

## AEROSHELL HYDRAULIC FLUIDS

AeroShell Hydraulic Fluids are used in hydraulic applications on aircraft and consist of:-

- AeroShell Fluid 4
- AeroShell Fluid 41
- AeroShell Fluid 71
- AeroShell Fluid 31
- AeroShell Fluid 51
- AeroShell Fluid 61
- AeroShell Shock Strut Fluid (SSF)
- AeroShell Landing Gear Fluid (LGF)

AeroShell Fluids 4 and 41 are mineral hydraulic fluids; the latter has superior cleanliness characteristics and is the more widely used grade.

AeroShell Fluid 71 is a preservative mineral hydraulic fluid for use in hydraulic systems and components that are in storage as well as hydraulic system test rigs.

AeroShell Fluid 31 is a synthetic hydrocarbon fire resistant hydraulic fluid. This type of fluid is increasingly replacing mineral hydraulic fluids.

AeroShell Fluid 51 is a low temperature synthetic hydrocarbon fire resistant hydraulic fluid.

AeroShell Fluid 61 is a preservative synthetic hydrocarbon fire resistant hydraulic fluid.

AeroShell SSF and LGF are hydraulic fluids specifically for landing gear shock struts of some aircraft.

For some types of aircraft, proprietary non-inflammable fluids of non-petroleum origin (phosphate ester type) are required. Shell Companies can supply Skydrol 500B-4 and LD-4 phosphate ester fluids against a known demand.

## BACKGROUND

For many years, hydraulic systems have been utilised in military and commercial aircraft. They have provided power transfer which has been proven to be reliable, efficient and lightweight compared to mechanical or electrical power transfer services. Since the 1940s, MIL-H-5606 hydraulic fluid, a mineral oil-based fluid, has been one of the most widely used types of fluid. This hydraulic fluid has provided excellent operational properties over the temperature range of  $-54^{\circ}\text{C}$  to  $135^{\circ}\text{C}$  ( $-65^{\circ}\text{F}$  to  $275^{\circ}\text{F}$ ). A major deficiency of MIL-H-5606 fluids, which was recognised early in its use, was its high degree of flammability. The hazard generated by the flammability of the fluid was greatly increased by the high pressure required for hydraulic system operation,  $2.07 \times 10^7$  Pascals (3000 psi), and the vulnerability of hydraulic lines widely distributed throughout the aircraft.

Recognition of fire hazards associated with MIL-H-5606 (NATO Code H-515) fluids, resulted in the commercial aircraft industry developing hydraulic systems based on phosphate ester based hydraulic fluids. However, the phosphate ester based fluids were not adopted by the military at that time because they were not compatible with MIL-H-5606 fluids nor with many of the materials (e.g. elastomers) used in MIL-H-5606 hydraulic systems in the aircraft. There was a view that the use of two incompatible hydraulic fluids could cause supply/logistic problems and could result in significant problems if the two fluids were ever inadvertently intermixed as they were not compatible or miscible. The cost of converting a MIL-H-5606 based hydraulic system to a phosphate ester based system was believed to be prohibitive owing to the requirement to change the elastomeric seals as well as many of the other materials used within and also outside the hydraulic system with which the fluid may come into contact (e.g. wiring insulation, paint, etc.). The commercial aircraft industry has found a significant reduction in the number of hydraulic fluid fires since the adoption of phosphate ester hydraulic fluids, and now all big civil transport aircraft use this type of fluid in the main hydraulic system.

Although the military did not move to phosphate ester type fluids they did identify the need for a more fire resistant fluid as a direct replacement for MIL-H-5606. As a result a synthetic hydrocarbon-based fluid, MIL-H-83282 was developed. This fluid is completely compatible with MIL-H-5606 fluids and MIL-H-5606 hydraulic system materials. All physical properties of MIL-H-83282 (now MIL-PRF-83282) were equivalent to or superior to those of MIL-H-5606 (now MIL-PRF-5606) except for low temperature viscosity. In particular all fire resistant properties of MIL-PRF-83282 are superior to those of MIL-PRF-5606.

More recently MIL-PRF-87257 was introduced in order to address the concerns over the low temperature viscosity of MIL-PRF-83282.

## APPLICATIONS

Whenever an aircraft is certified, the hydraulic fluids are specified for each application point on the Type Certificate. The Type Certificate will specify, either by specification number or by specific brand names, those hydraulic fluids which are qualified to be used. The U.S. Federal Aviation Administration (FAA) regulations state that only hydraulic fluids qualified for specific applications can be used in certified aircraft. Therefore, it is the responsibility of the aircraft owner or designated representative to determine which hydraulic fluid(s) should be used.

## MAIN REQUIREMENTS

The main requirements for aircraft hydraulic fluids are:

- Low freezing point
- Minimum viscosity change with temperature
- Good corrosion and oxidation stability
- Good seal compatibility
- Shear stable
- Supercleanliness
- Fire resistant
- Good anti-foam properties
- Good low and/or high temperature stability

In addition most aviation hydraulic fluid specifications list other requirements which are either specific to the type of hydraulic fluid or to the intended application.

