Marine Lubrication: Stem to Stern
Taro® Special HT 70 provides excellent performance and cleanliness in high-performance, slow-speed, crosshead engines.
Wouldn’t it be wonderful if one lubricating oil and one grease covered every marine lubrication need?

In real life, the situation is more complicated.
It would be great to need only one lubricating oil and one grease to cover all marine lubrication requirements.

Unfortunately, not only does every piece of machinery or system require its own specific type of lubricant, similar machinery and systems of different manufacturers need different lubricants, depending on the requirements set by the original equipment manufacturer (OEM), and related to application and operating conditions.

For an effective operation of a marine vessel, the following types of products are required:

- Slow-speed engine cylinder oils
- Slow-speed engine system oils
- Medium-speed engine oils
- High-speed diesel engine oils
- Turbine oils
- Hydraulic oils
- Gear oils
- Air compressor oils
- Refrigerating compressor oils
- Gas compressor oils
- Open gear lubricant
- Greases
- Rust preventative
- Cooling water treatments

Most lubricants come in a variety of different SAE or ISO viscosity grades and a range of base numbers (BN):

- Engine oils are available with base numbers ranging from 5 to 85, and in SAE viscosity grades 30, 40, 50, and 15W-40.
- Hydraulic, turbine, gear, and compressor oils are available in different ISO viscosity grades ranging from ISO 15 up to 680 or even higher.
- Greases are available with different properties and consistencies.

In addition, a number of lubricants are available in both mineral and synthetic versions, and requirements for biodegradable oils are soon to come.

Our laboratory in Ghent, Belgium, provides state-of-the-art testing, research and development, and technical support.
Chevron delivers the industry’s best-rated marine lubricants at over 600 ports around the world.
There are three different marine diesel applications:

- Slow-speed, two-stroke crosshead engines (60–250 rpm)
- Medium-speed, four-stroke trunk piston engines (400–1000 rpm)
- High-speed, four-stroke engines (> 1000 rpm)

2.1 Slow-speed diesel engines

Slow-speed, two-stroke crosshead engines are the predominant marine propulsion engines, also in use for land-based power generation applications. Lubrication of crosshead engines is separated into cylinder and crankcase lubrication.

2.1.1 Cylinder lubrication

Cylinder lubrication of slow-speed engines is a “once-through” or “total-loss” system. The cylinder oil is injected into the cylinder and distributed on the liner surface by the reciprocating movement of the piston. The cylinder oil burns and is partly scraped down to the scavenging air space where it is drained. The lube oil consumption (feed rate) is controlled by power output and speed, rather than by the condition of cylinder liners and piston rings, as with medium-speed engines.

With the ever-increasing maximum firing pressures (from around 90 bar in the mid-70s, to around 150 bar in the late 90s) the thermal load on combustion chamber parts increased simultaneously. Cylinder oils with improved thermal and oxidation stability were developed to meet the requirements of the latest design engines with cylinder liner temperatures up to 270°C.

The cylinder oil viscosity will determine oil film thickness and spreadability of the oil on the liner surface. The general requirement for cylinder oil viscosity is SAE 50, with a few exceptions where SAE 60 may be used.

A certain alkalinity level of cylinder oil, expressed in base number (BN), is required to neutralize acidic combustion products. The base number is therefore related to the sulphur content of the fuel. The BN also reflects the detergency level of the oil, for example, the ability of the oil to keep the piston rings, lands, and grooves free from deposits. On the other hand, excess alkalinity, when using low sulphur fuel for prolonged periods of time, may promote ash deposits on piston crowns and exhaust valves. In general, 70 BN cylinder oils cover the vast majority of uses. A correct balance must be established between base number and applied oil feed rate and the sulphur level of the fuel.

For vessels sailing continuously in sulphur oxide emission control areas such as the North Sea and the Baltic, where ships have to use fuel with a maximum of 1.5% sulphur, 40 or 50 BN cylinder oils with sufficient detergency are recommended.

