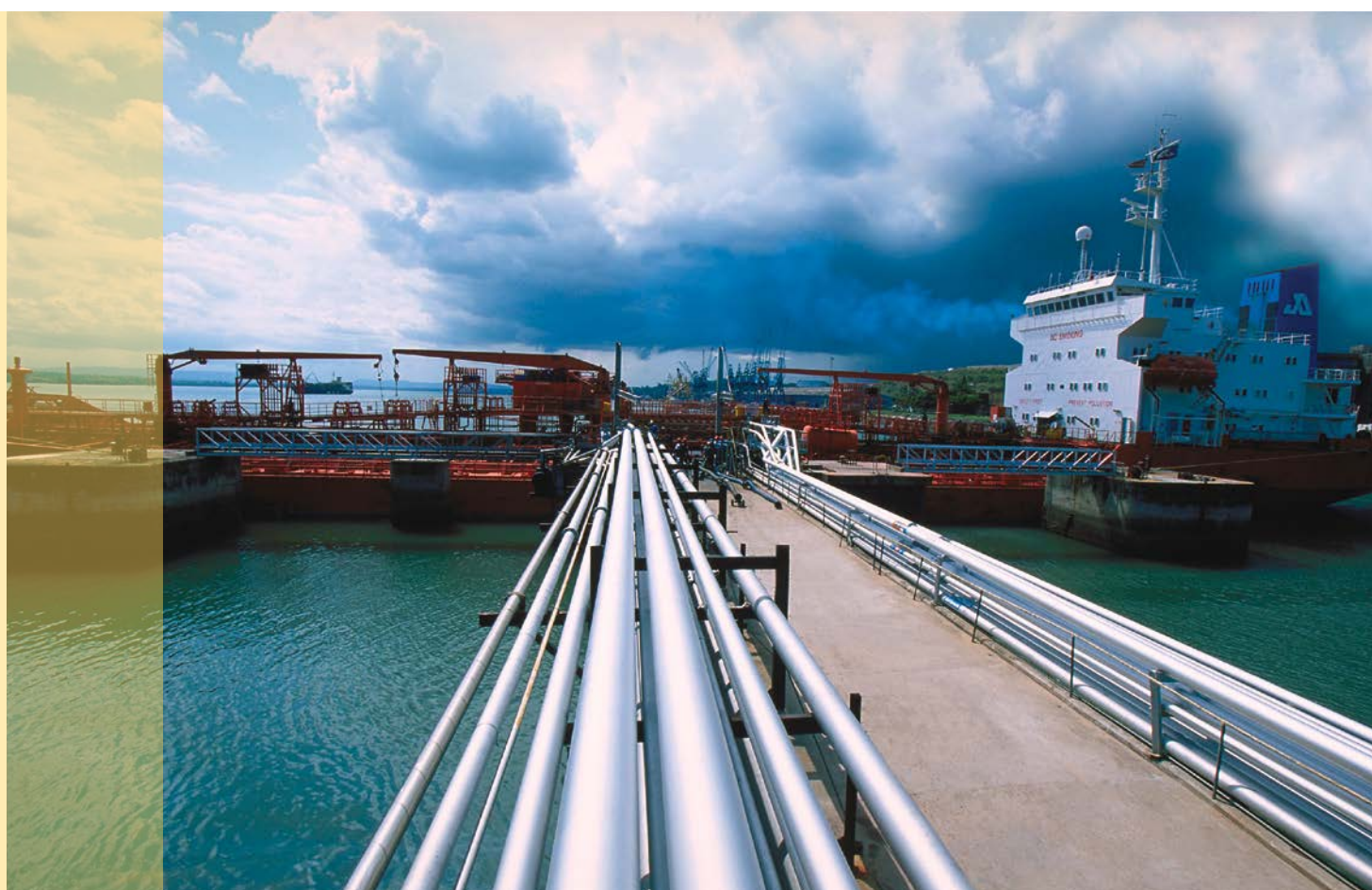




Marine Lubrication Stem to Stern

The complete marine lubricant product line








Marine Lubrication Stem to Stern

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A photograph of two workers in blue overalls and high-visibility vests standing on a green-painted deck of an offshore oil platform. One worker is pointing towards a large white crane structure on the left. The background shows various pieces of industrial equipment, including a white spherical radar dome and a sign that reads "WELCOME ABOARD" and "THINK SAFETY". The sky is clear and blue.