## TYPICAL PROPERTIES

In the following section typical properties are quoted for each hydraulic fluid; there may be deviations from the typical figures given but test figures will fall within the specification requirement.

## USEFUL OPERATING TEMPERATURE RANGE

The useful operating temperature ranges are quoted for guidance only and are based on the requirements as quoted in the relevant specification.

## COMPATIBILITY

Mineral hydraulic fluids (MIL-PRF-5606, MIL-PRF-6083) are completely compatible and miscible with synthetic hydrocarbon hydraulic fluids (MIL-PRF-83282, MIL-PRF-87257 and MIL-PRF-46170) and vice versa.

Mineral hydraulic fluids (MIL-PRF-5606 and MIL-PRF-6083) and synthetic hydrocarbon hydraulic fluids (MIL-PRF-83282, MIL-PRF-87257 and MIL-PRF-46170) are not compatible with phosphate ester hydraulic fluids and on no account should they be mixed.

## CHANGEOVER

Since mineral hydraulic fluids are compatible with synthetic hydrocarbon fluids changeover can be easily accomplished.

Two commonly used methods to convert existing MIL-H-5606 based hydraulic systems to MIL-PRF-83282 have been:

(1) draining the aircraft's hydraulic system or the hydraulic system reservoir of MIL-PRF-5606 and refilling with MIL-PRF-83282, thereafter servicing the aircraft's hydraulic system with MIL-PRF-83282 and

(2) merely topping off the reservoir with MIL-PRF-83282, as needed.

Both methods have been used with great success with no reported problems.

## COMPATIBILITY WITH MATERIALS

When using hydraulic fluids containing a synthetic oil the compatibility with sealing materials, plastics or paints has to be examined.

As a general rule Shell Companies do not make recommendations regarding compatibility since aviation applications are critical and the degree of compatibility depends on the operating conditions, performance requirements, and the exact composition of materials. In many cases the equipment manufacturers perform their own compatibility testing or have their elastomer supplier do it for them. Many elastomer suppliers do produce tables showing the compatibility of their products with a range of other materials. Therefore the information provided can only be considered as guidelines.

<b>Elastomer/ Plastic</b>	<b>Mineral Oil Based Hydraulic Fluids</b>	<b>Synthetic Hydro- carbon Based Hydraulic Fluids</b>
Fluorocarbon (Viton)	Very Good	Very Good
Acrylonitrile	Good	Good
Polyester	Good	Good
Silicone	Poor to Good	Poor to Good
Teflon	Very Good	Very Good
Nylon	Poor to Good	Poor to Good
Buna-S	Poor	Poor
Perbunan	Good	Good
Methacrylate	Good	Good
Neoprene	Fair to Good	Fair to Good
Natural Rubber	Poor to Fair	Poor to Fair
Polyethylene	Good	Good
Butyl Rubber	Very Poor to Poor	Very Poor to Poor
Poly Vinyl Chloride	Poor to Good	Poor to Good

Compatibility Rating:

Very Good – Good – Fair – Poor – Very Poor

### TYPES OF HYDRAULIC FLUIDS

<b>Mineral</b>	<b>Synthetic Hydrocarbon</b>	<b>Phosphate Ester</b>
AeroShell Fluid 4	AeroShell Fluid 31	Skydrol 500B4
AeroShell Fluid 41	AeroShell Fluid 51	Skydrol LD4
AeroShell Fluid 71	AeroShell Fluid 61	
AeroShell Fluid SSF		
AeroShell Fluid LGF		

### HYDRAULIC FLUID CLEANLINESS - SUPERCLEAN PROPERTIES

Hydraulic fluid users should be keen to ensure optimum performance of hydraulic equipment and extend equipment life. One way of achieving this is by reducing wear of hydraulic system components. There are many ways in which wear can occur but one of the most common is due to particulates in the hydraulic fluid.

The latest issues of MIL-PRF-5606, MIL-PRF-6083, MIL-PRF-46170, MIL-PRF-83282 and MIL-PRF-87257 require hydraulic fluids to be "Superclean". By superclean it is meant that there is a very tight control on particulates in the fluid. Over the years hydraulic systems and components have been reduced in size and operating pressures have increased with the result that particulates in the hydraulic fluid can cause system failures through blocking nozzles and pipes or through erosion (for example particulates hitting metal surface and eroding it away) and/or wear. Thus these specifications include very tight limits on particulates and typically for MIL-PRF-5606H, MIL-PRF-83282D and MIL-PRF-87257A the requirement is of the order:

<b>Particle Size</b>	<b>Microscopic Count</b>	<b>Automatic Count</b>
5 to 15 µm	2,500	10,000
16 to 25 µm	1,000	1,000
26 to 50 µm	250	150
51 to 100 µm	25	20
over 100 µm	10	5

MIL-PRF-5606H allows automatic method only

MIL-PRF-83282D allows both methods

MIL-PRF-87257A allows automatic method only

Shell manufacturing plants when manufacturing these fluids go to considerable effort to meet these stringent limits, this includes multistage filtration, pre-cleaning of containers immediately before filling and packaging the fluid in 'clean room' conditions.

However, it is pointless for Shell manufacturing plants to go to these extreme lengths if operators themselves do not handle the fluid correctly in order to ensure that the superclean properties are maintained and enhanced.

