaded bearings
- Formation of emulsions that impede oil purification and lubrication
- Bacterial growth on the water/oil interface leading to corrosion and undesired changes in the lubricating oil characteristics

The nature of water

In some cases, it is very important to know if the ingress of water is pure seawater or fresh water. In many cases when seawater is detected, the vessel will have to be dry-docked.

The nature of water is determined by performing a routine spectrographic element analysis on the oil sample. When water is detected, the amount of sodium (Na) and chlorine (Cl) can be extrapolated and their concentrations in the water phase can be calculated. Sodium chloride (NaCl) is the predominant salt in seawater. Typical deep ocean seawater contains about 55% chlorine (Cl) and 31% sodium (Na).

To determine the nature of water, we must focus is on its chlorine content. Sodium is also present in water cooling treatments and lubricant additives, and sodium content can be influenced by sediments and rocks and fuel-related materials. Based on international studies, water can be subdivided into various salinity levels. Depending on measured chlorine concentration, water can be defined as salt, brackish or fresh, as shown in Table 1.

Table 1: Salinity levels

	mg/l Cl	Nature of Water
Very Fresh	< 110	FRESH
Fresh	+ 110 to 220	
Slightly Fresh	+ 220 to 440	
Rather Fresh	+ 440 to 880	
Slightly Brackish	+ 880 to 1,760	BRACKISH
Brackish	+ 1,760 to 3,520	
Very Brackish	+ 3,520 to 7,040	
Slightly Salt	+ 7,040 to 14,080	SALT
Salt	+ 14,080	

Example: A sample containing 0.5% water and measuring 100 ppm Cl will show a chlorine content of 20,000 ppm in the water phase. This means that the nature of water is "salt".

Determining the nature of water provides valuable information for establishing the source of water ingress, especially in stern tubes, thrusters, or settling and storage tanks. The nature of water is displayed on the FAST™ used oil analysis reports for these systems.

In-service warning limits

The maximum tolerated level of water contamination differs for the various types of equipment being lubricated, kinds of lubricating oils, and operating conditions. Table 2 contains a summary of the warning limits for water contamination of in-service lubricating oil. This information is based on general experience and manufacturer's requirements.

Table 2: Warning limits for water (%)

Equipment	Attention	Urgent
Medium-speed Diesel Engines	0.2	0.5
Slow-speed Engine System Oil	0.2	0.5
Turbo Chargers	0.05	0.5
Turbo Generators	0.05	0.5
Steam Turbines	0.05	0.5
Gear Boxes	0.05	0.5
Hydraulic Systems	0.05	0.5
Air Compressors	0.05	0.5
Refrigeration	0.05	0.5
Compressors	0.01	0.05
Stern Tubes	1.0	3.0

Finally, the best recommendation is to be alert and stop water ingress as soon as possible to keep your oils dry. ■

Chevron

marine lubricants information bulletin 3

elemental analysis

Most laboratories in the oil industry are equipped with an emission spectrometer (ICP-AES or rotating disk spectroscopy), which can be used for analyzing impurities in marine lubricants.

Detection

Analysis techniques using emission spectrometers measure the light energy emitted by metal atoms when subjected to high levels of energy such as heat. All metals emit light of their own specific wavelength. Modern equipment is designed so that up to 20 different elements (i.e., metals) can be detected simultaneously. Lubricating oil samples often have to be diluted with a solvent before they can be tested. Lubricating greases and deposit samples should be ashed, and the resulting ash must be dissolved in water.

Table 1: Common sources of elements in lubricating oil

	Equipment	Cooling system	Environment	Lubricating oil	Grease	Fuel oil
Aluminum (Al)	✔				✔	✔
Antimony (Sb)	✔				✔	
Barium (Ba)		✔		✔	✔	
Boron (B)		✔		✔	✔	
Calcium (Ca)		✔	✔	✔	✔	
Chromium (Cr)	✔	✔				✔
Copper (Cu)	✔					
Iron (Fe)	✔	✔				
Lead (Pb)	✔			✔	✔	
Magnesium (Mg)	✔	✔	✔	✔		
Manganese (Mn)	✔					
Molybdenum (Mo)	✔			✔	✔	
Nickel (Ni)	✔					✔
Phosphorus (P)		✔		✔	✔	
Potassium (K)		✔	✔	✔	✔	
Silicon (Si)			✔			✔
Sodium (Na)		✔	✔	✔	✔	✔
Tin (Sn)	✔					
Vanadium (V)						✔
Zinc (Zn)	✔			✔	✔	

Limitations

Even modern techniques, however, have their limitations. One such limitation is that the origin of the chemical compound containing a particular metal present in the lubricant stays unknown. For example, zinc found in a lubricating oil sample could originate from the equipment as well as from a lubricating oil additive or from a tank coating material. Not all elements detected and reported originate from a single source. To make an educated guess, consult Table 1 when interpreting wear metal analysis.

Another limitation is the maximum particle size of the wear metals and contaminants that can be measured. Not all particles over five microns are detected. Particles over ten microns are not detected at all because these larger particles settle out in the equipment and in the test solutions and are not carried along into the energy source. For an accurate detection of metals in particles larger than five microns, other techniques such as X-ray spectrometry should be used. Normally wear particles range in size up to ten microns. However, excessive wear like piston or bearing seizures generate even larger particles and wear chips. These larger particles, as well as system debris, are often not detected because they may be removed by filters or settle out in places where the oil is stagnant.

Factors to consider

Only a few equipment manufacturers have established maximum limits for wear metals. Those that have only mention a few metals such as iron and copper. This can be expected because manufacturers do not know what kind of oil or grease will be used in their equipment. Therefore, the amount of wear metals is less important than the trending over time. An increase might indicate a change that has to be monitored. Additionally, spare parts installed during repairs may be manufactured with different alloys. Finally, it is important to consider the oil consumption of the equipment involved and, for some applications, purification and treatment of the oil during use.

Interpretation

To make wear metal analysis a useful tool in assessing the oil and/or equipment condition, be sure to monitor the results over a prolonged time period and look for sudden changes. Chevron's FAST™ used oil analysis service offers the possibility to view the four most recent results immediately on the report. Graphical representation is provided for the most important elements: iron and copper. Some types of failures occur so suddenly that metal analysis performed at any practical frequency might not provide an advanced warning. Also, some failures, such as bearing fatigue, can generate large particles that settle out or are removed by filters. The sample, however, will still show normal wear metal results.

Conclusions and possible corrective measures should always be taken based on trend changes in element concentrations in combination with the existing knowledge of the equipment and of the operating conditions onboard. ■

marine lubricants information bulletin 4

base number

Lubricating oils for modern diesel engines are not only designed to provide adequate lubrication under varying temperatures and operating conditions, they also keep the engine clean and provide protection against chemical corrosion from acidic combustion products. These important properties are “added” to the lubricating oil by means of alkaline additives often referred to as detergents and dispersants.

Base Number (BN)

A lubricant’s BN measures its potential to neutralize the acidic products formed during combustion. These products are caused by sulphur in the fuel oil.

The BN is often referred to as “alkalinity.” More specifically, it is the quantity of acid — expressed in terms of the equivalent number of milligrams of the alkaline potassium hydroxide — that is required to neutralize all alkaline constituents in one gram of sample. A BN of 70 for a typical slow-speed engine cylinder oil means that a quantity of acid equivalent to 70 milligrams of potassium hydroxide is required to neutralize the alkaline additives present in one gram of this oil.

Marine fuel oils contain varying amounts of sulphur, which can range from 0.3 to 4.5% by weight. During fuel combustion, the sulphur is oxidized to SO_2 and SO_3. Part of these sulphur oxides combine with water during combustion and form sulphurous and sulphuric acids. These acids are extremely corrosive to engine components and need to be neutralized to prevent corrosive wear. Bases are needed to neutralize acids. This means that oil-soluble bases must be present in lubricating oils used in internal combustion engines.

Oil-soluble bases

The most commonly used basic detergents in these bases are organic soaps and salts of alkaline earth metals such as calcium, barium and magnesium. Calcium and magnesium sulfonates and calcium phenates are widely applied. The trick is to connect an alkaline metal compound such as calcium carbonate, which is not soluble in lubricating oil, to other molecules so that the new compound is oil soluble and can neutralize acids without creating harmful side effects. Oil-soluble bases, such as calcium sulfonate and calcium phenate, are also excellent deposit control additives.

The most critical areas for deposit formation in diesel engines are the piston crown and ring area. Excessive deposit formation on the piston crown may cause bore polishing, whereas deposits building up in the piston ring area may result in ring sticking. These deposits cause improper sealing of the combustion chamber and result in loss of compression, blowby, loss of oil control, increased wear and subsequent problems. The deposits formed on the piston are a mixture of soot and ash. Soot originates from the incomplete combustion of hydrocarbons, and ash contains those components that cannot be further oxidized. These combustion by-products are not oil soluble.

To protect against deposit formation, the substances must be prevented from forming or the particles formed must be kept very small and be dispersed in oil to be removed, for example, through the centrifugal filter or separator or when the oil is drained. The oil-soluble bases, such as calcium sulfonates and calcium phenates, prevent the particles from coagulating and keep them in suspension.

Selecting the correct BN for a diesel engine lubricant depends on various factors such as engine design, specific application in the engine, and sulphur content of the fuel. The type of fuel applied also plays a major role in this decision.

Slow-speed engine cylinder lubricants

Slow-speed engine cylinder oils, used for once-through lubrication of cylinders and liners, must have a high BN to manage the acids formed during combustion of the heavy fuel oils burned in these engines. The engines sometimes have extremely large bores and long strokes and the surface to protect is huge. Therefore, sufficient alkalinity must be available close to the oil quill as well as far below.

The amount of alkalinity introduced in the combustion chamber is directly linked with the oil feed rate and the BN of the applied cylinder oil. The amount of sulphuric acid generated from the combustion process is directly linked to the sulphur content in the fuel and the engine load. It is important to maintain a correct balance between them. Excess alkalinity may potentially cause deposit formation, whereas a shortage in alkalinity leads to excessive corrosion. In a correctly balanced system, corrosion is controlled rather than prevented, preserving a proper liner surface structure, which allows a strong oil film to build up.

Engines operating continuously with heavy fuel oil with high sulphur content (> 2%wt) typically use 70 BN products. However, engines operating continuously with low sulphur content heavy fuel oil (< 1%wt) typically use a 40 BN cylinder oil. These are only guidelines; for specific cases, please refer to the engine manufacturer's documents.

Slow-speed engine system oils

Slow-speed engine system oils, used in engines with oil cooled pistons, must possess some degree of detergency/dispersancy to ensure clean crankcase and piston interiors. A moderate alkalinity level in the oil also neutralizes the acidic combustion products that may leak into the crankcase through the stuffing box seals. The average BN levels for fresh system oils range from five to ten.

There are no minimum limits set for the BN of used slow-speed engine system oils. It is normal to see the BN of these oils increase over time from the ingress of used cylinder oil. However, a sudden increase in BN may indicate severe leakage through the stuffing box seals.

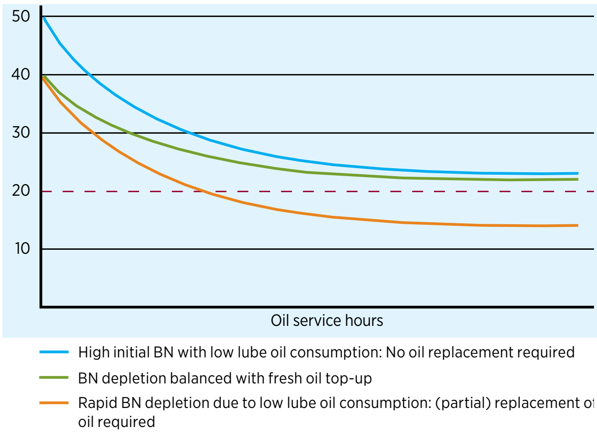
Medium-speed engine lubricants

Medium-speed engine oils, used for the lubrication of cylinders, liners, and bearings, are available with various BN levels. The BN requirements are specified by the engine manufacturer.

Table 1 presents a summary of typical BN requirements for medium-speed engines shown by function of the applied type of fuel and its sulphur content. The information in this table should only be used as a guideline. For specific cases, please refer to the engine manufacturer's documents.

Oil consumption is an important factor to consider when selecting the appropriate BN level of a lubricant. Lube oil in low-consuming engines depletes faster because less BN is topped-up during operation. Examples of typical medium-speed engine BN depletion curves are shown in Figure 1.

Figure 1: BN depletion of medium-speed engines



Other features in engine design also play roles in the selection of the appropriate BN level. An engine equipped with bore polishing rings can use higher BN oil because the deposit buildup on the piston is mechanically limited.

Many engine manufacturers specify the minimum required BN level of the oil in service in relation to the fuel in use. Their limits should be considered when judging used oil analysis results. As guideline, the BN of used diesel engine oil should be greater than 50% of the fresh oil value. ■

Table 1: Base number requirement guidelines — medium-speed engine oils

Fuel type	Sulphur, mass %	Fresh Oil BN
Gas Oil	< 0.5	5 – 15
Marine Diesel Oil	0.5 – 1.8	10 – 20
Intermediate Fuel Oil	1.0 – 3.0	15 – 30
Heavy Fuel Oil	0.3 – 3.0	20 – 40
Heavy Fuel Oil	> 3.0	30 – 60

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marine lubricants information bulletin 5

cleanliness of hydraulic oils

The hydraulic systems onboard every vessel range from small systems for operating the engine room skylight to huge central systems to operate cargo pumps, deck machinery, and steering gears. Common in these systems is the hydraulic oil used to transport “fluid power” to the equipment.

Characteristics of hydraulic oils

Along with transporting “fluid power,“ hydraulic oil must adequately lubricate the moving parts, such as the pumps, motors, and valves, present in hydraulic systems.

A critical property of a hydraulic fluid is its viscosity. Low internal friction is desirable, and an oil with a low viscosity at the system operating temperature is usually recommended. However, each hydraulic system has individual viscosity requirements based on the requirements of the hydraulic pump.

Other important characteristics of hydraulic oils are:

Oxidation Stability: Enables operation of the oil during long periods of time, even under severe conditions

Rust Prevention: Protects vital system parts against corrosion in the presence of water

Demulsibility: Rapidly separates any water from the oil

Anti-wear: Provides adequate lubrication of moving parts, even under boundary lubrication conditions

Air Release: Readily releases entrained air

Anti-foam: Prevents buildup of a stable foam layer, especially in the reservoir

Low Pour Point: Permits low temperature operations

High Viscosity Index: Minimizes viscosity changes with temperature and allows a wider operating temperature range

Oil cleanliness

Taking care of the oil in the system will prevent the untimely replacement of the oil, save considerable costs, and protect the hydraulic equipment. Selecting the proper viscosity grade is best done in cooperation with the equipment manufacturer and the lubricant supplier.

New systems often need to be flushed before entering service to remove the system debris accumulated during construction and the oil-soluble rust preventatives applied onsite. If flushing is prescribed, do not overlook or take shortcuts in the procedure because system debris may result in pump failures within a very short operating time. Additionally, oil-soluble rust preventatives negate some hydraulic oil characteristics such as foam, air release, and demulsibility properties.

After commissioning, hydraulic systems must be checked on a regular basis for the presence of water, especially in the oil reservoir. A considerable amount of water can accumulate there from the air-breathing action that occurs in varying temperatures. Free water should be thoroughly drained to avoid the buildup of a water bottom, which can result in corrosion, sludge formation, and, possibly the hydrolysis of the oil’s additive components. Also, hydraulic oils must be kept as clean as possible before and during use.

It can safely be stated that the cleaner the oil, the longer the system will function. Not only do large, hard particles cause detrimental effects, such as abrasive wear leading to pump failures, but the buildup of small, soft particles (silt) eventually results in pump wear or valve sticking.

To avoid the buildup of particulate matter in hydraulic systems, most systems are equipped with filters to protect vital components from damage by particulate matter. These filters should be serviced and/or changed frequently in accordance with the manufacturer's instructions. Using dirty or malfunctioning filters results in undesirable system wear. Small systems, without filters, require more frequent oil changes to avoid the buildup of particulate matter and provide prolonged equipment life.

Monitoring hydraulic oil cleanliness

The cleanliness of the hydraulic oils in use must be monitored on a regular basis. Large systems should be sampled once a year to monitor the oil condition and contamination level, and the basic properties to check are: viscosity, water content, and amount of particulate matter.

There are several methods available to establish the amount of particulate matter present in hydraulic oils: gravimetric analysis for particulate matter (filter residue), microscopic examination (sizing and counting of particles) of filter residues, and automatic particle counting in a representative oil sample.

Some generally accepted warning limits for contamination levels are shown in Table 1.

The following particle count limits are generally accepted for high-pressure systems:

NAS 1638 Class: 8 or 9
ISO Code: 16/12

Seventy-five percent of hydraulic system failures are related to particulate matter contamination of the hydraulic oil. Contact your Chevron marine sales representative for detailed information about our line of hydraulic oils. ■

Table 1: Warning limits for contamination levels

Filter residue (using 0.8-micron membrane filters)	
0 – 50 mg/kg	Oil is clean
50 – 150 mg/kg	Oil is generally acceptable
150 – 300 mg/kg	Oil is suspect; filters need to be changed; monitoring recommended
300 – 400 mg/kg	Oil is heavily contaminated and should be severely filtered
Above 400 mg/kg	Oil is heavily contaminated and should be replaced
High-pressure system (above 70 bar) limits	
0 – 30 mg/kg	Oil is clean
30 – 100 mg/kg	Oil is suspect; filters should be changed; monitoring recommended
Above 100 mg/kg	Particulate matter content is too high. Oil should be changed unless the amount of particulate matter can be rapidly reduced by filtration.

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marine lubricants information bulletin 6

viscosity classifications

The first and most important task of lubricating oil is to keep moving metal parts separated from each other, thus avoiding metal-to-metal contact, which leads to destructive wear. Even finely machined metal surfaces have a certain roughness.

Contact of these minute metal projections should be minimized; however, some contact always occurs and results in normal wear of the metal surfaces. If contact is not minimized, heat is generated when the metal parts touch. The heat causes local welding and transfer of metal, which creates scuffing or seizing of the equipment. These actions are called adhesive wear. The oil property that governs the thickness of the separating oil film is the viscosity.

Viscosity

The commonly used kinematic viscosity is defined as a measure of the restrictive flow of a fluid under gravitational force. The "cgs" unit of kinematic viscosity (one centimeter squared per second), is called one stoke (St). The SI unit for kinematic viscosity is one meter squared per second and is equivalent to 10,000 St. Usually, centistokes (cSt) is used (1 cSt = 0.01 St = 1 mm^2/s).

The absolute or dynamic viscosity is equal to the kinematic viscosity, multiplied by the density of the fluid. It is usually expressed in centipoise (cP) (1 cP = 0.001 Pa.s).

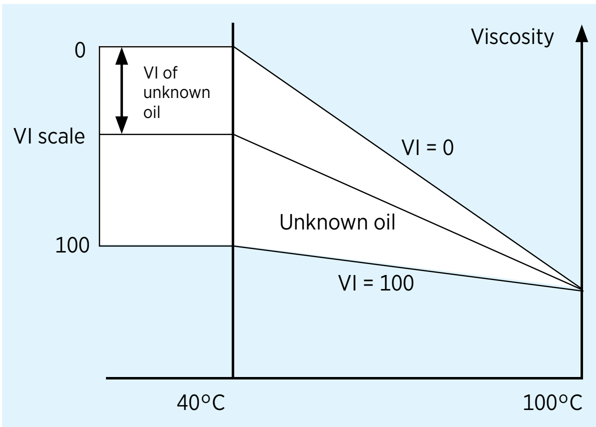
Viscosity index (VI)

The viscosity of lubricating oil changes with temperature and the rate of change depends on the composition of the oil. Naphthenic base oils change more than paraffinic base oils. Certain synthetic lubricants change much less than paraffinic oils.

To assess this lubricating oil property, the American Society for Testing and Materials (ASTM) created a method to provide a number called the Viscosity Index (VI). The VI correlates the amount of viscosity change for a given oil, compared to two reference oils having the highest and lowest viscosity indices at the time the VI scale was first introduced (1929). A standard paraffinic oil was given a VI of 100 and a standard naphthenic oil a VI of 0.

Figure 1 shows the relationship between viscosities at 40°C and 100°C. The method has been updated and revised several times to include VI values higher than 100.

