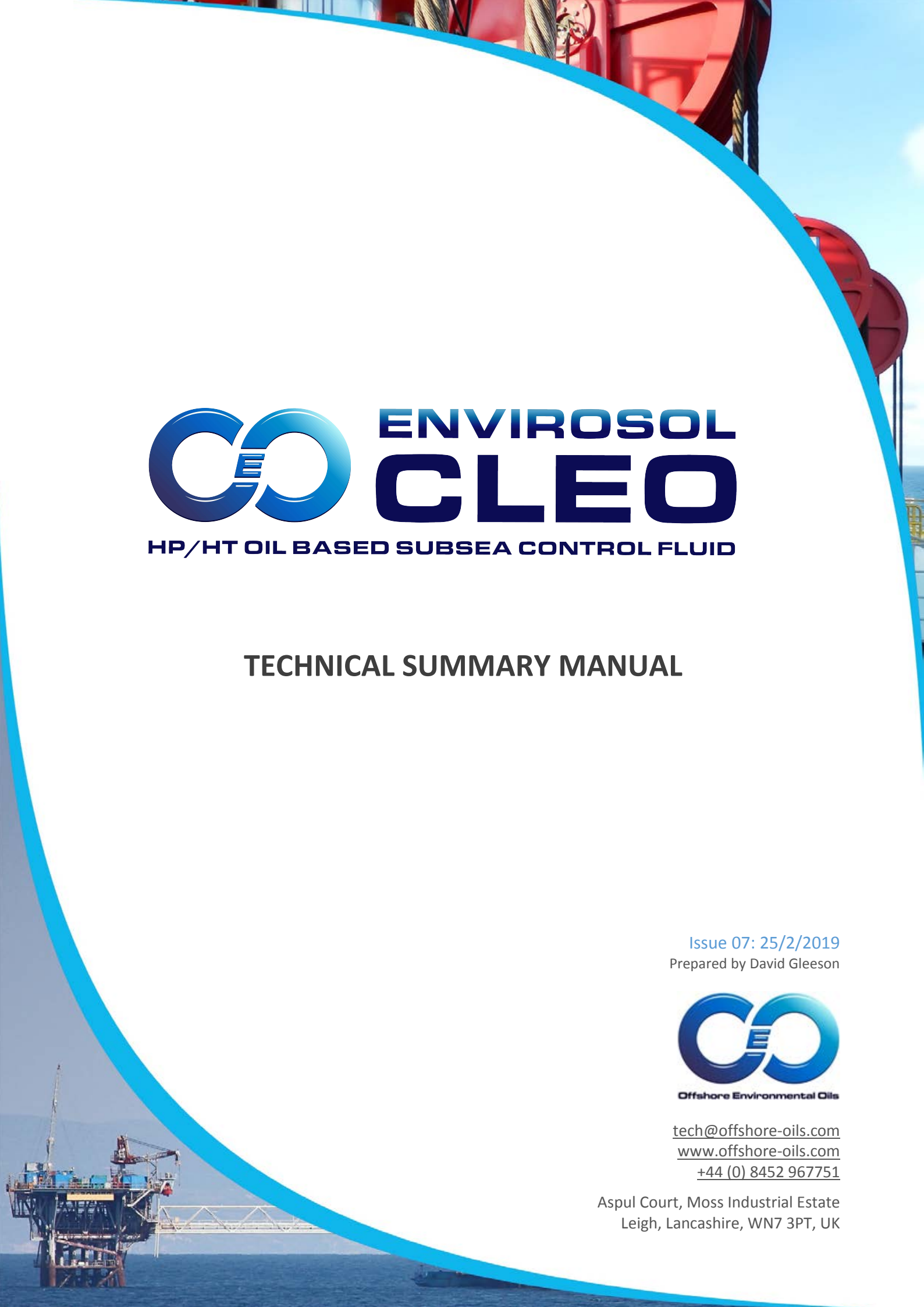

ENVIROSOL CLEO

HP/HT OIL BASED SUBSEA CONTROL FLUID

TECHNICAL SUMMARY MANUAL

Issue 07: 25/2/2019

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1.0 PRODUCT OVERVIEW

CLEO High Temperature Environmental Oil

CLEO is a High Temperature Environmental Oil based Subsea Control Fluid.