Thus it is recommended that operators take extreme care by:

- never opening containers to atmosphere
- using containers of correct size
- using a dispensing device which includes fine filtration
- ensuring hydraulic system is clean and free from metal particles, dust, dirt and other contaminants
- periodically connecting the aircraft hydraulic system to ground hydraulic trolley and circulating fluid through fine filtration.

The latest issues of specifications MIL-PRF-5606, MIL-PRF-6083, MIL-PRF-46170, MIL-PRF-83282 and MIL-PRF-87257 require approved grades to meet the above levels of particulate contamination. The ISO 4406, BS.5540, NAS 1638 or SAE 749 requirements for cleanliness are NOT required by these specifications and thus AeroShell grades approved to these specifications are not automatically tested against these other cleanliness requirements. However, it has been found that normally AeroShell Fluid 4 is typically between Classes 8 and 9 in NAS 1638, whilst AeroShell Fluid 41 is typically between Classes 4 and 5 in NAS 1638.

### AEROSHELL HYDRAULIC FLUIDS IN NON-AVIATION APPLICATIONS

AeroShell Hydraulic Fluids are widely used in non-aviation applications because of their superior performance, particularly at temperature extremes, when compared with standard industrial hydraulic fluids. Many non-aviation equipment manufacturers do permit use of AeroShell Hydraulic Fluids in their equipment and in many cases list the product in the appropriate manuals. Otherwise in selecting an AeroShell Hydraulic Fluid for a non-aviation application the properties of the hydraulic fluid must be examined. This will only give an approximate indication as to the expected performance in the specific application. However, such data must be regarded as guidance only. There is no laboratory test that can give a complete prediction of performance in actual use, and the final stage in any decision must involve performance tests in either the actual equipment or in the laboratory/test house under conditions expected in service.

## SUMMARY OF AEROSHELL HYDRAULIC FLUID SPECIFICATION APPROVALS

SPECIFICATION	AEROSHELL FLUID						
	4	31	41	51	61	71	SSF/LGF
	U.S. Production	European Production	U.S. Production	European Production			
MIL-PRF-5606A	Meets	Equivalent	-	-	-	-	-
MIL-PRF-5606H	-	-	Approved	Approved	-	-	-
MIL-PRF-6083F	-	-	-	-	-	Approved	-
MIL-PRF-46170C	-	-	-	-	Approved	-	-
MIL-PRF-83282D	-	-	Approved	-	-	-	-
MIL-PRF-87257A	-	-	-	-	Approved	-	-
DEF STAN 91-48 Grade Normal	Equivalent	Approved	-	-	-	-	-
DEF STAN 91-48 Grade Superclean	-	-	Equivalent	Approved	-	-	-
DEF STAN 80-142	-	-	-	-	-	Equivalent	-
H-515	-	-	Approved	Approved	-	-	-
H-520	-	Approved	-	-	-	-	-
H-537	-	-	Approved	-	-	-	-
H-538	-	-	-	-	Approved	-	-
H-544	-	-	-	-	-	Approved	-
C-635	-	-	-	-	-	Approved	-
BMS 3-32	-	-	-	-	-	-	Approved

# AEROSHELL FLUID 4

AeroShell Fluid 4 is a mineral hydraulic oil with very good low temperature characteristics and capable of operating over a wide temperature range. AeroShell Fluid 4 is composed of a mineral oil base stock and a complex additive package which results in a product with excellent low temperature flow and anti-wear properties, exceptional antifoam characteristics, and excellent oxidation stability.

AeroShell Fluid 4 is dyed red.

## APPLICATIONS

AeroShell Fluid 4 is intended for use as a hydraulic fluid in undercarriage retraction mechanisms, flap jacks and control mechanisms, brakes, shock absorbers, automatic pilots, oleo legs, tail wheels, servo units, etc. AeroShell Fluid 4 is also suitable for lubricating de-icing pumps and gearboxes.

AeroShell Fluid 4 should be used in systems with synthetic rubber components and must not be used in systems incorporating natural rubber. The latter systems require castor base fluids with which AeroShell Fluid 4 is not interchangeable. Refer to the General Notes at the front of this section for more information on compatibility.

AeroShell Fluid 4 is compatible with AeroShell Fluids 31, 41, 51, 61 and 71, although it is not recommended that AeroShell Fluid 4 is used in systems which require the use of a superclean fluid nor should it be mixed with superclean fluids for operational reasons.

Chlorinated solvents should not be used for cleaning hydraulic components which use AeroShell Fluid 4. The residual solvent contaminates the hydraulic fluid and may lead to corrosion.