Figure 1: Schematic Representation of Viscosity Index



A low VI means a relatively large viscosity change with temperature and a high VI denotes a smaller change of viscosity with temperature. Hence, the VI of an oil is important in applications where an appreciable change in temperature of the lubricating oil could affect the startup or operating characteristics of the equipment. Deck machinery and emergency equipment are examples of typical applications onboard ships.

Viscosity classification

As the selection of the proper viscosity grade is extremely important, various viscosity classification systems have been developed over the years. The viscosity classification for engine oils was developed by the Society for Automotive Engineers (SAE) in 1911. After many revisions and updates, this classification system is still in place.

The current SAE J300 Viscosity Classification is shown on the next page in Table 1. SAE grades 0W through 25W, where W stands for winter, have a maximum viscosity specified at low temperatures (–5°C through –35°C), to ensure easy starting under low temperature conditions, and a minimum viscosity requirement at 100°C to ensure satisfactory lubrication at the final operating temperature. Only SAE grades 20W through 60W have limits set at 100°C, because these grades are not intended to be used in low temperature conditions.

For marine applications, monograde oils (i.e., oils without the addition of VI improvers of SAE 30 or SAE 40) are used because of the steady operating conditions in a ship's engine room.

Conversely, automotive oils are normally formulated by adding VI improvers to provide multigrade performance and thus deliver excellent temperature/viscosity relations. VI improvers are very large molecules, which are chemically made by linking together smaller molecules into so-called polymers. The use of these special polymers makes it possible to meet the low temperature viscosity requirements of the W grades, as well as the high temperature requirements of the non-W grades. In a 15W-40 multigrade engine oil, the typical viscosities are:

Viscosity at –15°C, cP	3,000
Viscosity at 40°C, mm^2/s (cSt)	105
Viscosity at 100°C, mm^2/s (cSt)	14
Viscosity Index	135

This example shows that the high VI offers a relatively small change in viscosity with temperature, and, as a result of the high VI, the multigrade oil meets the 15W grade low temperature viscosity requirements, as well as the 40 grade high temperature viscosity requirements.

Viscosity classification: industrial oils

Many different viscosity classification systems have been used in the past in different parts of the world. It has been difficult to reach agreement on the number of different grades to be included, the viscosity limits for these grades, and the temperature at which the viscosity should be specified. It is only since 1972 that a worldwide viscosity classification system for industrial lubricants came into place.

The current ISO 3448 viscosity classification system, which is also adopted by the ASTM, is shown on the next page in Table 2. The classification is based on a series of viscosity grades, each being approximately 50% more viscous than its preceding grade, while the viscosity deviation within a grade is plus or minus 10% of the nominal viscosity of that grade.

Used oil viscosities

The viscosity is determined on every oil sample tested in Chevron's FAST™ used oil analysis service. Used lubricating oils may show an increase of the viscosity because of oxidation/nitration or contamination such as the soot loading of a diesel engine oil. Dilution with high viscosity heavy fuel oil or the use of a higher viscosity grade lubricant are other possible causes.

A viscosity decrease of a used lubricating oil may be related to the use of a lower viscosity grade lubricant or dilution with low viscosity fuel oil. Viscosity results of used lubricating oil samples are compared to the original equipment manufacturer's (OEM's) requirements whenever possible. If this is not feasible, the generally accepted limit for viscosity change is ±15% of the fresh oil value at 40°C. For large diesel engines, an increase of the engine oil's kinematic viscosity at 40°C up to 45% is still accepted. ■

Table 1: Engine oil viscosity classification — SAE J300 revised May 2004

SAE viscosity grade	Low-temperature (°C) cranking viscosity[2], mPa.s max.	Low-temperature (°C) pumping viscosity[3] mPa.s max. with no yield stress	Low-shear-rate kinematic viscosity[4] (mm^2/s) at 100°C min.	Low-shear-rate kinematic viscosity[5] (mm^2/s) at 100°C max.	High-shear-rate viscosity (mPa.s) at 150°C and $10^6 s^{-1}$ min.
0 W	6,200 at –35	60,000 at –40	3.8	—	—
5 W	6,600 at –30	60,000 at –35	3.8	—	—
10 W	7,000 at –25	60,000 at –30	4.1	—	—
15 W	7,000 at –20	60,000 at –25	5.6	—	—
20 W	9,500 at –15	60,000 at –20	5.6	—	—
25 W	13,000 at –10	60,000 at –15	9.3	—	—
20	—	—	5.6	< 9.3	2.6
30	—	—	9.3	< 12.5	2.9
40	—	—	12.5	< 16.3	2.9 (0W-40, 5W-50, and 10W-40 grades)
40	—	—	12.5	< 16.3	3.7 (15W-40, 20W-40, 25W-40, 40 grades)
50	—	—	16.3	< 21.9	3.7
60	—	—	21.9	< 26.1	3.7

1. mPa.s = 1cP; 1 mm^2/s = 1 cSt. All values are critical specifications as defined by ASTM D 3244.
2. ASTM D 5293
3. ASTM D 4684 Note: The presence of any yield stress detectable by this method constitutes a failure regardless of viscosity.
4. ASTM D 445
5. ASTM D 4683, CEC L-36-A-90 (ASTM D 4741)

Table 2: Industrial lubricant viscosity classification

Viscosity system grade ISO standard 3448 ASTM D 2422	Mid-point viscosity, mm^2/s (cSt), at 40°C	Kinematic viscosity limits, mm^2/s (cSt), at 40°C	
		Min	Max
ISO VG 2	2.2	1.98	2.42
ISO VG 3	3.2	2.88	3.52
ISO VG 5	4.6	4.14	5.06
ISO VG 7	6.8	6.12	7.48
ISO VG 10	10	9.00	11.0
ISO VG 15	15	13.5	16.5
ISO VG 22	22	19.8	24.2
ISO VG 32	32	28.8	35.2
ISO VG 46	46	41.4	50.6
ISO VG 68	68	61.2	74.8
ISO VG 100	100	90.0	110
ISO VG 150	150	135	165
ISO VG 220	220	198	242
ISO VG 320	320	288	352
ISO VG 460	460	414	506
ISO VG 680	680	612	748
ISO VG 1000	1,000	900	1,100
ISO VG 1500	1,500	1,300	1,650

marine lubricants information bulletin 7

lubricant compatibility

Often when switching from one supplier to another, the question arises whether lubricants in use and in storage can safely be mixed with lubricants from the new supplier. Some oils are incompatible because of differences in additive chemistry. If these oils are mixed, insoluble material may form and be deposited in the oil system.

There have been cases where grease-like substances plugged lines and filters in circulating systems, resulting in equipment shutdown. Analysis of these substances showed that they were derived from oil additives. Incompatibility can exist between two different Chevron products or between a Chevron product and that of a competitor.

Cause of incompatibility

In rare cases, an adverse reaction may occur between two oils at certain working conditions in a system. Most often the cause of incompatibility is the neutralization of an acidic additive in one oil by an alkaline additive in the other oil.

During the reaction, a soap forms (usually a calcium soap) that can precipitate a grease-like gel that interferes with lubrication and oil flow. However, mixed oils may not always lead to incompatibility issues. They can exist without precipitation or reaction in an operating system for an indefinite period, provided no water is present.

Incompatibility reactions are not reversible. Removing water by drying the system and the oil does not remove the formed gel or eliminate the soap.

Chevron product compatibility

Chevron products containing acidic additives are classified in List A of Table 1 (see next page). Products shown in List B of the table contain alkaline additives. The products in both lists are compatible with other products in the same list; however, products in List A are not compatible with products in List B and visa versa.

Products shown in List C contain no acidic or alkaline additives and are compatible with the products shown in both Lists A and B.

Changing from alkaline to acidic

Small amounts of the alkaline-type compounding from the oils in List B mixed with the oils in List A can cause:

- Stable emulsions to form when water contamination occurs
- Grease-like, oil insoluble deposits that may block filters and small oil passages

For example, the last effect is a concern in a turbo charger system where Regal® R&O or Cetus® PAO replaces an engine oil. This incompatibility can be prevented by flushing the circulating system thoroughly with a straight mineral oil.

Table 1: Compatibility lists

LIST A	LIST B	LIST C
Oils containing acidic additives	**Oils containing alkaline additives**	**Oils not containing either**
Regal® R&O	Taro® DP/XL	Compressor Oil EP VDL
Regal EP	Taro Special HT 70	Capella® WF
Rando® HDZ	Taro Special HT LS 40	Capella HFC 55
Meropa®	Veritas® 800 Marine	Refrigeration Oil Low Temp
Pinnacle® Marine Gear 220	Delo® 1000 Marine	LPG Compressor Oil
Cetus® PAO	Ursa® Marine	Uncompounded (steam) cylinder oils
Cetus DE	Delo 6170 CFO	—
Compounded stern tube oils	Ursa Extra Duty 40	—
Texatherm® 46	Delo SHP	—

The flushing procedure will dilute the concentration of the alkaline compound to below 10 ppm of calcium in the final operating charge of oil. This requires at least one 100% volume flush with the straight mineral oil after the alkaline oil is drained from the system. Only one full system flush is required if the holdup of oil in the system after draining can be verified to be less than 3% of the system capacity.

Changing from acidic to alkaline

The amount of acidic material that reacts with alkaline compounds in change is so small that the volume of precipitate is negligible. Furthermore, the alkaline compounds are detergents, and therefore can keep a small amount of reaction material in suspension. Therefore, changing an oil system from oils in List A to oils in List B does not ordinarily require intermediate flushing. However, in all cases where the type of oil is changed, the system should be completely drained.

Chevron lubricants with competitive products

Chevron lubricants are fully compatible with equivalent competitive lubricants recommended for the same application.

For example, all Chevron two-stroke cylinder oils such as Taro Special HT 70 are fully compatible with the equivalent cylinder oils marketed by ExxonMobil, BPCastrol, etc. The same is applicable to medium-speed engine oils, hydraulic oils, turbine oils and gear oils from various companies.

This implies that the oils in use can safely be topped up with the recommended Chevron lubricants, provided that the normal top-up procedures are being followed (not more than 10% fresh oil added at a time). Unused equivalent lubricant from different suppliers, as shown in vessel lube charts, can normally be mixed in any ratio.

However, it is important to note that compatibility problems may occur when different types of oils from one or more suppliers are mixed. For example, if a hydraulic oil is mixed with a medium-speed engine oil from a different supplier, it can be expected that in the presence of some water, insoluble reaction products will form. These kinds of product mixtures should always be avoided.

Synthetics

In general, product mixtures of various synthetic lubricants should always be avoided, because various types of synthetics are not always compatible.

The compatibility of some common types of synthetic lubricants with mineral oil based lubricants is listed below.

Synthetic Lubricant Type	Compatibility with Mineral Oil
Alkylbenzenes	Excellent
Polyalphaolefins	Excellent
Diesters	Good
Polyglycols	Poor
Phosphate Esters	Fair
Polyolesters	Fair

Summary

- Equivalent products from various suppliers can be mixed without problem.
- Mixing different types of products from the same or different suppliers should be avoided.
- Product mixtures of various types of synthetic products should always be avoided. ■

marine lubricants information bulletin 8

synthetic oils

Mineral base oil and synthetic lubricants are widely available, especially those used in industrial lubrication applications, and they have many applications onboard ships. It is important to select the right lubricant for your hydraulic system.

Mineral base oils

These oils are mixtures of a wide range of hydrocarbons. They are derived from crude oils by distillation, solvent extraction, and hydro-finishing/cracking processes.

Mineral-oil based lubricants are blends of mineral base oils with additives to enhance or introduce specifically desired properties to the oil or suppress certain undesired characteristics.

Mineral-oil based lubricants, widely available at low to moderate prices throughout the world, provide satisfactory lubrication for most applications onboard ships. However, in specific conditions, such as some “filled-for-life” systems or under extremely demanding operating conditions, mineral-oil based lubricants can fail and synthetic-based lubricants should be considered.

Synthetic base oils

Historically, special purpose demands triggered the development of synthetic lubricants. For example, conventional mineral-oil based lubricants could not meet extreme low- (Arctic) or high-temperature operations and fire resistance requirements. Synthetic base oils, a complex mixture of hydrocarbons, are the result of a carefully controlled chemical reaction process that produces a “pure” chemical of pre-selected composition. This reaction process produces an unlimited variety of products.

Many synthetic-based lubricants are formulated with additives similar to those in mineral-oil based lubricants. However, some synthetics require newly developed additives. This is true of the fully formulated lubricants for internal combustion engines and heavy-duty gear cases. Various types of synthetic-based oils used to formulate synthetic lubricants have certain advantages over conventional mineral-oil based products. These advantages are:

- Low pour point
- Low volatility
- Low toxicity
- High viscosity index
- High oxidation stability
- High flash and fire points

Some pros and cons

Although synthetic lubricants are more expensive than mineral-oil based products, they offer operating or performance advantages that decrease operating costs. For example, synthetic lubricant is the preferred choice for lubricating cargo gas compressors that compress various gases. Mineral base oils can only be used with a limited number of these gases. However, synthetic oils, based on polyalkylene glycol, can be used with many of the gases shipped today.

Synthetic-based oils have a longer service life in addition to their extended overhaul periods. When used in air compressors, turbo chargers, and gear applications, synthetic-based oils may be more economical. For some systems, outside contamination (by water and/or dirt) and not lubricant breakdown may cause frequent oil changes. Using synthetic oils in these systems increases rather than decreases costs.

Synthetic lubricants are the best choice to use in extremely low- (Arctic) or high-operating temperatures. Some modern heavy fuel oil purifiers are located in special purifier rooms and work under extreme high-temperature conditions. Using synthetic gear oil for this application will extend the life of the equipment.

Not all synthetics and mineral oils are fully compatible; changing from synthetic base oil to mineral base oil can create potential problems. Systems must be drained and flushed when changing from one type of oil to another.

Seal compatibility issues can create another possible problem. Equipment seals selected for operation with mineral oils can show unexpected swelling or hardening with certain types of synthetic oils and visa versa. Your equipment manufacturer can help you avoid these problems.

Our conventional mineral-oil based lubricants, formulated with state-of-the-art additives, provide adequate lubrication for the majority of equipment installed onboard ships. However, for some specific applications, synthetic lubricants offer better performance that cannot be achieved by mineral oils.

Some synthetic lubricant products are already available in specific areas. These products are:

LPG Compressor Oil: A polyalkylene-glycol-based lubricant specifically developed for enclosed hydrocarbon and gas compressors, such as Sulzer-Burckhart “K” gas compressors.

Cetus® PAO 46 and 68: These polyalphaolefin compressor oils are used in rotary vane and screw-type air compressors and turbochargers.

Cetus® DE 100: A compressor oil, formulated with diesters, used in reciprocating (starting) air compressors.

Pinnacle® Marine Gear: A gear lubricant that is a mixture of polyalphaolefins and diesters. We recommend using this on enclosed gears operating at extreme temperatures or under severe conditions.

Ulti-Plex® Synthetic Grease EP: A high-temperature grease, composed of a lithium-complex thickener and synthetic-based oil, designed for the most extreme temperature environments and for applications that require extended re-lubrication intervals.

Capella® HFC 32, 55 and 100: Refrigerating compressor oils, formulated with polyolesters, intended for systems charged with chlorine-free refrigerants. ■

Synthetic lubricants: Advantages compared to mineral oils

Synthetic Base Type	Main Advantages	Applications
Alkylbenzenes	Low temperature performance	(Refrigeration) compressor oils mineral oil-like solvency
Polyalphaolefins	Wide temperature performance range, low volatility	Engine oils, gear oils, hydraulic oils, air compressor oils
Diesters	Wide temperature performance range, low volatility	Gas turbine oils, air compressor oils, hydraulic oils
Phosphate Esters	Fire resistance	Fire-resistant hydraulic fluids
Polyalkylene Glycols	Wide temperature performance range, hydrolytic stability, frictional properties	Gas compressor oil, gear oils
Polyolesters	Wide temperature performance range, low pour point	Jet engine oils, refrigeration compressor oils (chlorine-free refrigerants)

Chevron

marine lubricants information bulletin 9

wire rope lubrication

Vessel lubrication charts often list products suitable for general lubrication onboard a ship. One product frequently listed is a lubricant used to protect steel wire ropes.

Steel wire rope construction

A steel wire rope is made of individual wires that are twisted together to form strands. The strands are wrapped around a core to create a final rope.

The core of a wire rope can be made of different types of material such as hemp, nylon, plastic, or another strand of wires. The selection of core material, number of wires per strand, number of strands, and the way the wires are twisted and strands are laid, depends on the rope's required strength, application, and cost.

Working environment

Wire ropes are usually used in less than ideal conditions. There are some applications, such as on an engine room crane or an elevator, which are not considered severe. However, most wire ropes are used on deck where they are exposed to corrosive seawater and varying ambient and working temperatures.

When in use, wire rope is subject to heavy loads, high pressures, and surface wear. The rope is also exposed to changing loads and pressures that cause the strands to move within the rope and result in internal wear. These unfavorable conditions can cause premature failure if the rope is not properly relubricated.

Lubrication requirements

Lubrication protects the wires of the rope against corrosion and minimizes external and internal wear. To provide this protection, a lubricant must have some very specific characteristics.

The basic requirements for lubricants are listed in the ISO 4346 standard Steel Wire Ropes for General Purposes – Lubricants – Basic Requirements.

To meet these requirements, a lubricant must:

- Have good covering properties
- Be water-repellent, water-resistant, and not emulsifiable
- Not be subject to significant embrittlement
- Not have grit, abrasives, water, chlorine, or similar impurities
- Not contain additives or compounds, which can form corrosive products caused by water contamination or additive degradation

In addition, the lubricant must be able to penetrate into the core of the wire rope.

Relubrication practices

Wire ropes are initially lubricated during manufacturing. This lubrication protects the rope from corrosion during transportation and storage and reduces friction and wear during its initial use. However, the initial lubricant does not last. Relubrication is required because the lubricant works out of the rope or dries out after a certain period of use.

To obtain maximum service life, ropes should be relubricated at regular intervals These intervals are dictated by various factors, such as the type of lubricant used, rope storage conditions, and method and frequency of use.

There are several techniques for relubrication; the most common are “painting” and “swabbing.” These techniques, however, rarely penetrate the lubricant down to the core of the rope. Using a high-pressure lubricator is preferred, because it provides good penetration of the lubricant into the rope. The degree of penetration achievable with any technique also depends on the type of lubricant used.

Lubricant types

Several types of lubricants, using various methods of application, are available on the market.

“Asphaltic” products, the most commonly used lubricants, are manufactured from very high-viscosity residual lubricants. These products often contain a nonflammable solvent for easy application and better penetration into the wire rope. They can be applied by brush, swabs, or spray guns, but cannot be used in high-pressure lubricators. Asphaltic-type products that do not contain a diluent solvent require heating. The resulting tacky coating sometimes shows “dripping” problems in hot areas or becomes brittle under low-temperature conditions.

Another group of available lubricants is based on paraffin wax, with or without a solvent. Products without solvents must be melted before application. These products are generally applied by brush or swab.

Additionally, there are many types of greases on the market. Some of them are excellent at lubricating wire ropes, depending on composition and method of application.

State-of-the-art relubrication

To sustain the life of wire rope, it is necessary to properly relubricate them at regular intervals. Rope tests show that the service life of a regularly relubricated wire rope is two to three times longer than that of a dry rope. Modern high-pressure lubricators, together with the latest technology lubricants, provide state-of-the-art relubrication and maintenance for wire ropes.

Before lubrication, a rope must be cleaned with wire brushes, a scraper, compressed air, or superheated steam. Old layers of lubricant and dirt may need to be removed from the rope by using a suitable solvent.

For wire rope relubrication, we recommend using **Ulti-Plex® Synthetic Grease EP** in high-pressure lubricators. This high-performance, multipurpose grease is manufactured from high-viscosity synthetic-based oils and a lithium-complex thickener with special rust and oxidation inhibitors and extreme pressure and tackiness additives.

The rust and corrosion inhibition and superior water wash-out resistance make this lubricant ideal for this application.