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.

1

The Complete Marine Lubricant Product Line

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 treatment

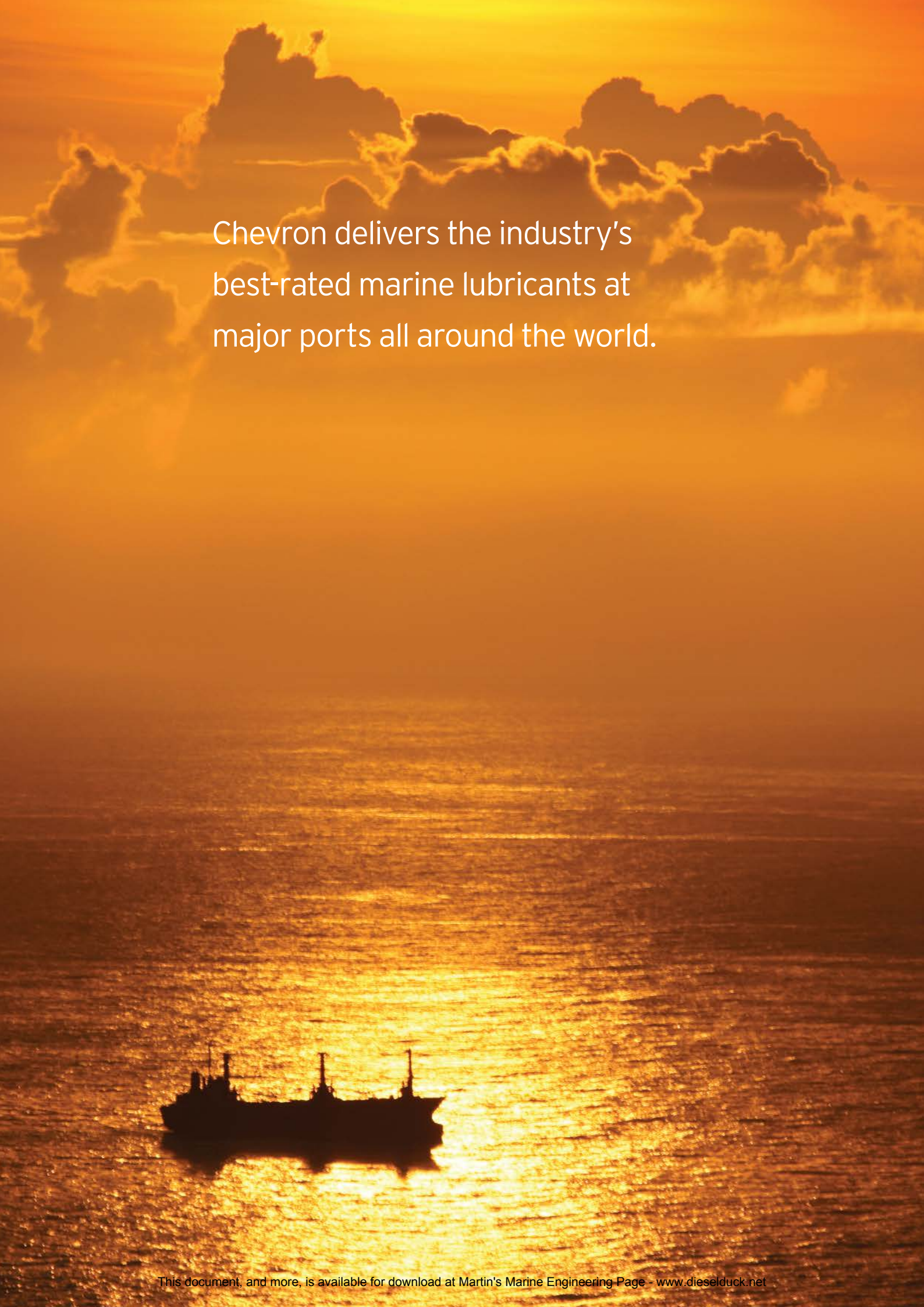
Most lubricants come in a variety of different SAE or ISO viscosity grades and a range of base numbers (BN):