## SPECIFICATIONS

<b>U.S.</b>	Meets MIL-H-5606A (Obsolete – see AeroShell Fluid 41)
<b>British</b>	Meets DTD.585 (Obsolete – see AeroShell Fluid 41) Approved DEF STAN 91-48 Grade Normal (European production only)
<b>French</b>	Approved DCSEA 415/A
<b>Russian</b>	Analogue to AMG-10
<b>NATO Code</b>	H-520 (European production only)
<b>Joint Service Designation</b>	OM-18 (European production only)

PROPERTIES	DEF STAN 91-48 Grade Normal	TYPICAL (European Production)
Oil type	Mineral	Mineral
Kinematic viscosity mm <sup>2</sup> /s @ 100°C @ 40°C @ -40°C @ -54°C	4.0 min 13 min 500 max 3000 max	5.30 14.1 491 2300
Flashpoint Pensky Martin Closed Cup °C	81 min	105
Pourpoint °C	-60 max	< -60
Total acid number mgKOH/g	0.2 max	0.01
Relative Density @ 15.6/15.6°C	–	0.87
Evaporation @ 100°C %m	20 max	10
Colour	Red	Red
Copper corrosion	2 max	Passes
Low temperature stability	Must pass	Passes
Shear stability	Must pass	Passes
Foaming characteristics	Must pass	Passes
Phosphorus content % m/m	0.035 to 0.050	Passes
Oxidation & corrosion stability 168 hrs @ 135°C – metal weight change – change in viscosity @ 40°C % – change in acid number mgKOH/g	Must pass –5 to +20 0.2 max	Passes +2.0 +0.1
Anti-wear properties, scar diam mm	1.5 max	0.95
Rubber swell 168 hrs @ 70°C vol change %	19 to 30	25

A viscosity/temperature curve is shown at the end of this section.

# AEROSHELL FLUID 31

AeroShell Fluid 31 is a synthetic hydrocarbon based aircraft hydraulic fluid with greatly improved fire resistance characteristics when compared with conventional petroleum products.

AeroShell Fluid 31 has a specially designed base stock which imparts a relatively high flash point, excellent low temperature properties and good oxidation and thermal stability. In addition, AeroShell Fluid 31 is formulated with high technology additives to provide oxidation and corrosion resistance, antiwear, and anti-foaming protection.

AeroShell Fluid 31 is superclean filtered to ensure optimum performance in particulate monitored systems.

AeroShell Fluid 31 is dyed red.

The useful operating temperature range is  $-40$  to  $+205^{\circ}\text{C}$ .

## APPLICATIONS

AeroShell Fluid 31 is recommended for use in aircraft, ordnance, and missile systems operating from  $-40^{\circ}\text{C}$  to  $+205^{\circ}\text{C}$ . This fluid should be considered for use in auto pilots, shock absorbers, brakes, flight control systems, hydraulic servo-controlled systems and other systems using synthetic elastomer seals.

An increasing number of aircraft manufacturers now recommend use of this type of fluid in aircraft hydraulic systems in preference to mineral hydraulic oils. This move has been prompted by need to use fluids with better fire resistant properties.

AeroShell Fluid 31 is also approved for use in the Honeywell (formerly Garrett) cooling turbine (cabin air compressors).

Increasingly this type of hydraulic fluid is being adopted for use in hydraulic systems of military aircraft in place of mineral hydraulic fluids.

AeroShell Fluid 31 is a synthetic hydrocarbon oil and should not be used in contact with incompatible seal materials. Refer to the General Notes at the front of this section for further information.

AeroShell Fluid 31 is compatible with AeroShell Fluids 4, 41, 51, 61 and 71 and can be used in systems designed to operate with MIL-PRF-5606, MIL-PRF-6083, MIL-PRF-87257 and MIL-PRF-46170 fluids.

Chlorinated solvents should not be used for cleaning hydraulic components which use AeroShell Fluid 31. The residual solvent contaminates the hydraulic fluid and may lead to corrosion.

## SPECIFICATIONS

<b>U.S.</b>	Approved MIL-PRF-83282D
<b>British</b>	(MIL-PRF-83282D)
<b>French</b>	Equivalent to DCSEA 437/A
<b>Russian</b>	-
<b>NATO Code</b>	H-537
<b>Joint Service Designation</b>	OX-19

PROPERTIES	MIL-PRF-83282D	TYPICAL
Oil type	Synthetic Hydrocarbon	Synthetic Hydrocarbon
Kinematic viscosity $\text{mm}^2/\text{s}$ @ $205^{\circ}\text{C}$ @ $100^{\circ}\text{C}$ @ $40^{\circ}\text{C}$ @ $-40^{\circ}\text{C}$	1.0 min 3.45 min 14.0 min 2200 max	1.07 3.53 14.33 2098
Flashpoint Cleveland Open Cup $^{\circ}\text{C}$	205 min	237
Fire Point $^{\circ}\text{C}$	245 min	251
Total Acidity mgKOH/g	0.10 max	0.01
Evaporation loss 6.5 hrs @ $150^{\circ}\text{C}$ % m	20 max	10
Relative density @ $15.6/15.6^{\circ}\text{C}$	Report	0.850
Pourpoint $^{\circ}\text{C}$	$-55$ max	Below $-55$