CLEO was developed to bridge the technology gap between water based fluids and the extreme HT/HP developments of the future by providing a very stable high temperature fluid capable of maintaining temperatures in excess of 250 °C for a project lifetime.

In addition, with the potential future requirements for closed loop systems in some sectors this environmental oil is not only acceptable for direct discharge to sea but is designed to offer all the properties of traditional oil based fluids in closed loop systems.

CLEO has a comparatively low viscosity for an oil based fluid which is useful when the fluid is to be used in fields with long step-outs.

CLEO is fully compatible with Brayco Micronic SV3 (and SV/B) and can be used to replace such fluids in existing systems where a stronger focus on environmental discharge is required.

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	August 2012	D. Gleeson	R&D Manager
2	0	October 2012	D. Gleeson	R&D Manager
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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	CLEO	Test Method
Viscosity (cSt)		ASTM D445 IP71 ISO 3104
@ -20 °C	154	
@ 0 °C	37.0	
@ 20 °C	14.6	
@ 40 °C	8.5	
@ 60 °C	5.3	
@ 100 °C	2.3	
Pour Point	<-40 °C	IP15
Specific Gravity (gcm^{-3})		
20	0.914	IP365
Appearance	Transparent, colourless / pale yellow liquid	
Flash Point /°C	>200 °C	ASTM D92 / IP36
Upper Temperature Stability	250 °C	
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 0.600 mm	IP239/01 1 hour duration, 1475rpm rotation, 30 kgf load
Solubility in Water	Insoluble	
Solubility in Mineral / Crude Oil	Soluble	
Coefficient of Thermal Expansion	0.0008 m^3/m^3 °C	
Bulk Modulus N/m^2 ($x10^9$)	1.73 x 10^9 N/m^2	
Specific Heat Capacity		
0 – 25 °C	2.11 MJ/m^3K	
25 – 50 °C	2.18 MJ/m^3K	
Thermal Conductivity		
Mean Temperature 25 °C	0.141 W/(m.K)	ISO 9301

Shell 4 ball, thermal properties, coefficient of thermal expansion and bulk modulus testing were all conducted by independent laboratories.

Note these properties are typical for the product but do not constitute a specification

2.1 PHYSICAL PROPERTIES AS A FUNCTION OF PRESSURE @ 4 °C

Pressure (bara)	Relative Volume	Density (g cm^{-3})	Instantaneous Compressibility ($bar^{-1} \times 10^{-6}$)	Bulk Modulus ($N\ m^{-2} \times 10^{9}$)	Dynamic Viscosity (cP)
1.1	1.0000	0.9254	120.1	0.83	35.70
35.5	0.9959	0.9292	71.7	1.39	36.34
70.0	0.9934	0.9315	62.8	1.59	37.59
138.9	0.9891	0.9356	55.1	1.81	41.29
276.8	0.9817	0.9427	52.5	1.91	52.18
414.7	0.9746	0.9495	51.8	1.93	66.71
552.6	0.9677	0.9563	51.5	1.94	84.26
690.5	0.9609	0.9631	50.9	1.96	104.5

3.0 PRODUCT TESTING

3.1 THERMAL STABILITY

CLEO has undergone extensive accelerated aging testing based on the procedures laid out in API 17F and is considered fit for service at temperatures as high as 250 °C as shown in the 6 months aging data below.

Aging Temp /°C	Aging Time	Appearance (relative to unused fluid)	Qualitative description of separation in fluid	Weight of solids recovered (mg/L of fluid)	Specific Gravity @ 20 °C	Lubricity (IP239 Shell 4 ball, 1 h wear test, 30 kg load, 1460 rpm) Mean Wear Scar Diameter	Viscosity @ 40 °C / cSt
None	None	Clear and bright colourless / pale yellow fluid	None	n/a	0.916	0.600 mm	8.4
250	Six months	Clear and bright yellow fluid	None	n/a	0.912	0.627 mm	8.6

Low temperature stability studies have also been undertaken, with CLEO remaining visually unchanged after aging at -25 °C for 6 months.