- Engine oils are available with base numbers ranging from 5 to 70, 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.
- Greases are available with different properties and consistencies.

In addition, a number of lubricants are available in both mineral and synthetic versions.



The Chevron laboratory provides state-of-the-art testing, research and development, and technical support.



Chevron delivers the industry's
best-rated marine lubricants at
major ports all around the world.

2 Engine Oils

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 (oil feed rate) is either mechanically or electronically controlled by the engine, based on engine speed, power output and sulphur level of the fuel.

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.

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 ECAs (Emission Controlled Areas) — for example, the North Sea or the Baltic — where ships have to use fuel with a maximum of 1.0%wt sulphur, a low BN cylinder oil with sufficient detergency such as Taro Special HT LS 40 is recommended. For vessels sailing in multi-sulphur conditions, a mid-BN cylinder oil such as Taro Special HT 55 — designed to optimize Sulphur-Base balance for a wide range of fuels — may be an appropriate choice.

TABLE 1: SLOW-SPEED ENGINE CYLINDER OILS

Chevron Product	SAE Viscosity Grade	Base Number	Application
Taro® Special HT 70	50	70	High sulphur fuel, all engine designs
Taro Special HT 55	50	55	High or low sulphur fuel, all engine designs
Taro Special HT LS 40	50	40	Low sulphur fuel, all engine designs

2.1.2 Crankcase lubrication

Modern slow-speed engine crankcase lubrication requires a 5–10 BN system oil with excellent separating characteristics and high detergency performance level in order to keep the piston-cooling gallery and crankcase clean and free from deposits.

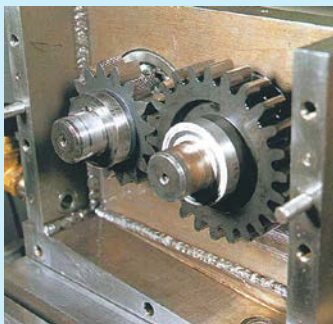
The introduction of PTO/PTI gears on slow-speed engines necessitated increased load-carrying capacity of system oils. The load-carrying capacity is assessed by the FZG gear test. A specified set of gears (indicated by the letter "A") runs at constant speed in a sump containing the test oil with a constant 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 and cavitation. For this reason, Chevron introduced the SAE 20 version of the standard system oil in order to dilute the high viscosity and high BN system oil in place. This SAE 20 system oil – Veritas 800 Marine 20 – 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

Chevron Product	SAE Viscosity Grade	Base Number	Application
Veritas® 800 Marine 20	20	5	System top-up or partial replacement
Veritas 800 Marine 30	30	5	General use



Left: An FZG test rig used to assess the load-carrying capacity of slow-speed engine system oils.



Right: A view of the piston ring area through a scavenging port of a slow-speed engine.



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 set by the OEM.

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 sulphur 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.



Above: Cleanliness of piston ring area.
Below: Cleanliness of piston cooling gallery.