<table>
<thead>
<tr>
<th>Chevron Product</th>
<th>SAE Viscosity Grade</th>
<th>Base Number</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taro® Special 70*</td>
<td>50</td>
<td>70</td>
<td>High sulphur fuel, older design engines</td>
</tr>
<tr>
<td>Taro Special HT 70</td>
<td>50</td>
<td>70</td>
<td>High sulphur fuel, all engine designs</td>
</tr>
<tr>
<td>Taro Special HT LS 40</td>
<td>50</td>
<td>40</td>
<td>Low sulphur fuel, all engine designs</td>
</tr>
</tbody>
</table>

* Taro Special 70 will be discontinued by the end of Quarter 3, 2008.
2.1.2 Crankcase lubrication

In the past, two types of system oils were available for slow-speed engine crankcase lubrication: a detergent oil with a BN of around 8 for engines with oil-cooled pistons requiring a certain detergency level to keep the piston-cooling gallery free from carbon deposits, and an R&O (rust- and oxidation-inhibited) oil for engines with water-cooled pistons, to avoid emulsification in case of water contamination.

Over time, improved chemistry allowed for the combination of these properties into one 5–10 BN system oil providing adequate detergency and water-separating characteristics.

The introduction of PTO/PTI gears on slow-speed engines necessitated increased load-carrying capacity of system oils. The load-carrying capacity is assessed by the FZG gear test. A specified set of gears (indicated by the letter “A”) runs at constant speed in a sump containing the test oil with a constant temperature. The load on the gears is increased in steps. After each load step, the weight loss of the gears is measured until lubrication completely fails. This failure load step indicates the maximum load-carrying capacity of the test oil. The test conditions for engine oils are 8.3 m/s pitch line speed of the gears with an oil bath temperature of 90°C. An FZG FLS (Failure Load Stage) of 11 is generally required for today’s system oils. On Chevron’s product data sheets, the FZG value is shown as FZG 11 (A/8.3/90).

An SAE 30 viscosity grade is generally applicable for marine slow-speed engine system oils. The viscosity of the oil in service, however, slowly increases over time. This is partly due to ageing (oxidation) of the oil, but mainly due to the ingress of waste cylinder oil entering the system through leaking piston rod stuffing boxes and recycling of stuffing box drain oil. Along with the viscosity, the base number of the system oil will increase as well. Contamination with high alkaline cylinder oil additives has a negative influence on the water-separating characteristics of the system oil, and increases the risk of bearing lacquering. At a viscosity of around 160 cSt it becomes necessary to take action. It has been common practice to reduce viscosity and base number by diluting the system oil with lower viscosity turbine or hydraulic oil. Oils of different nature, however, may influence the characteristics of the system oil in service. Consequently, Chevron introduced the SAE 20 version of the standard system oil. This grade has the exact same chemical properties, but with lower viscosity.

Besides the main engine application, the system oil is commonly used for the intermediate shafting and stern tube as well.

### TABLE 2: SLOW-SPEED ENGINE SYSTEM OILS

<table>
<thead>
<tr>
<th>Chevron Product</th>
<th>SAE Viscosity Grade</th>
<th>Base Number</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veritas® 800 Marine 20</td>
<td>20</td>
<td>5</td>
<td>System top-up or partial replacement</td>
</tr>
<tr>
<td>Veritas 800 Marine 30</td>
<td>30</td>
<td>5</td>
<td>General use</td>
</tr>
</tbody>
</table>
2.2 Medium-speed diesel engines

Medium-speed, four-stroke, trunk piston engines are used for both propulsion and diesel generator applications. Unlike slow-speed engines, there is no separation between cylinder and crankcase lubrication, and the system oil needs to fulfill the requirements for both. Being directly exposed to blow-by gases and fuel leakage, the oil requires much higher dispersancy to cope with contamination.

Except for the slow-speed engine, where the amount of cylinder oil is exactly adjusted to the operating conditions, medium-speed engines have splash lubrication, which means excess cylinder lubrication. The base number of medium-speed engine oils can, therefore, be lower than slow-speed engine cylinder oils, while maintaining the required quantity of alkaline additive.

