EO Environmental Oils

Environmentally Superior ISO Oil Alternatives

TECHNICAL SUMMARY

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1.0 PRODUCT OVERVIEW

EO Environmental Oils

EO Environmental Oils are environmentally superior alternatives to existing ISO Hydraulic Oils.

EO Environmental Oils are based on environmentally acceptable oils and carry an OCNS Class E (for UK discharge) and Yellow 1 status (for Norwegian Discharge).

EO Environmental Oils exhibit excellent corrosion protection, microbiological protection, stability, material compatibility and all round technical performance.

EO Environmental Oils exhibit outstanding lubrication and anti-wear characteristics, providing comparable system performance to standard ISO hydraulic oils across a wide range of offshore applications.

EO Environmental Oils are available in a number of viscosity grades including EO08, EO12, EO18, EO22, EO32, EO46, EO68, EO100, EO150, EO220 and higher viscosity grades.

Some grades (8, 22, 32 and 220 cst) are also available as a high di-electric (insulation) EΩ grade with keV >55 (to BS EN 60156 IEC 156), making them suitable for use in many electrical insulation related applications.

EO Environmental Oils are capable of operating in a wide range of offshore hydraulic equipment; however, please always consult us prior to use to establish compatibility with your system and to clarify performance attributes.

This manual summarises some of the key technical parameters of the fluid established to date and will be updated regularly as fresh data becomes available.

DOCUMENT REVISION HISTORY

Issue	Revision	Issue Date	Authorised by	Position
1	0	February 2013	D. Gleeson	R&D Manager
2	0	January 2014	D. Gleeson	R&D Manager
3	0	April 2014	D. Gleeson	R&D Manager
4	0	January 2015	D. Gleeson	R&D Manager
5	0	April 2015	D. Gleeson	R&D Manager
6	0	May 2015	D. Gleeson	R&D Manager

Please note that this document is subject to revision on a regular basis. Please ensure you have the latest revision before using this data in applications of a critical nature.

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2.0 PHYSICAL PROPERTIES SUMMARY

Property	EO 08	EO 12	EO 18	EO 22	EO 32	EO 46	EO 68	EO 100	EO 150	EO 220	Test Method
Density @20°C / gcm^{-3}	0.918	0.925	0.937	0.943	0.952	0.962	0.976	0.984	0.994	0.998	IP365
Viscosity (cSt)											ASTM D445 IP71 ISO 3104
@ 20 °C	14.6	24.4	38.3	44.8	79.8	117	192	265	449	615	
@ 40 °C	8.0	12.0	18.0	22.0	32.0	46.0	68.0	100	150	220	
Pour Point		<-25 °C									IP15
Appearance		Transparent, yellow liquid									
Flash Point /°C		>180 °C									ASTM D92 IP36
Breakdown Voltage*		>55 keV available on request for electrically insulating EΩ grades **									BS EN 60156 IEC 156
PCB Content/ mg kg^{-1}		None Detected									BS EN 61619 ASTM D4059
Neutralisation Value		<0.2 mg KOH g^{-1}									BS2000.1 IEC62021
Furfural		< 0.1 mg/kg or ppm									IEC 61198
PCA Content		None									IEC 346
PCB Content		None									IEC 6169
Water content		<200 ppm typical, lower on request for electrically insulating EΩ grades **									IEC 733 ASTM D1533
Cleanliness Level (Minimum)		17/14/12									ISO 4406
		NAS 6									NAS 1638
		6B/6C/6D/6E/6F									SAE AS4059
Shell 4 Ball*		Mean Wear Scar Diameter <0.9 mm									IP239/01 (1 hour, 1475rpm rotation, 30 kgf load).
Solubility in Water		Insoluble									
Solubility in Mineral / Crude Oil		Soluble									

* Falex, Shell 4 Ball, dielectric breakdown strength testing were all conducted by independent laboratories.

** Electrically Insulating Grades include EΩ 08, EΩ 22, EΩ 32 and EΩ 220

3.0 PRODUCT TESTING

3.1 THERMAL STABILITY

EO Environmental Oils have undergone accelerated aging testing based on the procedures laid out in ISO 13628-6 and is considered fit for service at temperatures as high as 120 °C.