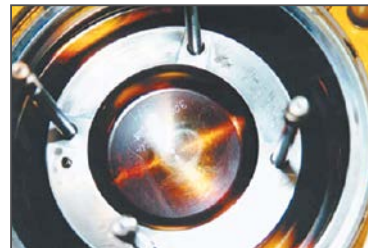


CHART 1: BASE NUMBER DEPLETION OF CRANKCASE OIL IN SERVICE

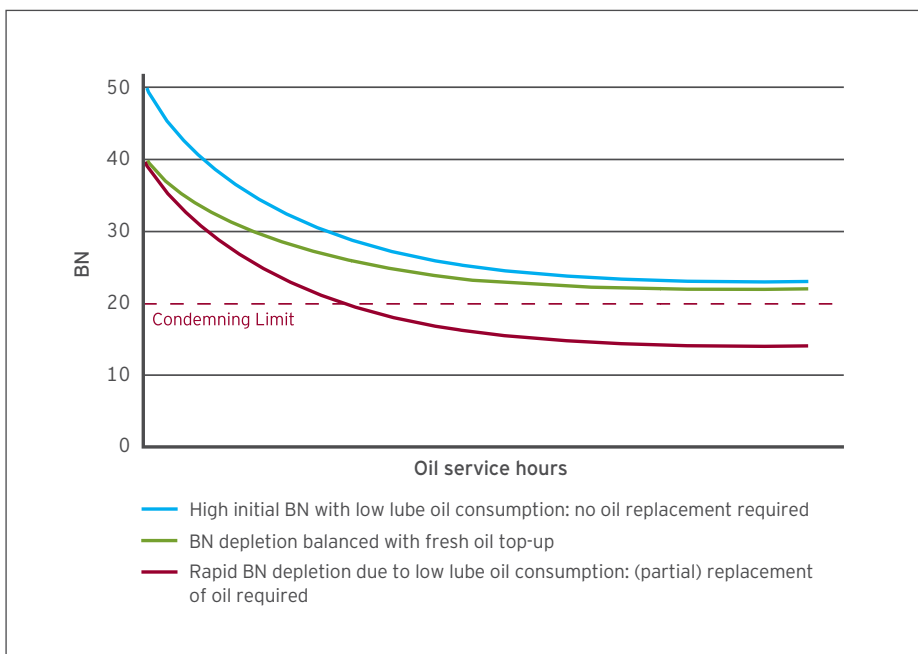


TABLE 3: MEDIUM-SPEED DIESEL ENGINE OILS

Chevron Product	SAE Viscosity Grade	Base Number	Application
Delo® 1000 Marine 30, 40	30, 40	12	MDO and gasoil operation
Taro® 20 DP 30, 40	30, 40	20	High sulphur MDO/MGO operation, HFO auxiliary operation
Taro 30 DP 30, 40	30, 40	30	HFO operation
Taro 40 XL 40	40	40	HFO operation
Taro 50 XL 40	40	50	HFO operation/low oil consumption

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 are generally required for marine high-speed diesels using multigrade oils.

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 engines, requiring SHPD (Super High-Performance Diesel) oils.