As with slow-speed engine cylinder oils, the medium-speed engine oils require sufficient detergent and dispersant properties to allow marine diesel and heavy fuel operation. It is essential for reliable engine operation and extended time between overhauls to keep the piston ring area and cooling gallery clean and the crankcase free from sludge, even under the most severe running conditions.

During operation, the alkalinity (base number) of the oil in service depletes due to acid neutralization. Base depletion is compensated by fresh oil additions necessary to make up for oil consumption. The ideal situation is to establish a balance between lube oil consumption and base depletion, maintaining a base number equilibrium above the condemning limit (generally 50% of the fresh oil base number).

Lube oil consumption is mainly related to engine hardware. Piston ring and liner condition is critical in this respect. With the introduction of the anti-bore polishing-ring and consequent lube consumption figures as low as 0.3 g/kWh, high base number oils are not only required for high fuel sulfur levels, but to compensate for the low oil refreshment rate as well. In addition to the regular 30 and 40 base number oils, most oil companies have also introduced 50, 55 or 60 base number products.

Engine oils generally contain zinc compounds to enhance anti-wear properties. For EMD manufactured engines with silver-lined bearings, zinc-free oil must be present to counter incompatibility of zinc and silver. Delo® 6170 CFO is a 17 BN engine oil for diesel engines used in railroad, power generation, oil well drilling and marine applications requiring zinc-free oils.
2.3 High-speed diesel engines

Onboard deep-sea marine vessels, high-speed diesel engines are mainly used in emergency equipment such as generators, fire pumps, air compressors, and life boats. Inland marine and fishing vessels use high-speed diesels for propulsion and generators.

As most of these engines are derived from automotive-type diesels, the lubricant oil must comply with automotive specifications and OEM requirements. API CG-4 or CH-4 and ACEA E2-96 are generally required for marine high-speed diesels using multigrade oils, API CF for engines using single grade oils. An API CF-2 low ash formulation is available for two-stroke trunk piston engines such as GM-DDA series 53, 71, 92 and 149, requiring an SAE 40 oil with less than 1% ash.

Since emergency equipment is located outside engine room spaces and is exposed to variable ambient temperatures, lubricant oil for such applications needs to have a viscosity suitable for cold start conditions, while maintaining the required viscosity at operating temperature. A multigrade SAE 15W-40 is generally recommended. SAE 30 and 40 grades are available for propulsion engines.

The high-speed ferry market is relatively new. High-speed ferries are either powered by gas turbines or large high-power, high-speed diesel engines such as the MTU 1163 series engines, requiring SHPD (Super High-Performance Diesel) oils.
TABLE 4: HIGH-SPEED DIESEL ENGINE OILS

<table>
<thead>
<tr>
<th>Chevron Product</th>
<th>Performance requirements</th>
<th>Applications</th>
<th>OEMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ursa® Marine</td>
<td>High-performance</td>
<td>Emergency diesels SAE 15W-40 Other SAE 30/40</td>
<td>Caterpillar Cummins Yanmar MAN Daihatsu Deutz Petter Scania Ruston Bukh Daewoo BM 228.0/228.1 MTU Category 1</td>
</tr>
<tr>
<td>Delo SHP</td>
<td>Super high-performance</td>
<td>Propulsion SAE 30/40 (High-speed ferries, etc.)</td>
<td>Caterpillar Cummins Yanmar MAN Daihatsu Deutz Petter Scania Ruston Bukh Daewoo</td>
</tr>
<tr>
<td>Ursa Extra Duty</td>
<td>Special requirement</td>
<td>Two-stroke, low ash, SAE 40</td>
<td>Detroit Diesel</td>
</tr>
</tbody>
</table>

CHART 2: VISCOSITY-TEMPERATURE CHART OF URSA MARINE SERIES HIGH-SPEED ENGINE
Turbine oils are primarily developed for lubrication of bearings and gears of steam and gas turbines. Turbine oils are actually highly refined paraffinic base oils with rust, oxidation, and foam inhibitors.

