Statoil Lubricants
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LoadWay Marine

Dedicated marine transmission oil

Friction Fighters™

STATOIL
changing your day

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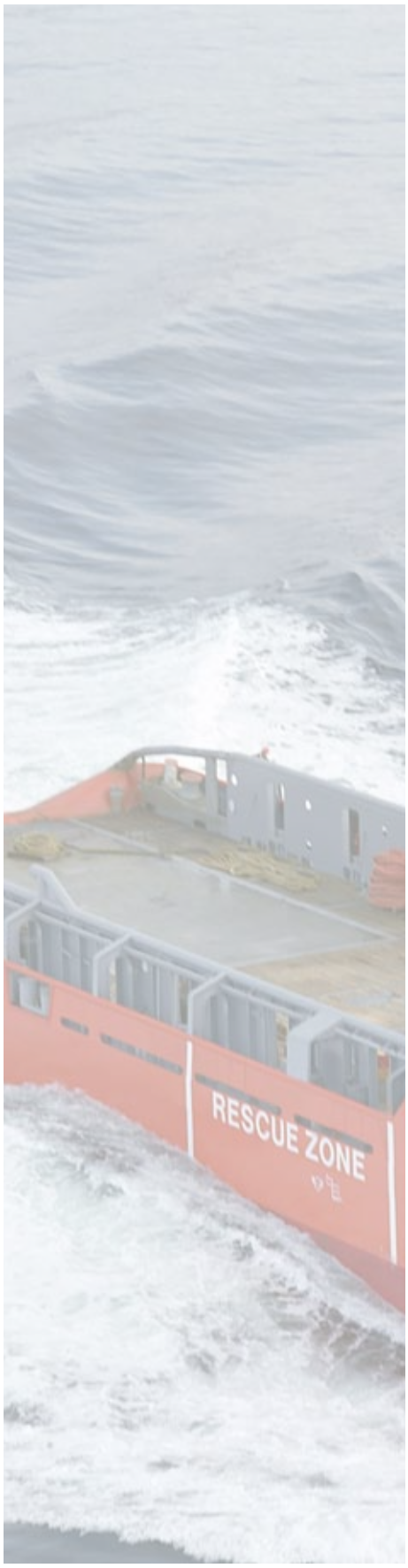

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Introduction

Statoil LoadWay Marine is a dedicated series of marine transmission oil especially developed for the most modern and demanding propulsions systems usually found on supply vessels in the off shore sector, modern fishing vessels and high speed ferries. The significance of these propulsion systems is the contradicting technical requirements of the integrated parts, the mode of operation and in high sea applications, demand for guaranteed and trouble free application.

Statoil LoadWay Marine carries the approvals of all leading manufacturers of advanced marine propulsion systems as well as those of manufacturers of the various components, e.g. clutches, gears, seals and stern tubes.

Statoil LoadWay Marine ensures safe and extended operation of the most advanced propulsion systems.