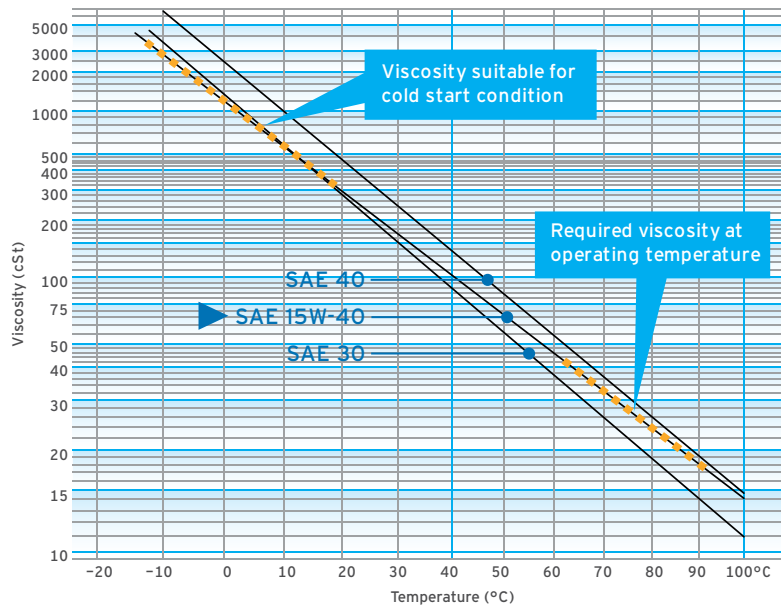




TABLE 4: HIGH-SPEED DIESEL ENGINE OILS

Chevron Product	Performance requirements	Applications	OEMs
Ursa® Marine	High-performance API CG-4 ACEA E2 MAN 270/271 MB 228.0/228.1 MTU Type I	Emergency diesels SAE 15W-40 Other SAE 30/40	Caterpillar Cummins Yanmar MAN Daihatsu Dorman Hatz Mercedes Scania SKL
Delo® SHP	Super high-performance API SF ACEA E2 MB 228.2 MTU Type II CCMC D5 SHPD	Propulsion SAE 40 (High-speed ferries, etc.)	Deutz Petter Scania Volvo Valmet Ruston Bukh MTU Mitsubishi Lister
Delo 6170 CFO 40	Zinc-free requirement	EMD engines	Caterpillar
Ursa Extra Duty	Special requirement	Two-stroke, low ash, SAE 40	Detroit Diesel

CHART 2: VISCOSITY-TEMPERATURE CHART OF URSA MARINE SERIES HIGH-SPEED ENGINE





3 Turbine Oils

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 turbochargers, speed governors, hydraulic systems, and screw and piston air compressors.

TABLE 5: TURBINE OILS

Chevron Product	SAE Viscosity Grade	Application
Regal® R&O	32, 46	Turbines, screw air compressors
	68	Steam and gas turbines, turbochargers, hydraulic systems, etc.
Regal EP	100	Extreme pressure version: steam turbines



4 Hydraulic Oils

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:

Chevron Product	SAE Viscosity Grade	Application
Rando® HDZ	15, 22	Servo, control systems, turbo couplings
	32, 46	Hatch covers, screw air compressors
	68, 100	Cranes, winches, thrusters, CPP systems, gears



5 Gear Oils

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.

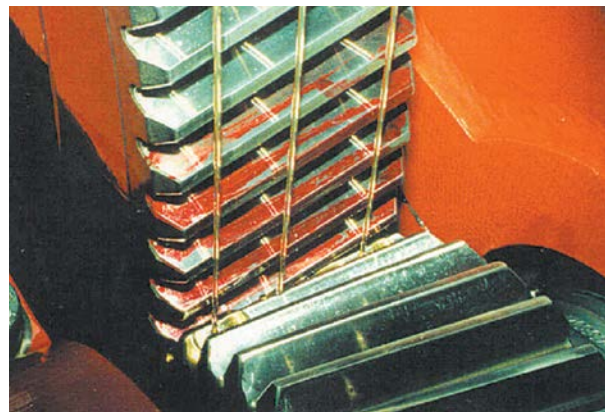
- **EP Additives:** An EP additive chemically reacts with the metal surface under conditions of extreme pressure to form a surface film that prevents the welding of opposing asperities.
- **Hydrodynamic lubrication:** When the shape and relative speed of the sliding surfaces cause the formation of an 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.



Gear oils require increased load-carrying capacity.

TABLE 7: GEAR OILS

Chevron Product	SAE Viscosity Grade	Application
Mineral: Meropa®	68, 100	Thrusters
	150, 220, 320	Spur and bevel reduction gears
	460, 680	Worm gears, gear couplings
Synthetic: Pinnacle® Marine Gear	220	High-temperature applications (centrifuge gears)



6 Compressor Oils

For marine applications, there are three compressor systems:

- Air compressors
- Refrigerating compressors
- LPG/LNG 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.