Aging Temp /°C	Aging Time	Appearance	Qualitative description of separation in fluid	EO32		EO220	
				Specific Gravity @ 20 °C	Viscosity @ 40 °C / cSt	Specific Gravity @ 20 °C	Viscosity @ 40 °C / cSt
None	None	Clear and bright yellow fluid	None	0.952	32.0	0.998	220.0
120	3 months	Clear and bright orange fluid	None	0.951	32.0	0.999	220.0

Low temperature stability studies have also been undertaken, with EO series Fluids remaining visually unchanged after aging at -25 °C for 3 months.

3.2 COMPATIBILITY WITH OTHER FLUIDS.

Extensive compatibility studies have been undertaken with Shell Tellus T46, Diesel Oil, CLEO, Brayco Micronic SV/3 and SV/B in accordance with the ISO 13628-6 specification which typically includes:-

- Compatibility at 4, 20, 70 °C for a minimum of 1 month.
- % v/v mixing ratios of 90:10, 75:25, 50:50, 25:75 and 10:90 at each temperature.

Further compatibilities for HDEO, HDEO^{EP}, Monoethylene Glycol and Methanol have also been undertaken as follows:-

- Compatibility at 4 and 20 °C for a minimum of 1 month.
- % v/v mixing ratios of 95:5, 90:10, 75:25, 50:50 for HDEO, HDEO^{EP} and methanol.
- 100 and 1000 ppm (weight) addition of monoethylene glycol.

Additionally, all fluids within the EO Series are fully compatible with each other at all ratios and temperatures.

Further extended compatibilities with a wider range for fluids and temperatures are currently being undertaken.

3.3 METAL COMPATIBILITY

EO Environmental Oils have been shown to be fully compatible with a wide range of metals in testing based on ISO 13628-6.

A summary of selected results after aging at 70 °C for 12 weeks are shown overleaf, showing that the EO Environmental Oils have excellent compatibility with all metals tested.

Metal	Aging time / weeks	EO 32		EO 220	
		Metal Test Piece to ISO 13628-6	Appearance of Fluid to ISO 13628-6	Metal test piece to ISO 13628-6	Appearance of Fluid to ISO 13628-6
17 – 4 – PH UNS S17400	12	Pass	Pass	Pass	Pass
AlCNC10	12	Pass	Pass	Pass	Pass
AISI A29 4340 Gas Nitrided	12	Pass	Pass	Pass	Pass
AISI A29 4340	12	Pass	Pass	Pass	Pass
AISI A350 LF2 Carbon Steel	12	Pass	Pass	Pass	Pass
AISI 410	12	Pass	Pass	Pass	Pass
AISI 420	12	Pass	Pass	Pass	Pass
AISI 440C	12	Pass	Pass	Pass	Pass
AISI 4130	12	Pass	Pass	Pass	Pass
AISI 4140	12	Pass	Pass	Pass	Pass
Aluminium Bronze UNS C63000	12	Pass	Pass	Pass	Pass
Aluminium Bronze ASTM B418	12	Pass	Pass	Pass	Pass
Alloy 3	12	Pass	Pass	Pass	Pass
Becol UNS C17200	12	Pass	Pass	Pass	Pass
Carbon Steel UNS K02401	12	Pass	Pass	Pass	Pass
Chrome Core	12	Pass	Pass	Pass	Pass
Copper	12	Pass	Pass	Pass	Pass
DGS1043	12	Pass	Pass	Pass	Pass
Duplex 9490	12	Pass	Pass	Pass	Pass
Electroless Nickel Plated	12	Pass	Pass	Pass	Pass
Elgiloy	12	Pass	Pass	Pass	Pass
Inconel 625	12	Pass	Pass	Pass	Pass
Inconel 718	12	Pass	Pass	Pass	Pass
Inconel 718 Silver Coated	12	Pass	Pass	Pass	Pass
Inconel 718 Gold Coated	12	Pass	Pass	Pass	Pass
Inconel 725 GV50H	12	Pass	Pass	Pass	Pass
Inconel 725 Silver Coated	12	Pass	Pass	Pass	Pass
Inconel 825	12	Pass	Pass	Pass	Pass
Inconel 925	12	Pass	Pass	Pass	Pass
KR16	12	Pass	Pass	Pass	Pass
Mild Steel	12	Pass	Pass	Pass	Pass
Monel Alloy 400	12	Pass	Pass	Pass	Pass
Monel Alloy K500	12	Pass	Pass	Pass	Pass
MP35N	12	Pass	Pass	Pass	Pass
Nitronic 50	12	Pass	Pass	Pass	Pass
Phosphor Bronze PB102	12	Pass	Pass	Pass	Pass
Super Duplex AM8831	12	Pass	Pass	Pass	Pass
Super Duplex UNS S32760	12	Pass	Pass	Pass	Pass
Silicon Nitride	12	Pass	Pass	Pass	Pass
Stainless Steel 304	12	Pass	Pass	Pass	Pass
Stainless Steel 316	12	Pass	Pass	Pass	Pass
Stainless Steel 316 Ti	12	Pass	Pass	Pass	Pass
Stainless Steel 416	12	Pass	Pass	Pass	Pass
Stainless Steel 431	12	Pass	Pass	Pass	Pass
Super Duplex (OEM)	12	Pass	Pass	Pass	Pass
Toughmet 3 AT110 (UNS C72900)	12	Pass	Pass	Pass	Pass
Umbilical TP19D	12	Pass	Pass	Pass	Pass
Zirconia	12	Pass	Pass	Pass	Pass
Zn plated Washer	12	Pass	Pass	Pass	Pass
6% Ni Bonded Tungsten Carbide	12	Pass	Pass	Pass	Pass
10% Ni Bonded Tungsten Carbide	12	Pass	Pass	Pass	Pass