3.2 COMPATIBILITY WITH BRAYCO MICRONIC SV/3 AND SV/B

Extensive compatibility studies have been undertaken with Brayco Micronic SV/3 and SV/B in accordance with the API 17F specification including: -

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

In all cases, no changes in the mixtures of CLEO and Brayco Micronic SV/3 or SV/B have been observed, with the fluids remaining clear and bright and fully compatible after 1 month. All viscosities remained within 5% of the original values after the aging period in compliance with the API 17F Specification.

3.3 COMPATIBILITY WITH CONTROL, COMPLETION AND OPERATIONAL FLUIDS

Extensive compatibility studies have been undertaken with a range of commonly used control, completion and operational fluids. Testing was undertaken either in accordance with API 17F or using a procedure with similar aging times, mixture ratios, and temperatures. Fluids tested for compatibility include:

- Pelagic 100, Pelagic 100 HC, Oceanic HW443, Transaqua HT-2 and Transaqua HC10.
- Calcium chloride and bromide brines, zinc chloride and bromide brines, potassium and caesium formate, Hycal II, Hycal III brines.
- Brayco Micronic SV/B, Brayco Micronic SV/3, OB200, HDEO, HDEO^{EP}, USF 04.
- 35% Hydrochloric Acid, Methanol, Monoethylene Glycol, Silicon Oil.
- Diesel Fuel, MEGA 600 Lubricant, Greasil 4000, Ambergrease SIL, Molykote G Rapid Plus
- Mobil EAL Envirosyn 32H, Panolin Atlantis 32, Shell Cornea Oil, Shell Tellus S2V 32

Please refer to the main technical manual for detailed compatibility results for each fluid.

3.4 METAL COMPATIBILITY

CLEO has been shown to be compatible with a wide range of metals in testing based on API 17F as tabulated below. Selected materials have been tested at 70, 150 or 250 °C.

Metals compatibility after 12 weeks immersed in CLEO and CLEO with 10% Sea Water at 70 °C

9Cr1Mo Alloy 18 - 22 C	Becol (UNS C17200)	Monel 400
17-4-PH (UNS S17400)	Brass CZ101 (UNS C22000)	Monel K500
A182 F22 (UNS K21590)	Brass CZ102 (UNS C23000)	MP35N
ASTM A182 F51 Super Duplex (UNS S31803)	Brass CZ106 (UNS C26000)	Nitronic 50
ASTM A182 F53 Super Duplex (UNS S32750)	Brass CZ108 (UNS C27200)	Phosphor Bronze PB102
A182 F55 UNS S32760 (Super Duplex)	Brass CZ120 (UNS C37700)	SIS 2387
ALCNC10	Brass (UNS C46400)	Silicon Nitride
AISI A29 4340	BS 735 A50 (Spring Steel)	Stainless Steel 304
AISI A29 4340 (Gas Nitrided)	Carbon Steel UNS K02401	Stainless Steel 316
AISI A350 LF2 Carbon Steel	Chrome Core	Stainless Steel 316 Ti
AISI 410	Copper	Stainless Steel 416
AISI 420	CuAl10Ni	Stainless Steel 431
AISI 440C	DGS1043	Super Duplex (OEM)
AISI 1040	Duplex 9490	Super Duplex AM8831
AISI 4130	Elgiloy	Titanium
AISI 4140	Inconel 625	Toughmet 3 AT110 (UNS C72900)
AISI 6150	Inconel 718	Tungsten Carbide (6% Nickel Bonded)
Alloy 3	Inconel 725 GV50H	Tungsten Carbide (10% Nickel Bonded)
Alloy 450	Inconel 825	Tungum (UNS C699100)
Aluminium Bronze AISI B418	Inconel 925	Umbilical TP19D
Aluminium Bronze HM9843	KR16	Zirconia
Aluminium Bronze (UNS C63000)	Kvaerner Umbilical	