2 Background

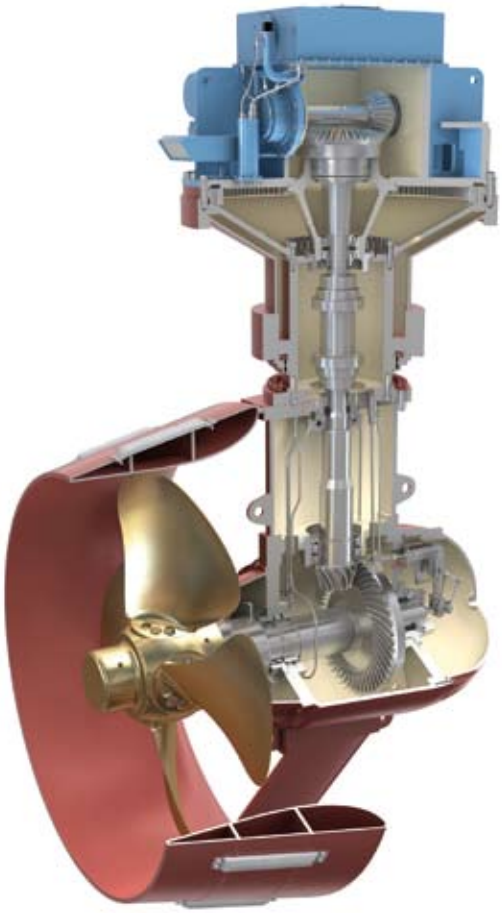

Figure 1 *Azimuthing thruster*

The development of off shore oil fields has lead to a higher dependence on highly sophisticated supply vessels. The demand on these vessels in terms of reliability and manoeuvrability is tremendous and consequently they are equipped with the most advanced propulsion systems. Furthermore, the oil fields are often located in the most storm riddled waters on earth, which leads to an even higher strain on the equipment as compared to regular shipping.

In spite of this, lacking better alternatives, the manufacturers of marine propulsion systems have been forced to recommend, and the ship owner forced to use, oils developed for industrial gears. For logistical reasons and to enable a rationalized use of oil onboard the vessels, even marine motor oils have been recommended and used. Although both types of oils, in the past, have shown adequate level of performance, the use has not been without problems, especially in modern and sophisticated equipment.

Traditional industrial gear oils, often formulated to carry as much load as possible, have caused staining of clutch plates, corrosion of yellow and bearing metals and damaged seals. More modern industrial gear oils are often formulated to protect against micro pitting. These oils contain friction modifying chemistry which may cause the clutch to slip or worse, not engage at all.

Motor oils, on the other hand, lack the load carrying properties required by highly, often shock loaded, gears and transmissions.

Statoil has therefore, in cooperation with leading manufacturers, developed a series of oils especially developed for marine propulsion systems, including gears, clutches, hydraulics and seals.

3 Gathering the technical requirements

Wear Protection	>12
Micro Pitting	High
Seal Performance	B+V Simplex / Deep Sea Seals
Clutch Perfomance	Ortlinghaus
Water Sepapration	Readily
Air Release @ 75˚C	Readily
Corrosion on Cupper	low
Steel Corrosion	None
Foam Characteristics	low

Table 1 *Summary of technical requirements*

Figure 2 *Ortlinghaus clutch*

The work started with a gathering of the technical requirements. Several equipment manufacturers (OEM) of both components and integrated propulsion systems contributed their particular requirements. Four major requirements were common among the system manufacturers and supported by the various component manufacturers. In addition to these four, a number of less pronounced but equally important requirements were noted.

3.1. Clutch performance in accordance with Ortlinghaus GmbH in house test.

Ortlinghaus GmbH is a leading manufacturer of clutches for marine transmissions and has developed an in house test to evaluate oils frictional characteristics. The test measures the oils dynamic and static friction over 10.000 engagements. The minimum requirements are set at 0.12µ for the static friction and 0.08µ for the dynamic friction. Although lower values might work, the levels are set in order to cover all cases with a comfortable margin of safety.

3.2. Micro pitting performance “high” according to FVA 54/I-IV.

Micro pitting is a wear mechanism that shows itself on gear tooth surfaces and may lead to noise, vibration and reduced resistance to pitting which in turn may lead to gearbox failure. Micro pitting occurs in a fully lubricated contact where there is no metal to metal contact and is caused by surface fatigue in turn caused by thousands of rollover.

The FVA 54/I-IV is an industry test designed to evaluate an oils protective properties. An oil completing the 576 hour long test within the tolerances are given the rating “high” or “10”.

3.3. Load carrying capacity greater than load stage 12 in the FZG A/16,6/90oC.

To protect the gears from scuffing and seizure, the oil must be compounded with special load carrying additives, known as EP additives. These additives react chemically with the surface metal and form a load carrying layer or EP-film. The FZG test measures the EP-films load carrying ability by stepwise increasing the load. The FZG A/16,6/90oC test is the most stringent version of the FZG methods and consequently used to measure the strongest EP-films.

Figure 3 *Sterntube seal*

3.4. Neutrality to seals.

The seals used in pods, thrusters and stern tubes are carefully developed and designed to offer optimal performance. The oil which comes in direct contact with the seal must not in any way cause it to change in shape or properties. Leading manufacturers of seals have developed tests for determining the oils effect on various elastomer types.