For application by brush or swab, **Rustproof Compound L** is recommended. This petrolatum-type product contains a nonflammable solvent for easy application. Detailed product information can be obtained from your Chevron marine sales representative. ■

marine lubricants information bulletin 10

cetus® DE 100 application guidelines

Cetus® DE 100 is a synthetic lubricant used to lubricate piston air compressors. It is formulated with diester-based fluid and exhibits a high degree of inherent detergency that keeps compressor parts clean and in service. The lubricant is miscible with nondetergent mineral or PAO-based compressor oils, such as Chevron's Compressor Oil EP VDL or Cetus PAO synthetic compressor oil.

Application guidelines

Cetus® DE 100's good solvency keeps components clean; however, its use requires these precautions:

- Make sure that all compressor components in contact with the lubricant are as clean as possible before changing lubricant products. Carbonaceous deposits from petroleum oils previously used may be loosened and dislodged by the detergent-cleaning action of Cetus DE 100.
- Change filter elements as required.
- Monitor oil pressure drop across the filters after changing to Cetus DE 100. It is important to follow the compressor manufacturer's recommended procedure when changing oils.

Changing oils

Reciprocating compressors (cylinder and crankcase lubrication change over)

1. Drain mineral oil from the compressor and inspect its internal condition.
2. Remove the cylinder heads and side covers from the compressor, and inspect the pistons, intake and discharge valves. If they are covered by carbon and/or heavy deposits, remove and clean them.
3. Remove deposits from the crankcase housing and/or any accessible air passageways when inspecting or cleaning the valves.
4. Blow out all accessible oil pipes. If possible, run Cetus DE 100 lubricant through the lube lines into a suitable container. Five to ten minutes of flow should flush old mineral oil deposits. The flushing oil can be used for further cleaning purposes if it is not too heavily contaminated.
5. Drain and clean the downstream filters and separators.
6. Start the compressor, using the same lubrication rate as used with the previous lubricant, after completing the inspection and cleanup. Because of the extremely low volatility of Cetus DE 100 synthetic lubricant and its good metal-wetting properties, the volume of oil required to maintain good lubrication is often less than that of other oils. To determine the optimum rate for these ester-based oils, inspect a cylinder wall after operation and adjust the rate so that the walls are wet.
7. Periodically inspect the downstream filters, separators, and air flow passages for sludge from portions of the compressor which were not cleaned. Cetus DE 100 synthetic lubricant removes deposits from inaccessible oil lines and passages, which may reduce filter efficiency.

Rotary compressors

1. Drain all mineral oil from the unit. For best results, drain the unit when it is warm.
2. Open the manual condensate drain valve and drain all liquid.
3. Remove the pipe plug from the bottom of the separator/receiver tank and drain all liquid.
4. Remove the pipe plug from the bottom of the oil cooler and drain completely.
5. Clean the oil filter completely or replace it.
6. Disconnect all oil piping that could trap oil and drain the pipes. If possible, run Cetus® DE 100 lubricant through lube lines into a suitable container. Five to ten minutes of flow should flush old mineral oil deposits. The flushing oil can be used for further cleaning purposes if it is not too heavily contaminated.
7. Start the compressor after completing the inspection and cleanup.
8. Periodically inspect the downstream filters, separators, and air flow passages for sludge from portions of the compressor which were not cleaned. Cetus DE 100 synthetic lubricant removes deposits from inaccessible oil lines and passages, which may reduce filter efficiency and require an earlier change.

To minimize the requirement for periodic inspections, follow the compressor manufacturer's recommended procedures for the thorough cleaning of all valves, air passages, intercoolers, and separators. Some compressor manufacturers recommend using mineral solvents to clean compressors. Only use this type of solvent on severely lacquered or varnished machines where the deposits cannot be wiped or scraped off.

If using a mineral solvent, make sure that all loosened deposits and solvents are removed before filling the compressor with Cetus DE 100 lubricant. Any residual solvent can decrease the life of the synthetic lubricant.

Another, less preferred method for removing resistant deposits is to run the unit on the selected Cetus DE 100 lubricant for approximately 100 hours, drain the unit while it is hot, clean or replace the filter, and re-fill it with fresh Cetus DE 100 lubricant.

Materials compatibility

The guide below lists the types of materials generally acceptable for use with Cetus DE 100. This list is for guidance only. Before using the lubricant, consider any specific formulations, methods of manufacture and/or application, and the conditions and degree of exposure for all seals, paints, and plastics.

Polycarbonate bowls

A number of air line filters and separator manufacturers use polycarbonate plastic bowls in their units. Numerous tests demonstrated that compatibility problems can occur when using polycarbonate bowls with Cetus DE 100 lubricant. To avoid compatibility problems, we recommend either covering poly–carbonate bowls with metal bowl guards or replacing them with metal bowls. ■

Plastic compatibility

Acceptable	Marginal	Not Acceptable
✔ Nylon	~ Polyurethane	✘ Polyethylene
✔ Fluorocarbon (PTFE)	~ Polypropy-lene	✘ Lexan
✔ Polyacetal (Delrin)	~ Polysulfone	✘ PVC
		✘ Acrylic

Paints and coatings compatibility

Acceptable	Marginal	Not Acceptable
✔ Epoxy	~ Phenolic	✘ Acrylic
✔ Baked Phenolic	~ Industrial Latex	✘ Household Latex
✔ 2-Comp. Urethane	~ Single-Comp. Urethane	✘ Vinyl (PVC)
✔ Moisture-Cured Urethane	~ Alkyls (Baked-Finished preferred)	✘ Varnish and Lacquer

Seal material compatibility

Acceptable	Not Acceptable
✔ Fluorocarbon (Viton, PTFE, Fluorel)	✘ Ethylene-Propylene Terpolymer (EPDM)
✔ Fluorosilicone Rubber	✘ Polychloroprene (Neoprene)
✔ Silicone Rubber	✘ Butyl Rubber
✔ Epichlorohydrin	✘ Natural Rubber
✔ Medium Nitrile Rubber (Buna N, NBR 30–36% acrylonitrile)	✘ Low Nitrile Rubber (Buna N, NBR < 30% acrylonitrile)
✔ High Nitrile Rubber (Buna N, NBR 36% acrylonitrile)	✘ Styrene-Butadiene Rubber (Buna S, SBR)
✔ Polyacrylate Rubber	✘ Ethylene/Acrylic Rubber
✔ Chlorosulfonated Polyethylene (Hypalon)	✘ Ethylene-Propylene Copolymer Rubber (EPR)
✔ Polyurethane	✘ Polysulfide (Thiokol)

marine lubricants information bulletin 11

chevron brands, MPID and regional equivalents

Chevron Marine Lubricants provides products under three master brands: Chevron, Texaco and Caltex. Most of the products in the portfolio are globally available and supplied with the same product name, but may have different master brands, depending on which region or country the product is lifted.

Chevron brands, MPID and regional equivalents

Some of the products in the Marine Lubricants product portfolio — mainly ancillary grades — have been developed to match specific regional requirements, with heritage product names which are not globally available. Wherever possible, Chevron Marine Lubricants will supply the products listed on the vessels' Lubechart — products referred to as Parent Product. If the Parent Product is not available in the region or country of lifting, a Regional Equivalent will be supplied instead — if existing.

*The Parent Product and its Regional Equivalent are **direct equals**, of same or similar performance level for intended application and are fully miscible and compatible.*

Marine Product ID (MPID)

To simplify regional product equivalents, Chevron Marine Lubricants recently introduced the Marine Product ID (MPID). The MPID is a code assigned to identify products into a single product code for each Parent Product and its Regional Equivalent. The concept is also used for product or name changes to help manage transition from old to new products.

This means that only a parent product name or MPID is required; *should the Parent Product not be available in a specific region, Chevron Marine Lubricants will ensure that the correct Regional Equivalent is supplied instead*.

Only the Parent Product's name and MPID are listed on the Chevron Marine Lubricants website, World Port Directory, OnePort and vessel Lubechart. On the vessel Lubechart, any products with Regional Equivalents are listed in the footnotes for information. Regional Equivalents are provided in subscript on the Product Datasheets.

The Marine Lubricants Delivery Receipt (MLDR), which you receive with the supply, will state the name of the Parent Product ordered, and will list the Regional Equivalent supplied in case, to match the product name mentioned on the packaging.

Examples

As an example of this, Chevron Delo Gold Ultra 15W-40 (high speed engine oil with API CI-4/ACEA E7 performance) is the Parent Product and supplied under the Chevron brand in North America and the Caltex brand in Asia Pacific. However, Ursa Marine 15W-40 is supplied in Europe and Ursa Super TD 15W-40 in Latin America, respectively, as Regional Equivalents. These Regional Equivalents are of same performance level as the parent product.

The table on page 2 provides a comparison of Chevron Parent Products and the Regional Equivalents, depending on the port of supply. ■

Chevron Marine Lubricants Parent Products and Regional Equivalents

Parent Product	Regional Equivalents
Delo Gold Ultra 15W-40	Ursa Marine 15W-40 Delo 400 Multigrade SAE 15W-40 Ursa Super TD API CH 4 15W-40 Delo Gold Ultra E SAE 15W-40
Delo 400 MGX SAE 15W-40	Ursa Ultra LE 15W-40, Delo 400 LE 15W-40
Delo 100 Motor Oil SAE 40	Ursa Extra Duty SAE 40
Delo 400 SAE 40	Ursa HD SEA 40 Delo Silver SAE 40 Ursa LA 3 SAE 40
Delo 400 XSP SAE 5W-40	Delo 400 LE Synthetic SAE 5W-40 Ursa Ultra X SAE 10W-40
Delo 710 LE 20W-40	Delo 6170 CFO SAE 40
Havoline Outboard 2T	Motex 2T Outboard Havoline 2-Cycle Engine Oil TC-W3 Super Outboard 3
1000 THF	Textran TDH Premium
Havoline ATF III-H	Automatic Transmission Fluid MD-3 Texamatic 7045E Texamatic 1888
Delo Gear EP-5 SAE 80W-90	Multigear EP-5 80W-90 Geartex EP-C 80W-90 Geartex EP-5 SAE 80W-90 Thuban GL-5 EP 80W-90 Gear Oil GL-5 SAE 80W-90
Hydraulic Oil 5606	Hydraulic Oil 5606A
Meropa WG 460	Cylinder Oil W460
Delo Starplex EP 2	Starplex EP 2
Molytex EP 2	Moly Grease EP 2 Multifak Moly EP 2
Texatherm 46	Heat Transfer Oil 46
Capella Low Temp AB 68	Refrigeration Oil Low Temp 68
Cetus PAG	LPG Compressor Oil
Delo XLI Corrosion Inhibitor – concentrate	Havoline XLI
Delo XLC Antifreeze/Coolant – concentrate	Havoline Xtended Life Coolant – concentrate Havoline Xtended Life Antifreeze/Coolant – concentrate Havoline XLC – concentrate

Note: This table is subject to changes as the product portfolio is updated. *September 2020*

Chevron

marine lubricants information bulletin 12

marine industry greases

Grease lubricants have many applications onboard marine vessels; they provide sealing and retention on lubricated parts. Unlike oil lubricants, grease does not require frequent replenishment and, in open systems, it is used to coat surfaces where it is impractical to use oil.

Grease is a semi-solid product consisting of a thickener dispersed in a liquid lubricant. The thickener forms a network structure that holds the lubricant stationary, comparable to a sponge holding water. The two most distinguishing properties of grease are its consistency and dropping point.

Grease consistency

The consistency of grease is reflected by a penetration number. To determine the penetration number for a grease, a test amount is worked for 60 strokes to obtain a uniform sample. Then, a standard cone penetrates the sample under specified conditions of load, time, and temperature. Lastly, penetration depth is measured, and the depth is expressed in tenths of a millimeter.

Based on the penetration depth, the National Lubricating Grease Institute (NLGI) consistency grade is defined, as shown in Table 1. The NLGI in the United States defined a series of consistency grades ranging from 000 (very soft) to 6 (very hard). Each grade corresponds with a range of values for the penetration depth.

Dropping point

As temperature increases, grease gradually softens until it starts to become "liquid." The dropping point is the temperature at which liquid starts to form. It is measured by heating a sample in a test cup, with a small orifice at the bottom, until the first drop of material falls from the lower end of the cup. The dropping point for a grease is largely determined by the thickener. Unlike calcium soaps, lithium soaps and, especially, lithium-complex soaps, result in high dropping points.

Table 1: NLGI classification for greases

NLGI Grade	Worked Penetration Depth Range (mm/10)
000	445–475
00	400–430
0	355–385
1	310–340
2	265–295
3	220–250
4	175–205
5	130–160
6	85–115

The dropping point determines the maximum usable temperature for a grease. In systems without frequent relubrication, we recommend staying at least 15°C to 30°C below the dropping point of the grease in service. However, with frequent or continuous relubrication, this service temperature limit can be raised.

Key properties

The key properties of a grease must match its intended application and required performance criteria. These properties relate to the composition of the grease.

Thickener and oil phase play important roles in grease composition. The thickener is usually present at a concentration level between 5% and 30%, depending on the desired consistency or “hardness“ of the grease.

Metal soaps, such as calcium and lithium, are widely used as a thickener in marine greases today. While metal soaps are produced by the reaction of a single organic acid to the metal hydroxide, complex soaps are synthesized by the co-crystallization of two or more organic compounds with the metal hydroxide. This creates a more complex soap structure and provides higher thermal stability.

Additional non-soap chemicals, urea or inorganic materials (bentonite clays), can be applied in certain cases.

Table 2 (on the next page) shows the general characteristics and applications of the main grease families used by the marine and general industries. Lubricants provide the lubrication qualities of a grease and consist of mineral paraffinic or synthetic-based oil and a combination of various additives. These additives are:

- Anti-oxidants to prevent oil degradation as a result of heat or oxidation
- Rust and corrosion inhibitors to protect lubricated metal surfaces against rust from saltwater contamination
- Anti-wear additives to strengthen the lubricating film and reduce adhesive wear
- Tackifiers, such as fibrous molecules, to enable the grease to cling to the metal surface and prevent it from being thrown off when the equipment is rotating
- Solid friction modifiers, such as graphite powder of Molybdenum Disulphide (MoS_2), to allow the grease to tolerate very high loads or shock loads

Chevron marine grease products

As shown in Table 3 on the next page, our range of high-performing greases for specific marine applications meet the lubrication requirements of onboard marine vessels. These greases are formulated to meet the demands of extreme pressure, temperature, and corrosive environments — ideal properties for many marine applications.

Our marine grease product line includes:

Multifak® EP, an excellent multipurpose grease, is based on lithium soap. It has a smooth, buttery texture and is highly adhesive and water-resistant. This grease achieves high load-carrying capacity and low wear rates as a result of antiwear additives included in the formula. Multifak EP has two consistency grades, 0 and 2, that will satisfy the grease requirements for a majority of marine equipment. We especially recommend the 0 grade for use in central lubrication systems.

For protection against seizure under highly loaded service conditions, we recommend our **Molytex® EP 2** grease. This multipurpose, extreme-pressure lithium grease contains MoS_2 as a solid filler. This grease is specifically developed for use in constant-velocity joints.

Molytex EP 2 can also be used for all types of anti-friction bearing arrangements, from plain sleeve-type to rolling element bearings and bushings and other sliding surface or pivot points.

We also recommend Molytex EP 2 for the lubrication of (deck) cranes. Compared with other products in the market, this product increases the service life of rudder shafts by up to 30 percent.

The presence of MoS_2 in grease provides an extra measure of protection in shock-loading situations. During heavy shock-loading, the lubricant film between metal surfaces can temporarily squeeze out, which can result in equipment damage. The MoS_2 in the lubricant prevents metal-to-metal contact and protects the equipment.

We recommend **Texclad® 2** for applications on deck where exceptional water resistance is desired during continuous wet operation and where temperatures remain relatively low. This water-stabilized calcium grease contains selected graphite and molybdenum disulphide fillers. The presence of these solid lubricants guarantees reliable lubrication even under extreme heavy-duty operating conditions, such as open gear operations. The high adhesiveness to metals in Texclad 2 resists displacement or run-off and prevents the metal-to-metal contact of gear teeth, chains, and wire ropes. Additionally, the product is bitumen-free, which provides a more environmentally acceptable lubricant solution. Extended use of mineral grease at temperatures above 130°C causes rapid oxidation and degradation of the grease in service.

As an extension to the range of mineral greases, we offer **Ulti-Plex® Synthetic Grease EP**. This grease is formulated with a lithium-complex thickener and a synthetic base stock. It is designed for use in extreme temperature environments and for applications requiring extended re-lubrication intervals. Ulti-Plex Synthetic Grease EP provides outstanding thermal stability up to 140°C in continuous service and up to 230°C in central lubrication systems.

This grease retains its pumpability in temperatures as low as –30°C and provides proper bearing lubrication at temperatures as low as –50°C. Its anti-corrosion properties make it a superior multipurpose marine lubricant for use in deck equipment, offshore drilling equipment, and lubricated shaft bearings, cranes, and winches.

Table 2: Grease types — properties and applications

Thickener	Appearance	Water resistance	Temperature resistance	Specific properties	Applications
Soap thickened greases					
Sodium (Na)	Rough, fibrous	–	+/–	Good metal adhesion	Older equipment with frequent relubrication; roller-element bearings.
Calcium (Ca)	Smooth, buttery	++	–		Bearings in wet conditions; rail lubricant.
Lithium	Smooth, buttery to slightly stringy	+	+	Resistant to softening and leakage	Wheel bearings; multi-purpose grease.
Complex soap thickened greases					
Calcium complex	Smooth, buttery	++	++	Inherent load carrying capacity	High-temperature bearings.
Lithium complex	Smooth, buttery	+	++	Resistant to softening and leakage	Wheel bearings; high-temperature service including various roller-element applications.
Non-soap thickened greases					
Polyurea	Smooth, slightly opaque	++	++	Oxidation resistant less resistant to leakage	Roller-element bearings; Constant velocity joints.
Organo-clay	Smooth, buttery	++	++	Resistant to leakage	High temperature bearings with frequent relubrication; steel mill roll neck bearings.

Table 3: Chevron's range of marine greases

Product Name	Thickener	Base oil	Consistency (NLGI-class)	Dropping Point (°C)	Application Range (°C)
Multifak® EP 0	Li-soap	mineral	0	200	–30 to 120
Multifak EP 2	Li-soap	mineral	2	200	–30 to 120
Molytex® EP 2	Li-soap	mineral	2	210	–30 to 120
Texclad® 2	Ca-soap	mineral	2	106	–10 to 60
Ulti-Plex® Synthetic Grease EP	Li-complex soap	synthetic	1.5	285	–50 to 230

Grease compatibility

Before replacing your current grease, contact your Chevron marine representative for advice on the compatibility of using a new grease with the one in service. The compatibility diagram in Table 4 serves as a guideline and lists the main thickener systems used by the industry. Actual compatibility may, however, depend on the additive or base oil system of the specific products being mixed.

The Chevron Technology laboratory is one of the best-equipped grease testing facilities in the world. In addition to testing general physico-chemical characteristics, the lab conducts performance bench tests and continuously monitors the quality of grease batches produced and tests used greases arriving from the field. Our technical department personnel can always provide advice on grease compatibility issues. ■

Table 4: Compatibility between different grease types

	Aluminum Complex	Barium Complex	Calcium	Calcium Complex	Clay	Lithium	Lithium Complex	Polyurea	Sodium
Aluminum Complex		Incompatible	Incompatible	Incompatible	Incompatible	Borderline	Borderline	Borderline	Incompatible
Barium Complex	Incompatible		Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible
Calcium	Incompatible	Incompatible		Compatible	Incompatible	Compatible	Compatible	Compatible	Incompatible
Calcium Complex	Incompatible	Incompatible	Compatible		Incompatible	Borderline	Borderline	Borderline	Incompatible
Clay	Incompatible	Incompatible	Incompatible	Incompatible		Incompatible	Incompatible	Incompatible	Incompatible
Lithium	Borderline	Incompatible	Compatible	Borderline	Incompatible		Compatible	Borderline	Borderline
Lithium Complex	Borderline	Incompatible	Compatible	Borderline	Incompatible	Compatible		Borderline	Borderline
Polyurea	Borderline	Incompatible	Compatible	Borderline	Incompatible	Borderline	Borderline		Incompatible
Sodium	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Borderline	Borderline	Incompatible	

Compatible

Borderline — sample should be checked

Incompatible

marine lubricants information bulletin 13

bright stock

Solvent-extracted bright stock, with a viscosity in the range of 28.0 to 35.0 mm^2/s (cSt) at 100°C, is often used in higher-viscosity grade lubricants such as slow-speed engine cylinder oils. The old “bright stock is bad” belief can no longer be confirmed.

