



**ENVIROSOL
USFO4**
OIL BASED UMBILICAL STORAGE FLUID

TECHNICAL SUMMARY MANUAL

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1.0 REPORT OVERVIEW

USF 04 is a low viscosity environmental oil based umbilical storage fluid offering maximum mixed fluid stability towards wellbore chemicals in aggressive HPHT (and less demanding) environments.

USF 04 can offer significant savings during umbilical commissioning due to its superior compatibility with SURF (Subsea, Umbilical, Riser, Flowline) chemicals and allows Operators increased flexibility to perform SURF chemical commissioning while off the critical path to first oil / gas.

USF 04 can also negate the need for Topside or Subsea intervention for the interface requirements to First Oil or for Future Extensions.

The high level of compatibility combined with outstanding stability, excellent health and safety properties and impressive environmental credentials makes USF 04 a compelling choice as a storage fluid across both thermoplastic and steel tube umbilicals.

USF 04 has undergone chemical compatibility testing far beyond any previous industry standards for USF's, including a wide range of temperatures and mix ratios and extended service related testing. Testing includes blockage flow tests and HPHT testing of mixtures to ensure stability in extreme situations and minimisation of potential issues in service.

USF 04 customers gain access to an extensive compatibility database which can offer further project cost savings by accessing data on chemical previously tested.

USF 04 is designed to have the lowest viscosity profile possible for an 'oil based' product as shown in the physical properties summary.

USF 04 is OCNS Class E with no substitution warnings in the UK and Yellow in Norway.

This data provides a broad technical review on the Technical Performance of USF 04 and will also demonstrate our commitment to producing superior products that offer a real technical and environmental advance for this market sector.

If you require more detailed results on any other aspect of product performance, please contact our technical team.

DOCUMENT REVISION HISTORY

Issue	Revision	Issue Date	Authorised by	Position
1	0	January 2017	D. Gleeson	R&D Manager
2	0	February 2018	D. Gleeson	R&D Manager
3	0	February 2019	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.

Information given in this publication is based on Technical Data gained in our own and other laboratories and is believed to be true. However, if the material is used in conditions beyond our control, we can assume no liability for results obtained or damaged incurred through the application of the data present herein.

Certified ISO 9001-2015
For the Development, Manufacture and Supply of Speciality Chemicals



Certificate No 2906- QMS-001



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2.0 PHYSICAL PROPERTIES

2.1 PHYSICAL PROPERTIES SUMMARY

Property	USF 04	Test Method
Kinematic Viscosity (cSt)		ASTM D445 IP71 ISO 3104
@ -20 °C	36.9	
@ 20 °C	6.5	
@ 40 °C	4.1	
@ 80 °C	1.8	
Pour Point	<-40 °C	IP15
Specific Gravity (g cm⁻³)		IP365
-20 °C	0.844	
20 °C	0.820	
40 °C	0.810	
80 °C	0.792	
Appearance	Transparent, colourless / pale yellow liquid	
Upper Temperature Stability	200 °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 0.870 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 m³/m³ °C	0.0007	
Mean Bulk Modulus	1.81x 10 ⁹ Nm ⁻² (35.5 - 687 Bara)	
Mean Compressibility	56.7 x 10 ⁻⁶ bar ⁻¹	
Flashpoint	138 °C	ASTM D92
Specific Heat Capacity	0.763 MJ/m ³ K (0 – 25 °C)	
	1.419 MJ/m ³ K (25 – 50 °C)	
	1.234 MJ/m ³ K (50 – 75 °C)	
	0.960 MJ/m ³ K (75 – 100 °C)	
Thermal Conductivity	0.131 W/m ⁻¹ K ⁻¹ (Mean temp 0 °C)	ISO 9301
	0.132 W/m ⁻¹ K ⁻¹ (Mean temp 25 °C)	
	0.130 W/m ⁻¹ K ⁻¹ (Mean temp 70 °C)	
	0.128 W/m ⁻¹ K ⁻¹ (Mean temp 100 °C)	

Shell 4 Ball, COTE, flashpoint, specific heat capacity, thermal conductivity bulk modulus and compressibility testing were all conducted by independent laboratories.