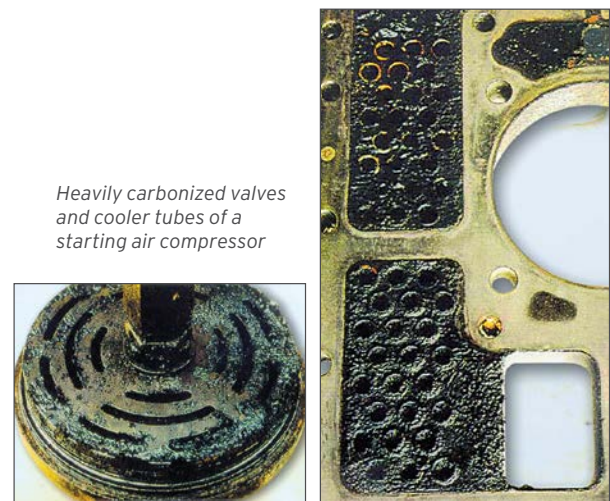
Diester-based air compressor oils have proven to prevent carbon formation on valves and cooler tubes of piston air compressors, providing for reduced

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



TABLE 7: AIR COMPRESSOR OILS

Chevron Product	SAE Viscosity Grade	Application
<i>PAO-based synthetic:</i> Cetus® PAO	46, 68	Screw and rotary air compressors Turbo chargers (68 grade)
<i>Mineral:</i> Compressor Oil EP VDL	100	Reciprocating air compressors requiring DIN 51506 VDL specification
<i>Diester-based synthetic:</i> Cetus DE	100	Reciprocating air compressors

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.

For extreme low-temperature operation with conventional gases, an alkylbenzene lubricant is recommended.

TABLE 8: REFRIGERATING OILS

Chevron Product	SAE Viscosity Grade	Application
<i>Mineral:</i> Capella® WF	68	Conventional gases (R12, R22, ammonia)
<i>Synthetic polyolester:</i> Capella HFC	32, 55, 100	Chlorine-free gases (R134a, R404a)
<i>Synthetic alkylbenzene:</i> Refrigeration Oil Low Temp	68	Low-temperature operation (R22, R502)

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 9: LPG/LNG COMPRESSOR OILS

Chevron Product	Viscosity	Application
LPG Compressor Oil	185 cSt at 40°C	LPG/LNG compressors

7 Heat Transfer Fluids

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

Chevron Product	ISO Viscosity Grade	Max. Bulk Temperature	Max. Film Temperature	Application
Texatherm®	32, 46	315°C	335°C	Heat transfer systems



8 Open Gear Lubricants, Greases, and Rust Preventatives

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 molybdenumdisulphide 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 molybdenumdisulphide 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 11: OPEN GEAR LUBRICANTS, GREASES, AND RUST PREVENTATIVES

Chevron Product	Type	NLGI	Application
Multifak® EP	Lithium soap Mineral oil EP	0	Central lubrication systems (e.g. steering gears)
		2	General lubrication; plain, ball, and roller bearings
Molytex® EP	Lithium soap Mineral oil EP, MoS ₂	2	Plain, ball, roller, and thrust bearings under shock-load conditions
Ulti-Plex® Synthetic Grease EP	Lithium complex soap Synthetic oil EP	1.5	High-temperature applications
Texclad® 2	Calcium soap High-viscosity mineral oil Graphite and MoS ₂	2	Open gears, wire ropes and general deck applications
Rustproof Compound L	Solvent cutback petrolatum	–	Spare parts, wire ropes

9 Cooling Water Treatment and Corrosion Inhibitors

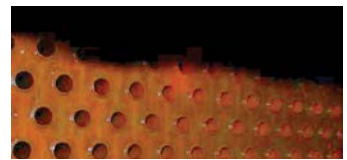
Water-cooled machinery requires protection against general and localized corrosion and cavitation corrosion of metal surfaces. Most corrosion inhibitors are concentrates that have to be diluted with fresh water.

Onboard, the cooling water treatment should provide protection against corrosion of cast iron, steel, aluminum and copper alloys, and should be compatible 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.