Table continued

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PROPERTIES	MIL-PRF-83282D	TYPICAL
Low temperature stability 72 hrs @ -40°C	Must pass	Passes
High temperature stability 100 hrs @ 205°C	Must pass	Passes
Gravimetric Filtration, mg/100ml Filtration time                    minutes	0.3 max 15 max	0.2 Less than 15
Particle Count, Automatic, per Lt 5 to 15 µm 16 to 25 µm 26 to 50 µm 51 to 100 µm >100 µm	10000 max 1000 max 150 max 20 max 5 max	1331 190 55 4 0
Water content                    ppm	100 max	82
Foam resistance    ASTM Seq 1	Must pass	Passes
Flame propagation            cm/s	Must pass	Passes
Rubber swell, NBR-L            %	18 to 30	Passes
4-Ball Wear, 1 hr @ 75°C scar dia, mm 1 kg load/1200 rpm 10 kg load/1200 rpm 40 kg load/1200 rpm	0.21 max 0.30 max 0.65 max	0.18 0.24 0.50
Oxidation & corrosion stability 168 hrs @ 121°C – metal weight change – viscosity change @ 40°C    % – change in acidity    mgKOH/g	Must pass 10 max 0.2 max	Passes Less than 10 Less than 0.02
Flammability	Must pass	Passes

A viscosity/temperature curve is shown at the end of this section.

## AEROSHELL FLUID 41

AeroShell Fluid 41 is a mineral hydraulic oil manufactured to a very high level of cleanliness, and possesses improved fluid properties. AeroShell Fluid 41 contains additives which provide excellent low temperature fluidity as well as exceptional anti-wear, oxidation - corrosion inhibition and shear stability. In addition metal de-activators and foam inhibitors are included in this high viscosity index fluid to enhance performance in hydraulic applications. AeroShell Fluid 41 is capable of wide temperature range operation.

AeroShell Fluid 41 is dyed red.

### APPLICATIONS

AeroShell Fluid 41 is intended as a hydraulic fluid in all modern aircraft applications requiring a mineral hydraulic fluid. AeroShell Fluid 41 is particularly recommended where use of a "superclean" fluid can contribute to improvements in component reliability, and can be used in aircraft systems operating unpressurised between  $-54^{\circ}\text{C}$  to  $90^{\circ}\text{C}$  and pressurised between  $-54^{\circ}\text{C}$  to  $135^{\circ}\text{C}$ .

AeroShell Fluid 41 should be used in systems with synthetic rubber components and must not be used in systems incorporating natural rubber. Refer to the General Notes at the front of this section for further information.

AeroShell Fluid 41 is compatible with AeroShell Fluids 4, 31, 51, 61 and 71 and SSF/LGF.

Chlorinated solvents should not be used for cleaning hydraulic components which use AeroShell Fluid 41. The residual solvent contaminates the hydraulic fluid and may lead to corrosion.

### SPECIFICATIONS

<b>U.S.</b>	Approved MIL-PRF-5606H* (both U.S. and European production)
<b>British</b>	Approved DEF STAN 91-48 Grade Superclean* (European production only) Meets DEF STAN 91-48 Grade Normal (European production only) Equivalent to DEF STAN 91-48 Grades Superclean* & Normal (U.S. production only)
<b>French</b>	Approved DCSEA 415/A
<b>Russian</b>	Analogue to AMG-10
<b>NATO Code</b>	H-515* (equivalent H-520)
<b>Joint Service Designation</b>	OM-15* (equivalent OM-18)

\*Superclean grades

The British specification DEF STAN 91-48 covers two grades (normal and superclean) of mineral hydraulic fluid which differ only in their cleanliness limits. AeroShell Fluid 41 is manufactured to meet the superclean requirements and thus it also meets the requirements of the normal grade.



PROPERTIES	MIL-PRF-5606H	TYPICAL	
		U.S. Production	European Production
Oil type	Mineral	Mineral	Mineral
Kinematic viscosity mm <sup>2</sup> /s			
@ 100°C	4.90 min	6.13	5.30
@ 40°C	13.2 min	15.68	14.1
@ -40°C	600 max	384	491
@ -54°C	2500 max	1450	2300
Viscosity index	–	214	Over 200
Flashpoint, Pensky Martin closed cup °C	82 min	104	105
Autoignition temperature °C	–	230	230
Pourpoint °C	-60 max	<-60	<-60
Total acid number mgKOH/g	0.20 max	0	0.01
Evaporation loss 6 hrs @ 71°C %m	20 max	16.5	10
Water content ppm	100 max	55	<100
Relative density @15.6/15.6°C	Report	0.874	0.87
Colour	Red	Red	Red
Particulate contamination, number of particles per 100 ml in size range			
5 to 15 µm	10000 max	1200	808
15 to 25 µm	1000 max	550	116
25 to 50 µm	150 max	70	44
50 to 100 µm	20 max	5	10
over 100 µm	5 max	0	1

PROPERTIES	MIL-PRF-5606H	TYPICAL	
		U.S. Production	European Production
Copper corrosion	2e max	lb	2b
Steel on steel wear, scar diam, mm	1.0 max	0.65	0.95
Rubber swell, L rubber %	19 to 30	22	25.4
Corrosiveness & oxidation, 168 hrs @ 135°C			
– metal weight change	Must pass	Passes	Passes
– viscosity change @ 40°C %	-5 to +20	8.08	+0.1
– acid number change mgKOH/g	0.20 max	0.02	+0.1
Low temperature stability 72 hrs @ -54°C	Must pass	Passes	Passes
Shear stability			
– viscosity change @ 40°C	Must pass	Passes	Passes
– acid number change	0.2 max	Less than 0.2	Less than 0.2
Gravimetric filtration mg/100ml	0.3 max	0.1	Less than 0.3
filtration time min	15 max	10	Less than 15
Foaming tendency	Must pass	Passes	Passes
Barium content ppm	10 max	Nil	Nil

A viscosity/temperature curve is shown at the end of this section

# AEROSHELL FLUID 51

AeroShell Fluid 51 is a synthetic hydrocarbon and ester based fluid for use in hydraulic systems which require reliable operation in extreme low and high temperatures as well as performance outside the capability of traditional MIL-PRF-5606 mineral based fluids.