Mineral base oils

Mineral base oils are complex mixtures of paraffins, naphthenes, and aromatics. These hydrocarbons have different molecular arrangements of hydrogen and carbon atoms. The hydrocarbon composition of base oils is related to the crude oil source and the type of refinery process used to manufacture them. For example:

- Paraffins are saturated straight and branched strings of hydrocarbons
- Naphthenes are saturated cyclic hydrocarbon structures
- Aromatics contain unsaturated alkyl rings

Saturated paraffins and naphthenes are suitable hydrocarbons for base oils. Unsaturated aromatics are prone to oxidation that produces sludge and lacquer formation and, therefore, are undesirable in base oils.

The properties of base oils are related to their predominating chemical structure, which includes:

- Boiling range
- Viscosity
- Density
- Pour point
- Solvency
- Oxidation resistance
- Thermal stability

For the majority of applications, the most important characteristics of base oils are viscosity and viscosity index. The viscosity index (VI) is the rate of change in viscosity with changes in temperature.

Mineral base oil enhancement

The properties of base oils can be enhanced by refining methods. Solvent refining is the most common method for high-viscosity oils.

Solvent-extracted base oils have a higher VI than non-refined base oils. This happens when solvent extraction removes aromatic components, which have lower VI. For example, paraffinic base oils have a higher VI than naphthenic base oils. Typical naphthenic base oils have a VI below 50; whereas typical paraffinic base oils have a VI above 80. Chevron exclusively uses solvent neutral oils with a minimum VI of 90, which are generally referred to as high-viscosity index (HVI) base oils.

Base oils cover a wide viscosity range from approximately 4 to 35 mm^2/s (cSt) at 100°C. The viscosity level defines the grade of base oil into light, medium, and heavy neutral oils and bright stocks. The higher the molecular weight of the hydrocarbons, the more viscous the base oil.

Table 1 contains examples of typical HVI paraffinic base oils that are commonly used for lubricants blending.

Table 1: Typical HVI paraffinic base oils

Approximate viscosity range	mm²/s (cSt) at 100°C
100 neutral oil (light)	4.0 – 4.5
150 neutral oil (light)	5.0 – 5.5
300 neutral oil (medium)	7.0 – 8.0
500 neutral oil (heavy)	10.5 – 11.0
600 neutral oil (heavy)	11.5 – 12.0
150 bright stock (light)	28.0 – 35.0

Marine slow-speed engine cylinder oils

Paraffinic base oils are used for blending slow-speed engine cylinder oils because of their excellent properties, which include high VI, good oxidation resistance, good thermal stability, low volatility and good demulsibility. These base oils are usually a mixture of medium-viscosity neutral oil and high-viscosity bright stock. This combination is commonly available on a worldwide basis, thus ensuring uniformity of the finished cylinder oil.

The base oils used for blending cylinder oils, such as Taro® Special HT 70 and Taro Special HT LS 40, are thoroughly tested. The results must pass Chevron's stringent quality requirements before receiving approval.

Apart from the base oils, a critical component of slow-speed engine cylinder oils is the additive package used. The main purposes of these additive packages are:

- Neutralizing acidic combustion by-products
- Providing detergency or cleaning effect
- Preventing deposit formation by keeping deposit precursors soluble in the oil (dispersant)
- Reducing friction and wear

A carefully selected combination of base oils and additives results in a high-performance slow-speed engine cylinder oil.

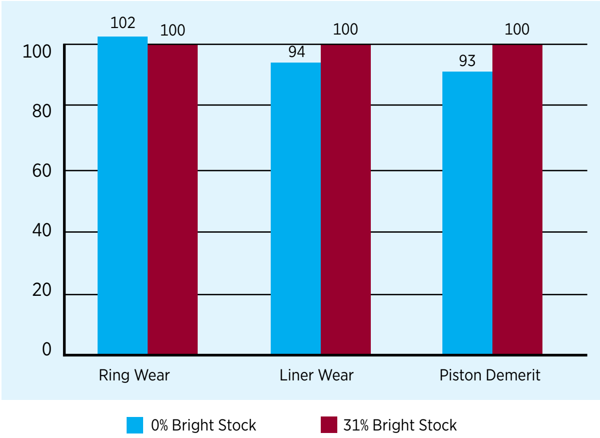
Solvent neutral oil versus bright stock

A laboratory engine test with slow-speed engine cylinder oils provided conclusive information on the effect of using different base oils. The corrosive wear test was conducted on two different cylinder oils containing 0% and 31% bright stock and exactly the same additive package. Three parameters were analyzed: ring wear, liner wear and piston cleanliness.

The results, displayed in Figure 1, show that when a good quality bright stock is selected, there are no performance differences between a fully formulated cylinder oil blended with solvent neutral oils plus bright stock, and the same cylinder oil with only solvent neutral oils. The differences shown are all within the tolerances of the engine test.

Conclusion

Figure 1: Corrosive wear test — Bolnes corrosive wear matrix, relative performance, %



Specially selected and tested highly refined, solvent-extracted bright stocks give at least equal performance in fully formulated slow-speed engine cylinder oils. ■

Chevron

marine lubricants information bulletin 14

polyester-based synthetic refrigeration oils

Capella® HFC (polyolester) synthetic oil helps ship owners address environmental issues and regulations and minimize the number of different lubricating oils used onboard. Specifically developed for use with HFC (chlorine-free) refrigerants, such as R134a and R404a, Capella HFC exhibits excellent performance in HFC systems.

Application guidelines

Capella® HFC should only be used in systems designed to operate with chlorine-free refrigerants. When a ship's onboard refrigeration system is converted to an environmentally acceptable HFC refrigerant, the new system must use a synthetic polyolester-based compressor lubricant. Polyolesters are the best lubricant for HFC systems because they have low miscibility of the refrigerant, outstanding thermal stability, and excellent deposit control.

Do not use Capella HFC in compressors using conventional HFC and HCFC (chlorinated) refrigerants such as R12 and R22. Using the oil in these compressors can cause difficulties related to differences in the design of compressor systems.

Polyolester-based synthetic refrigeration oil can also be used in older compressors using conventional refrigerants. Using polyolester-based synthetic refrigeration oil in systems still using conventional refrigerants, however, can increase the level of water in the lubricating oil. In time, this increase can lead to serious copper-plating problems and rapid oil degradation.

Additionally, compatibility with different sealing materials can be a problem because polyolester-type lubricants are hygroscopic and easily absorb moisture. To avoid moisture absorption, special filters/dryers are incorporated in systems designed for HFC refrigerant gases. For this reason, Capella HFC is supplied in small packages to avoid long storage time after the product is opened.

Refrigerating systems that convert HFC gases not only have to change to a polyolester-type lubricant, such as Capella HFC, but must also modify their filters/dryers, control devices and seals. Conversion of refrigerating systems to chlorine-free HFC refrigerants and systems should always be done in close cooperation with the system's manufacturer. ■

marine lubricants information bulletin 15

complete guide to delo® XLI corrosion inhibitor – concentrate

Section 1 provides instruction on using Delo® XLI Corrosion Inhibitor – Concentrate for the first time, or changing over the system from another cooling water treatment to Delo XLI Corrosion Inhibitor – Concentrate.

Section 2 provides guidelines for monitoring and recording important parameters of the cooling water treatment during service.

Section 1: Flushing and Changeover

Delo® XLI Corrosion Inhibitor – Concentrate (Delo XLI) is a high performance, readily biodegradable coolant based on Carboxylate technology which performs better than traditional coolants in terms of efficient heat transfer, increased corrosion protection, non-depletion and extended service life. Delo XLI offers protection for all commonly used materials in engine cooling water systems, including aluminium and copper.

Delo XLI is recommended for cooling water treatment operating below 100°C and is a concentrate that should be diluted in water. Before filling the engine with a 6–7.5% solution of Delo XLI in water, the existing fluid must be drained from the engine coolant system. Depending on the condition of the system, it may be necessary to thoroughly flush the system to remove loose deposits and precipitates.

Preferably, flushing is done with a 4.5–5% solution of Delo XLI in fresh water. Using Delo XLI for this process aids the removal of deposits and helps provide corrosion protection during and after the flushing operation.
For new systems, a simple flush is usually sufficient to remove any cooling fluid and the few deposits present. In older systems, hard water scale, corrosion deposits, and precipitates from former water treatment chemicals are not removed by flushing only. **Depending on the nature and amount of the deposits, the engine must operate for some time to allow cleaning of the system by the standard 4.5–5% solution of Delo XLI.**

Delo XLI will gradually clean loose deposits and sludge from the system. These contaminants should be systematically removed by partial draining and skimming until the system is fully clean. Delo XLI has very low depletion rate in-service.

Supplemental additions of XLI should only be added to make up for losses from cooling water leakage.

The concentration levels of the coolant should be checked weekly using a refractometer. A hand held Delo XLI Refractometer can be ordered from your account manager.

The cooling water treatment must meet the requirements of the original engine manufacturer (OEM). Always check the guidelines.

Quality of fresh water*

We strongly recommend using distilled water or deionised water to dilute Delo XLI in engine cooling systems. If distilled water or deionised water is not available, use water that meets or exceeds the minimum acceptable water requirements listed below to minimize scale deposits:

PROPERTIES/CHARACTERISTIC	VALUE
Water type	Distillate or deionized freshwater
Prohibited	Sea water, river water, brines, industrial waste water, and rain water
Should not contain any	Chlorine, Sulphide, and Ammonia
Total hardness *($CaCO_3$ + $MgCO_3$), max, mg/kg*	170
pH at 20°C	5.5–9.0
Chloride ion content *(Cl^-), max, mg/kg*	40
Sulphate content *(SO_4^{2-}), max, mg/kg*	100

General guidelines

1. Apply sufficient Delo® XLI in relation to your cooling system capacity.
2. Flushing and changeover operations must be completed in the presence of qualified ship staff.
3. If the vessel is equipped with an HT and LT circuit, it is advisable to change both systems one at a time.
4. When zinc anodes are installed in the fresh water system, it is advisable to remove them.
5. Check that the vessel is not using any biocide for jacket cooling water (JCW) treatment. If it is, please consult your Chevron representative.
6. The flushing operation should be conducted under safe conditions, such as using proper Personal Protection Equipment (PPE), testing correct functioning of expansion tank low level alarm and JCW circuit temperature sensors and gauges, making all affected ship staff aware of the operation, and any other steps which help ensure a safe flushing process.
7. It is preferable to perform draining at the lowest part of the cooling unit. This will remove deposits that might have originated anywhere in the system.
8. Take fluid samples before commencing the flushing operation (see page 3, "Taking Fluid Samples").
9. When changing from one coolant to another, first take a sample of the old existing coolant for analysis.

Flushing procedure for new engines

In new build engines, pipes and tanks may contain debris such as dust, rust and free moving particles and objects. It is vital to clean the cooling system of these before filling with Delo XLI.

1. Completely drain the cooling water system (hereafter referred to as "the system") and confirm that there is no cooling medium.
2. Preferably, fill the system with good quality fresh water* and add 4.5–5% solution of Delo XLI. (The percent of Delo XLI can be calculated using the formula in Figure 1 on page 3.)
3. Purge the system well.

4a. If the engine has a separate cooling water pump (e.g., 2-stroke slow speed engine), run the pump for 2–3 hours after the flushing solution has been heated to normal cooling water temperature.

4b. If the engine has an attached cooling water pump (generally the case with 4-stroke medium speed engines), run it at idle load or operate the engine in-service for sufficient time (generally one hour) after the flushing solution has been heated to the normal cooling water temperature.

5. Allow the system to cool down moderately to avoid thermal shocks and drain it completely.
6. Check the drain flushing fluid for deposits and precipitates.
7. Repeat steps 2 through 5 if the flushing fluid contains significant amounts of deposits or precipitates.
8. Check the cooling system filters (if present). Replace them when required.
9. Calculate the cooling water capacity, fill the system with good quality fresh water* and add chemical by 6–7.5% concentration. Maintain in-service levels for Delo XLI between 6–7.5%.

   When using the expansion tank to dose the system, take care to circulate well and keep in mind that the changes in concentration will only be visible after a couple of days.

Flushing procedure for in-service engines while vessel is in dry-dock

1. Completely drain the system, if possible, and follow the steps listed under "Flushing procedure for new engines". **If it is not possible to completely drain the system, follow steps 2–10 below.**
2. Drain the system in a controlled manner by opening the bottom-most drain valve/cock, and concurrently filling the system with a solution of good quality fresh water*.
3. Continue step 2 until nitrite levels drop to 100 ppm (if nitrite-based treatment chemicals were in use) and drain as many contaminants as possible.
4. Add 4.5–5% solution of Delo XLI in fresh water. This will be flushing fluid. Purge the system.

During the last day of dry-dock, when main engines, auxiliary engines, boiler, etc. are running:

5a. If the engine has a separate cooling water pump (e.g., 2-stroke slow speed engine), run the pump for 2–3 hours after the flushing solution has been heated to normal cooling water temperature.

5b. If the engine has an attached cooling water pump (generally the case with 4-stroke medium speed engines), run it at idle speed or operate the engine in-service for sufficient time (generally one hour) after the flushing solution has been heated to the normal cooling water temperature.

6. Allow the system to cool down moderately to avoid thermal shocks. At this point it is preferable to drain the system completely, and if the flushing fluid contains significant amounts of deposits or precipitates, repeat Steps 2 through 6 until clear, then fill the system with good quality fresh water* and add Delo XLI to make Delo XLI concentration 6–7.5%. Maintain in-service levels for Delo XLI between 6–7.5%.

* Good quality fresh water: Water which is soft in nature, with low Chlorides (≤40 ppm) and pH+ (5.5–9.0). We generally advise using onboard generated water for this purpose; however, for new ships, please ask shipyard to provide good quality fresh water.

Figure 1: Calculating percent of Delo® XLI concentration

$$\% \text{ Delo XLI} = \frac{\text{Delo XLI (liters)}}{\text{Total fresh water in circuit (liters)} + \text{Delo XLI (liters)}} \times 100$$

Flushing procedure for in-service engines while vessel is en route

This procedure has been designed to changeover the system from another chemical treatment to Delo XLI while the vessel is en route. Ensure that the cooling water valves are in good working order prior to commencing this process, especially the fresh water filling valve(s) in the expansion tank and system drain valve.

In addition, it is advisable that all operations are executed under personal supervision of senior engineering staff.

Phase 1: Drain and fill in-service water to drop nitrite levels below 100 ppm

1. Because the changeover is taking place while equipment is in operation, it is advisable to drain the water slowly to avoid thermal shocks. If the Fresh Water Generator (FWG) is running, monitor the temperature closely to ensure there is no impact on the operation of the FWG.
2. Drain the system in a controlled manner by opening the bottom-most drain valve/cock, and concurrently filling the system with good quality fresh water to maintain system water level. Reduce the content of the nitrite treatment to 100 ppm (if nitrite-based treatment chemicals were in use) and drain as many contaminants as possible.
3. Always monitor the expansion tank level and continuously replenish the water at the same rate as it is drained.
4. Maintain the JCW temperatures at engine outlet as per recommendation of OEM (may require JCW heater).
5. Check any filters in the fresh water cooling circuit frequently. Keep the standby filters ready for use.
6. Monitor the expansion tank(s) water for contamination and drain sediments regularly from the bottom.

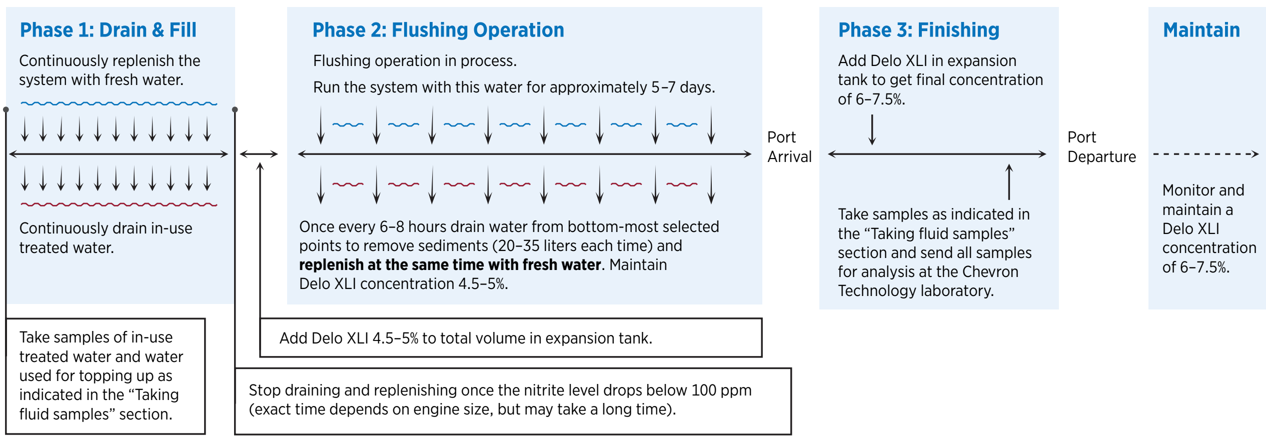
Phase 2: Flushing operation

7. Add Delo XLI to bring its concentration to 4.5–5%. The percent of Delo XLI can be calculated using the formula in Figure 1.
8. Every 6–8 hours drain 20–35 liters from the system to flush out any deposits.
9. Maintain Delo® XLI concentration of 4.5–5%.
10. Monitor the system for possible leaks. Delo XLI will clean any deposits and sludge from the system, hence it is possible to have minor leaks.
11. Pay extra attention to generator engine cooling, air compressor and other machinery cooling systems.
12. Continue this operation for 5–7 days or until the deposits have stopped coming out of the system.

Phase 3: Finishing

13. Increase the Delo XLI concentration to 6–7.5% and maintain at this level.

Figure 2: Changeover to Delo XLI for in-service engines while vessel is en route



Taking fluid samples

During the changeover process to Delo XLI, it is recommended the following samples are taken for analysis. Speak to your account manager about FAST™ trending and analysis services.

A. Before changeover procedure starts, take one sample (50–60 ml) each from:

- LT system at the circulation pump,
- LT system from central cooling water expansion tank,
- HT system at the circulation pump,
- HT system from jacket water expansion tank,
- Fresh water used for flushing and topping-up.

B. After changeover procedure is complete, take one sample (50–60 ml) each from:

- Fresh cooling water prepared and meant for filling the system,
- LT system at the circulation pump,
- LT system from central cooling water expansion tank,
- HT system at the circulation pump,
- HT system from jacket water expansion tank.

C. Send samples to the address indicated on the FAST sample kit.

Frequently asked questions

1. **Does the whole system need to be drained and flushed before the filling water is treated with Delo XLI?**

   It would be good to take a sample and have it analyzed in the lab. That way we can determine the nitrite and it could be the reference sample for further trend analysis. Normally for a system treated by nitrite-based chemicals, drain the system as much as possible and confirm nitrite dropped below 100 ppm before introduction of Delo XLI.

2. **What are the consequences of using Delo XLI as a top-up product for existing corrosion inhibitor system?**

   We do not advise adding Delo XLI to the existing product. This is due to the cleaning effect of Delo XLI and not because of compatibility issues or other factors, because flakes, sediment, and sludge might form. It is important to have detailed knowledge of the actual status of the cooling systems. Visual aspects and coolant analysis are very important in this respect.

3. **What is the exact percentage of Delo XLI dosage in fresh water?**

   Depending on the quality of the top-up water, the Delo XLI concentration must be between 6–7.5%. Under no circumstances should it be lower than 5%.

4. **Is flushing with water alone sufficient or must we use a Delo XLI solution in water?**

   In many cases, historical deposits and debris are present. It is recommended to have these efficiently removed. Therefore, it is better to flush with a 4.5–5% Delo XLI. The best result is obtained when Delo XLI is introduced in a running engine (hot flush).

5. **What is the depletion rate of the product annually if the system has no leakage?**

   The product performs a minimum of 32,000 hours on condition that concentration was properly maintained, but more is possible depending on conditions. The corrosion inhibitors are long life, which means the depletion is limited. However, if the system is not clean, corrosion inhibitors from Delo XLI are partially consumed. This is why it is important to drain and flush the system.