Coatings Compatibility after 12 weeks immersed in CLEO at 70 °C

36CrNiMo4 (OEM)	Inconel 725 Silver Coated	Xylan 1014
Electroless Nickel Plated	Molycoat D-7409 (CWST)	Xylan 1052
Everslik 1201 (OEM Specification)	Niklad ELV811 Coated A182 F22	Xylan 1212
Everslik 1201 (CWST)	Rislan	Xylan 1213
Everslik 1201/1301 (CWST)	Sermagard 1105 (CWST)	Xylan 1400
Everslik 1301 (CWST)	Sermagard 1105 + 1280 (OEM Specification)	Xylan 1424
Inconel 718 Gold Coated	Sermagard 1105 + Everslik 1201 (CWST)	Xylan 1425
Inconel 718 Silver Coated	Sermagard 1105 + Everslik 1201 + Xylan 1400 (CWST)	Zinc Phosphate Coated Mild Steel
		Zinc Coated Washer

Metals compatibility after 12 weeks immersed in CLEO at 150 °C

9Cr1Mo Alloy 18 - 22 C	Brass CZ101 (UNS C22000)	Monel 400
17-4-PH (UNS S17400)	Brass CZ102 (UNS C23000)	Monel K500
A182 F22 (UNS K21590)	Brass CZ106 (UNS C26000)	MP35N
ASTM A182 F51 Super Duplex (UNS S31803)	Brass CZ108 (UNS C27200)	Nitronic 50
ASTM A182 F53 Super Duplex (UNS S32750)	Brass CZ120 (UNS C37700)	Phosphor Bronze PB102
A182 F55 UNS S32760 (Super Duplex)	Brass (UNS C46400)	SIS 2387
ALCNC10	BS 735 A50 (Spring Steel)	Silicon Nitride
AISI A29 4340	Carbon Steel UNS K02401	Stainless Steel 304
AISI A29 4340 (Gas Nitrided)	Chrome Core	Stainless Steel 316
AISI A350 LF2 Carbon Steel	Copper	Stainless Steel 316 Ti
AISI 410	CuAl10Ni	Stainless Steel 416
AISI 420	DGS1043	Stainless Steel 431
AISI 440C	Duplex 9490	Super Duplex (OEM)
AISI 1040	Elgiloy	Super Duplex AM8831
AISI 4130	Inconel 625	Titanium
AISI 4140	Inconel 718	Toughmet 3 AT110 (UNS C72900)
AISI 6150	Inconel 725 GV50H	Tungsten Carbide (6% Nickel Bonded)
Alloy 450	Inconel 825	Tungsten Carbide (10% Nickel Bonded)
Aluminium Bronze AISI B418	Inconel 925	Tungum (UNS C699100)
Aluminium Bronze HM9843	KR16	Umbilical TP19D
Aluminium Bronze (UNS C63000)	Kvaerner Umbilical	Zirconia

*The results for metals tested at temperatures 150 °C are included to show that these metals have been tested and pass the test when tested as these temperatures. The 3 months aging test at 150 °C **does not** qualify these materials for service at these temperatures and we recommend that further testing is undertaking before approving these materials for service at these elevated temperatures.*

Coatings Compatibility after 12 weeks immersed in CLEO at 150 °C

36CrNiMo4 (OEM)	Inconel 718 Silver Coated	Xylan 1052
Electroless Nickel Plated	Inconel 725 Silver Coated	Xylan 1212
Everslik 1201 (OEM Specification)	Molycoat D-7409 (CWST)	Xylan 1213
Everslik 1201 (CWST)	Niklad ELV811 Coated A182 F22	Xylan 1424
Everslik 1201/1301 (CWST)	Sermagard 1105 (CWST)	Zinc Phosphate Coated Mild Steel
Everslik 1301 (CWST)	Sermagard 1105 + Everslik 1201 (CWST)	Zinc Coated Washer
Inconel 718 Gold Coated		

*The results for coatings tested at temperatures 150 °C are included to show that these coatings have been tested and pass the test when tested as these temperatures. The 3 months aging test at 150 °C **does not** qualify these materials for service at these temperatures and we recommend that further testing is undertaking before approving these materials for service at these elevated temperatures.*