AeroShell Fluid 51 is formulated with high technology additives to provide oxidation and corrosion resistance, anti-wear, and anti-foaming protection.

AeroShell Fluid 51 is superclean filtered to ensure optimum performance in particulate monitored systems.

AeroShell Fluid 51 is dyed red.

The useful operating temperature range is  $-54^{\circ}\text{C}$  to  $+135^{\circ}\text{C}$ .

## APPLICATIONS

AeroShell Fluid 51 is recommended for use in aircraft, ordnance and missile systems operating from  $-54^{\circ}\text{C}$  to  $+135^{\circ}\text{C}$ . This fluid should be considered for use in auto pilots, shock absorbers, brakes, flight control systems, hydraulic servo-control systems and other systems using synthetic elastomer seals. This fluid is especially recommended for use in high altitude aircraft that normally operate with extended loiter times and high endurance levels such as UAVs and ELINT systems.

AeroShell Fluid 51 is a synthetic hydrocarbon oil and should not be used in contact with incompatible seal materials. Refer to the General Notes at the front of this section for further information.

AeroShell Fluid 51 is compatible with AeroShell Fluids 4, 31, 41, 61 and 71 and can be used in systems designed to operate with MIL-PRF-5606, MIL-PRF-6083, MIL-PRF-83282 and MIL-PRF-46170 fluids.

Chlorinated solvents should not be used for cleaning hydraulic components which use AeroShell Fluid 51. The residual solvent contaminates the hydraulic fluid and may lead to corrosion.

## SPECIFICATIONS

<b>U.S.</b>	Approved MIL-PRF-87257A
<b>British</b>	(MIL-PRF-87257A)
<b>French</b>	–
<b>Russian</b>	–
<b>NATO Code</b>	H-538
<b>Joint Service Designation</b>	OX-538

PROPERTIES	MIL-PRF-87257A	TYPICAL
Oil Type	–	Synthetic Hydrocarbon
Kinematic viscosity $\text{mm}^2/\text{s}$ @ $100^{\circ}\text{C}$ @ $40^{\circ}\text{C}$ @ $-40^{\circ}\text{C}$ @ $-54^{\circ}\text{C}$	2.0 min 6.7 min 550 max 2500 max	2.12 6.80 440 1945
Flashpoint $^{\circ}\text{C}$	160 min	175
Fire Point $^{\circ}\text{C}$	170 min	185
Total Acidity $\text{mgKOH/g}$	0.20 max	0.00
Evaporation loss 6.5 hrs @ $150^{\circ}\text{C}$ % m	20 max	13.5
Relative density @ $15.6/15.6^{\circ}\text{C}$	Report	0.838
Pourpoint $^{\circ}\text{C}$	$-60$ max	$-65$
Low temperature stability 72 hrs @ $-54^{\circ}\text{C}$	Must pass	Passes
High temperature stability – change in viscosity @ $40^{\circ}\text{C}$ % – change in acidity	5 max 0.1 max	Less than 5 Less than 0.1
Gravimetric Filtration, $\text{mg}/100\text{ml}$ Filtration time minutes	0.3 max 15 max	0.12 12
Particle Count, Automatic, per Lt 5 to $15\ \mu\text{m}$ $16$ to $25\ \mu\text{m}$ $26$ to $50\ \mu\text{m}$ $51$ to $100\ \mu\text{m}$ Over $100\ \mu\text{m}$	10000 max 1000 max 150 max 20 max 5 max	2400 250 90 5 0

Table continued

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PROPERTIES		MIL-PRF-87257A	TYPICAL
Water content	ppm	100 max	65
Foam resistance	ASTM Seq 1	65 ml max	20
Flame propagation	cm/s	0.40 max	Conforms
Rubber swell, NBR-L	%	19 to 30	23
4-Ball Wear, 75°C - scar dia, mm			
1 kg load		0.21 max	0.17
10 kg load		0.30 max	0.22
40 kg load		0.65 max	0.52
Chlorine content	ppm	50 max	Less than 50
Flammability		Must pass	Passes
Oxidation & corrosion stability			
- metal weight change		Must pass	Passes
- viscosity change	%	10 max	Less than 10
- change in acidity	mgKOH/g	0.2 max	Less than 0.02

# AEROSHELL FLUID 61

AeroShell Fluid 61 is a synthetic hydrocarbon base hydraulic fluid specifically inhibited to provide excellent oxidation stability for the oil and good corrosion preventive protection to the hydraulic system.