Turbine oils can be used in a variety of machinery not requiring sophisticated additive packages. Turbine oils are suitable for all kinds of equipment where an economical, yet high-quality, stable lubricant with good water-separating characteristics is sufficient. Besides steam and gas turbines, turbine oil is used for turbo chargers, speed governors, hydraulic systems, and screw and piston air compressors.

**TABLE 5: TURBINE OILS**

<table>
<thead>
<tr>
<th>Chevron Product</th>
<th>SAE Viscosity Grade</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regal® R&amp;O</td>
<td>32, 46</td>
<td>Turbines, screw air compressors</td>
</tr>
<tr>
<td></td>
<td>68</td>
<td>Steam and gas turbines, turbo chargers,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hydraulic systems, etc.</td>
</tr>
<tr>
<td>Regal EP</td>
<td>100</td>
<td>Extreme pressure version: steam turbines</td>
</tr>
</tbody>
</table>
Compared with turbine oils, hydraulic oils are more advanced, particularly with respect to anti-wear performance, air release properties, and viscosity index. Also, hydraulic oils must meet cleanliness codes (particle size and quantity) set by equipment manufacturers.

The high anti-wear performance of hydraulic oils is required for lubrication of the vane, gear, and piston pumps and motors incorporated in hydraulic systems. A typical FZG failure load stage of 11 to 12 is comparable with gear oils. Hydraulic oils are also suitable for reduction gears where oil-immersed disc clutches prohibit the use of EP gear oils.

High viscosity index of around 150 and low pour point is required to allow operation of marine applications in both tropical and arctic conditions.

- **Viscosity index (VI):** The effect of temperature change on viscosity. Paraffinic mineral oils generally have a VI of 90-100. High VI hydraulic oils are treated with VI improvers and have a VI of around 150.

- **Pour Point:** The lowest temperature at which oil will flow under test conditions specified by ASTM method D 97 or D 5950.

Hydraulic oils are available in a variety of viscosity grades ranging from ISO 15 for servo systems to ISO 100 for vane pumps and gears.

**TABLE 6: HIGH VI HYDRAULIC OILS:**

<table>
<thead>
<tr>
<th>Chevron Product</th>
<th>SAE Viscosity Grade</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rando® HDZ</td>
<td>15, 22</td>
<td>Servo, control systems, turbo couplings</td>
</tr>
<tr>
<td></td>
<td>32, 46</td>
<td>Hatch covers, screw air compressors</td>
</tr>
<tr>
<td></td>
<td>68, 100</td>
<td>Cranes, winches, thrusters, CPP systems, gears</td>
</tr>
</tbody>
</table>
One of the most significant characteristics of gear oils is the load-carrying capacity. The nature of loads encountered in gears is typically different from loads in hydraulic systems and engines. Lubrication in hydraulic systems and engines is predominantly hydrodynamic; with gears, elasto-hydrodynamic lubrication plays an important role.

Gear oils are treated with EP (extreme pressure) additives, which provide protection against metal-to-metal contact, even under severe boundary lubrication conditions.

- **EP Additives**: An EP additive chemically reacts with the metal surface under conditions of extreme pressure to form a surface film that prevents the welding of opposing asperities.

- **Hydrodynamic lubrication**: When the shape and relative speed of the sliding surfaces cause the formation of an oil film having sufficient pressure to separate the surfaces.

- **Elasto-hydrodynamic lubrication**: Where the lubricant oil film separating the surfaces is concentrated to a very small area of contact (point or line contact). At that point, high local pressure causes compression of the oil and consequent viscosity increase.

- **Boundary lubrication**: Moving parts not completely separated by oil film. Metal contact occurs resulting in high friction and wear.

The FZG gear test is also applicable to gear oils. The test conditions, however, are more severe. Whereas hydraulic and engine oils are tested with a gear set running at 8.3 m/s pitch line speed and 90°C oil temperature, gear oils are tested at 16.6 m/s and 140°C. Gear oils typically meet FZG failure load stage better than 12 under such conditions [FZG 12 (A/16.6/140)].