Note the values reported here are typical values and do not constitute a specification.



2.2 PHYSICAL PROPERTIES AS A FUNCTION OF TEMPERATURE

Temperature / °C	Kinematic Viscosity / cSt	Dynamic Viscosity / cP	Density / g cm ⁻³
-20	37.40	31.42	0.840
-15	27.70	23.20	0.838
-10	20.80	17.37	0.835
-5	16.60	13.82	0.832
0	13.40	11.12	0.830
5	10.50	8.69	0.827
10	9.00	7.43	0.825
15	7.90	6.50	0.822
20	6.50	5.33	0.820
25	5.50	4.50	0.818
30	4.80	3.91	0.815
35	4.30	3.50	0.813
40	3.90	3.16	0.810
45	3.58	2.89	0.808
50	3.23	2.60	0.806
60	2.60	2.08	0.801
70	2.35	1.87	0.796
80	1.90	1.50	0.792

2.3 PHYSICAL PROPERTIES AS A FUNCTION OF PRESSURE AT 4 °C

Pressure / (bara)	Bulk Modulus x 10 ⁹ / N m ⁻²	Instantaneous Compressibility x 10 ⁶ / bar	Relative Volume	Dynamic Viscosity / cP	Density / g cm ⁻³
1.1	1.55	64.6	1.0000	8.69	0.827
35.5	1.69	59.3	0.9978	8.80	0.829
70.0	1.72	58.3	0.9957	9.22	0.831
138.9	1.75	57.2	0.9918	10.34	0.834
276.8	1.78	56.1	0.9840	13.35	0.840
414.7	1.80	55.6	0.9764	17.08	0.847
552.6	1.81	55.3	0.9690	21.37	0.853
687.0	1.81	55.2	0.9619	26.14	0.860

3.0 PRODUCT TESTING.

3.1 LOW TEMPERATURE STABILITY

USF04 has undergone stability testing at low temperatures based on the procedures laid out in API 17F and is considered suitable for use as low as -40 °C as shown in the 3 months' data below.

Aging Temperature	Aging Time	Appearance (relative to unused fluid - at test temperature)	Appearance (relative to unused fluid - warmed too ambient)
Initial Sample	None	Clear and bright, colourless / pale yellow liquid	Clear and bright, colourless / pale yellow liquid
+5 °C	3 months	Clear and bright, colourless / pale yellow liquid	Clear and bright, colourless / pale yellow liquid
-25 °C	3 months	Clear and bright, colourless / pale yellow liquid	Clear and bright, colourless / pale yellow liquid
-40 °C	3 months	Clear and bright, colourless / pale yellow liquid	Clear and bright, colourless / pale yellow liquid

3.2 SURF CHEMICAL COMPATIBILITY

USF 04 has been tested for compatibility with a range of SURF (Subsea, Umbilical, Riser, Flowline) chemicals at 5, 20 and 70 °C in mixing ratios of 90:10; 75:25; 50:50; 25:75; and 10:90 for 4 weeks.

Extended compatibilities including comparative flow testing through a small orifice (<1 mm) before and after aging at 120 °C for mixing ratios of 90:10; 50:50; and 10:90 for 4 weeks have been undertaken to ensure stability in extreme situations and minimisation of potential issues in service.

Selected fluid mixtures (50:50%v/v) have undergone compatibilities including comparative flow testing through a small orifice (<1 mm) before and after aging at 150 °C and 1037 Bar for 4 weeks.