Coated Metal	Aging time / weeks	EO 32		EO 220	
		Metal Test Piece to ISO 13628-6	Appearance of Fluid to ISO 13628-6	Metal test piece to ISO 13628-6	Appearance of Fluid to ISO 13628-6
Xylan 1014	12	Pass	Pass	Pass	Pass
Xylan 1052	12	Pass	Pass	Pass	Pass
Xylan 1212	12	Pass	Pass	Pass	Pass
Xylan 1213	12	Pass	Pass	Pass	Pass
Xylan 1400	12	Pass	Pass	Pass	Pass
Xylan 1424	12	Pass	Pass	Pass	Pass

3.4 ELASTOMER COMPATIBILITY

EO Environmental Oils have been shown to be compatible with a range of elastomers in accordance with testing based on the ISO 13628-6 specification with the results after aging at 70 °C for 3 months as tabulated below.

EO Environmental Oils shows excellent compatibility with a wide range for elastomeric materials.

EO Environmental Oils have been found to be incompatible with silicone and EPDM materials tested to date, which is typical for these types of fluids.

Elastomer compatibility at 70 °C for EO32 and EO220

Elastomer	Aging time	EO32 and EO220		
		Swell	Hardness	ISO 13628-6
Aflas (Clwyd)	3 months	Pass	Pass	Pass
Ecoflon 4 25% Carbon Filled PTFE (Economos)	3 months	Pass	Pass	Pass
FFKM PFR06HC 90 Shore A (Solvay)	3 months	Pass	Pass	Pass
FFKM PKR95HT 90 Shore A (Solvay)	3 months	Pass	Pass	Pass
FKM 70.16-14 (Angst and Pfister)	3 months	Pass	Pass	Pass
FKM FOR 3752(Solvay)	3 months	Pass	Pass	Pass
FKM FOR 9381 92 Shore A (Solvay)	3 months	Pass	Pass	Pass
FKM FR58-90 James Walker	3 months	Pass	Pass	Pass
FKM Mix 80 (FCH)	3 months	Pass	Pass	Pass
FKM P757 92 Shore A (Solvay)	3 months	Pass	Pass	Pass
FKM P959 93 Shore A (Solvay)	3 months	Pass	Pass	Pass
FKM PL855 91 Shore A (Solvay)	3 months	Pass	Pass	Pass
FKM VBR X856 90 Shore A (Clwyd)	3 months	Pass	Pass	Pass
FKM V70GA 70 Shore A (Trelleborg)	3 months	Pass	Pass	Pass
FKM V858-95 (Parker)	3 months	Pass	Pass	Pass
FKM VPL85540 92 Shore A (Solvay)	3 months	Pass	Pass	Pass
FKM VPL 85730 91 Shore A (Solvay)	3 months	Pass	Pass	Pass
FKM PL958 91 Shore A (Solvay)	3 months	Pass	Pass	Pass
FKM V1238-95 95 Shore A (Parker)	3 months	Pass	Pass	Pass
HNBR H9T20 (Trelleborg)	3 months	Pass	Pass	Pass
HNBR KB163-90 (Parker)	3 months	Pass	Pass	Pass
Hytrel 5556 Shore 55D Thermoplastic Polyester (Dupont)	3 months	Pass	Pass	Pass
Hytrel 6356 Shore 63D Thermoplastic Polyester (Dupont)	3 months	Pass	Pass	Pass
Hytrel 7246 Shore 72D Thermoplastic Polyester (Dupont)	3 months	Pass	Pass	Pass
NBR K09G 90 Shore A (Pimseal)	3 months	Pass	Pass	Pass
NBR N107-90 (Parker)	3 months	Pass	Pass	Pass
NBR N552-90 90 Shore A (Parker)	3 months	Pass	Pass	Pass
NBR N674-70 70 Shore A (Parker)	3 months	Pass	Pass	Pass
NBR N702-90 (Parker)	3 months	Pass	Pass	Pass
NBR N1059-90 (Parker)	3 months	Pass	Pass	Pass
NBR N7022 70 Shore A (Trelleborg)	3 months	Pass	Pass	Pass
NBR N7023 70 Shore A (Trelleborg)	3 months	Pass	Pass	Pass
NBR N9002 90 Shore A (Trelleborg)	3 months	Pass	Pass	Pass
PEEK 450G (Victrex)	3 months	Pass	Pass	Pass
PEEK W4685 (Parker)	3 months	Pass	Pass	Pass