Synthetic PAO-based gear oil with higher thermal stability is recommended to meet continuous high-temperature operation conditions such as lubricant or fuel separator gears.

As with hydraulic oils, gear oils are available in a range of viscosity grades, from ISO 68 up to ISO 680.

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As with hydraulic oils, gear oils are available in a range of viscosity grades, from ISO 68 up to ISO 680.

### TABLE 7: GEAR OILS

<table>
<thead>
<tr>
<th>Chevron Product</th>
<th>SAE Viscosity Grade</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral: Meropa®</td>
<td>68, 100</td>
<td>Thrusters</td>
</tr>
<tr>
<td></td>
<td>150, 220, 320</td>
<td>Spur and bevel reduction gears</td>
</tr>
<tr>
<td></td>
<td>460, 680</td>
<td>Worm gears, gear couplings</td>
</tr>
<tr>
<td>Synthetic: Pinnacle® Marine Gear</td>
<td>220</td>
<td>High-temperature applications (centrifuge gears)</td>
</tr>
</tbody>
</table>
For marine applications, there are three compressor systems:

- Air compressors
- Refrigerating compressors
- LPG compressors

6.1 Air compressors

Onboard ships, compressed air is an essential power transmission medium. The necessity for reliable starting compressors is often overlooked. Marine engines won’t start without compressed air. For safety reasons, a specified number of starting procedures is legally required to maneuver with slow-speed engines, while essential control systems are often pneumatically operated.

Air compressor oils are available in both mineral and synthetic versions.

Compression temperatures of reciprocating two-stage starting air compressors can rise to over 250°C—temperatures where rapid oil degradation starts and carbonization of valves and cooler tubes might become a problem. Synthetic oils are beneficial for their higher thermal and oxidation stability, whereas mineral oils may offer a more economical solution in three-stage compressors working at lower compression temperatures.

Synthetic lubricants for reciprocating (starting) air compressors are generally manufactured from diester base stocks.

Synthetic lubricants for screw and rotary air compressors are generally manufactured from polyalphaolefine (PAO) base oils.

Diester-based air compressor oils have proven to prevent carbon formation on valves and cooler tubes of piston air compressors, providing for reduced maintenance and part costs, and extended drain intervals. Therefore, synthetic compressor oils can be very cost-effective when problems arise.

PAO-based rotary air compressor oils are often required for their low pour point and excellent thermal, oxidation and hydrolytic stability.

- **Thermal stability**: Ability of oil to resist cracking and decomposition on prolonged exposure to elevated temperature
- **Oxidation stability**: Resistance of oil to oxidation
- **Hydrolytic stability**: Ability of additives and certain synthetic lubricants to resist chemical decomposition in the presence of water

ISO VG 68 synthetic PAO-based compressor oils are recommended for turbo charger bearings; providing for reduced bearing friction, hence, improved turbo charger efficiency; reduced maintenance and extended drain intervals. Chevron Cetus® PAO 68 is approved by ABB as “special low friction oil”, required for their VTR..4 series turbo chargers.

Heavily carbonized valves and cooler tubes of a starting air compressor
6.2 Refrigerating compressors

Oils for domestic- and cargo-refrigerating compressors and air conditioning compressors are available in mineral and synthetic versions. The choice for mineral or synthetic products is dictated by the requirements for solubility and compatibility with different types of refrigerating gases.

Conventional R12 and R22 systems require mineral oil. Mineral refrigerating oils are de-waxed to prevent wax crystallization at low temperatures (low pour point).

Environmental legislation demanded for chlorine-free refrigerant gases such as R134a and R404a. These refrigerant gases specifically require polyolester synthetic lubricants.

6.3 LPG/LNG compressors

Mineral hydrocarbon oils are not always suitable for crankcase lubrication of enclosed natural gas compressors. Condensated natural gas would dilute the mineral oil when entering the crankcase, resulting in reduced oil viscosity. Natural gas compressor oils are therefore manufactured with polyalkyleneglycol (PAG) lubricants, having very low solubility for natural gas.