6. **How much Delo XLI dosage is required annually to maintain sufficient protection level if system has no leakages?**

   In good conditions without leakage, there is no need to add Delo XLI. After the system is flushed and filled with a 6–7.5% Delo XLI solution (minimum 5%), the protection level is sufficiently high. The concentration can be measured with a refractometer by the engine room crew.

7. **Does Delo XLI react when it comes in contact with air in expansion tanks?**

   The product does not react with air. Nevertheless, it is important to exclude air from the cooling system to reduce/avoid corrosion.

8. **Which tests are generally recommended to check and maintain the quality of treated water?**

   We recommend following tests:

   a. Delo XLI concentration — see Section 2, Part I.
   b. pH value — see Section 2, Part II.
   c. Chloride levels — see Section 2, Part III.

9. **How do I maintain the test records?**

   Please refer to Section 2, Part IV for a monthly monitoring log. The comments provide a recommended range to maintain the parameters for each category.

Section 2: Monitoring and Recording

After a successful changeover to Delo® XLI, it is important to monitor and record the condition of the cooling water, and make maintenance adjustments as necessary.

Chevron recommended test frequency

Delo XLI concentration	Every week
pH and Cl	Every two weeks
FAST™ analysis	Every system (HT/LT) every 6 months

Record the test results using the log sheet on page 11, or sign up for Chevron's FAST.XLI coolant monitoring program by emailing CMLtechservice@chevron.com.

Part I. Measuring Delo XLI Concentration with a Refractometer

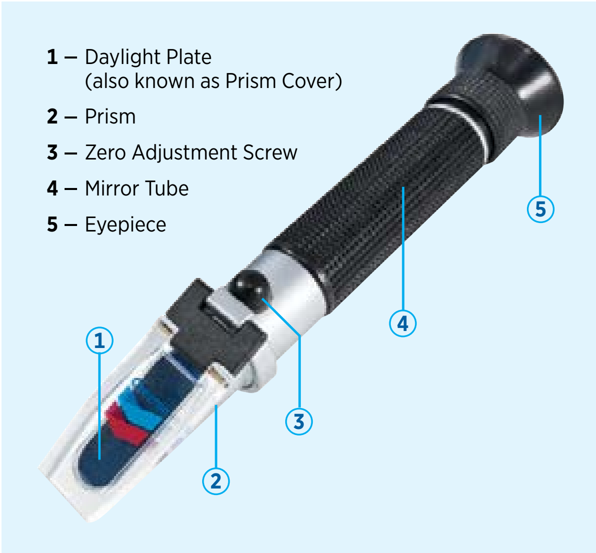
Read this user guide before using the refractometer, and keep it as a reference for future use. By following the guidelines highlighted here, you will extend the life of the refractometer and obtain the best measuring results, thereby enabling effective corrective actions to improve your operations. This user guide can also be used for refractometer models with minor differences (i.e., models with range of 0–5% Brix or with a self-correcting lens).

NOTE: Be sure that you are using a refractometer designed to measure % Brix. (Some types of refractometers are designed to measure concentration of ethylene glycol or battery fluid, with the scale in the prism surface showing either % by volume of antifreeze, freezing point in °C, or both. Using the wrong type of refractometer will yield invalid test results.)

The hand-held refractometer spot test is a quick method for determining the concentration of XLI in water. This method is easy to perform and does not require extensive sample handling or expensive equipment.

Summary

The refractive index of the solution (in % Brix) is measured by a hand-held refractometer. The reading is plotted on a calibration curve, from which the concentration of XLI is determined. Note that % Brix is NOT equal to % XLI — this is why the calibration curves must be used. Measure all solutions between 15–30°C.



Equipment

Refractometer: Brix 0–10% Item No. 2710

Procedure

1. Select the appropriate refractometer (Brix 0–10% Item No. 2710).
2. Ensure the prism surface and the plastic cover are clean. If not, clean them with distilled water and wipe dry with paper tissue. Do not immerse the refractometer in water.
3. Check the zero setting of the refractometer with water as described in Figure 3. Perform this operation prior to every set of measurements.

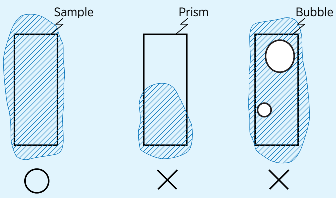
4. Check that the water sample temperature is between 15–30°C.
5. Hold the refractometer in a horizontal position.
6. With a clean pipette, place a few drops of the sample between the prism and daylight plate until the prism is completely covered with liquid. The liquid should not have bubbles.
7. Point the instrument toward a light source and look into the eyepiece. Keep the refractometer horizontal. Turn the eyepiece so that the scale is in sharp focus.
8. The Brix % reading is the dividing line where the boundary between light and dark (the edge of the shadow) crosses the scale.
9. If the edge of the shadow is not sharp, turn the eyepiece to bring the edge of the shadow into sharp focus. It is also possible that the edge of shadow is not sharp because the measuring surfaces were not sufficiently clean or dry, or an insufficient sample of coolant was used. Rinse the prism with distilled water, wipe dry and repeat the test.
10. The concentration of coolant can be derived from the conversion table shown in Figure 5.

Figure 3: Scale adjustment

1. Open daylight plate and put a few drops of distilled water on the prism surface.

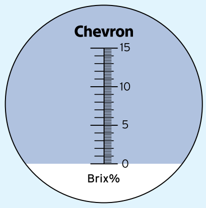
2. Close the daylight plate gently.

3. Water spreads all over the prism surface.



4. Look into eyepiece and turn it so that the scale is in sharp focus.

5. The boundary line must appear near the zero point.



6. Set boundary line at the zero point by turning Zero adjustment screw with a screwdriver.

7. After scale is adjusted, wipe water off the prism and daylight plate.

Figure 4: Sample measurement

1. Put a few drops of the sample on the prism.

2. Read the value of scale at the boundary line.
   Do not turn the Zero adjustment screw.

3. Wipe the sample off the prism and daylight plate with soft tissue paper, and clean them with water.

Calculations

In the absence of calibration curves, empirical calculation formulas can be used:

% Delo XLI = (% Brix – 0.0031) / 0.3695

(An estimation can be obtained using this formula:
% XLI = % Brix × 2.7)

Precautions

1. The refractometer is a precision optical instrument. Handle it with care; avoid sudden impacts.
2. The prism is made of soft glass material. Take care not to scratch its surface.
3. After use, clean prism surface and daylight plate with a soft cloth soaked in water, and wipe off moisture with a dry cloth.
4. Best readings are obtained with a sample temperature of 15–30°C. Temperature correction is not not required in this temperature range.

Figure 5: Conversion table of % Brix into % Delo® XLI

Brix % at 20°C refractometer	Vol % Delo XLI	Brix % at 20°C refractometer	Vol % Delo XLI
0.0	0.00	4.6	12.44
0.1	0.26	4.7	12.71
0.2	0.53	4.8	12.98
0.3	0.80	4.9	13.25
0.4	1.07	5.0	13.52
0.5	1.34	5.1	13.79
0.6	1.62	5.2	14.06
0.7	1.89	5.3	14.34
0.8	2.16	5.4	14.61
0.9	2.43	5.5	14.88
1.0	2.70	5.6	15.15
1.1	2.97	5.7	15.42
1.2	3.24	5.8	15.69
1.3	3.51	5.9	15.96
1.4	3.78	6.0	16.23
1.5	4.05	6.1	16.50
1.6	4.32	6.2	16.77
1.7	4.59	6.3	17.04
1.8	4.86	6.4	17.31
1.9	5.13	6.5	17.58
2.0	5.40	6.6	17.85
2.1	5.67	6.7	18.12
2.2	5.95	6.8	18.39
2.3	6.22	6.9	18.67
2.4	6.49	7.0	18.94
2.5	6.76	7.1	19.21
2.6	7.03	7.2	19.48
2.7	7.30	7.3	19.75
2.8	7.57	7.4	20.02
2.9	7.84	7.5	20.29
3.0	8.11	7.6	20.56
3.1	8.38	7.7	20.83
3.2	8.65	7.8	21.10
3.3	8.92	7.9	21.37
3.4	9.19	8.0	21.64
3.5	9.46	8.1	21.91
3.6	9.73	8.2	22.18
3.7	10.01	8.3	22.45
3.8	10.28	8.4	22.73
3.9	10.55	8.5	23.00
4.0	10.82	8.6	23.27
4.1	11.09	8.7	23.54
4.2	11.36	8.8	23.81
4.3	11.63	8.9	24.08
4.4	11.90	9.0	24.35
4.5	12.17		

Part II. Measuring pH Value

Delo® XLI's unique corrosion inhibitor system is designed to protect aluminum and other system metals at lower pH levels than conventional coolants.

For general pH testing, Chevron recommends acid and base indicator strips measuring a pH range of 1–14. To determine specific values of the jacket cooling water, Chevron recommends narrow range strips measuring a pH range of 5.5–9.0, just above and below pH 7.0 (neutral).

Contact your customer service agent to order Cl and pH test strips.

Part III. Measuring Chloride Levels

Measurement and maintenance of chloride levels is necessary for optimal performance of the cooling water system. High chloride levels can significantly increase the risk of corrosion, and can also indicate sea water contamination in the cooling water system.

Chevron evaluated several commercially available chloride test strips, and recommends Hach® Quantab® titrators to measure the chloride content in cooling water treated with Delo XLI.

Recommended test strips: Hach Quantab titrators for chloride, 30–600 ppm (low range).

Summary

The test strips are specifically designed for measurement of chloride content in pure water, with accurate results in the range from 30 to 600 ppm.

In cooling water samples treated with Delo XLI the results are typically slightly higher than the actual chloride content in the solution; the higher the actual chloride level the bigger the deviation.

The test strips are a good way to determine if the chloride content in the cooling water is excessive (>100 ppm) and if so, further action may be required.

Note: The reading of the test strip is to be taken as soon as the upper band of the scale (initially yellow) turns black, indicating that the strip is completely saturated. Taking the readings later can lead to less accurate results.

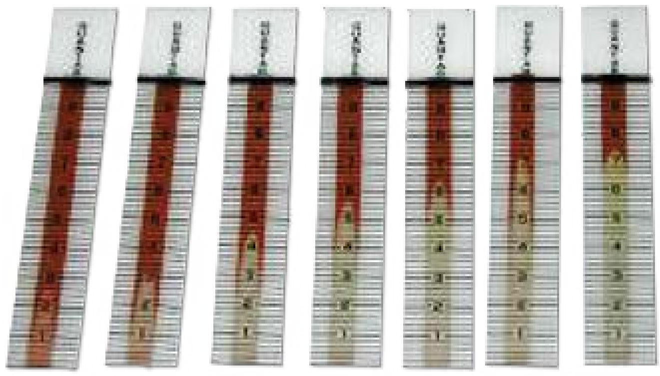
The test strips are not fit to measure the concentration of chloride in Delo XLI concentrate, since the liquid is too viscous to fully saturate the test strips. The amount of chloride in Delo XLI is low however, with minimal contribution to the total chloride content in the blended cooling water.

Note: The amount of chloride in Delo XLI is low, with minimal contribution to the total chloride content in the blended cooling water.

Other test methods

The Quantab test strips can be used to measure the chloride content in Delo XLI solutions. False results may occur if the test strips are exposed to other chemicals, leading to possible contamination. If further clarifications are required, a sample may be sent on shore for more accurate laboratory analysis, e.g., applying Ion Chromatography (IC).

Figure 6: Evaluation of Hach Quantab chloride test strips (7.5% Delo XLI in distilled water, tested with different chloride levels)



50 100 200 300 400 500 600

reference sample chloride content (ppm)	Quantab strip reading (units)	Quantab chloride content (ppm)
50	2.2	50
100	3.2	93
200	4.6	180
300	5.7	263
400	6.4	346
500	7.1	424
600	7.4	486

Part IV. Recording

Chevron recommends using the shipboard log sheet (on next page) two to three times a week to record the important parameters of your cooling water. A cloud-based system called the FAST.XLI Monitoring Program is also available; please contact your account manager for further details.

Figure 7 illustrates the limits and recommended corrective measures.

Figure 7: Cooling water treatment limits and comments

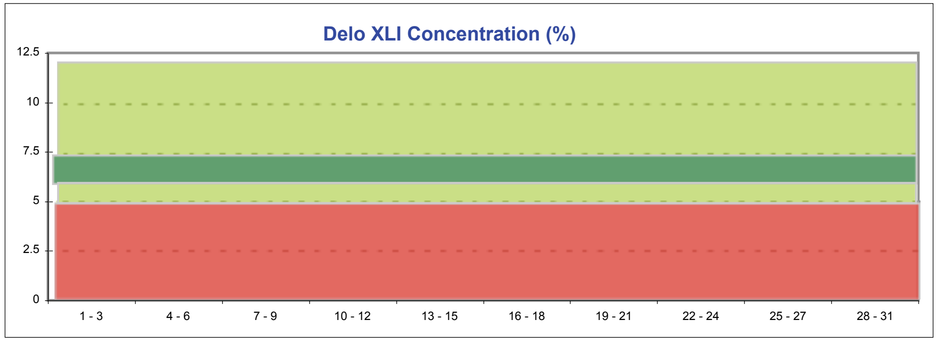
Appearance	Bright & Clear	**Normal**	Coolant is considered suitable for further service.
Appearance	Light Debris	**Attention**	Check system for rust and or water quality used for top up.
Appearance	Heavy Debris or Oil	**Urgent**	Drain and refill recommended.
pH	7.5–8.5	**Normal**	Coolant is considered suitable for further service.
pH	≥7.0 pH ≤7.4	**Attention**	Acidity is borderline. Follow up and use appropriate water at next top up.
pH	≥8.6 pH ≤9.0	**Attention**	Alkalinity is borderline. Follow up and use appropriate water at next top up.
pH	<7.0	**Urgent**	Water is acidic. Drain and refill with correct dosage and adequate water to increase the pH as recommended to between 7.5–8.5.
pH	>9.0	**Urgent**	Water is alkaline. Drain and refill with correct dosage and adequate water to reduce the pH as recommended to between 7.5–8.5. • Check: what was the last chemical used in the system and could this be interfering with the readings? • Check: what type of water was added to the system — shore (high in chlorides and/ or pH) or technical water (distilled water, typically more acidic) produced onboard with the fresh water generator. • Check: what is the pH of the makeup water tank? **For example: pH comes out at 9.7:** 1. Repeat the test. 2. If the high value is confirmed, drain some water. 3. Add Delo® XLI with the new make up water and measure pH. 4. If ≤9.0: OK. 5. If higher than 9.0, repeat steps 2 and 3 until a pH of ≤9.0 Is obtained **pH comes out at 9.1:** *Please check if the vessel just switched from competitive technology.* 1. If so, determine whether vessel had corrosion issues before switch. a. If not: closely monitor situation by sending samples to lab for analysis every 3 months. pH should drop after some time. b. If so: follow procedure above. 2. If not: drain and refill with the correct dosage of Delo XLI and adequate water.
Concentration Delo XLI	>6.0% XLI <7.5%	**Normal**	Coolant is considered suitable for further service.
Concentration Delo XLI	≥5.0% XLI ≤6.0%	**Attention**	Delo XLI concentration required to be above 6%, please top-up the system with Delo XLI and bring the concentration above 6%.
Concentration Delo XLI	≥7.5%	**Attention**	Our recommendation is to maintain Delo XLI concentration up to 7.5% for complete water care. Higher concentration will not harm the system.
Concentration Delo XLI	<5.0%	**Urgent**	Top-up the system with Delo XLI. Maintain Delo XLI concentration between >6.0% and <7.5%. Monitor Delo XLI concentration whenever water replenishment is carried out.
Chloride	<40 ppm	**Normal**	Coolant is considered suitable for further service.
Chloride	≥40 ppm Cl ≤100 ppm	**Attention**	Chloride content above normal levels. Drain the water from system and replenish with good quality water to reduce chloride level below 40 ppm. Look for causes of sea water ingress into the fresh water system and ensure no sea or desalinated water is used. Monitor chloride levels frequently.
Chloride	>100 ppm	**Urgent**	Action is required. Too high chloride contamination in the system. Incorrect water is used. Drain the water from system and replenish with good quality water and Delo XLI to reduce chloride level below 40 ppm. Look for causes of sea water ingress into the fresh water system and ensure no sea or desalinated water is used. Monitor chloride levels frequently.

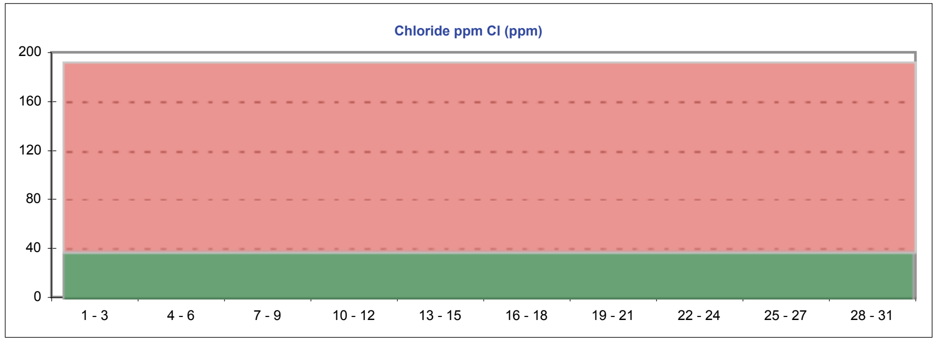
JACKET COOLING WATER TREATMENT PROGRAM

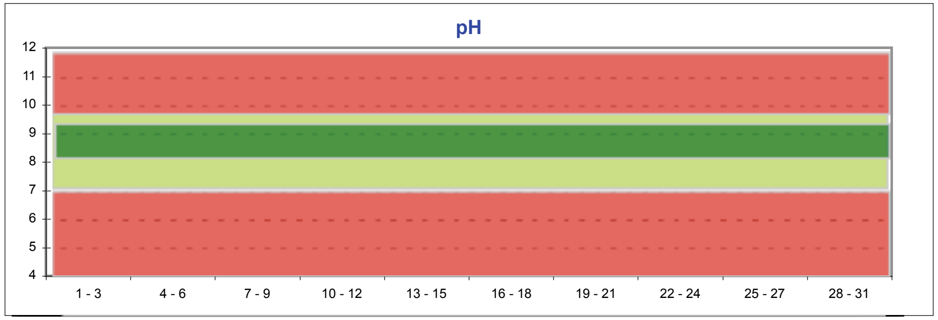
SHIPBOARD LOG SHEET

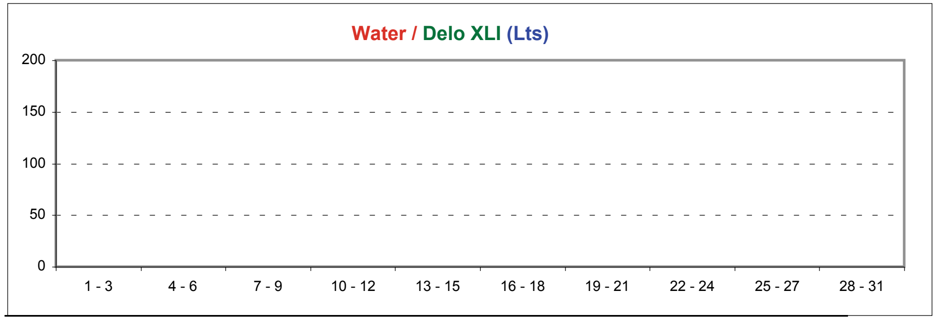
Ship's Name	m.t./m.v.	Type of ship			IMO No.		
Owner		Makeup water	Shore		System	Jacket HT	
Engine Make			Distilled			Jacket LT	
Engine Model			Mixed			Fuel Valves / Others	
Year	Month	**Product – Delo® XLI**				Others	

CAPACITY -	JACKET HT										
DATE	1 – 3	4 – 6	7 – 9	10 – 12	13 – 15	16 – 18	19 – 21	22 – 24	25 – 27	28 – 31	Summary
Delo XLI Concentration (%)											
Chloride ppm Cl (ppm)											
pH											
Delo added (ltr)											
Makeup water added (ltr)											









Comments :

Send fluid samples and direct technical enquiries to the below address:

Chevron Marine Lubricants – FAST Program
Couriers' contact: Sample reception, Tel. +32 (0)35458439

SGS Belgium NV
Polderdijkweg 16
B-2030 Antwerpen
Belgium

Tel. +32 (0)35458411
Email: cmltechservice@chevron.com

Chevron

marine lubricants information bulletin 16

hydraulic fluid changeover procedure

When switching suppliers, the question often arises on how to best transition from one hydraulic fluid to another. Some hydraulic fluids are incompatible, and may cause foaming, filter plugging, poor water separability or other performance issues if mixed.