Elastomer	Aging time	EO32 and EO220		
		Swell	Hardness	ISO 13628-6
PEEK W4738 (Parker)	3 months	Pass	Pass	Pass
PTFE (OEM)	3 months	Pass	Pass	Pass
PTFE (25% Carbon Filled) (OEM)	3 months	Pass	Pass	Pass
Silicone (OEM)	3 months	Pass	Pass	Pass
Turcon M12 (Trelleborg)	3 months	Pass	Pass	Pass
Turcon T29 Step Seal (Trelleborg)	3 months	Pass	Pass	Pass
Turcon T51 (Trelleborg)	3 months	Pass	Pass	Pass
Viton A 9009-75 (OEM)	3 months	Pass	Pass	Pass
Viton EPT90 (Clwyd)	3 months	Pass	Pass	Pass
Viton HTV90-A2 90 Shore A (Dupont)	3 months	Pass	Pass	Pass
Viton V747-75 (Parker)	3 months	Pass	Pass	Pass

3.5 FLUID LUBRICITY AND WEAR

3.5.1 Shell 4 Ball Test

Lubricity testing using the Shell 4 ball method as described in the ISO 13628-6 specification has been undertaken by an independent testing laboratory and results are outlined below.

3.5.1.a One Hour 4 Ball Wear Test

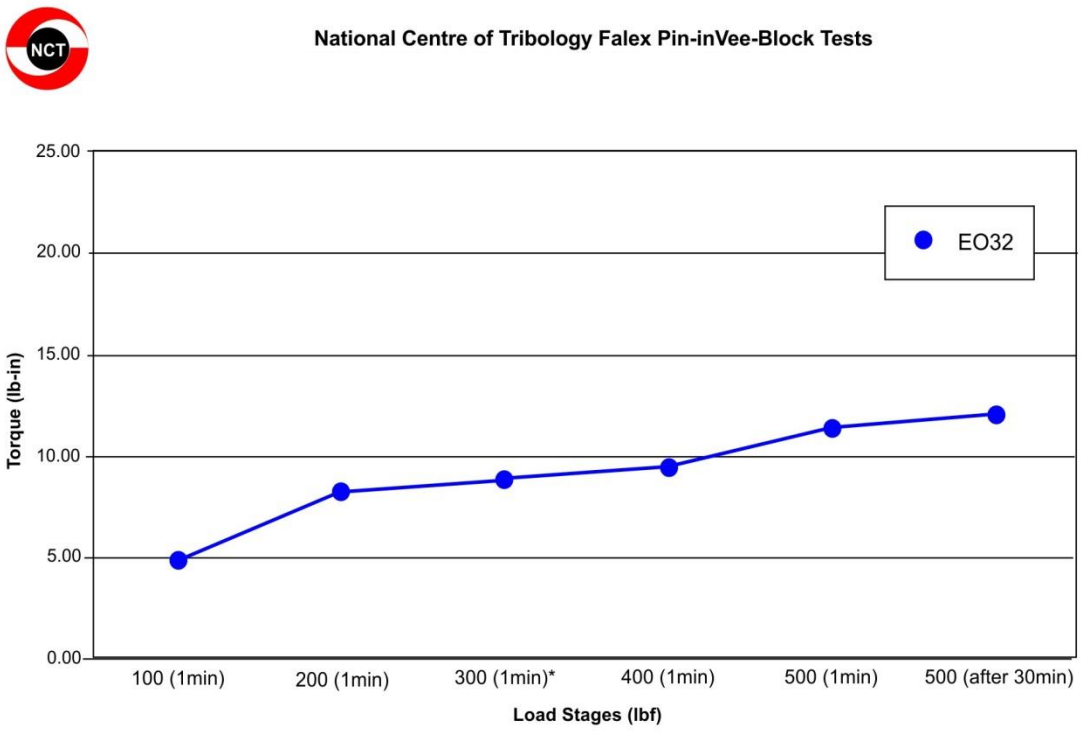
The results obtained for the one-hour wear tests at 30 kg load at 1475 (+/-25) rpm are shown below in table 2 with the mean wear scar diameters measured for EO32 demonstrating 70% less wear than the acceptance criteria of 1.2 mm.