<table>
<thead>
<tr>
<th>Table 7: Air Compressor Oils</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chevron Product</strong></td>
</tr>
<tr>
<td>PAO-based synthetic: Cetus PAO</td>
</tr>
<tr>
<td>Mineral: Compressor Oil EP VDL</td>
</tr>
<tr>
<td>Diester-based synthetic: Cetus DE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 8: Refrigerating Oils</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chevron Product</strong></td>
</tr>
<tr>
<td>Mineral: Capella® WF</td>
</tr>
<tr>
<td>Synthetic polyolester: Capella HFC</td>
</tr>
<tr>
<td>Synthetic alkylbenzene: Refrigeration Oil Low Temp</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 9: LPG/LNG Compressor Oils</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chevron Product</strong></td>
</tr>
<tr>
<td>LPG Compressor Oil</td>
</tr>
</tbody>
</table>
Ships running on heavy fuel require heating for HFO bunkers, HFO transfer and booster systems, HFO and lubricant oil centrifuges, as well as engine preheating and domestic heating.

Both steam and thermal oil can be used as heat transfer mediums. On most modern motor vessels, oil-filled heat transfer systems have replaced steam boilers for heating purposes.

Oil-filled heat transfer systems usually operate at around 200°C bulk oil temperature. The skin (oil film adjacent to the heat exchanger tubes) or film temperature, however, may exceed 300°C. Mineral heat transfer oils are manufactured with highly refined paraffinic base oils with inherently good thermal and oxidation stability.

**TABLE 10: HEAT TRANSFER FLUIDS**

<table>
<thead>
<tr>
<th>Chevron Product</th>
<th>ISO Viscosity Grade</th>
<th>Max. Bulk Temperature</th>
<th>Max. Film Temperature</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texatherm®</td>
<td>32, 46</td>
<td>315°C</td>
<td>335°C</td>
<td>Heat transfer systems</td>
</tr>
</tbody>
</table>

Heat Transfer Fluids
8.1 Open gear lubricants

Open gears such as windlass drives, crane slewing gears, and traversing gears of gantry cranes are traditionally lubricated with asphaltic lubricants. Although extremely tacky and water-resistant, asphaltic lubricants tend to soften and drip when exposed to the sun, which might be an environmental concern in certain port areas. Modern open gear lubricants are water-resistant greases, manufactured with calcium soap, high-viscosity base oils, and solid lubricants like graphite and molybdenum disulfide for shock-loading conditions. Besides open gears, this type of lubricant can be used for a variety of deck applications such as wire ropes, slow-rotating plain- and roller bearings, hinges, etc., thus replacing a number of bituminous, petrolatum, and special grease products.

8.2 Greases

Over the years, a wide variety of greases have been developed for different areas of industry and applications. For logistic and economical reasons, ships preferably use one or two multipurpose greases covering all shipboard applications.

For grease-lubricated plain, ball, and roller bearings and general grease points, a lithium soap grease with mineral oil, EP properties and an NLGI consistency number of 2 is generally applicable. An NLGI 0 grade is available for central lubrication systems where free gravitational flow from the grease reservoir to the grease pump suction requires thinner grease.

For added protection under shock-load conditions, the same grease is available with additional molybdenum disulfide as solid lubricant.

For high- and low-temperature applications, a synthetic grease is available that consists of polyalphaolefine lubricant and lithium-complex soap.

8.3 Rust preventatives

For protection of spare parts such as cylinder liners and pistons, a rust preventative product is available. Rust preventatives usually are a solvent cutback petrolatum, which can be brushed or sprayed, leaving a durable protective layer. Rust preventatives are suitable for wire rope protection as well.