Metal compatibility after 6 months immersed in CLEO at 250 °C

17-4-PH (UNS S17400)	Inconel 625 (UNS N06625)	Nitronic 50 (UNS S20910)
ASTM A182 F51 Super Duplex (UNS S31803)	Inconel 718 (UNS N07718)	Stainless Steel 304 (UNS S30400)
ASTM A182 F53 Super Duplex (UNS S32750)	Inconel 725 GV 50H (UNS N07725)	Stainless Steel 316 (UNS S31600)
ASTM A182 F55 Super Duplex (UNS S32760)	Inconel 825 (UNS N08825)	Stainless Steel 316Ti (UNS S31635)
Aluminium Bronze (UNS C63000)	Monel 400 (UNS N04400)	Toughmet 3 AT110 (UNS C72900)
Becol (UNS C17200)	Monel K500 (UNS N05500)	
DGS 1043 (UNS C63200)	MP35N (UNS R30035)	

*The results for metals tested at temperatures 250 °C are included to show that these materials have been tested and pass the test when tested as these temperatures. The 3 months aging test at 250 °C **does not** qualify these materials for service at these temperatures and we recommend that further testing is undertaking before approving these materials for service at these elevated temperatures.*

3.5 ELASTOMER COMPATIBILITY

CLEO has been shown to be compatible with a range of elastomers in testing based on the API 17F specification with the results after aging at 70 °C for 3 months as tabulated below.

CLEO has 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 CLEO

AC 155 (Accuseal)	HNBR 453702 90 Shore A (Freudenberg)	Orkot TXMM (Trelleborg)
AC 157 (Accuseal)	HNBR H9T40 90 Shore A (Trelleborg)	PEEK 450G (Victrex)
AC 173 (Accuseal)	HNBR N4007 90 Shore A (Parker)	PEEK 450CA30 (30% Carbon Filled) (Victrex)
Acetal (OEM)	HNBR 8097 (Pimseal)	PEEK 1000 (OEM)
Acylic (Direct Plastics)	HNBR KB163 90 Shore A (Parker)	PEEK W4685 (Parker)
Aflas (Clywd)	Hytrel 5556 Shore 55D (Dupont)	PEEK W4738 (Parker)
Arlon 1555 (Greene Tweed)	Hytrel 6356 Shore 63D (Dupont)	Polyamide Imide AMS 3670-1 (OEM)
BAM E014 FKM2	Lexan Margard (Sabic)	Polyamide Imide AMS 3670-4 (OEM)
Carbon Fibre (Carbon Fibre Seal Company)	LNP-PDX 82429 Carbon Filled PTFE (OEM)	Polypropylene (Direct Plastics)
Chemraz 510 (Green Tweed)	NBR K09G 90 Shore A (Pimseal)	Polyurethane (OEM)
Chemraz 600 (Green Tweed)	NBR N107-90 (Parker)	POM (polyoxymethylene) (OEM)
Ducoflex Hose Grade 350-13-33-06T (Duco)	NBR N300-90 (Parker)	PTFE (OEM)
Ecoflon 4 25% Carbon Filled PTFE (Economos)	NBR431 (Otto Gherkins)	PTFE (25% Carbon Filled) (OEM)
Elastolion 101 HNBR (James Walker)	NBR N552-90 90 Shore A (Parker)	PTKC (OEM)
Elastolion 280LF HNBR (James Walker)	NBR N674-70 70 Shore A (Parker)	PVDF (OEM)
Epichlorohydrin Bladder (OEM)	NBR N702-90 (Parker)	Turcite B Slydway (Trelleborg)
FFKM PFR06HC 90 Shore A (Solvay)	NBR N756-75 (Parker)	Turcon M12 (Trelleborg)
FFKM PKR95HT 90 Shore A (Solvay)	NBR N1059-90 (Parker)	Turcon T05 (Trelleborg)
FKM FR20-90 (James Walker)	NBR N1444-90 (Parker)	Turcon T12 (Trelleborg)
FKM FR58-90 James Walker	NBR N4263 (Parker)	Turcon T19 (Trelleborg)
FKM Mix 80 (FCH)	NBR N4274 Polypak (Parker)	Turcon T29 Step Seal (Trelleborg)
FKM 70.16-14 (Angst and Pfister)	NBR N7003 70 Shore A (Trelleborg)	Turcon T40 (Trelleborg)
FKM NT 80.7-70 (Angst and Pfister)	NBR N7022 70 Shore A (Trelleborg)	Turcon T42 (Trelleborg)
FKM FOR 9381 92 Shore A (Solvay)	NBR N7023 70 Shore A (Trelleborg)	Turcon T46 (Trelleborg)
FKM P757 92 Shore A (Solvay)	NBR N7083 70 Shore A (Trelleborg)	Turcon T51 (Trelleborg)
FKM P959 93 Shore A (Solvay)	NBR 8010 (Pimseal)	Ultra High Molecular Weight Polyethylene (UHMWPE)
FKM PL855 91 Shore A (Solvay)	NBR 8095 (Pimseal)	Viton 70 (OEM)
FKM VBR X856 90 Shore A (Clwyd)	NBR 8100 (Pimseal)	Viton 90 (OEM)
FKM V70GA 70 Shore A (Trelleborg)	NBR N9002 90 Shore A (Trelleborg)	Viton 8006 (Pimseal
FKM V75J Shore 75 A (Precision Polymer Engineering)	NBR PB80 80 Shore A (James Walker)	Viton 8096 (Pimseal)
FKM VPL85540 92 Shore A (Solvay)	NBR 70 (Ramsey Services)	Viton 8101 (Pimseal)
FKM VPL 85730 91 Shore A (Solvay)	NBR70 K6 (GAPI Compounds)	Viton A 9009-75 (OEM)
FKM PL958 91 Shore A (Solvay)	NBR 70 (Eriks Seals)	Viton Extreme 90 Shore A (Clwyd)
FKM V1238-95 95 Shore A (Parker)	NBR Solesele Type G (James Walker)	Viton HTV90-A2 90 Shore A (Dupont)
Fluoroloy Q9 (Saint Gobain Seals)	NBR Univoil 80 (James Walker)	Viton V747-75 (Parker)
Flourel (Parker)	Nylon 6 (Skiffy)	Viton V858-95 (Parker)
Hallite 53	Nylon 6,6 (Direct Plastics)	Viton VG109-90 (Parker)
Hallite T506	Nylon TLO (OEM)	Viton V9T40 (Trelleborg)
HNBR 2269-90 (Parco)	Nylon XLPE (OEM)	Zurcon Z25 (Trelleborg)
HNBR 4007 90 Shore A (Parker)	Orkot TXM C338 (Trelleborg)	Zurcon Z43 (Trelleborg)
HNBR 8026 (Pimseal)	Orkot C380 (Trelleborg)	Zurcon Z52 (Trelleborg)
HNBR KB163 90 Shore A (Parker)	Orkot TLM (Trelleborg)	Zurcon Z80 (Trelleborg)