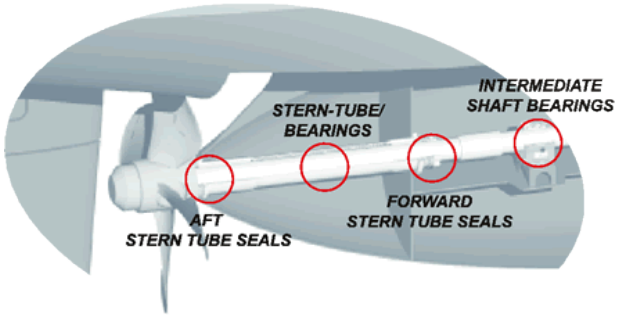

Figure 4 *Sterntube and propeller assembly*

3.5. Other important properties.

In a marine environment are parameters such as ability to separate from water and ability to protect surfaces from corrosion, most important. Since the propulsion systems contain sensitive metals and alloys, e.g. in hydraulic pumps and stern tubes, the oil must exhibit a low tendency to cupper and bearing metal corrosion. Air release is also important since small bubbles may otherwise form air pockets in propeller shafts and hubs.

4 Evaluation of current products and understanding of the challenge

By testing traditional industrial gear oils and marine motor oils against the gathered new requirements, Statoil developed a good understanding for the shortcomings. More importantly Statoil also developed a good understanding for each individual parameter and for the conflict between them.

When developing lubricating oils it is well known that exaggerated requirements on one parameter compromise performance on one or more other parameters.
The new requirements contain two particularly difficult conflicts. The challenge was consequently to balance these conflicts in the same lubricating oil.

4.1. Clutch performance vs micro pitting.

Surface roughness of the gear tooth is the single most important cause for micro pitting. The smother the surface, the lower the risk for micro pitting. However, the oils rheological properties and frictional characteristics may also greatly influence the phenomena.
The friction modifiers required to enhance the micro pitting performance are unfortunately in direct conflict with the requirements in the Ortlinghaus clutch test leading to lower coefficients of both dynamic and static friction.

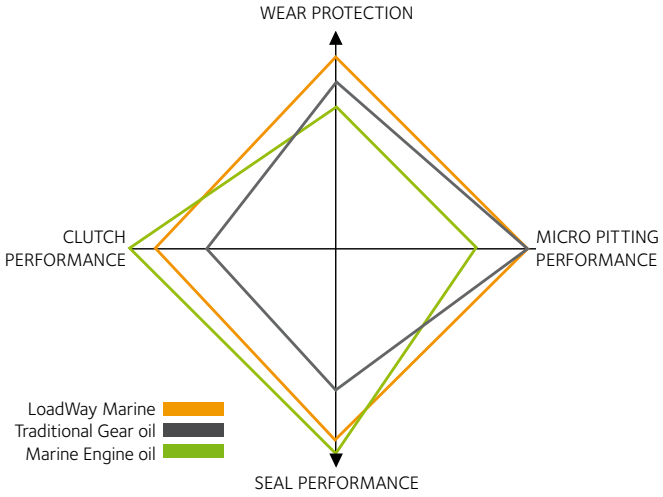

Figure 5 *The relation between the technical requirements*

4.2. Load carrying capacity vs neutrality to seal and corrosion of cupper.

The powerful and reactive chemistry required to reach high FZG values may unfortunately be aggressive to yellow metals, bearing metals and seals. The may also stain the frictional surfaces in the clutch, thereby altering its performance.

5 Raising to the challenge

5.1 Micro Pitting

The choice fell on a number of modern relatively mild EP-chemistries with documented performance in the area of micro pitting, this to avoid problems with seal performance and copper corrosion. The graph illustrates the protection against micro pitting for traditional gear oils, marine motor oils and Statoil LoadWay Marine. Extract from the test report is available in appendix 1.