<table>
<thead>
<tr>
<th>Chevron Product</th>
<th>Type</th>
<th>NLGI</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multifak® EP</strong></td>
<td>Lithium soap&lt;br&gt;Mineral oil&lt;br&gt;EP</td>
<td>0&lt;br&gt;2</td>
<td>Central lubrication systems (e.g. steering gears)&lt;br&gt;General lubrication; plain, ball, and roller bearings</td>
</tr>
<tr>
<td><strong>Molytex® EP</strong></td>
<td>Lithium soap&lt;br&gt;Mineral oil&lt;br&gt;EP, MoS₂</td>
<td>2</td>
<td>Plain, ball, roller, and thrust bearings under shock-load conditions</td>
</tr>
<tr>
<td><strong>Ulti-Plex® Synthetic Grease EP</strong></td>
<td>Lithium complex soap&lt;br&gt;Synthetic oil&lt;br&gt;EP</td>
<td>1.5</td>
<td>High-temperature applications</td>
</tr>
<tr>
<td><strong>Texclad® 2</strong></td>
<td>Calcium soap&lt;br&gt;High-viscosity mineral oil&lt;br&gt;Graphite and MoS₂</td>
<td>2</td>
<td>Open gears, wire ropes and general deck applications</td>
</tr>
<tr>
<td><strong>Rustproof Compound L</strong></td>
<td>Solvent cutback petrolatum</td>
<td>–</td>
<td>Spare parts, wire ropes</td>
</tr>
</tbody>
</table>
Water-cooled machinery requires protection against general and localized corrosion and cavitation corrosion of metal surfaces. Most corrosion inhibitors are concentrates that have to be diluted with fresh water.

Requirements are corrosion protection of cast iron, steel, aluminum and copper alloys, and compatibility with elastomers and plastics. Traditional corrosion inhibitors such as amines, nitrites, nitrates, phosphates, silicates and benzoates usually have adverse properties like poor stability, rapid depletion, incompatibility and toxicity.

Chevron Havoline® Extended Life cooling water treatments, developed with patented carboxylate technology, are environmentally acceptable, low toxic, and have extremely low depletion. They protect effectively against all types of corrosion while efficiently cooling the system.

<table>
<thead>
<tr>
<th>Chevron Product</th>
<th>Type</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Havoline XLI</td>
<td>Water-based</td>
<td>Fresh cooling water systems</td>
</tr>
<tr>
<td>Havoline XLC</td>
<td>Ethylene glycol-based</td>
<td>Fresh cooling water systems where anti-freeze protection is required</td>
</tr>
</tbody>
</table>

Cavitation on cooling water side of a cylinder liner
Marine lubricant suppliers must keep a comprehensive range of products available in a wide range of ports around the world in order to meet customers’ needs. The amount of stock held in any one location is a careful balance between maintaining product availability and the high cost of holding inventory for extended periods.

Chevron maintains this balance by offering three different categories of inventory at its various supply ports around the world:

**Complete Line**
Ports designated as “Complete Line” maintain an inventory of all Chevron products.

**Core Line**
Ports designated as “Core Line” maintain an inventory of the majority of Chevron products, sufficient to meet most requirements.

**Essential Line**
Ports designated as “Essential Line” maintain a limited stock of only the most essential lubricant grades. The Essential Line of products is designed to get any ship to a Core Line or a Complete Line port where most products will be available at a more economical cost.

To assist the planning of deliveries, Chevron maintains an up-to-date International Port Directory showing the product line available at each port, the delivery methods available (barge, truck, drum, etc.), the number of days’ notice required for orders and details of any local restrictions.

To achieve an efficient delivery, the lubricant supplier must schedule production at a blending plant, arrange delivery trucks or barges and liaise with the local agent, as well as handle customs clearance and cope with different time zones.

There are a few areas where the political situation prevents lubricant supplies. There are also some locations where the only products available are from the national or other local oil company.

Tremendous savings can be made by planning ahead. Lifting in some ports can require a minimum of ten days’ notice and availability is “subject to inquiry”, whereas taking delivery at the next port can often mean a delivery requiring only two days’ notice and significantly lower costs.

The ship manager and ship staff should be familiar with limitations and port restrictions to ensure continuity of supply and consistency of lubricant quality. Careful selection of the correct lubricants and planning of deliveries will result in the trouble-free lubrication of your vessels.
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