This Information Bulletin provides the following:

- Guidance on transitioning from one hydraulic fluid to another
- Brief descriptions of Chevron premium hydraulic fluids
  - Chevron Clarity® Synthetic (and non-synthetic) Hydraulic Oils AW
  - Chevron Rando® HD Premium Oil MV
  - Chevron Rando HDZ
- Recent Chevron compatibility testing

General guidelines for any fluid changeover to Chevron hydraulic oil products

- Always confirm the right product is used for the application.
- Follow OEM recommended lubricant flushing and change-out procedures, if available, including all relevant safety precautions.
- Properly dispose of used oil.
- With water-emulsifying hydraulic oils in a hydraulic system, we recommend following Procedure 1 as outlined below for both our Rando (HD and HDZ) and Clarity (Hydraulic and Synthetic Hydraulic Oils AW) product lines which are water-demulsifying oils and will not be compatible with these water-emulsifying hydraulic oils.

Guidelines for switching over to Chevron's ashless hydraulic oils

Clarity Hydraulic and Clarity Synthetic Hydraulic Oils AW are:

- Generally compatible with mineral oil/PAO based ashless hydraulic oils, but refer to the table below to confirm (if the product of interest is not listed, provide a sample of fresh and in-service fluid to be tested). Procedure 1 is the preferred recommendation for best performance results.
- Usually not compatible with water-demulsifying hydraulic oils containing calcium/zinc additives, but refer to the table below to confirm. Procedure 1 is the preferred recommendation for best performance results.
- Not compatible with water-emulsifying type products being used as hydraulic oils. Procedure 1 is the preferred recommendation for best performance results.

Our field experience has shown that in most cases, draining the hydraulic system of zinc/calcium containing hydraulic oil, and then charging the system with fresh Clarity Hydraulic or Synthetic Hydraulic Oil AW has resulted in no known performance issues (contamination at <5% level) (Procedure 2). However, in other cases, especially with old or contaminated in-service oil, foaming, filter plugging, or poor water separability properties have been observed. Therefore, a thorough flushing and cleaning is recommended and Procedure 1 needs to be followed.

We do not recommend the practice of topping-off a system containing any zinc/calcium containing hydraulic oil with Clarity® Hydraulic AW or Clarity Synthetic Hydraulic Oil AW.

There may be a transition period needed to purge out the built-up sludge and deposits in the system. The length of this transition may depend on the amount of deposits formed previously. After the oil change-out, it is recommended to routinely monitor the hydraulic operation and filter life, closely monitor and evaluate the oil condition on a periodic basis to ensure proper performance, and take any corrective action that may be needed, including changing filters.

Procedure 1 — Drain and Flush

1. Operate the hydraulic system under normal operating temperature and conditions for minimum of 1 hour. Then shut the hydraulic system down. The lubricant in the system should be warm/hot when initiating the lubricant change.
2. Relieve all pressure in the system and disconnect all electrical power.
3. Drain the entire system as best as possible and try to include oil in all hoses and lines, hydraulic pump and motor, oil cooler, valves, reservoir, and filters. (Extreme caution should be exercised when draining hot lubricant to prevent possible injury.)
4. Thoroughly clean the hydraulic system if needed. Examine and replace all worn seals. Replace filters and strainers.
5. We then recommend the customer fill the system with Chevron Canopus® 13, or the replacement fluid, and run at minimum pressure with no-load condition for a determined length of time to clean, and flush the system. In some cases, a more viscous fluid, like Chevron Canopus 68 may be the preferred flushing oil.
6. Thoroughly drain the system as outlined in Step 3, rechecking filters for any contamination.
7. Refill the entire system to the correct level with fresh oil and operate system under normal operating conditions. An additional flush with the replacement fluid is recommended so that the new oil will be the lubricant being applied to the application when the operation re-starts to achieve the best performance results.

Procedure 2 – Drain and Fill

1. Operate the hydraulic system under normal operating temperature and conditions for minimum of 1 hour. Then shut the hydraulic system down. The lubricant in the system should be warm/hot when initiating the lubricant change.
2. Relieve all pressure in the system and disconnect all electrical power.
3. Drain the entire system (tank and reservoir) as best as possible and if desired for better performance include draining oil in the hoses, lines, hydraulic pump and motor, oil cooler, valves, reservoir, and filters. (Extreme caution should be exercised when draining hot lubricant to prevent possible injury.)
4. Thoroughly clean the hydraulic system if needed. Examine and replace all worn seals. Replace filters and strainers.
5. Refill the entire system to the correct level with fresh oil and operate system under normal operating conditions.

Chevron Clarity Synthetic Hydraulic Oils AW

Ashless, high viscosity index Clarity Synthetic Hydraulic Oils provide outstanding thermal, oxidation, and shear stability. Clarity provides hydraulic system energy efficiency. Clarity is also for systems operating in environmentally sensitive locations.

Chevron Rando® HD Premium Oil MV

Chevron Rando HD Premium Oil MV is an ISO 32 product with very high viscosity index (VI), beneficial for relatively extreme temperature swings and hydraulic system energy efficiency. Even after significant use, the VI of HD Premium Oil MV can remain higher than the starting (fresh oil) VI of other products. HD Premium Oil MV also contains a seal swell agent to help combat leakage. HD Premium Oil MV provides excellent thermal, oxidation, and shear stability as well. Rando HD Premium can be used where zinc anti-wear characteristics are preferred.

Chevron Rando HDZ Oils

Chevron Rando HDZ Oils also provide excellent thermal, oxidation, and shear stability, along with hydraulic system energy efficiency. Rando HDZ can be used where zinc anti-wear characteristics are preferred.

Do not use in high pressure systems in the vicinity of flames, sparks and hot surfaces.

For further information, please contact Chevron Technical Services at CMLtechservice@chevron.com ■

Product Compatibility Table[1]

Chevron Replacement Product (all fresh oil unless noted)	Product to be replaced	Compatible?[1]
Chevron Clarity® Hydraulic Oil AW (fresh)	Citgo Dimension Hydraulic Fluid (fresh)	Yes
Chevron Clarity Hydraulic Oil AW 46 (fresh)	Castrol SHF 46 (fresh)	Yes
Chevron Clarity Hydraulic Oil AW 46 (fresh)	Citgo Dimension Hydraulic Fluid (fresh)	Yes
Chevron Clarity Synthetic Hydraulic Oil AW (fresh)	Chevron Rando HDZ (fresh)	No
Chevron Clarity Synthetic Hydraulic Oil AW (fresh)	Mobil DTE 10 Excel 32 (fresh)	No
Chevron Clarity Synthetic Hydraulic Oil AW 46 (fresh)	Shell Tellus EE 46 (fresh)	Yes
Chevron Clarity Synthetic Hydraulic Oil AW 46 (fresh)	Shell Tellus STX 46 (fresh)	Yes
Chevron Rando® HD Premium Oil MV (fresh)	Mobil SHC 524 (fresh)	Yes
Chevron Rando HDZ 15 (fresh)	Exxon Univis HVI 13 (fresh)	Yes
Chevron Rando HDZ 22 (fresh)	Mobilarma 522 (fresh)	Yes
Chevron Rando HDZ 32 (fresh)	Mobil DTE 10 Excel 32 (fresh)	Yes
Chevron Rando HDZ 32 (fresh)	Shell Tellus T 32 (fresh)	Yes
Chevron Rando HDZ 46 (fresh)	Chevron Hydraulic Oil 5606A (fresh)	Yes
Chevron Rando HDZ 46 (fresh)	Frontier Wear Guard AW 46 (fresh)	Yes
Chevron Rando HD 150 (fresh)	Chevron Regal R&O 150 (fresh)	No
Chevron Rando HD 22 (fresh)	Mobilarma 522 (fresh)	Yes[2]
Chevron Rando HD 32 (fresh)	Shell Tellus T 32 (fresh)	No
Chevron Rando HD 32 (fresh)	Mobil DTE 10 Excel 32 (fresh)	Yes
Chevron Rando HD 46 (fresh)	Fuchs Renolin AF 46 (fresh)	No
Chevron Rando HD 46 (fresh)	Mobil DTE 25 (fresh)	Yes
Chevron Rando HD 68 (fresh)	76 Unax AW 68	Yes

1. Compatibility of fresh oils may be different than in-service oils. Contamination and aging of oils can make them incompatible. Reported results are based on ASTM D7155-06 "Standard Practice for Evaluating Compatibility of Mixtures of Turbine Lubricating Oils." The Tier 1 method compares the visual appearance of specific mixtures strictly for changes in physical appearance and the data are reported here. The Tier 2 method compares selected performance properties of specific mixtures and were not performed here. Please note that Chevron's compatibility testing is typically limited to appearance only (as described above for Tier 1 method) and that Chevron has not tested the performance properties of a mixture of the two products; Chevron has not utilized the Tier 2 testing method. Chevron has relied upon the information provided to make the recommendation set forth in this document. Chevron has not evaluated the particular operating environment or the specific application. The statement that two lubricants are compatible using the ASTM D 7155 Tier 1 method offers no information about the performance characteristics of either product or of mixtures of the products regarding wear prevention characteristics, load carrying capacity, sludge-formation tendency, the mechanical shear stability of lubricants mixtures while in service or any other measurable aspect of lubricant performance. When changing lubricants, it is essential that all equipment manufacturer recommended procedures be followed, including drain and flush requirements.
2. Although fresh Chevron product is visually compatible, we do not recommend using this product in place of Mobilarma 522.

The above table includes hydraulic oil compatibility testing since 2009. Even if products have been tested as compatible (by appearance), draining and flushing remains the preferred practice.

marine lubricants information bulletin 17

scuffing & red deposits after fuel transition: causes and solutions

In a multi-fuel environment, operators face a range of options to ensure that their vessels are compliant with legislation, and continue to deliver reliable performance. The transition to Very Low Sulphur Fuels (VLSFOs) was successful in the vast majority of cases, but created a problem with red deposits for some vessels.

An investigation by Chevron Marine Lubricants demonstrates the need for a flexible but measured approach to evaluating and solving issues with marine main engines.

A number of vessels that have switched to VLSFOs reported abnormal main engine liner wear, identified through routine DOT.FAST® onboard testing. In these cases, evidence of liner scuffing and red deposits formed locally on piston crowns or top edges was recorded, with red colored iron burrs in the scavenge port discovered in a few instances.

In order to prevent further damage from occurring, Chevron Marine Lubricants worked with customers to carry out a comprehensive program of field monitoring. Alongside in-depth drip oil analysis with the DOT.FAST onboard and onshore service, a range of additional tests were conducted which we will review at length here.

Figure 1: Photographs (A–C) of damaged liners. Courtesy of Chevron Marine Lubricants, 2020

A) Piston with scuffing and deposits.

B) Iron burrs in scavenge port.

C) Cylinder liner with deep red layer with scoring marks.

These tests were chosen specifically by the technical team in order to identify and help treat the cause of the problems experienced by these engines.

Chevron field investigation overview

Following the identification of issues with piston rings, the Chevron Marine Lubricants Field Technical Specialist team identified seventeen vessels requiring further investigation. The age of the ships varied between four and twenty years, across a wide range of ship types including bulker, oil tanker and container vessels. All engines were two-stroke marine main engines from the major OEMs. It should be noted that in the majority of cases the piston rings fitted in these engines were not of the latest design — hard coated and gas sealing rings.

Cylinder condition observations

The issue of red deposits did not impact all of the cylinders, but it was found in some cylinders with pre-existing poor cylinder liner or piston ring pack condition.

In most cases the scuffing appeared only on individual liners. Some scuffed units showed red deposits on piston crowns with other units showing no signs of either scuffing or deposits.

Cylinder lubrication

It became clear that this issue wasn't limited to a single lubricant supplier or linked to the BN level of the lubricant used in the application. In fact, it was found in vessels using 40BN to 100BN lubricant grades. Therefore, the problem was unlikely to be the result of cylinder lubricant performance or engine brand.

Analysis of red deposits in the samples

To establish the cause of the deposit formation and to be able to advise on how to deal with the issue, identification of the chemical composition of the samples, as well as a detailed analysis of the used oil, was carried out. Details on the analytical methods employed can be found in Figure 2.

Figure 2: An example of the red deposits analysed at Chevron laboratories

Analytical methods

1. **CHN: Combustion Analysis with Thermal Conductivity Detection**
   Measures organic carbon, hydrogen and nitrogen content.
2. **XRD: X-Ray Diffraction**
   Detects crystalline compounds comparing with standard spectrum.
3. **SEM/EDX: Scanning Electron Microscopy/Energy Dispersive X-Ray Spectroscopy**
   Visual screening and point at specific particles to determine the elemental composition of the particles.
4. **XPS: X-Ray Photoelectron Spectroscopy**
   Oxidation state of the element identification based on binding energy.

Results from analysis of red deposits

1. CHN: Organic Carbon, Hydrogen, and Nitrogen

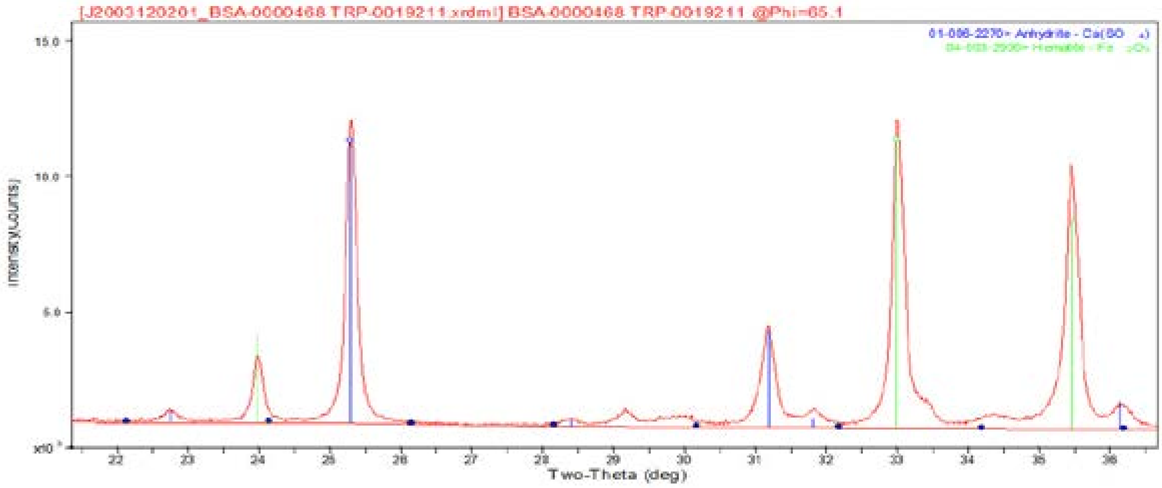
Figure 3: Measurement of Total Carbon, Hydrogen and Nitrogen

Test Method	Elements	Wt %
Test Method 31319 = ASTM D5291 and D5373	C	<1
	H	<1
	N	<1

Conclusion: There are very few carbon, hydrogen and nitrogen compounds in the deposit. This may indicate that all organic compounds have been burned off due to the very high combustion temperature.

2. XRD: X Ray Diffraction Analysis

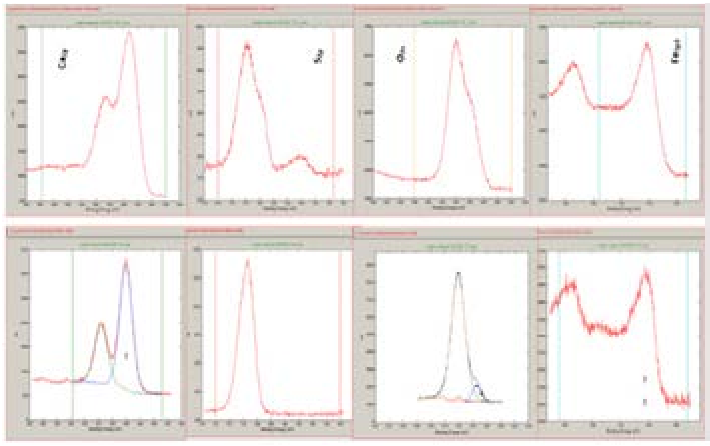
Figure 4: X-Ray Diffraction Analysis

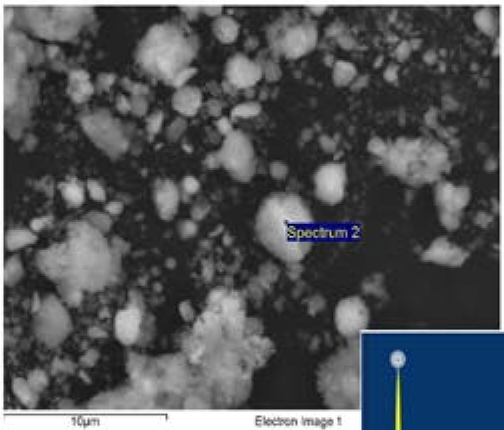


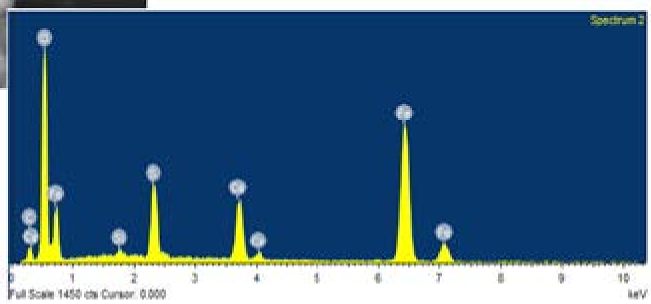
Conclusion: The XRD analysis indicates that the red deposit consists of mostly crystalline materials as Anhydrite $CaSO_4$ and Fe_2O_3 (Hematite). Hematite is even harder than ferrous metal.

3. SEM/EDX + XPS

Figure 5: SEM/EDX + XPS Visual screening and point at specific particles to determine the elemental composition of the particles







Conclusions:

- The major phase(s) in this sample (>95%) consists of Ca, S, Fe and O which are calcium sulfate and iron oxide.
- Trace amounts (<5%) of Ni, Cu, P, Si were also detected.
- Interestingly, the morphology of some of the iron particles are in the form of spheres (~10µm in size). While the most obvious inference is that the iron oxide is rust, please note that welding spatter also tends to form such spheres.
- The morphology of other types of particles are random and they too contain iron.
- The iron oxide spheres seem to have been bound by the calcium sulfate material.

Summary of findings

Following this program of analysis, the results indicate that the deposits contain very little organic material. This suggests that the source of the calcium sulphate — not a cause for concern in itself — is probably as a result of harmless detergent additives from the lubricants. The iron oxide, however, is the result of harmful abrasive wear of the piston and liner.

VLSFO Fuels

The key element that changed prior to the observation of red deposits is the introduction of lower sulphur fuel due to IMO 2020 implementation. Therefore, it is important to look in detail at the characteristics of the fuels in use.

We have calculated the CCAI (Calculated Carbon Aromaticity Index) and determined the combustion characteristics ECN (Estimated Cetane Number) via Fuel Combustion Analysis (FIA/FCA-IP 541) for the various fuel types most commonly bunkered post IMO-2020 enforcement, and compared them with HSFO, which would have been the predominant fuel used in these engines pre-2020.

Key characteristics of VLSFOs

- VLSFOs analysed showed excellent combustion properties — typically faster burning, higher energy release than traditional HFSO.
- The time between injection and reaching maximum pressure is shorter, hence peak combustion is reached earlier in the combustion cycle.
- Overall, more energy released — typically higher max ROHR level.

VLSFO from liner scuffing cases showed typically low CCAI and high ECN. The key observation is that most VLSFOs typically have a lower CCAI in comparison with compared to HSFOs.