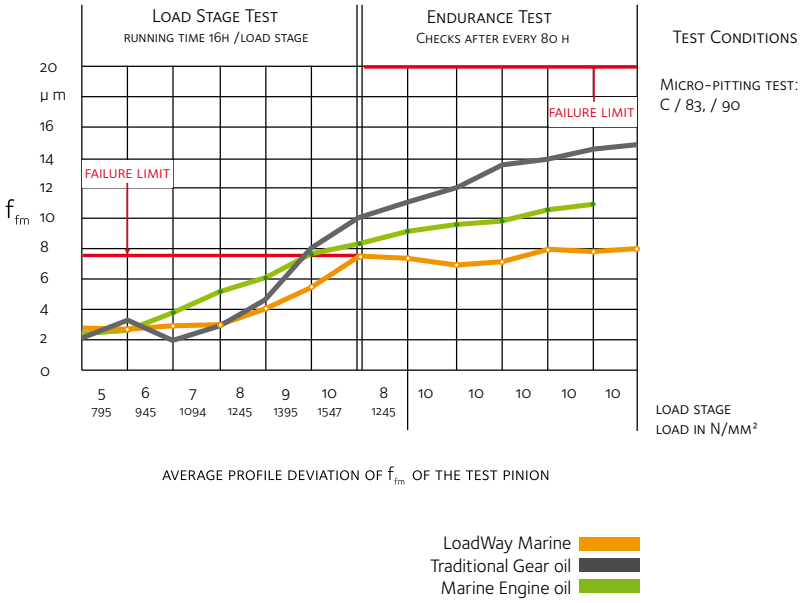

Figure 6 *Comparison of the micro pitting protection between traditional gear oil, v marine engine oil and Statoil LoadWay Marine*

5.2 Neutrality to seals.

The final Statoil LoadWay Marine has been tested and approved by both B+V Simplex and Deep Sea Seals. Copies of the approvals are available in appendix 1.

5.3 Wear Protection

Although mild to seals and sensitive metal alloys, the chosen technology in Statoil LoadWay marine is still powerful enough to pass load stage 12 in the more severe version of the FZG test, the FZG A/16,6/90oC test.

Each load stage equals a 20% increase in safety margin against scuffing and the DNV classification for maximum allowed load is therefore directly linked to the FZG value.

The value 12 in the FZG A/16,6/90oC equals 14 in the milder FZG A/8,3/90oC. Statoil LoadWay marine therefore allow for a higher loading of the propulsion system with retained safety margins.

Extract from the test report is available in appendix 1.

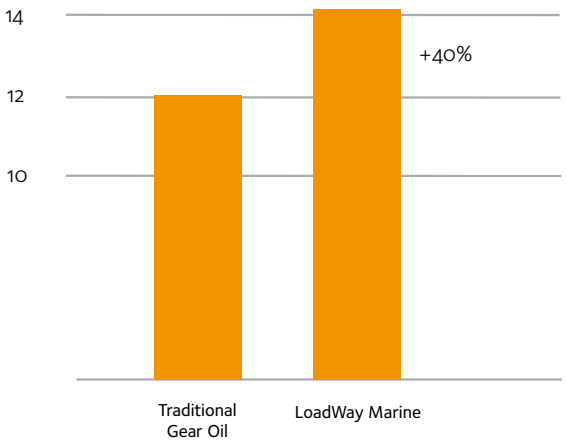

Figure 7 *FZG Test*

5.4 Friction.

A test matrix of 32 different base fluid and additive combinations were tested for frictional characteristics at the Luleå Technical University (LTU). The test rig was set up to mimic the conditions in the Ortlinghaus test and a number of important conclusions could be drawn.

Beside the important knowledge about the various chemistries influence on friction, one important and relevant factor was confirmed, the coefficient of friction increases with the viscosity of the oil. The final Statoil LoadWay Marine 68 passed the Ortlinghaus test with a dynamic coefficient of friction of 0.10µ and a static coefficient of friction of .12µ. Consequently, the more viscous grades, ISO VG 100 – 220, will give higher values. Extract from the test report is available in appendix 1.