## APPLICATIONS

AeroShell Fluid 61 is designed for use where a fire resistant preservative grade hydraulic fluid is required and is suitable for operational use as well as preservation of components during storage and shipment.

AeroShell Fluid 61 has an operating temperature range of -40°C to +204°C.

AeroShell Fluid 61 is compatible with AeroShell Fluids 4, 31, 41, 51 and 71.

AeroShell Fluid 61 is a synthetic oil and should not be used in contact with incompatible seal materials. Refer to the General Notes at the front of this section for further information.

Chlorinated solvents should not be used for cleaning hydraulic components which use AeroShell Fluid 61. The residual solvent contaminates the hydraulic fluid and may lead to corrosion.

## SPECIFICATIONS

<b>U.S.</b>	Approved MIL-PRF-46170C Type I*
<b>British</b>	-
<b>French</b>	-
<b>Russian</b>	-
<b>NATO Code</b>	H-544
<b>Joint Service Designation</b>	-

\*The US specification covers two grades, Type I and Type II. The only difference between the two grades is that Type II is dyed red for aerospace use whereas Type I is undyed.

PROPERTIES	MIL-PRF-46170C Type I	TYPICAL
Oil Type	-	Synthetic Hydrocarbon
Kinematic viscosity mm <sup>2</sup> /s @ 100°C @ 40°C @ -40°C @ -54°C	3.4 min 19.5 max 2600 max Report	3.71 15.43 2488 15022
Flashpoint Cleveland Open cup °C	218 min	233
Fire Point Cleveland Open Cup °C	246 min	248
Acid or Base number mgKOH/g	0.2 max	0.07
Evaporation loss 22 hrs @149°C % m	5.0 max	2.39
Relative density @ 15.6/15.6°C	-	0.859
Pourpoint °C	-54 max	Below -54
Water Content ppm	500 max	278
Auto-ignition temperature °C	343 min	354
Colour	Undyed	Undyed
Particle Count, Automatic, per Lt 5 to 25 µm 26 to 50 µm 51 to 100 µm Over100 µm	10000 max 250 max 50 max 10 max	1414 39 4 0

Table continued

Table continued

PROPERTIES	MIL-PRF-46170C Type I	TYPICAL
Trace sediment            mg/l	0.005 max	0.001
Rubber swell, 168 hrs @ 70°C            % swell	15 to 25	21.5
4-Ball Wear, 75°C scar dia, mm 10 kg load/1200 rpm 40 kg load/1200 rpm	0.3 max 0.65 max	0.23 0.38
Galvanic corrosion	Must pass	Passes
Oxidation & corrosion stability 168 hrs @ 121°C – metal weight change – viscosity change @ 40°C    % – change in acidity    mgKOH/g	Must pass 10 max 0.3 max	Passes Less than 10 Less than 0.3
Low temperature stability	Must pass	Passes
Rust prevention	Must pass	Passes
Flammability	Must pass	Passes

A viscosity/temperature curve is shown at the end of this section.

# AEROSHELL FLUID 71

AeroShell Fluid 71 is a preservative mineral hydraulic fluid of improved cleanliness. AeroShell Fluid 71 is composed of a mineral base oil with an additive package which results in a product with excellent corrosion preventative properties as well as excellent oxidation stability, and good anti-wear characteristics.

AeroShell Fluid 71 is dyed red.

The useful operating temperature range is  $-54^{\circ}\text{C}$  to  $+121^{\circ}\text{C}$ .

## APPLICATIONS

AeroShell Fluid 71 is intended for preserving hydraulic equipment in storage and also for use in rig testing of hydraulic components.

AeroShell Fluid 71 should only be used in hydraulic systems employing synthetic rubber seals suitable for MIL-PRF-5606/DEF STAN 91-48 (AeroShell Fluids 4 or 41) type of fluids. Refer to General Notes at the front of this section for further information.

AeroShell Fluid 71 is compatible with AeroShell Fluids 4, 31, 41, 51 and 61.

Chlorinated solvents should not be used for cleaning hydraulic components which use AeroShell Fluid 71. The residual solvent contaminates the hydraulic fluid and may lead to corrosion.

## SPECIFICATIONS

<b>U.S.</b>	Approved MIL-PRF-6083F
<b>British</b>	Equivalent DEF STAN 80-142
<b>French</b>	Equivalent to DCSEA 535/A
<b>Russian</b>	–
<b>NATO Code</b>	C-635
<b>Joint Service Designation</b>	Equivalent PX-26

PROPERTIES	MIL-PRF-6083F	TYPICAL
Oil type	Mineral	Mineral
Kinematic viscosity $\text{mm}^2/\text{s}$ @ $-40^{\circ}\text{C}$ @ $-54^{\circ}\text{C}$ @ $40^{\circ}\text{C}$	800 max 3500 max 13 min	525 2400 14.3
Flashpoint Pensky Martin Closed Cup $^{\circ}\text{C}$	82 min	88
Total Acidity $\text{mgKOH/g}$	0.2 max	0.12
Pourpoint $^{\circ}\text{C}$	$-59$ max	Below $-59$
Relative density @ $15.6/15.6^{\circ}\text{C}$	–	0.879
Water content $\text{ppm}$	500	200
Colour	Red	Red
Trace sediment $\text{mg/l}$	0.005 max	0.002
Oxidation & corrosion stability 168 hrs @ $121^{\circ}\text{C}$ – metal weight change – viscosity change @ $40^{\circ}\text{C}$ – acid number change $\text{mgKOH/g}$	Must pass $-5$ to $+20$ 0.2 max	Passes Passes Less than 0.2
Copper corrosion	3a max	Passes
Corrosion inhibition	Must pass	Passes