Please note that while testing based on API 17F (Annex C) is considered one of the most robust standard elastomer testing regimes available, this does not qualify elastomers for use at 70 °C and is instead an accelerated screen test to provide compatibility information at typical storage and operational temperatures. To be more specific, in line with the Arrhenius rate equation, testing for 3 months at 70 °C provides an accelerated compatibility profile covering up to 2 years at 40°C during storage, and 20+ years at seabed temperatures. If materials are to be used at temperatures above 40°C for periods in excess of 2 years, then further testing at elevated temperatures would be recommended to confirm compatibility.

Elastomer compatibility at 150 °C for CLEO

Chemraz 510 (Green Tweed)	Nylon 6,6 (Direct Plastics)	Turcon T05 (Trelleborg)
Chemraz 600 (Green Tweed)	PEEK 450G (Victrex)	Turcon T12 (Trelleborg)
Ecoflon 4 25% Carbon Filled PTFE (Economos)	PEEK 450CA30 (30% Carbon Filled) (Victrex)	Turcon T19 (Trelleborg)
		Turcon T29 Step Seal (Trelleborg)
FFKM PFR06HC 90 Shore A (Solvay)	PEEK 1000 (OEM)	Turcon T40 (Trelleborg)
FFKM PKR95HT 90 Shore A (Solvay)	PEEK W4685 (Parker)	Turcon T42 (Trelleborg)
FKM P959 93 Shore A (Solvay)	PEEK W4738 (Parker)	Turcon T46 (Trelleborg)
FKM VPL85540 92 Shore A (Solvay)	PTFE (OEM)	Turcon T51 (Trelleborg)
FKM VPL 85730 91 Shore A (Solvay)	PTFE (25% Carbon Filled) (OEM)	Viton Extreme 90 Shore A (Clwyd)
FKM PL958 91 Shore A (Solvay)	Turcon M12 (Trelleborg)	Zurcon Z43 (Trelleborg)