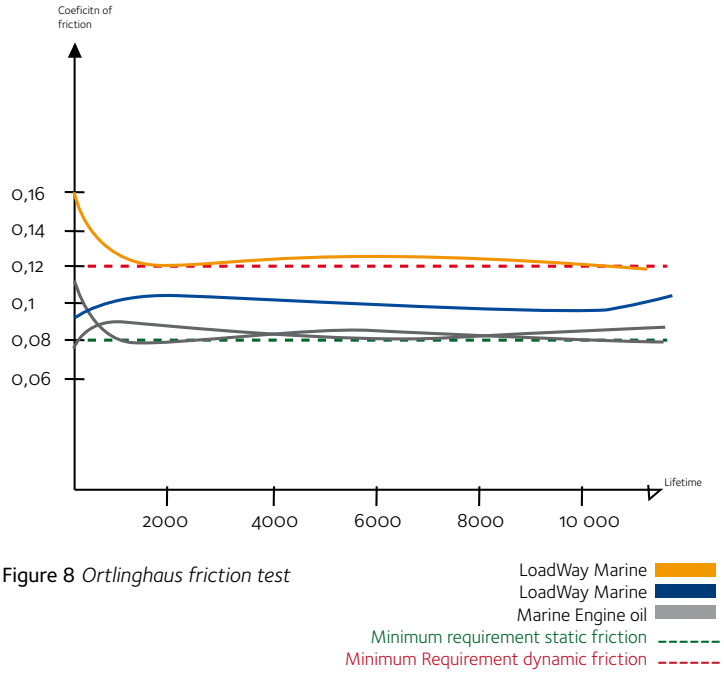

Figure 8 *Ortlinghaus friction test*

5.5 Other important features.

The less pronounced OEM requirements were not overlooked. Statoil LoadWay Marine meets or exceeds the most stringent industry requirements for corrosion on steel and yellow metal, air release and foaming and of course also on water separation.

6 The solution, introducing Statoil LoadWay Marine

Statoil LoadWay Marine is available in four different viscosities, ranging from ISO VG 68 through to ISO VG 220. This enable ship owner and propulsion system manufacturers to chose the perfect oil for any given situation. Product data sheets for all four are available in appendix 2. The table summarises the requirements and compares Statoil LoadWay Marines performance against every single parameter.

Table 2 *Specification for marine propulsion systems*

Parameter	Method	Requirement	Statoil LoadWay Marine
Wear protection	FZG A/16,6/90°C	>12	>12
Micro Pitting	FVA 54/I-IV	10	10
Clutch Performance	Ortlinghaus GmbH Dynamic friction Static friction	 >0.8μ >0.12μ	 0.10μ 0.12μ
Seal Performance	B+V Simplex Wet procedure Dry procedure	 Pass Pass	 Pass/Approved Pass/Approved
Seal Performance	Deep Sea Seals ltd.	Pass	Pass/Approved
Water Separation	ASTM D 1401	<30 minutes	19 minutes
Air Release	DIN 51 381	<13 minutes	10 minutes
Cupper Corrosion	ISO 2160	<2	1
Corrosion on Steel	ASTM D 665 B	Pass	Pass

With the new oil Statoil has managed to solve the conflicts and proven it possible to meet the contradicting requirements without compromise.

In Statoil LoadWay Marine, ship owners and propulsion system manufacturers, have an oil they can safely rely on for trouble free operation in the most demanding marine applications.

7 Additional benefits

For logistical reasons and to offer a rationalised use of lubricating oils on board the vessels, it is desirable with lubricants that can safely function in as many applications as possible. Supply vessels, fishing vessels and ferries have a number of gears, winches and hydraulic systems, all in need of high quality lubricants.

Although Statoil LoadWay Marine was specifically developed for marine propulsion systems it exceeds stringent industry specifications for a number of auxiliary equipment.
Statoil LoadWay marine exceeds the German norm for gears, DIN 51 517-3, and the counterpart for hydraulics, DIN 51 524-2.

Statoil LoadWay Marine can therefore safely be used in all types of gears, winches and hydraulic systems on board any vessel.