3.3 SURF CHEMICAL COMPATIBILITY SUMMARY TABLE.

SURF Chemical	Compatibility Testing Completed				
	5 °C 1 bar	20 °C 1 bar	70 °C 1 bar	120 °C 1 bar	150 °C 1037 Bar
Brines					
Synthetic Sea Water	✓	✓	✓	✓	✓
Caesium Formate Brine	✓	✓	✓	✓	
Potassium Formate Brine	✓	✓	✓	✓	✓
Sodium Formate Brine	✓	✓	✓	✓	
Sodium Bromide Brine	✓	✓	✓	✓	
Sodium Chloride Brine	✓	✓	✓	✓	
Potassium Chloride Brine	✓	✓	✓	✓	
Calcium Bromide Brine	✓	✓	✓	✓	
Calcium Chloride Brine	✓	✓	✓	✓	
Zinc Bromide Brine	✓	✓	✓	✓	
Calcium Bromide / Calcium Chloride brine	✓	✓	✓	✓	✓
Zinc Bromide / Calcium Bromide brine	✓	✓	✓	✓	
Zinc & Calcium Bromide, Calcium Chloride Brine	✓	✓	✓	✓	
Solvent / Base Chemicals					
Methanol	✓	✓	✓	✓	✓
Ethanol	✓	✓	✓	✓	
1-propanol	✓	✓	✓	✓	
Isopropanol	✓	✓	✓	✓	
50/50% w/w MEG/Water	✓	✓	✓	✓	✓
Monoethylene Glycol	✓	✓	✓	✓	✓
DiEthylene Glycol (DEG)	✓	✓	✓	✓	
Triethylene Glycol	✓	✓	✓	✓	
Tetraethylene Glycol	✓	✓	✓	✓	
Butyl DiGlycol (BDG)	✓	✓	✓	✓	
Diesel	✓	✓	✓	✓	✓
Kerosene	✓	✓	✓	✓	
Toluene	✓	✓	✓	✓	
Xylenes	✓	✓	✓	✓	✓
Hydraulic Fluid					
Brayco Micronic SV/3	✓	✓	✓	✓	
CLEO	✓	✓	✓	✓	
HDEO ^{EP}	✓	✓	✓	✓	
Castrol Transaqua HT2	✓	✓	✓	✓	
Oceanic HW443R	✓	✓	✓	✓	
Oceanic HW540	✓	✓	✓	✓	
Oceanic HW540E	✓	✓	✓	✓	
Oceanic HW740R	✓	✓	✓	✓	
Pelagic 100	✓	✓	✓	✓	
Other Chemicals					
N-Methyl Pyrrolidinone	✓	✓	✓	✓	✓
Glutaldehyde Solution (25% in water)	✓	✓	✓	✓	
Wacker AP200 Silicone Oil	✓	✓	✓	✓	
4-dodecylbenzene sulphonic acid	✓	✓	✓	✓	
Acetic Acid	✓	✓	✓	✓	
Formic Acid	✓	✓	✓	✓	
Tetrakis hydroxy methyl phosphonium sulfate	✓	✓	✓	✓	
Limonene	✓	✓	✓	✓	
Inhibex 501	✓	✓	✓	✓	



3.4 UMBILICAL COMPATIBILITY.

3.4.1 Thermoplastic Umbilical Compatibility

USF04 has undergone independent testing at SFS (Subsea Fluid Services) to confirm compatibility with Nylon 11 and PermaLiner Hoses manufactured by Oceaneering when tested in accordance with ISO 13628-5 (2009) specifically: -

- Nylon 11 was tested to 5000psi in cyclic pressure tests at 40 °C for 30 days.
- Oceaneering PermaLiner hose was tested to 5000psi in cyclic pressure tests at 40 °C for 30 days.

No failures occurred in any of the samples during the cyclic pressure tests, and the hoses were then further evaluated by Oceaneering including a burst test and were confirmed as fully compatible under normal operational conditions. A compatibility statement is available on request.