Figure 6A: ROHR = Rate of Heat Release

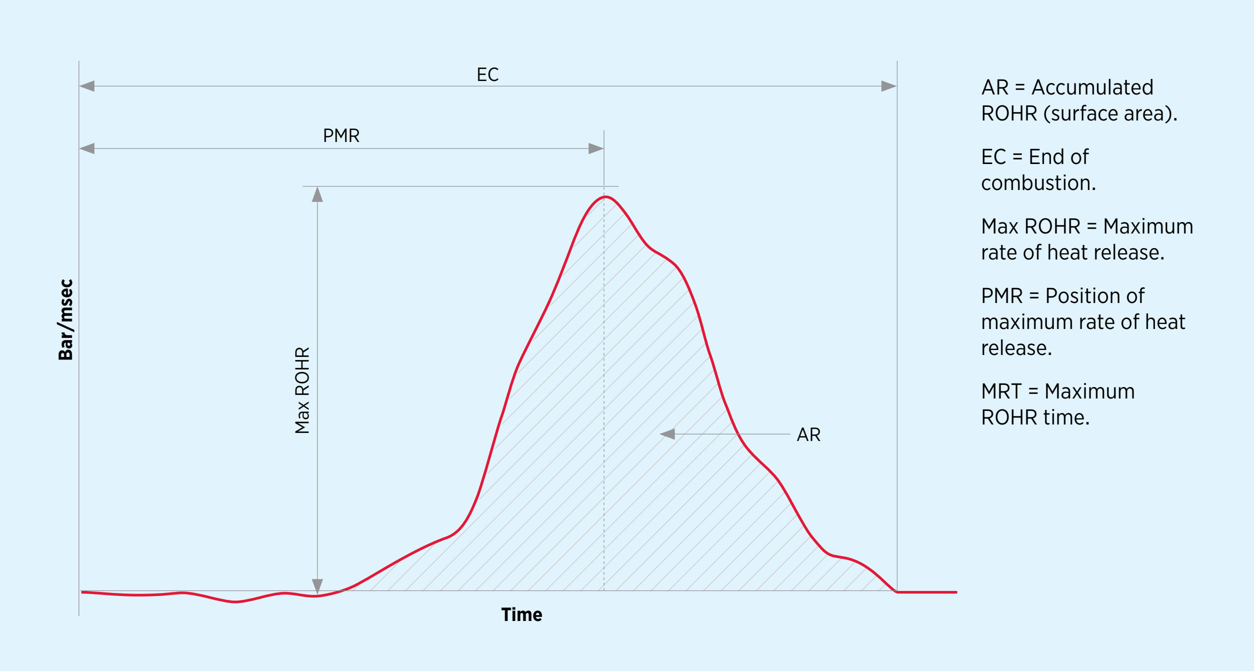


Figure 6B: Comparison of ROHR from different batches of VLSFO

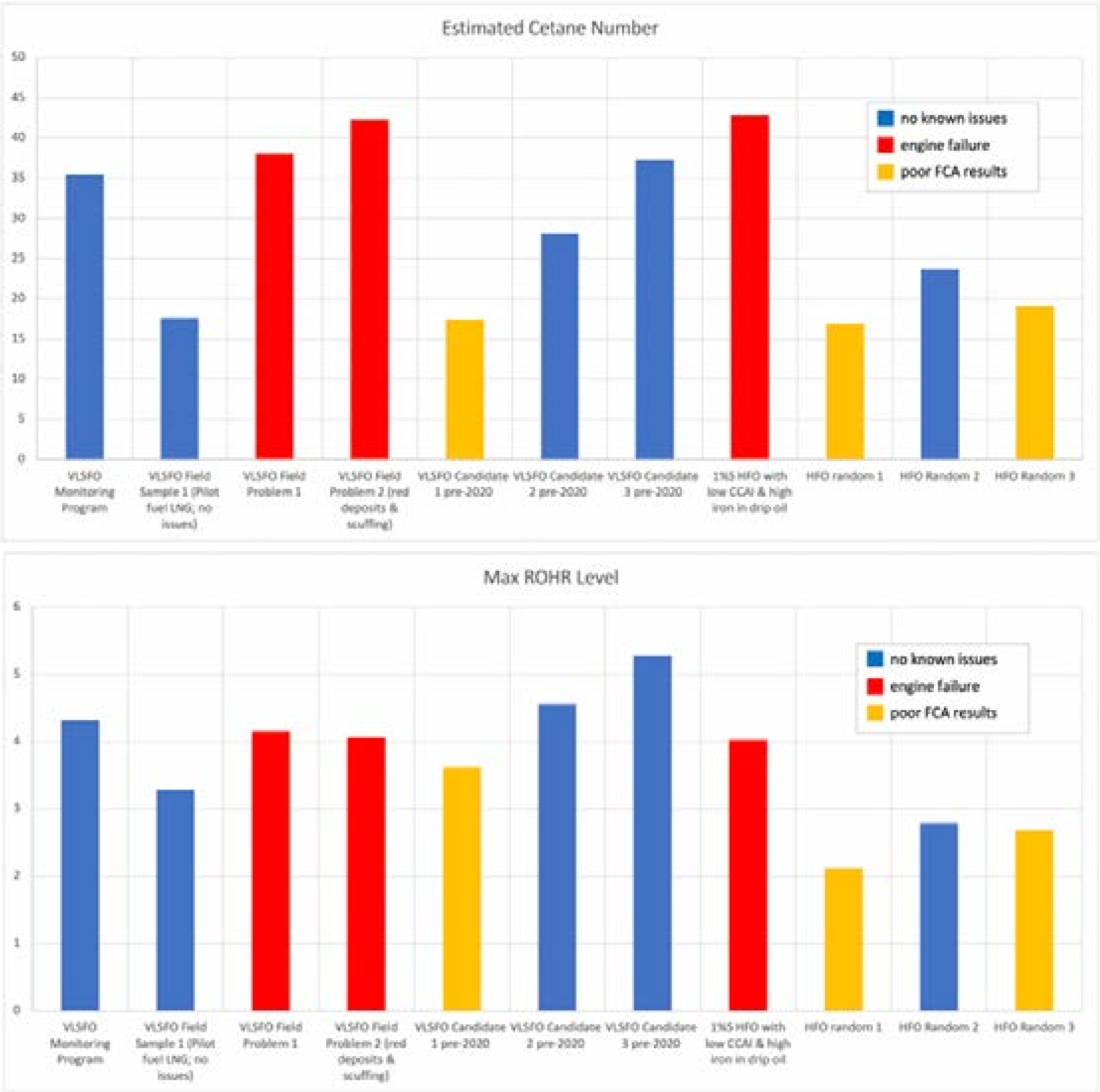


Figure 7A: Difference in FCA Test — Comparison of the combustion process in VSLFO and HSFO

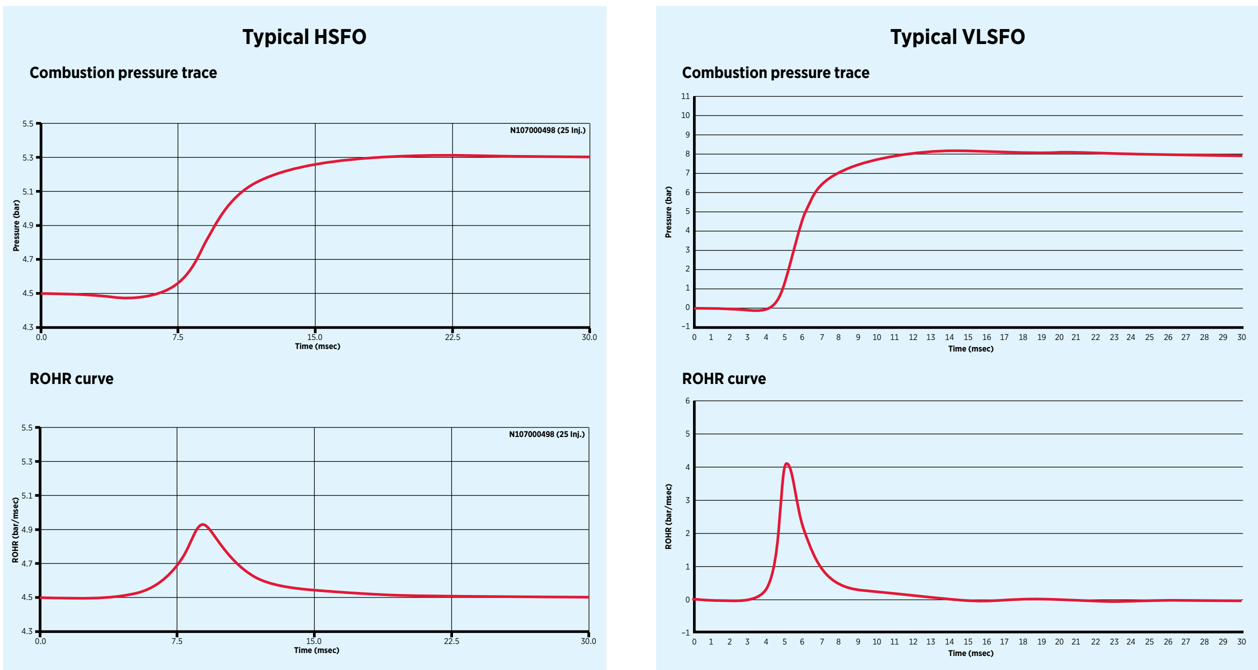
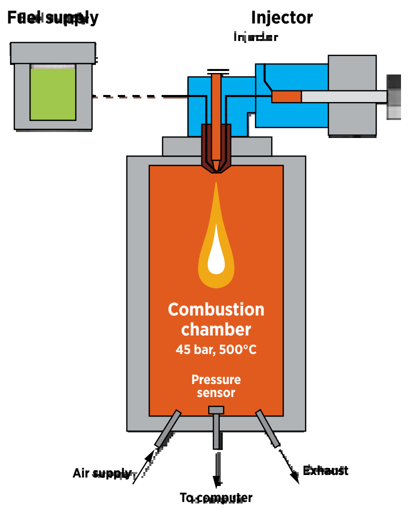


Figure 7B: Fuel Combustion Analyzer



Conclusion

Vessels experiencing issues with red deposits tend to have been in operation for a few years. Analysis of the deposits indicates that they are mostly composed of inorganic compounds, formed as a result of piston and liner wear. The issues are not related to the base number or the lubricant brand used, as typically the engine experienced the problem in only one or a few of the cylinders.

Fuel analysis indicates that VSLFO typically has higher combustion engine density properties, resulting in more harsh operating conditions and more stress on the engine components. According to Luc Verbeeke, Senior Engineer, Chevron Marine Lubricants, the vast majority of customers transitioned well to VLSFO and the typical higher energy content of the fuels means more value for money.

"While newer ships do not have a problem using these fuels, engines already closer to an overhaul did struggle sometimes," said Luc Verbeeke. "Cylinder units that could have run for another six months or a year on HSFO did not survive the tougher conditions with the new fuels."

Combined with incorrect fuel handling when transitioning to VLSFO, these challenges with older engines and the impact of flushing waste material from tank cleaning through engines account for most of the scuffing incidents observed. The fact that reports of scuffing have since declined to usual levels suggests that the industry has now come to terms with the procedures it needs to operate safely and reliably with VLSFO, and that the engine maintenance program recommended by Chevron Marine Lubricants helps provide vital protection against liner wear and damage. ■

Figure 8: Chevron's DOT.FAST® Onboard Testing Kit

Routine testing with Chevron's DOT.FAST® onboard testing kit can help identify abnormal main engine liner wear which may lead to liner scuffing and red deposits.

Chevron

marine lubricants information bulletin 18

onboard & onshore drip oil analysis for two-stroke marine engines

Reliable, accurate analysis of drip oil conducted onboard, supported by in-depth laboratory diagnostics, remains important following the widespread shift to lower sulfur fuels since the introduction of IMO 2020 marine fuel emissions legislation.

Introduction

With the general move from high sulfur fuel oils to fuels with a sulfur content of lower than 0.5% from 1st January 2020, ship operators might have assumed that problematic corrosive wear within marine two-stroke engines would disappear. As a result, some may believe it is not necessary to measure for non-magnetic iron particles often interpreted to be indicative for corrosive wear, only the for larger, magnetic iron particles that are often connected to immediately damaging abrasive and adhesive wear. Chevron's experience indicates that this is not the case and required further exploration.

As long as there is sulfur in fuel there is the risk of cold corrosion, particularly with modern engines operating at a slow speed with a very long stroke. Many newer engines are still at risk of corrosion and it is important to continue monitoring this corrosion when operating on very low sulfur fuel oil (VLSFO). Furthermore, the presence of larger, magnetic iron particles is not in itself enough to confirm that cylinders are suffering from abrasive or adhesive wear. It can also indicate high levels of corrosive wear.

For these reasons, Chevron Marine Lubricants believes that monitoring of total iron content is the best way to monitor engine wear via regular testing with the DOT.FAST® onboard kit. Further, deeper analysis using DOT.FAST laboratory services can deliver even more accuracy and can distinguish between iron particles (as well as other metals) in the drip oil to predict or diagnose problematic wear.

Drip oil

Drip oil — sometimes called scrape-down oil — is used cylinder oil collected from the scavenge space of marine two-stroke engine cylinder liners. Analyzed on a regular basis, drip oil samples can track cylinder condition and identify trends that may necessitate remedial action on the part of the engine operator.

The two key parameters in drip oil are:

- Remaining alkalinity (or residual BN): The combustion of fuel containing sulfur forms acids which, untreated, can cause excessive corrosive wear. The cylinder oil's alkalinity reserve, represented by the base number (BN), counters this effect. Too low remaining alkalinity suggests there may not initially have been enough alkalinity to tackle acid formation effectively.
- Iron content: The presence of iron in drip oil indicates the level of wear taking place in the cylinder, and whether the wear is acceptable or could lead to cylinder condition challenges. Both the amount and the type of iron in drip oil needs to be analyzed to fully understand the state of the cylinder.

Cylinder wear

The most relevant types of wear in marine engine cylinders are chemical or corrosive wear and mechanical wear, which can be caused by adhesion or abrasion.

- Corrosive wear: Caused by acid — usually sulfuric acid arising from the fuel sulfur content — attacking the mechanical parts in the combustion space. Mild corrosion will result in the formation of mainly iron oxides and salts, which actually help to maintain the cylinder condition by providing a liner surface structure that promotes a stable lubricating oil film. Excessive corrosion will release larger iron particles, also known as ferrous magnetic debris, wearing the liners and piston rings down quickly.

- Abrasive wear: Occurs when hard particles (such as cat fines) larger than the oil film thickness get trapped between cylinder liner surface and piston rings. The softer surfaces will be scored and both small (soluble) and large (insoluble) iron particles will be generated.
- Adhesive wear: Caused by hard contact between cylinder liner surface and piston rings due to a lack of oil film. In the absence of a protective coating on the cast iron metal surface, the piston ring will weld to the cylinder liner under the high pressure and temperature occurring in the combustion chamber. This weld will tear off as the piston moves, resulting in heavy damage to both the cylinder liner surface and the piston ring, with both small and large iron particles being released.

Iron content

From the description of wear above, it is clear that corrosive and adhesive/abrasive wear are associated with different types of iron particles.

- Small particles (soluble and non-magnetic): These include iron oxides and salts and are more often associated with corrosive wear.
- Large particles (insoluble and magnetic): These particles are predominantly associated with abrasive and adhesive wear, as well as with an excessive amount of corrosive wear.

Figure 1: Excessive alkalinity caused by overfeeding

Figure 2: Excessive corrosion

Despite this association, it is important to note that the type of wear cannot always be neatly identified from these particles alone. For example, high corrosive wear can result in large particles in the cylinder oil, while abrasive or adhesive wear will generate small particles often associated with corrosive wear as well. These ambiguities make rigorous analysis essential to correctly identify the primary type of wear in engine cylinders.

The sweep test provides an example of the challenges low-sulfur fuels can pose for conventional drip oil analysis. The sweep test determines the optimal cylinder oil feed rate relative to the sulfur content in the fuel. This engine and operation-specific 'feed rate factor' can then be used to recalculate the optimal feed rate when switching to fuels with different sulfur content.

Sweep test

The sweep test is normally performed while operating on high-sulfur fuel. Starting at a high feed rate, operators progressively reduce the feed rate each day until the engine manufacturer's minimum recommended rate is reached. At high feed rates, drip oil analysis shows high residual BN — the oil has an excess of alkalinity to neutralize any acids formed in the engine during the combustion. As well as using an excessive amount of cylinder oil, alkalinity overfeeding can lead to the formation of deposits on the piston top and ring lands. The optimal feed rate will show enough remaining BN to indicate that there was sufficient alkalinity originally to neutralize acids, but not so much as to cause these deposits.

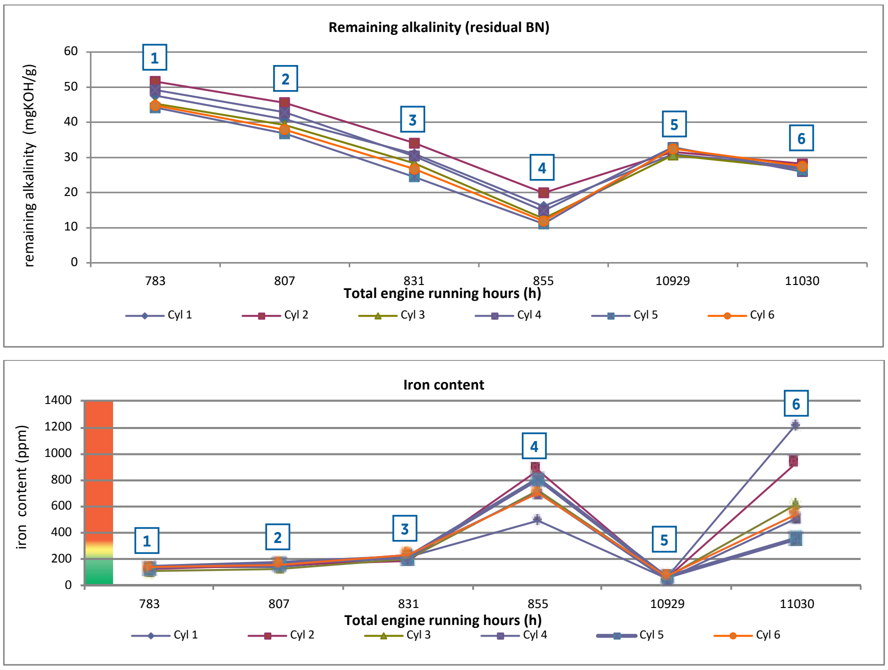
As the feed rate is lowered, more of the alkalinity reserve is consumed and the residual BN decreases until a point is reached where the cylinder oil does not adequately protect the liner from corrosion. At this stage, corrosion will occur and the iron content in the drip oil sample will increase. A low level of corrosion is acceptable, and the ideal feed rate lies within this range. The optimal feed rate factor therefore sits on the curve between too much residual BN and too much iron content in the drip oil.

As vessels without scrubbers have not been allowed to carry high sulfur oil since March 2020, very low sulfur fuel oil is increasingly used for sweep tests. But the optimal feed rate factor can be more challenging to determine on low-sulfur fuel. While with high sulfur fuel there are two parameters that can be used to determine the optimal cylinder oil feed rate — iron content and residual BN — when running the test with low sulfur fuel, iron content is the focus. This is because the alkalinity reserve in the cylinder oil depletes far less and residual BN remains closer to that of the fresh cylinder oil. Further, the feed rate can be reduced significantly without getting an early warning that corrosion has started, and the cylinder can enter boundary lubrication conditions as the feed rate drops below a point where the oil film between the piston ring pack and liner is inadequate.

Onboard analysis

The DOT.FAST® onboard test kit provides an accurate way to identify the point at which iron particles in the cylinder

Figure 3: Sweep test on MAN ES 6S50ME-B9.3 using HSFO and early experience using VLSFO



Points 1–4 show sweep test results with HSFO in combination with Taro Ultra 100 (100 BN). While the residual BN in the drip oil samples decreases steadily as the cylinder oil feed rate is lowered, the iron content increases due to the increased level of corrosion occurring in the cylinders. At point 4 the alkalinity reserve in the cylinder oil is depleted and the wear level is excessively high. Point 2 shows the optimal 'cylinder oil feed rate factor', with both the residual BN and the iron content at optimum levels.*

Points 5–6 show cylinder oil feed rate optimization using VLSFO in combination with Taro Ultra 40 (40 BN). At point 5 the residual BN is at acceptable level and the iron content indicates optimized conditions at the given cylinder oil feed rate, however the reduction of the feed rate at point 6 results in excessive wear without a significant drop of the residual BN.