Table 3v

Characteristics	Method	Unit	Requirement	Statoil Loadway Marine 68
Viscosity @ 0C min	DIN 51 562 &	mm²/s	<1400	900 [2)]
Viscosity @ 40C **min** **max**	DIN 51 569	mm²/s	 61,2	 68
Viscosity @ 100C	DIN 51 562	mm²/s	>7,8	9,1 [2)]
Pour point	DIN ISO 3016	C	<-12	<-12
Flash point	ASTM D92	C	>195	225
Insolubles	DIN 5884	mg/kg	<50	No traces
Water content	DIN ISO 12937	%	<0,05	<0,02
Rust Prevention	DIN 51 585	rating	0 -A	Pass
Copper Corr.	DIN 2160	rating	<2	1b
Oxidate stability	DIN 51 587	mg KOH/mg	<2,0	<2,0 after2000h
Seal Compability	DIN 53 521 & DIN 53 505	vol% shore A	0-10 0--6	-3 [1)] 4
Air release at 50˚C	DIN 51 381	minutes	<13	10
Dry Filterbility Seq. 1 **Seq. 2**	DIN 13357-2	% %	>80 >60	104 [3)]
Wet Filterbility Seq. 1 **Seq. 2**	DIN 13357-1	% %	>70 >50	4)
Foam char. seq I **seq II** **seq III**	DIN 51 566	ml	150/0 75/0 150/0	0/0 40/0 0/0
Demulsibility @ 54 C	DIN 51 599	minutes	<30	19
FZG A/8.3/90	DIN 51 354 II	fail load stage	10	12
wear test **vane pump**	DIN 51 389	mg loss ring mg loss vane	<120 <30	5)
Specific Gravity	DIN 51 757	g/ml	report	0,882 [2)]
Sulphated Ash	DIN EN 7	%	report	0
Acid Number	DIN 51 558	mg KOH/mg	report	0,46

1) Values are outside the stringent requirements for DIN 51 524. The values are however within the repeatability of the test as well as the requirements for SS 15 54 34 and ISO 11158. The oil is also approved by B+V Simplex, Freudenberg and other leading seal manufacturers.
2) Values generated on related Statoil LoadWay EP 68.
3) The value is generated using the alternative CETOP method on the ISO VG 100. 104 equal full filterability and no blocking.
4) Test included in the specification April 2006. No problems expected based on experiences with similar formulations.
5) Specific test for hydraulic fluids. No problems expected based on experiences with similar formulations.

Table 3 *v*

Characteristics	Method	Unit	Requirement	Statoil Loadway Marine 68
Viscosity @ 40 C min max	DIN EN ISO 3104	mm^2/s	61,2 74,8	68
Viscosity Index	DIN ISO 2909		90	98
Specific gravity @15C	DIN 51 757	g/ml	report	0,882[2]
Flash point	DIN EN ISO 2592	C	>180	225
Pour Point	DIN ISO 3016	C	<-12	<-12
Acid Number	DIN 51 558	mg KOH/mg	Report	0,46
Water content	DIN ISO 3733	%	<0,1	clear & bright
Foaming, sequence 1-3	ISO 6247	ml	100/10	0/0, 40/0, 0/0
Demulsibility	DIN ISO 6614	min.	<30	19
Copper Corr.	DIN EN ISO 2160	rating	<1	1
Rust Prevention	DIN ISO 7120	rating	0-A	0
Oxidative stability Viscosity increase	ASTM D 2893	%	6	2,9
Wear protection (FZG A/8,3/90)	DIN 51 354 II	fail load stage	12	12
Wear Protection FE8 Rollers Cage	DIN 51 819 II	mg mg	<30 Report	91) 55
Seal Compability volume increase hardness strength strength	DIN 53 521 & DIN 53 505 & DIN 51 538	% shore A % %	-5/ + 10 -10 / + 10 <30 <30	-3 4 -4 -11

1) Value generated on ISO VG 220, the good margin ensures passing data at ISO VG 68
2) Values generated on related Statoil LoadWay EP 68