USF04 has been shown to be compatible with a several grades of Umbilical liner materials in testing based on the API 17F specification with the results after aging at 70 °C for 3 months namely

Hytrell 4056	Hytrell 6356	Hytrell 7246	Nylon TLO	Nylon XLPE
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3.4.2 Steel Line Umbilical Compatibility

USF04 has been shown to be compatible with a several grades of Steel Line Umbilical materials in testing based on the API 17F specification with the results after aging at 70 °C for 3 months namely

TP19D (UNS S320001)	SAF 25047 (UNS S32750)	Cast Spool (ASTM 607)	Super Duplex (UNS S32760)
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3.5 METAL COMPATIBILITY

USF04 has been shown to be compatible with a wide range of metals in testing based on API 17F.

Metals compatibility after 12 weeks immersed in USF04 at 70 °C

6% Ni Bonded Tungsten Carbide	A182 F53 (UNS 32750 Super Duplex)	Mild Steel
9Cr1Mo Alloy 18-22C	A182 F55 (UNS S32760 Super Duplex)	Monel Alloy 400
10% Ni Bonded Tungsten Carbide	Brass CZ101 (UNS C22000)	Monel Alloy K500
17 – 4 – PH	Brass CZ102 (UNS C23000)	MP35N
AICNC10	Brass CZ106 (UNS C26000)	Nitronic 50
AISI A29 4340	Brass CZ108 (UNS C27200)	Phosphor Bronze PB102
AISI A350 LF2	Brass CZ120 (UNS C37700)	Silicon Nitride
AISI 410	Brass (UNS C46400)	Stainless Steel 304
AISI 420	BS 735A50 (Spring Steel)	Stainless Steel 316
AISI 440C	Chrome Core	Stainless Steel 316 Ti
AISI 515-60 (UNS K02401)	Copper	Stainless Steel 416
AISI 1040	CuAl10Ni	Stainless Steel 431
AISI 4130	DGS1043	SIS 2387 (OEM)
AISI 4140	Duplex 9490	Super Duplex AM8831
AISI 6150	Elgiloy	Super Duplex UNS S32750
Alloy 450	Inconel 625	Super Duplex UNS S32760
Aluminium Bronze ASTM B418	Inconel 718	Titanium
Aluminium Bronze HM9843	Inconel 725 GV50H	Toughmet 3 AT110 (UNS C72900)
Aluminium Bronze (UNS C63000)	Inconel 825	Umbilical TP19D
A182 F22 (UNS K21590)	KR16	Tungum (UNS C69100)
A182 F51 (UNS S31803 Super Duplex)	Kvaerner Umbilical	Zirconia



Coatings Compatibility after 12 weeks immersed in USF04 at 70 °C

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

3.6 ELASTOMER COMPATIBILITY

USF04 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.