Table continued

Table continued

PROPERTIES	MIL-PRF-6083F	TYPICAL
Particle Size per 100 ml		
5 to 25 µm	10000 max	1170
26 to 50 µm	250 max	90
51 to 100 µm	50 max	10
Over 100 µm	10 max	1
Low temperature stability 72 hrs @ -54°C	Must pass	Passes
Shear stability change in viscosity @ 40°C %	2.0 max	0.06
Rubber swell L rubber %	19 to 28	23
Evaporation loss 22 hrs @ 100°C %m	75 max	62
Foaming tendency	Must pass	Passes
Steel on steel wear, wear scar diam, mm	1.0 max	Passes
Gravimetric filtration mg/100ml filtration time mins	0.5 max 15 max	Less than 0.5 12

A viscosity/temperature curve is shown at the end of this section.

## AEROSHELL SSF AND LGF

AeroShell Shock Strut Fluid (SSF) and AeroShell Landing Gear Fluid (LGF) are mineral hydraulic fluids (MIL-PRF-6083 and MIL-PRF-5606 respectively) to which additional additives have been added to improve the extreme pressure characteristics and the fluid's natural lubricity. The lubricity agent provides a stable thin film layer to the metal surfaces at mild operating conditions. When severe conditions exist (landing/touchdown), the extreme pressure additive supplies the load carrying needed at the metal-to-metal surfaces to prevent the occurrence of such phenomena as "ladder cracking" and "slip stiction" of the piston component of the landing gear.

AeroShell SSF is AeroShell Fluid 71 plus additives.

AeroShell LGF is AeroShell Fluid 41 plus additives.

### APPLICATIONS

AeroShell SSF is recommended for all normal applications whilst the better low temperature properties of AeroShell LGF make it particularly suitable in areas of low temperature operations.

AeroShell SSF and AeroShell LGF are compatible with each other as well as with AeroShell Fluids 4, 41 and 71.

AeroShell SSF and LGF are straw yellow in colour.

### SPECIFICATIONS

<b>U.S.</b>	–
<b>British</b>	–
<b>French</b>	–
<b>Russian</b>	–
<b>NATO Code</b>	–
<b>Joint Service Designation</b>	–
<b>Boeing</b>	Approved BMS 3-32A (AeroShell SSF is approved to Type I and AeroShell LGF is approved to Type II)
<b>McDonnell Douglas</b>	Approved DPM-6177

AeroShell SSF and LGF are not covered by any military specification.

### EQUIPMENT MANUFACTURERS APPROVALS

AeroShell SSF and LGF are approved for use in the shock struts of the following aircraft:

<b>Boeing</b>	707/720, 727, 737, 747 (except those using BMS 3-11 fluids), 757, 767 and 777
<b>Lockheed</b>	L1011 Tristar
<b>McDonnell Douglas</b>	DC-8, DC-9, DC-10, MD-80, MD-11
<b>Airbus</b>	CML Code 02-004A (SSF)

For use in the landing gear shock struts of other aircraft, operators must check with the respective manufacturer first.

PROPERTIES	SSF TYPICAL	LGF TYPICAL
Base hydraulic fluid specification	MIL-PRF-6083F	MIL-PRF-5606H
Kinematic viscosity mm <sup>2</sup> /s @ 40°C @ -40°C @ -54°C	14.5 560 2640	14.5 423 1780
Flashpoint °C	108	110
Neutralisation Number mgKOH/g	2.6	2.4
Evaporation % SSF 22 hrs @ 99°C LGF 6 hrs @ 71°C	65 –	– 18.0



Table continued

PROPERTIES	SSF TYPICAL	LGF TYPICAL
Relative density @ 15.6/15.6°C	0.882	0.874
Pourpoint °C	-62	Below -68
Foaming		
Seq I Foam/Collapse time sec	30/30	45
Seq II Foam/Collapse time sec	20/10	-
Seq III Foam/Collapse time sec	30/30	-
Corrosion – Oxidation Stability (121°C/168 hrs)		
Metal Weight Change mg/cm <sup>2</sup>		
Copper	+0.002	-0.06
Aluminium	0	-0.005
Steel	0	-0.02
Magnesium	+0.002	+0.01
Cadmium	0	+0.01
Fluid Properties		
Change in viscosity %	+15	+10.5
Change in Acid Number mgKOH/g	+0.5	+0.05
Insolubles	1.0mg/100ml	Clear
4-ball wear, scar diam. mm	0.43	0.43
Colour	Yellow	Yellow

## TYPICAL TEMPERATURE/VISCOSITY CURVE OF AEROSHELL HYDRAULIC FLUIDS