Further compatibilities of selected elastomers have also been undertaken at 250 °C and are tabulated below, with PTFE and PEEK both meeting the requirements of API 17F after aging for 3 months at 250 °C.

The results for elastomers tested at temperatures ≥ 150 °C and 250 °C are included to show that these elastomers have been tested and pass the test when tested as these temperatures. The 3 months aging test at ≥ 150 °C and 250 °C ***does not*** *qualify these materials for service at these temperatures and we recommend that further testing is undertaking before approving these materials for service at these elevated temperatures.*

3.6 FLUID LUBRICITY AND WEAR

3.6.1 Shell 4 Ball Test

Lubricity testing using the Shell 4 ball method as described in the API 17F specification have been undertaken by an independent testing laboratory and are outlined below.

3.6.1.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 CLEO demonstrating 50% 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
CLEO	0.72	0.48	0.70	0.48	0.72	0.50	0.600	Wear scars asymmetric

3.6.1.b 4 Ball Weld Point Load

The results obtained for the one-hour wear tests at 30 kg load at 1475 (+/-25) rpm are shown below with the mean wear scar diameters measured for CLEO demonstrating 50% less wear than the acceptance criteria of 1.2 mm as specified in API 17F.

Lubricant	Initial Test Load (kg)	Initial Seizure Load* (kg)	Weld Point Load (kg)	Duration of Load steps (sec)	RPM	Comments
CLEO	10	80	>120	10	1470	Wear scars asymmetric

* measured from friction traces

The initial test load showed that CLEO passes the API 17F specification requiring a weld load of >120 kg.

3.7 FILTERABILITY

300 ml (18.3 in^3) of control fluid is filtered under specified conditions through a 0.8 µm filter membrane at a controlled pressure drop of 0.05 MPa (7.25 psi). Filterability is calculated from the ratio of filtration near the start of filtration, to the filtration rate at specified higher filtered volume.

The results for CLEO are tabulated below and show that both the dry and wet oil exceed the requirements required in API 17F. Indeed, both the wet and dry oil give filterability results > 80%.

Fluid	Test 1	Test 2	Test 3	Average Filterability	API 17F
CLEO (dry)	90.5%	89.2%	86.3%	88.7%	Pass
CLEO (wet) +0.5% Sea Water	89.0%	84.2%	85.8%	86.3%	Pass

3.8 SEA WATER CONTAMINATION

Extensive compatibilities of CLEO with 5 and 10% sea water in accordance with API 17F have been undertaken across a range of temperatures and the results after 4 weeks shows only a slight haze in the oil phase upon cooling from 70 °C as would be expected for a fully saturated oil.

3.9 DEWATERING CAPABILITY OF SYNTHETIC FLUID

The purpose of this section is to verify that the moisture absorption process is reversible.

Water content (ppmw) and % saturation is measured by suitable methods; the testing was carried out using a Pall HPN021 oil drying unit, with a fluid flow rate of 21 L min-1 and a typical vacuum of 0.7 Bar. The moisture level equivalent to 80% saturation of CLEO was determined as 2500 ppm water, with 30% saturation equivalent to 200 ppm water. The fluid was run through the drying equipment at 20 °C (±5 °C), and samples taken periodically for % saturation, using the moisture sensor and water content (ppmw). Testing was undertaken in triplicate with all three runs showing that CLEO comfortably meets the acceptance criteria laid out in API 17F as the water content is reduced from >80% saturation to <30% saturation within the 35 cycle limit.

3.10 BACTERIAL CONTAMINATION

Bacterial and Fungal resistance was tested by mixing CLEO 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: -

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

Both sets of tests showed no evidence of bacterial or fungal growth after 12 months aging.