USF04 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 USF04

AC 103N (Accuseal)	HNBR 8026 (Pimseal)	PEEK 1000 (OEM)
AC 124 (Accuseal)	HNBR 8097 (Pimseal)	PEEK W4685 (Parker)
AC 155 (Accuseal)	HNBR KB163 90 Shore A (Parker)	PEEK W4738 (Parker)
AC 157 (Accuseal)	HNBR N4007 90 Shore A (Parker)	Polypropylene (Direct Plastics)
AC 173 (Accuseal)	Hytrel 4056 (Du Pont)	Polyurethane (OEM)
Acetal (OEM)	Hytrel 6356 (Du Pont)	POM (polyoxymethylene) (OEM)
Arlon 1555 (Greene Tweed)	Hytrel 7246 (Du Pont)	PTFE (OEM)
AWC 800 Thermoset Polyurethane (Chesterton Customseal)	NBR K09G 90 Shore A (Pimseal)	PTFE (25% Carbon Filled) (OEM)
	NBR N107-90 (Parker)	PVC (Direct Plastics)
BAM E014 FKM2	NBR N229-50 (Parker)	S12 P1 Bladder (EPE Italiana)
BAM-E015 HNBR	NBR N300-90 (Parker)	Turcon M12 (Trelleborg)
Carbon Fibre (Carbon Fibre Seal Company)	NBR N552-90 90 Shore A (Parker)	Turcon T05 (Trelleborg)
Chemraz 510 (Green Tweed)	NBR N702-90 (Parker)	Turcon T12 (Trelleborg)
Chemraz 600 (Green Tweed)	NBR N756-75 (Parker)	Turcon T19 (Trelleborg)
DPU BD57 Polyurethane (DMR Seals)	NBR N1059-90 (Parker)	Turcon T29 Step Seal (Trelleborg)
FFKM PFR06HC 90 Shore A (Solvay)	NBR N1173 (Parker)	Turcon T40 (Trelleborg)
FFKM PKR95HT 90 Shore A (Solvay)	NBR N4274 Polypak (Parker)	Turcon T42 (Trelleborg)
FKM 90 (NMC)	NBR N7022 70 Shore A (Trelleborg)	Turcon T46 (Trelleborg)
FKM FOR 7352 91 Shore A (Solvay)	NBR N7023 70 Shore A (Trelleborg)	Turcon T51 (Trelleborg)
FKM FOR 9381 92 Shore A (Solvay)	NBR 8021 (Pimseal)	Ultra High Molecular Weight Polyethylene (UHMWPE)
FKM P757 92 Shore A (Solvay)	NBR 8095 (Pimseal)	
FKM P959 93 Shore A (Solvay)	NBR 8100 (Pimseal)	
FKM PL855 91 Shore A (Solvay)	NBR N9002 90 Shore A (Trelleborg)	Viton 8006 (Pimseal)
FKM VBR X856 90 Shore A (Clwyd)	NBR PB80 80 Shore A (James Walker)	Viton 8096 (Pimseal)
FKM V70GA 70 Shore A (Trelleborg)	NBR70 K6 (GAPI Compounds)	Viton 8101 (Pimseal)
FKM VPL85540 92 Shore A (Solvay)	NBR 70 (NMC)	Viton Extreme 90 Shore A (Clwyd)
FKM VPL 85730 91 Shore A (Solvay)	Nylon TLO (OEM)	Viton FR20-70 (James Walker)
FKM PL958 91 Shore A (Solvay)	Nylon XLPE (OEM)	Viton V747-75 (Parker)
Fluoroloy Q9 (Saint Gobain Seals)	Orkot TXM C338 (Trelleborg)	Viton V858-95 (Parker)
Flourel (Parker)	Orkot C380 (Trelleborg)	Viton V9T20 (Trelleborg)
Geolast 703-45 Thermoplastic Vulcanizate (Exxon Mobil)	Orkot TLM (Trelleborg)	XNBR N4263 Polypak (Parker)
	Orkot TXMM (Trelleborg)	Zurcon Z25 (Trelleborg)
Hallite 53	PEEK 450G (Victrex)	Zurcon Z43 (Trelleborg)
Hallite T506	PEEK 450CA30 (30% Carbon Filled) (Victrex)	Zurcon Z52 (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.



4.0 SOME MATERIALS TO AVOID

Listed below are several materials that have the potential to be incompatible with non-aqueous hydraulic fluids in general.

- Ethylene Propylene Rubber (EPR / EPDM).
- Silicone
- Porous seal materials and gaskets (e.g. paper or cork).
- Impregnated paper type Filter Elements.
- Paint coatings - samples should be submitted for further test.

Please contact us if you require more specific information on any of these materials.

5.0 FLUID CLEANLINESS

USF 04 is filtered to below AS4059 Class 6 B-F (equivalent to NAS 1638 Class 6) during manufacture and great care is taken during filling to ensure minimum particulate contamination.

6.0 PACKAGING OPTIONS

USF 04 is available for purchase in the following pack sizes:

- 200 Litre L-Ring drums
- 1,000 Litre IBC containers (palletised)
- Various Bulk Supply Options.