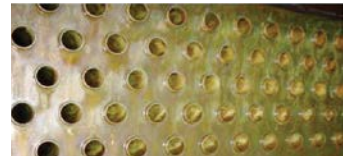
Havoline® Extended Life cooling water treatment, developed with patented carboxylate technology, are environmentally acceptable, low toxic, and have extremely low depletion. They protect effectively against all types of corrosion while efficiently cooling the system.

Air Cooler, Sulzer 12RTA84C-UG Main Engine – Pipe Bundle

Before change-over (traditional coolant)



After 4,000 hours with Havoline XLI



After 13,000 hours with Havoline XLI



TABLE 12: COOLING WATER TREATMENT

Chevron Product	Type	Application
Havoline XLI	Water-based	Fresh cooling water systems
Havoline XLC	Ethylene glycol-based	Fresh cooling water systems where anti-freeze protection is required



10 Promoting Environmental Sensitivity

Public opinion and government regulation have driven a new global focus on environmental responsibility. Many maritime companies intend to improve their environmental footprint, but have been unwilling to accept the traditional compromises — in additional operating costs or reduced performance — necessary to achieve ‘green’ operation.

Finding the correct ‘green’ lubricants is vital for true environmental responsibility, but it is not an easy choice. Marketers use non-specific descriptors such as ‘Bio Friendly’, ‘Green’, ‘Eco Safe’ and ‘Biodegradable’ to classify products as either biodegradable and/or non-toxic to marine organisms. In addition, government regulations may vary by country so there is no single standard for defining these products. What selection criteria should be used? Some considerations are:

- **Personal safety:** Is the product as safe (or safer) to handle than conventional products?
- **Aquatic toxicity rating:** Is it harmful to marine organisms if a spill does occur? And at what levels? Does it just pass the minimum point?
- **Biodegradability:** If a spill does occur, how long will the product remain in the marine environment? How quickly will it biodegrade?
- **Product performance:** Does the product provide lubrication performance as good as conventional lubricants, including service life, seal compatibility, lubrication properties and OEM specifications?
- **Product availability and compatibility** with other products
- **Product cost**

Aquatic toxicity testing determines how harmful products are for various marine organisms. Chevron’s Clarity product line was tested with a 96-hour LL50 test, in which toxicity is expressed as concentration in parts per million of the test material that results in a 50% mortality rate after 96 hours, generally considered acceptable if LL50 result is >1,000 ppm. Clarity products passed the test at over fifty times this amount with zero mortality results for fingerling rainbow trout and mysid shrimp.

For biodegradability, Clarity products were tested with the CEC L-33-A93 test protocol, which determines the time it takes before a product degrades to a certain percentage. According to definitions from the EPA OPPTS 835.3110 and OECD Guidelines, Clarity products can be called *inherently biodegradable*, which means that in less than 84 days the virgin product has biodegraded by more than 60%. In actual testing, Clarity products biodegraded by 60% in only 60 days.

Selection of ‘green’ lubricants is always a balance between the cost of operation and environmental benefits. Clarity products are created with Chevron’s proprietary highly refined base oils and advanced ashless additive technology. The Clarity line provides exceptional oxidation stability, water separability, foam suppression and protection against wear, rust and corrosion.

TABLE 13: CLARITY MARINE LUBRICANTS

Chevron Product	ISO Viscosity Grade	Application
Clarity® Machine Oils	100, 150, 220, 320	Deck equipment, gearboxes, separators
Clarity Hydraulic Oil AW	22, 100	Stern tubes (ISO 100), deck equipment, hydraulic systems
Clarity Synthetic Hydraulic Oil AW	32, 46, 68	Deck equipment, gearboxes, separators

11 Conclusion

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.

To assist the planning of deliveries, Chevron maintains an up-to-date online 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. The online directory is found at www.chevronmarineproducts.com/ports.

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.

For more detailed information regarding Chevron products and services, please visit our website at www.chevronmarineproducts.com.



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