The graphs above illustrate the importance of accurate tools to monitor the iron content in drip oil samples (using onboard & onshore analysis). They demonstrate that the residual BN can no longer be used to determine the optimal cylinder oil feed rate where low sulfur fuels are in use.

** Cylinder oil feed rate factor: cylinder oil feed rate (g/kWh) relative to the sulfur content in the fuel.*

oil start to rise, even with VLSFO in use in combination with low BN cylinder oils.

Some of the other onboard test kits commercially available focus on large iron particles that are generated in case of excessively high cylinder wear — often associated with 'abrasive' wear. These kits are typically based on inductive sensor technology and detect the presence of ferrous magnetic debris in the oil sample. Other kits focus on the small particles — soluble and non-magnetic iron — often associated with 'corrosive' wear. These small particles are generated both in case of high wear and as an early indication of increased wear. X-ray technology can detect both the large particles and the smaller, soluble iron, but can be significantly more expensive to implement. However, although these alternative devices can distinguish between different types of iron, as per above they do not distinguish between types of wear.

While it is desirable to understand the mechanism, it is impossible to determine from the type of iron only, and needs to be arrived at in combination with other data. Chevron Marine Lubricants' DOT.FAST® kit uses wet chemistry to measure the total iron content, picking up both the large particle ferrous magnetic debris as well as the soluble, non-magnetic iron. This enables early detection of increased wear of any type, even before any large iron particles are generated.

The DOT.FAST onboard test kit is designed to make the analysis easy to perform without training. Reagents are provided in the required quantities and the engineer needs only to transfer some drip oil by means of a pipette with a fixed volume into the vial, then break the inner vials to release the reagents. After filtering out any debris and other contaminants, the vials are then placed in the Chevron Drip Oil Analyzer, which uses photometric reading to determine the total iron content expressed in parts per million (ppm).

The use of onboard test kits enables crew to take immediate corrective action in many cases, but the interpretation of results may require additional expertise. For this reason, it is recommended to combine onboard analysis with onshore verification, especially in cases of sweep testing and cylinder oil feed rate optimization.

Onshore analysis

The addition of onshore analysis enables an in-depth evaluation of the drip oil samples, and the reports contain actionable comments generated by technical experts.

As well as the residual BN and the total iron content, additional parameters are measured with laboratory accuracy. Not only does the laboratory distinguish between small, non-magnetic iron particles and larger ferrous magnetic debris, but other wear metals such as copper, chromium and aluminum are also evaluated. High copper content can indicate running-in conditions for example, which results in high iron content as well, where there is no issue. Aluminum potentially indicates the presence of cat fines in the fuel, which will translate as abrasive wear and excessively high iron content in the drip oil samples accordingly.

Figure 4: Chevron's proprietary DOT.FAST® kit and Disporack™

Drip Oil Analyzer and MicroMan® Pipette *DispoRack™ with 12 ITUs (Iron Testing Units)*

Features and benefits:

DOT.FAST Onboard Test Kit

- Chemical testing with the Disporack™ unique in the industry
- Iron measured for soluble and insoluble particles (total iron content)
- Individual vials keep the chemistry free from contamination and maintain quality
- Minimize human error with fixed quantities
- Robust design for a long service life

DOT.FAST Onshore Analysis

- Analysis in specialized, ISO certified laboratories
- Total iron content and system oil dilution taken into account
- Expertly reviewed analysis
- Easy to interpret report with actionable recommendations
- Fast turnaround
- Historical reference data maintained on secure website

Accurate onboard testing:

1. *Collect drip oil samples from scavenge sampling valves.*

2. *Prepare the samples using the DispoRack and ITUs.*

3. *Test the prepared samples using the Drip Oil Analyzer.*

Next to that, the amount of system oil in the drip oil samples is determined, which is key for proper interpretation of the test results. System oil normally has a very low wear metal content and BN, and when it breaches the stuffing box between the crankcase and the cylinders to mix with the drip oil, this will dilute the results for all parameters. As such, a drip oil sample containing an acceptable concentration of iron by measurement may still reveal high cylinder wear if this sample happens to be highly diluted with system oil. For this, it is important to determine the 'system oil dilution factor'.

Engine oil samples are sent for onshore analysis using the FAST™ fluid analysis sample kit. This sample kit contains everything needed to deliver the samples, including standard sized sample bottles, labels and pre-addressed envelopes for Chevron's global laboratories. Analysis is conducted at ISO-certified laboratories and customers receive feedback in a FAST report within 24–48 hours of receipt of the final sample batch.

Conclusion

Analysis of all drip oil parameters remains important after IMO 2020 and the widespread move to low sulfur fuels. Onshore laboratory analysis is needed to distinguish between excess corrosion and abrasive/adhesive wear, regardless of whether the operator's onboard kit measures magnetic iron, iron oxides and salts ("soluble") iron or the total iron content. The difference is that equipment that determines the total iron content — such as the Chevron DOT.FAST® onboard test kit — enables operators to track corrosion and wear of any type at low levels. This is critical for modern two-stroke engines that may still be prone to cold corrosion even when using low-sulfur fuels, and for identifying other forms of wear that are not related to fuel sulfur. ■

marine fuels information bulletin 1

ISO 8217: test methods — precision and interpretation

The International Organization for Standardization's (ISO's) 8217 standard lists the required specifications for marine fuel oils and the standard test methods used to assess them.

Most bunker fuel orders specify a fuel quality defined by ISO 8217 and many of Chevron's customers have their bunker fuel deliveries analyzed by an independent laboratory to comply with ISO 8217.

It is Chevron's policy to supply bunker fuels that comply with the specifications agreed upon when the order is accepted and confirmed. Our terms of sale state that only retain samples provided by/on behalf of Chevron at the time of bunkering are considered valid samples. However, a test analyzed by a customer's chosen lab on the customer's retain sample may fail a specification limit, while Chevron's retain sample analysis shows the product to meet specifications. How is this possible?

If the samples were properly taken and closely represent the quality of the fuel delivered, the answer is found in the ISO 8217 reference to the individual test methods to be used, and in the ISO 4259:2006 standard on the "determination and application of precision data in relation to methods of test." If the prescribed test method defined in ISO 8217 was not used by one of the two parties, that party should obtain the result using the prescribed test method before initiating any discussion.

The following question and answer format describes how to interpret a test method's precision and specification limit. Please see ISO 4259:2006 for additional information about the interpretation of test results.

Is every single test result the "true value?"
No, every single test result is only an approximation of the true value. The intrinsic limitations of the test result are determined by the precision of the test method. True value is the average of an infinite number of single test results obtained by an infinite number of laboratories and, therefore, cannot be exactly established.

What defines the precision of a test method?
For each test method "repeatability" and "reproducibility" values are defined and listed. Repeatability is the difference between consecutive test results obtained by the same operator using the same apparatus under constant operating conditions on identical test material. It is only relevant for the individual testing laboratory.

Reproducibility is the closeness of agreement between individual results obtained in the normal and correct operation of the same method on identical test material (different operator, different apparatus, and different laboratories).

How is test reproducibility used to judge the acceptability of two test results?
If the difference between two single test results (obtained with the same method in two different laboratories, for example, a supplier's test result and a customer's test result) is less than or equal to the reproducibility "R" of the test method, then both test results are considered acceptable. Their average value is considered the estimated value of the tested property.

Example 1: RMG 380 test — density determination

Lab 1: Density at 15°C, ISO 12185:1996: 991.4 kg/m^3
Lab 2: Density at 15°C, ISO 12185:1996: 990.2 kg/m^3
Listed reproducibility "R" of method ISO 12185:1996: R = 1.5 kg/m^3

The difference between the two single test results, 991.4 kg/m^3 – 990.2 kg/m^3 = 1.2 kg/m^3, is less than R. Hence, the average value of the two test results is considered the estimated value of the density: (991.4 kg/m^3 + 990.2 kg/m^3)/2 = 990.8 kg/m^3

If the two results differ by more than R, both results are considered to be suspect and, in theory, each lab will then apply the procedures outlined in ISO 4259:2006. In practice, both parties will generally agree to accept the result obtained by a mutually selected third laboratory on a valid retain sample. In this case, it is important to ascertain that the third laboratory is using the prescribed test method and has accepted quality certificates.

Is it possible to estimate the product's compliance to a specification limit when only one single result is available?

Yes. ISO 4259:2006 includes supplier and customer guidelines to evaluate a product against a specification limit, using the customer's single test result. It is assumed that:

- The sample used for the analysis is a valid retain sample.
- The laboratory has performed the test under the conditions fully prescribed by the test method.

How can a supplier make an evaluation of maximum specification limit when there is only a single test result which is smaller than the specification limit?

The supplier can consider, with 95% confidence, that his or her product meets a maximum specification limit (A1) if the test result X ≤ A1 – 0.59R, where R is the reproducibility of the test method (see Example 2). If the supplier's single test result X′ is such that A1 – 0.59R < X′ ≤ A1, then there is a calculated risk that the product would fail the specification limit during multiple testing.

Example 2: Supplier with a single test result for density

Case 1

Density specification limit (A1): 991.0 kg/m^3 @ 15°C

R (test method ISO 12185:1996): 1.5 kg/m^3

Single test result X available on a representative sample for delivery: 990.0 kg/m^3 @ 15°C

It is 95% likely that this product will meet the specification limit upon multiple testing, because the condition X ≤ A1 – 0.59R is fulfilled.

(990.0 < 991.0 – 0.59 × 1.50 or 990.0 < 991.0 – 0.9 or 990.0 < 990.1)

Case 2

Density specification limit (A1): 991.0 kg/m^3 @ 15°C

R (test method ISO 12185:1996): 1.5 kg/m^3

Single test result X′ available on a representative sample for delivery: 990.5 kg/m^3 @ 15°C

It is likely that this product would fail the specification limit during multiple testing because the condition X′ ≤ A1 – 0.59R is not fulfilled.

(990.5 exceeds A1 – 0.59R or 990.5 > 991.0 – 0.9 or 990.5 > 990)

How can a customer make an evaluation about a maximum specification limit when there is only one single test result which exceeds the specification limit?

The customer can consider, with 95% confidence, that a product will fail the maximum specification limit requirement upon multiple testing if the single test result X > A1 + 0.59R (where A1 is the maximum limit and R is the reproducibility of the test method). If a customer's single test result X′ meets the condition A1 < X′ ≤ A1 + 0.59R, there is a statistical chance that multiple testing would still show the product to be on spec.

Example 3: Customer with a single test result for density

Case 1

Density specification limit (A1): 991.0 kg/m^3 @ 15°C.

R (test method ISO 12185:1996): 1.5 kg/m^3

Single test result X available: 992.2 kg/m^3 @ 15°C

It is 95% likely that the product will fail the specification limit upon multiple testing, because X > A1 + 0.59R.

(992.2 > 991.0 + 0.59 × 1.5 or 992.2 > 991.0 + 0.9 or 992.2 > 991.9)

Case 2

Density specification limit (A1): 991.0 kg/m^3 @ 15°C.

R (test method ISO 12185:1996): 1.5 kg/m^3

Single test result X′ available: 991.4 kg/m^3 @ 15°C.

The single test result exceeds the specification limit A1; however, because it is lower than A1 + 0.59R, multiple testing may still result in finding the density on spec (A1 + 0.59R ≥ X′ > A1).

(991.0 + 0.59 × 1.5 > 991.4 > 991.0 or 991.0 + 0.9 > 991.4 > 991.0 or 991.9 > 991.4 > 991.0)

For the evaluation of one single test result X with a minimum specification A2, the conditions applied by the supplier and customer are, respectively, X ≥ A2 + 0.59R and X < A2 – 0.59R.

Summary:

Test results deviate from the "true value"; this is inherent to all test methods. The precision statements are an integral part of every official test method and listed in the method. For more information, please see Appendix: Reproducibility of ISO 8217 or Equivalent IP/ASTM Test Methods. ■

Appendix: Reproducibility of ISO 8217 or Equivalent IP/ASTM Test Methods*

Acid number, mg KOH/g
ASTM D664
R (fresh oils) = 0.141 (x+1)
Where x is the average of the results being compared

Ash, %
ISO 6245
For ash content between 0.001 and 0.079 wt %:
R = 0.005
For ash content between 0.080 and 0.180 wt %:
R = 0.024

Ca, Zn, P, mg/kg

1. Ca
IP 501 (ICP) R = 0.6440x$^{0.65}$
IP 470 (AAS) R = 1.139x$^{0.8}$

2. Zn
IP 501 (ICP) R = 0.5082x$^{0.7}$
IP 470 (AAS) R = 0.580x$^{0.75}$

3. P
IP 501 (ICP) R = 1.2765x$^{0.55}$
IP 500 (UV) R = 1.2103x$^{0.4}$
Where x is the average of the results (mg/kg) being compared

Cat fines Al+Si, mg/kg

1. ISO 10478, IP 501
ICP detection:
Al: R = 0.337x
Si: R = 0.332x
Where x is the average of the results (mg/kg) being compared

2. IP 470
AAS detection:
Al: R = 0.789x$^{0.67}$
Si: R = 1.388x$^{0.67}$
Where x is the average of the results (mg/kg) being compared

CCAI (Calculated Carbon Aromaticity Index)
Precision (R) depends on the precision (R) of the density and viscosity of the residual fuel oil that enter into the calculation

Cetane index (4 variable equation)
ISO 4264
Precision depends on the precision of the original density and distillation recovery temperature calculations.

Cloud Point, °C
ISO 3015
For distillate fractions: R = 4°C

Density at 15°C, kg/m^3

1. ISO 3675
For transparent, non viscous products:
R = 1.2 kg/m^3 or 0.0012 kg/l
For opaque products: R = 1.5 kg/m^3 or 0.0015 kg/l

2. ISO 12185
For transparent middle distillates:
R = 0.5 kg/m^3 or 0.0005 kg/l
For crude oils and other petroleum products:
R = 1.5 kg/m^3 or 0.0015 kg/l

FAME, volume %
IP 579
Procedure A: 0.05–3.00 volume %:
R= 0.0499x + 0.0231
Procedure B: 3.0–20.0 volume %:
R = 0.0793x – 0.0413
Where x is the average of the results being compared

Flash point, P.M., closed tester
ISO 2719
Procedure A (distillate fuels): R = 0.071x
Where x is the average of the results (°C) being compared
Procedure B (residual fuel oils): 6°C

* Edition of test methods as cited in ISO 8217:2017 paragraph 2. Normative references

H_2S, mg/kg

IP 570

Procedure A

Distillate and residual fuels: $R = 0.4459x^{0.55}$

Procedure B

Residual fuels: $R = 0.5232x^{0.6}$

Distillate fuels: $R = 0.2389x^{0.7}$

Where x is the average of the results being compared

Kinematic viscosity, mm²/s

ISO 3104

Heavy fuels: at 50°C: R = 0.074x

Distillate fuels: at 40°C: R = 0.0082 (x + 1)

Where x is the average of the results being compared

Lubricity, µm

ISO 12156-1

R = 102

Micro carbon residue, mass %

ISO 10370

$R = x^{2/3} \times 0.2451$

Where x is the average of the results being compared

Micro carbon residue, on 10% volume distillation residue, mass %

ISO 10370

$R = x^{0.5} \times 0.2125$

Where x is the average of the results being compared

Oxidation stability, g/m³

ISO 12205

$R = 10.6\,(x/10)^{0.25}$

Where x is the average of the results being compared

Pour Point, °C

ISO 3016

R = 6.59°C

Sodium, mg/kg

1. IP 501 (ICP)

$R = 1.0667x^{0.55}$

2. IP 470 (AAS)

$R = 1.303x^{0.6}$

Where x is the average of the results being compared

Sulphur, mass %

1. ISO 8754

For values > 0.05 m/m % and ≤ 5.00 m/m %:

R = 0.0812(x + 0.15)

for values ≥ 0.03 m/m % and ≤ 0.05 m/m %:

R= 0.1781(x + 0.05)

Where x is the mean sulphur content

2. ISO 14596

For sulphur content in the range 0.03–0.0499 m/m %:

R = 0.005

For sulphur content in the range 0.05–0.0099 m/m %:

R = 0.02

For sulphur content in the range 0.10–0.99 m/m %:

R = 0.02

For sulphur content in the range 1.00–2.50 m/m %:

R = 0.04

Total sediment aged, mass %

ISO 10307-2

Heavy fuels: R = 0.294 √x

Distillate fuels containing heavy components:

R = 0.174 √x

Where x is the average of the test results in % (m/m)

Total sediment by hot filtration, mass %

ISO 10307-1

Heavy fuels: R = 0.294 √x

Distillate fuels containing heavy components:

R = 0.174 √x

Where x is the average of the test results in % (m/m)

Vanadium, mg/kg

1. ISO 14597

The method is applicable to products having V content in the range of 5 to 1000 mg/kg, although reproducibility data have only been determined up to 100 mg/kg for V

For V content between 5–30 mg/kg: R = 5 mg/kg

For V content between 31–100 mg/kg:

R = 10 mg/kg

2. IP 501

$R = 1.6799x^{0.6}$

Where x is the average of the results (mg/kg) being compared

3. IP 470

$R = 3.26x^{0.5}$

Where x is the average of the results (mg/kg) being compared

Water, volume %

1. ISO 3733

Water collected between 0.0 and 1.0 ml:

R = 0.2 ml

Water collected between 1.1 and 25 ml:

R = 0.2 ml or 10% of mean, whichever is greater

2. IP 12937

$R = x^{0.06877}$

Where x is the average of the results being compared

marine lubricants

global contact list

chevron marine lubricants

global contact list

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chevron marine lubricants

global contact list

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Email: CMLlubechart@chevron.com

FAST Helpdesk:
Email: CMLfast@chevron.com

DOT.FAST Helpdesk:
Email: DOT.FAST@chevron.com

Samples for FAST™ lubricant analysis services are to be sent to the following addresses

Inform the courier company that the receiver is 'Warehouse Assistant'.

Chevron Marine Lubricants — FAST Program
SGS Belgium NV
Polderdijkweg 16
B-2030 Antwerpen
Belgium
Tel: +32 (0)35458411

Samples landed in **mainland China only** should be sent to our Shanghai laboratory:

Chevron Marine Lubricants — FAST Program
SGS-CSTC Standards Technical Services Co., Ltd
No.88 Pugong Road, Fengxian District
Shanghai Chemical Industrial Park,
Shanghai, 201507, China
上海市奉贤区化学工业区普工路88号（201507)
Tel: +86 021 6027 6372

Learning Resources

Scan this QR code to search our YouTube channel for Chevron Marine Lubricants videos on how to conduct safe and reliable lubricant tests, how to order marine lubricants online using the OnePort customer portal, and useful tips and resources.

YouTube

Online Ordering

OnePort™ customer portal

Chevron's online portal makes lubricant procurement more efficient:

www.chevronmarineproducts.com

Visit our website chevronmarineproducts.com for more information.

TEXACO Chevron CALTEX
Our Family of Brands

one place for your lubrication needs

OnePort™
customer portal

Keep your business running smoothly with around-the-clock access to your orders and account information.

The OnePort™ customer portal has been designed with you in mind — its easy online access allows for a quick and simple process when ordering lubricants.

OnePort promotes efficiency and reduces order management time by eliminating unnecessary work from the lubricant procurement process. This in turn releases your valuable resources so you can focus on your core business activities. By improving product availability and visibility, the digital tool makes it easier for you to get what you need — anywhere in the world — whenever you need it.

OnePort is designed to make lubricant procurement more efficient — but rest assured, Chevron Marine Lubricants' world-class customer service representatives are always available globally to help you.

OnePort Benefits

- Multiple port and price enquiry
- Easy-to-use product selection
- Orders are linked to your recommended products
- Up to 5-port price comparison
- Quick order placement
- Local customer service representatives
- Improved communications with your Chevron customer service representative, reducing emails
- Summary of all orders in progress and status

everything you need at your **fingertips**

Digital order management

The launch of OnePort™ is a key part of Chevron Marine Lubricants' multi-year digitization investment program, delivering our customers peace of mind, wherever they are in the world. Using OnePort helps to lead your business to a brighter future by using a digital platform to keep your business running smoothly — we work hard, so you don't have to.

Quality

Here at Chevron, we pride ourselves on being an organization that provides quality and ease to our customers. That's why the OnePort system is easy to use — just contact your local Chevron representative for more information and get started today.

For more info, scan here to view our OnePort YouTube video:

Or visit chevronmarineproducts.com