Lubricant	Scar Diameter Rubbing Direction Ball 1 (mm)	Scar Diameter Right Angle Direction Ball 1 (mm)	Scar Diameter Rubbing Direction Ball 2 (mm)	Scar Diameter Right Angle Direction Ball 2 (mm)	Scar Diameter Rubbing Direction Ball 3 (mm)	Scar Diameter Right Angle Direction Ball 3 (mm)	Average Scar Diameter MWSD (mm)	Comments
EO32	0.32	0.32	0.32	0.32	0.38	0.42	0.347	Round wear scars

3.5.2 Falex Lubricity and Anti-wear Data

The results for the Falex pin-in-Vee block test as described in ISO 13628-6 (2006) Section C2.3 are shown below for the EO32 product.

Test Stage Load (lbf)	EO32
	Torque (lb-in)
100 (1 min)	4.73
200 (1 min)	8.19
300 (1 min)	8.82
400 (1 min)	9.45
500 (1 min)	11.34
500 (after 30 mins)	11.97
Load Tooth Increment after 30 minutes at 500 lbs	5



3.5.3 FZG Gear Oil Test

The FZG gear oil test A/8.3/90 according to DIN ISO 14635-1, which is equivalent to other standards as IP 334, ASTM D-5182, CEC L-07-A-95 and identical to ISO DIS 14635-1 is widely used test method for the evaluation of the scuffing properties of industrial gear lubricants is the FZG gear oil test A/8.3/90 according to DIN ISO 14635-1, which is equivalent to other standards as IP 334, ASTM D-5182, CEC L-07-A-95 and identical to ISO DIS 14635-1.

A-type gears are loaded stepwise in 12 load stages between a Hertzian stress of pC = 150 to 1800 N/mm². They are operated for 15 min at a pitch line velocity of 8.3 m/s and a starting oil temperature of 90 °C in each load stage, under conditions of dip lubrication without cooling. In the visual test the gear flanks are inspected after each load stage for scuffing marks.

Failure load stage is indicated when the faces of all pinion teeth show a summed total width of damaged areas which is equal or exceeds one tooth width. In the gravimetric test the gears are dismounted and weighed to determine their weight loss. From the curve of the weight loss the specific wear parameter can be evaluated as well scuffing load stage which is indicated by a steep increase of the wear curve.

The results from the FZG Gear Oil Test are tabulated below.

Lubricant	Failure Load	Weight Loss on the Wheel (mg)	Weight Loss on the Pinion (mg)
EO32	> Stage 12	6.9	19.4

This shows that EO32 shows outstanding lubrication in this test.

3.6 BACTERIAL CONTAMINATION

Bacterial and Fungal resistance was tested by mixing EO32 and EO220 with synthetic seawater (prepared to ASTM D1141-98) at a ratio of 50:50 v/v, with mixture aged at ambient and or 40 °C as follows:-

- EO32 and EO220 with fresh sea water, static – ambient and 40 °C.
- EO32 and EO220 with contaminated sea water, static – ambient and 40 °C.

Both sets of tests currently show no evidence of bacterial or fungal growth and tests are on-going after 4 months.

	Typical Plate after 4 months aging for EO32	Typical Plate after 4 months aging for EO220	Sea Water Alone for 12 weeks
Bacteria			
Mould